# Multifactorial approach in canine obesity management- challenges and opportunities

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ABBREVIATION LIST

BCS= Body Condition Score

BF= Body Fat

BW= Body Weight

$D_2O$ =Deuterium Oxide

DEXA= Dual-Energy X-ray Absorptiometry

DO= Diet Only

FD= Fitness and Diet

GRFs= Ground Reaction Forces

HRQL= Health-Related Quality of Life

Kcal= Kilocalories

LBM= Lean Body Mass

ME= Metabolized Energy content

MER= Maintenance Energy Requirement

NFE= Nitrogen-Free Extract

OA= Osteoarthritis

PA= Physical Activity

PT= Physical Therapy

QOL= Quality of Life

RER= Resting Energy Requirement

ROM= Range of Motion

TBW= Target Body Weight

TENS= Transcutaneous Electrical Nerve Stimulation

TW= Target Weight

WASVA= World Small Animal Veterinary Association

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# 1. INTRODUCTION

Canine obesity has become one of the most common problems in the veterinary field. Over the past decade, it has been estimated that around 33% of adult dogs are obese, with a concerning increase in prevalence similar to the rise of obesity incidence in the human population (GERMAN et al., 2006).

Obesity is a multifactorial condition characterized by an increase in optimal body weight by 15%. The primary cause of obesity is an imbalance between energy intake and expenditure. However, other risk factors, such as breed predisposition, age, sex, neuter status, owner behaviors (e.g., feeding table scraps, feeding while cooking, excess use of commercial snacks), and lack or low level of exercise can also contribute to the accumulation of adipose tissue (SANDØE et al., 2014). Obesity is linked to various health issues, including orthopedic disorders, respiratory distress, diabetes mellitus, hypertension, heat intolerance, neoplasia, reduced immunity, an elevated risk of anesthetic complications, and shorter life expectancy (BURKHOLDER et al., 2000). Obesity has also been shown to significantly reduce the dog's quality of life (YAM et al., 2006).

While caloric restriction remains a prevalent therapeutic method for addressing canine obesity, there is growing support for the idea that integrating various types of physical activities (PA) into weight loss programs could yield positive outcomes in terms of improving quality of life and even potentially reversing certain medical conditions (MLACNIK et al., 2006).

The primary objective of this thesis is to conduct a comprehensive literature review on various weight loss programs for canine patients. These programs will be categorized into those based on caloric restriction alone and those combining caloric restriction with different forms of PA. The ultimate goal is to determine which approach proves more advantageous for the dog's well-being. Additionally, the thesis will explore the potential challenges veterinary practitioners may encounter when implementing these weight-loss programs.

# 2. LITERATURE REVIEW

## 2.1 OBESITY AS A DISEASE

Overweight and obesity are considered among the most prevalent nutritional diseases of canines in the Western world. Obesity is defined as "an accumulation of excessive energy storage in the form of adipose tissue sufficient to contribute to disease" (National Institutes of Health, 1985) (FASCETTI et al., 2012). This leads to an undesirable body condition and can result in severe health effects, ultimately shortening the individual's lifespan. Dogs exceeding the optimal body weight by over 15% are considered overweight, while those surpassing optimal weight by over 30% are classified as obese (BURKHOLDER et al., 2000).

To effectively manage and treat obesity, a comprehensive understanding of its components, risk factors, and underlying pathology is crucial.

Distinguishing between two types of adipose tissue is essential: brown adipose tissue, prominent in neonates due to its role in thermogenesis, and white adipose tissue, which constitutes the central portion of adipocytes in adult tissues. Contrary to the previous belief that white adipose tissue primarily stores triglycerides as an energy source and for organ protection, recent studies (ROUSSET et al., 2004; LAFONTAN et al., 2005) have revealed its significant role in metabolism, designating it as an endocrine organ. White adipose tissue functions as an endocrine organ by releasing various factors collectively referred to as adipokines. These adipokines encompass growth factors, cytokines, steroid hormones, and other substances linked to appetite, glucose regulation, and energy metabolism. Examples of these adipokines include leptin, adiponectin, TNF-α, and IL-6 (JUGE-AUBRY et al., 2005; ROSEN et al., 2006; BADMAN et al., 2007; RADIN et al., 2009; ZORAN 2010). Furthermore, it has been established that adipose tissue comprises a diverse cell population, including pre-adipocytes, endothelial cells, stem cells, nerve cells, and macrophages, alongside adipocytes (RADIN et al., 2009). These elements collectively contribute to the development of obesity, leading to a state of mild inflammation and oxidative stress (GAYET et al., 2007; ERIMANN et al., 2009;

GERMAN et al., 2009; RADIN et al., 2009; WAKSHLAG et al., 2011). By comprehending the complexities of adipose tissue and its various roles, we can better address the challenges posed by canine obesity and its associated health concerns.

## 2.2 OBESITY RISK FACTORS

Obesity has many risk factors influencing its development, both environmental and genetic. First, breed predisposition is a prominent risk factor, as some breeds, such as Labrador retriever, Beagle, Cooker spaniel, and Cavalier King Charles spaniel, show a higher incidence of obesity (MEYER et al., 1978; EDNEY et al., 1986; DIEZ et al., 2006; GOSSELIN et al., 2007). Second, sex and neuter status dramatically impact the development of obesity. It has been shown that sex hormones contribute to the regulation of metabolism; therefore, the changes that occur in their production as a consequence of neutering cause a decrease in the metabolic rate and increase the chance of obesity development (COOK et al., 2004). As in humans, a link between low birth weight and obesity development in adult life has been described in dogs. A possible explanation is the "thrifty phenotype hypothesis," which proposes that metabolic adaptations occur in early life with lower birth weight due to scarce energy, and this adaptation will persist into adulthood (HALES et al., 2001). In a study done on a cohort of Labrador retrievers, which are known to be predisposed to obesity, the association between the two was shown, suggesting that low birth weight should be noted as a risk factor for obesity development, and proper dietary management is recommended throughout the dog's life as a preventative measure (MUGNIER et al., 2020). Another risk factor to take into consideration is the age of the animal. Dogs above the age of 7 years are considered "seniors", and are experiencing various changes in their physiology, including the digestive system (LAFLAMME 2012). Moreover, maintenance energy requirement (MER) declines with age. These changes might account for the decrease in lean body mass (LBM) (skeletal muscles) that comes with age. In the average animal, LBM is responsible for around 96% of basal energy requirements, highly affecting the individual's energy requirement (HARPER et al., 1998; LAFLAMME et al., 2000). Considering these and coupled with a significant decrease in PA in aging dogs, the chances of obesity increase (ELIA et al., 1991; CUPP et al., 2004;

KEALY 1999). Previous studies have demonstrated that reduced PA is associated with an increased risk of obesity in humans. Furthermore, obesity tends to decrease participation in PA, particularly in activities of moderate to vigorous intensity (HUGHES et al., 2006; DAVIS et al., 2006; HUGHES et al., 2008). The same has been shown to occur in dogs. In a study that utilized accelerometers over a 7-day period, researchers measured the levels of PA in a group of dogs with varying body condition score (BCS). The results revealed a notable difference in activity levels between obese dogs and those with an ideal BCS, with the obese dogs showing significantly lower PA levels (MORISSON et al., 2013). A central risk factor for developing obesity is establishing a positive energy balance- consuming more calories than are expended through energy expenditure. When PA is inadequate or reduced, and dietary intake is either increased or not adjusted to match energy requirements, obesity is likely to develop.

Other critical risk factors that should not be overlooked are the treatment of other pathologies that may cause increased appetite (glucocorticoids), different endocrine disorders (hyperadrenocorticism, hypothyroidism), and behavioral factors (food stealing and food-seeking behavior).

### 2.2.1 HUMAN-RELATED RISK FACTORS AND CORRELATION

According to recent studies, the prevalence of overweight and obesity in dogs is between 20-40%, with variations regarding global location (MCGREEVY et al., 2005; COLLIARD et al., 2006; LUND et al., 2006). Over the past few years, the increasing prevalence of obesity in both the human and canine populations in the Western world has sparked investigations into the possible link between the two. Research has revealed a clear and significant association between obesity in humans and dogs. The World Small Animal Veterinary Association (WASVA) formed a "One Health" committee in 2010, with the main focus being the prevention of zoonotic diseases from dogs and cats, though comparative medicine and the human-animal bond are matters of interest as well. Beyond the valuable insight into human health that can be achieved by studying companion animals, the significance of understanding the human-animal bond can be accounted for by its various influences

on humans and animals alike. Therefore, obesity is considered the most important health issue of man and pets in Western countries and the shared epidemic of obesity is often directly related to aspects of this shared lifestyle (SANDØE et al., 2014).

According to research, owners of overweight or obese dogs tend to show minimal interest in their own health and have a greater chance of being obese themselves. This phenomenon might be explained partly due to the owner's perception of health in general, as well as their perception of their dogs. The study showed that owners of obese dogs used treats and table scraps as a form of communication, had a higher chance of letting the dog sleep with them in bed, and were not concerned to contract diseases from their dogs (KINZEL et al., 1998). Furthermore, the socioeconomic status of the owner may also contribute to the likelihood of a dog becoming obese. It has been suggested that individuals with lower income levels have a higher probability of having an obese companion animal (KINZEL et al., 1998; COURCIER et al., 2010).

### 2.2.2 COMORBIDITIES

Obesity itself predisposes the dog to a shorter life expectancy and various obesity-related conditions (Table 1.) and disorders, including hyperlipidemia, dyslipidemia, orthopedic issues, cardiorespiratory ailments, hypertension, and urinary tract and reproductive disorders (KOLONIN et al., 2004). Obesity can result in elevated cholesterol levels, triglycerides, and phospholipids, which may correlate with insulin resistance observed in humans (KIM et al., 2003). Moreover, obesity significantly heightens the vulnerability to orthopedic disorders like humeral condylar fractures, cranial cruciate ligament rupture, intervertebral disc disease, and osteoarthritis (OA) (EDNEY et al., 1986; BROWN et al., 1996; KEALY et al., 1997; KEALY et al., 2000; IMPELLIZERI et al., 2000; SMITH et al., 2001; VAN HAGEN et al., 2005). Additionally, cardiac function can be impacted by obesity, leading to increased left ventricular volume, blood pressure, and plasma volume. There are also potential associations between obesity, portal vein thrombosis, and myocardial hypoxia (BABA et al., 1984; VAN WINKLE et al., 1993; BODEY eat al., 1996; TRUETT et al., 1998).

Table 1. Obesity related comorbidities in companion animals (GERMAN, 2016)

| | |
|---|---|
| Metabolic abnormalities | Hyperlipidemia/dyslipidemia<br>Insulin resistance<br>Glucose intolerance<br>Metabolic syndrome<br>Hepatic lipidosis (cat) |
| Endocrinopathies | Hyperadrenocorticism<br>Hypothyroidism<br>Diabetes mellitus<br>Insulinoma<br>Hypopituitarism<br>Hypothalamic lesions |
| Orthopedic disorders | Osteoarthritis<br>Humeral condylar fractures<br>Cranial cruciate ligament rupture Intervertebral disk disease |
| Cardiorespiratory diseases | Tracheal collapse<br>Brachycephalic airway obstruction syndrome<br>Laryngeal paralysis |
| Urogenital system | Urethral sphincter mechanism incompetence<br>Urolithiasis (calcium oxalate)<br>Transitional cell carcinoma<br>Dystocia |
| Neoplasia | Mammary<br>Transitional cell carcinoma |
| Functional alterations | Joint disorders<br>Respiratory compromise, e.g., dyspnea Hypertension<br>Dystocia<br>Exercise intolerance<br>Heat intolerance/heat stroke<br>Decreased immune functions<br>Increased anesthetic risk<br>Decreased lifespan |

## 2.3 IMPACT OF OBESITY ON QUALITY OF LIFE

Among orthopedic disorders, OA is the most common joint disease, with a prevalence of about 20% in adult dogs (ROUSH et al., 2002). Clinical signs of OA can be seen as discomfort or pain, decreased range of motion (ROM), muscle atrophy, and reduced ability to perform daily activities (TODHUNTER et al., 2002; MILLIS et al., 2002). Obesity is considered a risk factor for OA, suggesting that an increase in body weight (BW) leads to an increase in mechanical stress on joints and exacerbates their degeneration (KEALY et al., 1997). It has been observed that weight loss has a positive effect on the clinical signs of OA. Moreover, introducing different physical therapy (PT) modalities and increasing PA may assist in regaining muscle strength and performance, increasing ROM, and decreasing signs of discomfort and pain that appear with OA (IMPELLIZERI et al., 2000; MILLIS et al., 2002).

When discussing obesity and the impact it has on the patient's health, the question of health-related quality of life (HRQL) must be considered. One study (YAM et al., 2016) conducted an online survey, asking owners to rate the quality of life (QOL) of their dog, using a scale from poor to excellent covering four different categories assessing HRQL (energetic/enthusiastic, happy/content, active/comfortable, calm/relaxed). A significant difference was indicated between dogs that were in ideal body condition and dogs that were obese. The most notable difference was shown in the categories of energetic/enthusiastic and active/comfortable, with both having reduced scores in obese dogs. When looking at the energetic/enthusiastic category, the reduced score might be attributed to decreased capacity for extra activities such as playtime. Similarly, in the category of active/comfortable, the low scores might indicate decreased mobility due to mechanical reasons and potential joint pain, which could exacerbate as excess weight increases.

In relation to QOL, a common problem that may arise is displaying undesirable food-related behaviors: coprophagia, food guarding, and food stealing are more likely to happen in overweight and obese dogs. In addition, a link between these food-related behaviors and anxiety was observed, meaning obese dogs were more

reluctant to go outside, growl while eating, and bark at strangers. All are behavior patterns seen in a fearful dog (GERMAN et al., 2007).

## 2.4 ASSESSMENT OF OBESITY

Various methods are used in obesity assessment in order to determine a dog's body composition, and can be applied in research and clinical practice. The methods can be subjective or objective.

### 2.4.1 BODY CONDITION SCORE

BCS is a subjective method, semiquantitative measurement that is widely used in the clinical setting. Use observation, physical examination, and palpation to assign a BCS. Several schemes are available for BCS assessment, ranging from "emaciated" to "obese", and can be either a 5-point score or a 9-point score (Figure 1.), the latter being more commonly used in practice. When assessing BCS, body silhouettes are observed (lateral view of the animal and above the animal), bony prominences such as the ribcage, dorsal spinous process, and pelvic bones are palpated in order to estimate subcutaneous fat tissue, as well as abdominal palpation assessing intraabdominal fat (TOLL et al., 2010). It has been suggested that in the 9-point scoring system, each step increase in BCS above the optimal (BCS=5) corresponds to approximately 10% to 15% excess body weight (LAFLAMME 2012). BCS system is inexpensive, noninvasive, and can be used together with the owner when discussing weight loss protocols, helping the owner understand the situation, its seriousness, and the treatment objectives.

### 2.4.2 BODY FAT MEASUREMENTS

Objective methods include anthropometric measurements, dual-energy X-ray absorptiometry (DEXA), and estimation of body fat (BF) with deuterium oxide ($D_20$) dilution.

Anthropometric measurements are performed using a measuring tape, taking measurements from several anatomical locations such as shoulder height, cranial scapula to tale base length, pelvic circumference, and hook to stifle length. These are then used to calculate body mass index (BMI) and BF (BURKHOLDER et al., 2000).

DEXA is a noninvasive method for the estimation of BF. It utilizes X-rays at two distinct energy levels (70 and 140 kilovolts) to discern the type and quantity of various tissues within the scanned body region; it differentiates body tissues into bone and soft tissue mass (MAWBY et al., 2004).

$D_2O$ dilution is another noninvasive method in BF estimation. This method relies on the principle that body water primarily exists in nonfat tissues, making it an indirect indicator of fat-free (lean body) mass. $D_2O$ is a stable and safe tracer interchangeable with water; it is given intravenously (IV). By measuring total body water through this method, valuable insights into lean mass can be obtained (BURKHOLDER et al., 1998).

A study comparing the different methods of BF assessment has found a relatively positive correlation between %BF estimation by DEXA and by $D_2O$ and a significant correlation between %BF by DEXA and BCS. The optimal BCS of 5 in that study was linked to 11% BF, with every unit increase equal to 8.7% of BF (MAWBY et al., 2004).


Figure 1. Illustration of the 9-point body condition scoring system for dogs (LAFLAMME, D. R. P. C., 1997; WSAVA, 2013).

## 2.5 WEIGHT LOSS PROTOCOLS

The subject of obesity and the different approaches used for its treatment is a growing matter of investigation.

As previously stated, caloric restriction is crucial in achieving weight loss success, proving effective as a standalone method and in conjunction with PA.

### 2.5.1 CALORIC INTAKE AND RESTRICTION

One of the primary factors contributing to the development of obesity is the positive balance between energy intake and expenditure. Numerous approaches can be used to treat obesity, and caloric restriction is involved in the majority (LINDER et al., 2013).

Every weight loss protocol should be individually tailored and adjusted throughout the protocol for optimal weight loss rate, which is safe (1-2% per week), and get maximum owner compliance. The first step of a tailored weight loss program is patient assessment. A comprehensive review of the patient's medical history and medical records should be obtained in order to determine the previous health status and whether any medications are applied, that might be linked with obesity. Following the medical history, a thorough diet evaluation should be conducted, attaining information regarding the name, form, and quantities of the food that is used. In addition, it should be established if commercial treats and/or table scraps are given and in which amount. A precise amount of the total food (in calories) being fed to the dog can be very useful in the tailoring of a weight loss protocol. Lastly, the degree of overweight or obesity should be determined following with estimation of target weight (TW) using a BCS system (TOLL et al., 2010). When patient assessment is complete, a formula established on the 9-point BCS system, suggesting that one unit on the scale equates to a 10-15% change in BW is used (LAFLAMME 2006):

$$\text{Target weight} = (\text{starting weight}) \times \frac{100}{(100+[starting\ BCS-5]\times 10)}$$

It can then be used in the calculation of MER (MER= 132 × $BW^{0.73}$) (LAFLAMME et al., 1995; BURKHOLDER et al., 1998; BLANCHARD et al., 2004; LAFLAMME 2006). Energy restriction during weight loss protocols usually starts at about 50-60% of calculated MER for TW, depending on the sex and neuter status of the dog. Another simpler approach would be to start the weight loss protocol at the level of resting energy requirement (RER) (70 kcal/$kg^{0.75}$) based on TW and adjust the energy accordingly to reach 1-2% weight loss per week. After TW and energy restrictions are set, a suitable food should be chosen, assuring a well-balanced and complete diet, whether it be dry, wet food, or a combination of the two, according to the dog's and owner's preference. Today, most pet food companies have specifically formulated food for weight loss (low fat, high protein, and high fiber content) and are commercially available with a higher nutrient: calorie ratio, ensuring a complete and safe diet (Table. 2). It is important to note that nutrient uptake is also restricted with caloric restriction, especially when using standard food (LINDER et al., 2013).

Table 2. Average nutrient and caloric content comparison of veterinary diets intended for weight loss on basis of g/100 kcal

| Nutrient | Royal Canin obesity diet - dry | Royal Canin obesity diet - wet | Hill's metabolic diet - dry | Hill's metabolic diet - wet | Purina Pro Plan OM diet - dry | Purina Pro Plan OM diet - wet |
|---|---|---|---|---|---|---|
| Protein | 10.9 g | 12.4 g | 8.2 g | 8.1 g | 9.27 g | 13.21 g |
| Fat | 3.2 g | 3.6 g | 3.5 g | 3.8 g | 2.19 g | 3.59 g |
| NFE | 10.1 g | 4.4 g | 11.9 g | 11.4 g | 14.01 g | 6.67 g |
| Crude fiber | 2.4 g | 2.4 g | 4 g | 4.3 g | 3.55 g | 5.93 g |
| Omega-3 | - | - | 225 mg | 227 mg | 0.59 g | 0.03 g |
| Omega-6 | - | - | 703 mg | 735 mg | 0.04 g | 0.71 g |
| Carnitine | 10.6 mg | 5.3 mg | 8.7mg | - | - | - |
| Glucosamine | 32 mg | 12.4 mg | - | - | - | - |
| ME value (kcal/kg) | 3116 | 563 | 3094 | 886 | 2948 | 652 |

### 2.5.2 PHYSICAL THERAPY

Physical therapy (PT) is a growing field in veterinary medicine. According to the American Physical Therapy Association, PT is defined as: "physical therapy includes examining and evaluating patients with impairments, functional limitations, disability, and other health-related conditions to determine a diagnosis, prognosis, and intervention" (MILLIS et al., 2004).

PT is indicated as a treatment for a variety of conditions, including trauma, neural injury, rehabilitation, orthopedic injuries, OA, pain management, and obesity management. In addition, it can also be used as a preventative measure of injuries and can help maintain the animal's overall health, fitness, and QOL. In practice, different modalities such as manual therapy (massage, joint mobilization), laser, therapeutic ultrasound, electrotherapy, therapeutic exercises, thermotherapy, cryotherapy, hydrotherapy, and acupuncture are used.

In cases of obesity, it has been recommended to incorporate PA in weight loss programs (GERMAN et al., 2009; CHAUVET et al., 2011). The strategy of increasing PA in an obese patient will vary according to the starting health status of the patient, its abilities, and owner compliance. Taking these into consideration, an increase in PA might include added time to daily walks, or it might be the application of PT tailored protocols.

The modalities that are most commonly used are land treadmills and hydrotherapy. Hydrotherapy, e.g., underwater treadmill, has specific principles that can offer distinctive benefits that cannot be achieved in other forms of therapy. The basic principles of hydrotherapy include relative density, buoyancy, hydrostatic pressure, viscosity and resistance, and surface tension. Relative density of matter refers to the ratio of the weight of an object to the weight of an equal volume of water. The relative density of an object depends on its composition and is defined by a number value of specific gravity. The specific gravity of an object will determine if an object will sink or float. Therefore, the higher the relative density, the tendency to float decreases. Buoyancy comes from Archimedes' principle; a body that is fully or partially immersed in a resting fluid loses its weight, equating to the volume of the fluid displaced. The buoyancy principle helps patients with exercising, as it

decreases the load and weight bearing on painful joints. Hydrostatic pressure, stated as Pascal's law: When a submerged portion of the body is in a state of rest, the fluid surrounding it will exert uniform pressure across all surfaces of the body at that specific depth. It is proportional to the depth and density of the water. This can aid in edema reduction as well as pain perception. Viscosity and resistance; Viscosity is a property of liquids of internal friction, causing resistance to the inter-motion of their layers. Moving within water generates a resistance that corresponds to the velocity of motion. Surface tension is the force between surface molecules of water, causing greater resistance. All the mentioned properties assist and encourage the patient to move in a normal gait and decreased pain. In addition, water has high thermal capacity and increased conduction and convection abilities. Furthermore, adipose tissue is an insulator, effectively trapping and conserving heat. Therefore, when initiating hydrotherapy protocol in obese patients, precaution must be taken, and water temperature should be set at around 27 °C - 32 °C. Patients must be monitored constantly during the session to avoid overheating (LEVINE et al., 2004; VRBANAC et al., 2017).

Obesity and OA are strongly correlated. Obesity is likely to play a role in the initiation and advancement of OA due to the increased stress exerted on joints and articular cartilage, potentially leading to reduced PA and subsequent weight gain. As a consequence, a vicious cycle is created (RADITIC et al., 2004). Treatment and management of arthritic obese dogs using PT modalities is a valuable option. Various modalities and protocols may be used, which should be tailored to the individual patient and its condition. Low-impact therapeutic exercises, e.g., Controlled leash walks, walking on a treadmill, jogging, hydrotherapy (underwater treadmill, swimming), and going up and down stairs or ramp, are highly beneficial modalities often overlooked. Preparing the patient before the exercise by warming up using moist or dry hot packs, warm wet towels, and warm water bottle for 15-20 minutes, followed by passive ROM exercises, such as slow flexion and extension of the joints (15-20 slow repetitions) and massaging of the afflicted joints and muscle groups is essential. These will enhance blood circulation to the region, increase the flexibility of the tissue and collagen, and reduce pain, muscle spasms, and stiffness in the joints. Exercise sessions should be multiple (minimum 3 a day) and short, around 10-15

minutes, spread out evenly throughout the day and the week. A cool-down period after each session is necessary. A slow-paced walk for 3-5 minutes, followed by stretching and ROM exercises. Applying massage can help to decrease swelling, pain, and muscle spasms. Lastly, cryotherapy is recommended, applying cold packs or ice wrapped in a towel onto painful areas for 15-20 minutes to control and decrease blood flow and post-exercise inflammation (MARCELLINE-LITTLE et al., 2004).

In addition to those, when treating obese patients who suffer from OA, transcutaneous electrical nerve stimulation (TENS) can be used to alleviate pain. The mechanism of pain alleviation of electrical stimulation can be attributed to the gate control theory of pain, published by Melzack and Wall in 1965. Small cutaneous A-δ and C fibers transmit signals of pain, when a TENS current is applied, stimulation of large cutaneous (A-β) fibers occurs. Signals originating from A-β fibers initiate inhibitory neurons activity in the spinal cord, blocking the transmission of pain impulses to the brain from the periphery, therefore, decreasing the perception of pain. A high frequency with low intensity current (50-150 Hz) is considered suitable for initiating this mechanism for pain control (LEVINE et al., 2004). A study comparing the effects of a weight loss program combined with PT in varying degrees (land/water treadmill and TENS) between two groups of dogs suffering from OA has reported that within the group of dogs who were treated with intense PT (land treadmill and TENS sessions twice a week) had a significant improvement in the degree of lameness caused by OA, and were able to achieve weight loss more efficiently (MLACNIK et al., 2006).

### 2.5.3 RESTRICTED CALORIC INTAKE

When using solely caloric restriction in a weight loss protocol, it is important to formulate an individualized protocol that is safe and appropriate for the patient. After patient assessment, information about the current diet should be evaluated, considering the brand that is being fed, portion size, treats given, table scraps, additional pets in the household, number of people feeding the animal, and the living conditions of the animal in order to get an accurate accounting of the daily caloric

intake of the dog. If the patient's current diet was successfully obtained, and it is a well-balanced diet, weight loss can be achieved by restricting the caloric intake by 20-40%. However, in most cases, owners do not know or cannot recall the accurate feeding regimen, and a full and accurate diet history cannot be obtained. Therefore, a weight loss goal should be set and MER estimated following with a calculation of RER using the estimated optimal BW (RER = $TW_{kg0.75}$), and preceding with daily caloric intake calculation that will provide an adequate restriction that will result in weight loss. The recommendation is a restriction of 60-70% of the calories it will require to maintain the current weight. Additionally, it is highly recommended to calculate daily feeding portions based on the food that the patient is fed at home in order for the owner to have accurate and specific feeding instructions to follow, increasing owner compliance and weight loss success (MICHEL 2012).

The success of weight loss using caloric restriction alone has been evaluated in a large international study; of the 340 veterinary practices located in 27 countries, 926 overweight and obese dogs participated over 3 months study. The primary focus of this study was to determine the percentage of weight loss, while the secondary objectives were to assess changes in activity levels, QOL, and food-seeking behavior resulting from weight loss. Three weight loss diets were offered, all with high protein and fiber content (dry food, dry food for small dogs, and wet food). Following the TW estimation, daily energy allocations ranged from 251 to 335 kJ per $kg^{0.75}$ of TW per day, varying according to sex and neuter status. Energy intake adjustments were performed throughout the trial to achieve a 1-3% weight loss per week. At the end of the study, 96.8% of the dogs had lost weight, with only 7% reaching TW. Additionally, owners reported a significant increase in PA, with continuous improvement during the study. Furthermore, owners observed substantial improvements in QOL and food-seeking behavior. The study concluded that achieving TW is possible through a weight-loss protocol solely based on caloric restriction. Additionally, improvements in QOL and PA have been observed as positive outcomes resulting from weight loss efforts (FLANAGAN et al., 2017).

### 2.5.4 CALORIC RESTRICTION AND REGULAR PHYSICAL ACTIVITY

A clinical study on 35 client-owned obese dogs evaluated the relationship between energy intake and PA. Collar-mounted pedometers were used to measure the number of steps taken daily as a measure of activity (only on dogs >12kg due to inaccuracy). During a 2-week washout period, owners were asked to record the daily dietary intake and pedometer measurements, and therapeutic diets were gradually introduced. BCS, BW, sex, and age were recorded as a baseline by the end of the washout period. MER was then calculated using energy intake in kilocalories (kcal) and weight gain or loss that occurred during the washout period. BCS, BW, and pedometer measurements were recorded every two weeks until BCS 5 or 6 was attained. It should be noted that owners were advised to increase the level of activity of the dog (walking 3.22km) beyond the regular activity, but at the end of the study, no evidence of increased activity was recorded. According to pedometer measurements (mean number of recorded steps) at the end of the study, dogs were divided into two groups (active/inactive). All dogs participating in the study have reached a BCS of 5 or 6, without any significant difference between the two groups regarding the time taken to achieve TW and BW in kg. In contrast, the daily energy intake was significantly increased in more active dogs, suggesting that 1,000 steps increase corresponds to a 1 $kcal/kg^{0.75}$ increase in energy consumption. This study concluded that a successful weight loss program may be achieved with caloric restriction alone. Moreover, active dogs have higher energy intake yet can still achieve their TW in a weight loss program. The results of this study might provide insight into the relationship between energy intake and regular activity of the dog, but no conclusive evidence on the effects of PA on weight loss (WAKSHLAG et al., 2012).

### 2.5.5 CALORIC RESTRICTION AND INCREASED PHYSICAL ACTIVITY

A prospective randomized clinical trial compared the effectiveness of two weight loss interventions for overweight pet dogs: dietary caloric restriction and increased PA. 13 overweight dogs were assigned randomly to one of two interventions: dietary caloric restriction or enhanced PA. The dietary caloric

restriction intervention involved providing a therapeutic weight loss diet. In contrast, the PA intervention focused on boosting the dog's current PA level by at least one-third. The primary measure of success was body weight, with secondary standards encompassing neck, thorax, and abdominal circumference changes and PA gauged through a triaxial accelerometer. The results showed a significant reduction in BW through dietary caloric restriction but not via the PA intervention. Both groups exhibited substantial changes in abdominal and thoracic circumference. While the dietary caloric restriction group did not experience alterations in activity levels, the PA group demonstrated a noteworthy increase in vigorous activity. Ultimately, the study concluded that dietary caloric restriction proved more effective than increased PA in achieving controlled weight loss for overweight pet dogs. Although advising owners to enhance their dog's activity led to a modest rise in vigorous PA, this alone was insufficient to drive weight loss (CHAPMAN et al., 2019).

### 2.5.6 CALORIC RESTRICTION AND INTENSE PHYSICAL ACTIVITY

To explore the potential benefits of incorporating a controlled physical training regimen into a weight loss program for overweight dogs, aiming to enhance cardiorespiratory fitness and better maintain LBM compared to a weight loss approach solely based on caloric restriction, a prospective, nonrandomized clinical study was undertaken involving 19 overweight or obese dogs owned by clients. The study divided the participants into two groups: the fitness-and-diet (FD) group and the diet-only (DO) group. The FD group engaged in a training regimen consisting of both underwater and land-based treadmill exercises conducted three times a week. On the other hand, the DO group maintained their existing exercise routines without modification. The outcomes revealed that the mean weight loss was 13.9% for the FD group and 12.9% for the DO group. During the intervention, the FD group exhibited a 13% increase in mean accelerometer counts compared to the baseline. Both groups experienced a reduction in heart rate during exercise post-intervention. Notably, the FD group effectively preserved LBM during the intervention, while the DO group experienced a loss in LBM. These findings strongly support the inclusion of controlled physical training as a crucial component of obesity management in dogs (VITGER et al., 2016).

### 2.5.7 CALORIC RESTRICTION AND PHYSICAL THERAPY MODALITIES

As mentioned previously, a study assessing the impacts of a weight reduction regimen paired with a basic or more intricate PT plan involving TENS on lameness in overweight and obese dogs afflicted with OA was conducted. The investigation encompassed 29 adult dogs, categorized as overweight or obese with BCS of 4/5 or 5/5, presenting both clinical symptoms and radiographic evidence of osteoarthritis. The dogs were divided into two groups on enrollment, participating in a weight loss program. Energy allocation was set as 60% of daily MER, calculated for TBW of 15% less than the BW recorded initially (aiming for a 1% weekly weight loss). Owners of both groups were provided an introduction to the principles of massage (kneading and stroking of lumbar muscles and limbs) and passive ROM exercises of all limb joints. Owners were instructed to apply these modalities three times a day, daily. One group underwent caloric restriction alongside a home-based PT regimen, while the other followed the same dietary protocol alongside a rigorous PT protocol incorporating TENS (twice a week). The assessment of lameness was conducted through clinical evaluation and kinetic gait analysis performed on a treadmill equipped with four force plates, measuring the symmetry of ground reaction forces (GRFs) between the affected and unaffected limbs every 2 months over a span of 6 months. The outcomes exhibited notable weight reduction in both groups, with the caloric restriction and intensive PT group achieving more significant weight loss. After 6 months, mobility and symmetry indices of GRFs displayed enhancement, with the most substantial progress observed in the cohort that combined energy restriction with intensive PT. This underscores the potential of a combined dietary and PT approach to enhance health outcomes more effectively compared to diet-only interventions (MLACNIK et al., 2006).

## 2.6 CHALLENGES AND OPPORTUNITIES

Obesity management can be a challenging task and requires the cooperation of the owner and the veterinarian.

Many dog owners lack the proper knowledge about the importance of weight management and the implications obesity has on the health of their dogs. Therefore, client education is key regarding obesity management and treatment. It is the veterinarian's responsibility to communicate to the owner the risks of obesity, the benefits of a healthy weight and provide the appropriate solution. It has been reported that dog owners saw veterinary guidance as an essential part in managing their dog's obesity (JACKSON et al., 2001; BLAND et al.,2010). Providing specific feeding guidelines, treat feeding guidance, and continuous monitoring with energy requirements adjustments have been shown to be effective in weight management (YAISSLE et al., 2004; GERMAN et al., 2007). "Obesity clinics" that provide constant support, education, and monitoring during a weight loss program can operate as an addition to the standard veterinary clinic, and 79% of veterinary practices that provide this service have indicated that it is beneficial (BLAND et al., 2010).

Maintaining owner compliance throughout a weight loss program is a central challenge that veterinary practitioners face. Owners might be tempted to feed more treats, fail to follow the individualized diet, and get frustrated when weight loss is not observed, as it takes several months to achieve. In addition, caloric restriction holds the potential to cause hunger and consequently cause an increase in food-seeking behavior (GERMAN et al., 2007). Choosing weight loss specific formulated food with a detailed explanation of portion size can help tackle this problem; furthermore, assigning "treat allowance" equating to 10% of the daily caloric intake will allow the owners to continue engaging in one of the most enjoyable activities while maintaining appropriate energy balance (LAFLAMME 2012). Feeding devices, puzzles, and food-related enrichment activities can also be a way of dealing with the consequences of caloric restriction and can have an added value of increasing the energy expenditure of the dog (MICHEL 2012). Owners have reported that keeping a daily diary of their dog's daily food intake and activity is

helpful (JACKSON et al., 2001), especially in households with several people feeding the dog, preventing overfeeding (LAFLAMME 2012). Increasing exercise during a weight loss program can be beneficial in many ways. First, active dogs are able to achieve TW while consuming 20% more calories than less active dogs (WAKSHLAG et al., 2012); in that case, the potential for unsatisfied hunger and food-seeking behavior is decreased. Second, increasing PA during a weight loss program can contribute to fat loss (VAN DALE et al., 1989) while supporting the preservation of LBM (PHINNEY 1992). Third, a gradual increase in PA has been shown to have an impact on the QOL of the dog. It has been reported that dogs participating in a weight loss program have had a significant improvement in QOL when a gradual increase in PA was introduced, with a continuous improvement in every consecutive evaluation (FLANAGAN et al., 2017). Lastly, the correlation between human and canine obesity is evident, i.e., owners of obese dogs are likely to be obese themselves (KINZEL et al., 1998). Thus, encouraging dog owners to engage in PA with their dogs can have a positive and mutual effect on the physical and mental health of both (COLEMAN et al., 2008; CUTT et al., 2008; HOERSTER et al., 2011; LENTINO et al., 2012).

## 3. CONCLUSIONS

In this review, multiple studies comparing the different approaches to obesity treatment have been discussed and conclusions are the following:

1. The use of caloric restriction alone has been shown to be a successful approach in achieving target weight at a safe rate of 1-2% weight loss per week.
2. A challenge during weight loss protocol is the potential of developing hunger and, consequently, food-seeking behavior, as well as food stealing, is a significant factor that may influence the motivation and compliance of the owner, as they can be tempted to "cheat" and not follow the program that was assigned and failing to achieve target weight.
3. Loss of lean body mass has been observed while using only caloric restriction, and as lean body mass is a core factor in energy usage at rest, it can have an effect on weight management in the long run.
4. Approaching obesity management with caloric restriction and increased physical activity holds several advantages.
5. Increasing physical activity has been shown to help in the preservation of lean body mass as well as in the loss of fat tissue.
6. Incorporating physical therapy modalities as a form of physical activity can assist in weight loss while also alleviating pain caused by osteoarthritis, a prevalent comorbidity seen with obesity.
7. Physical therapy modalities, such as treadmill exercise, can help improve exercise tolerance in obese patients and, subsequently, their quality of life.
8. Increasing physical activity in dogs undergoing a weight loss program can allow owners to feed their dogs higher calories, thus, avoiding hunger development as a result of the caloric restriction.
9. Physical activity is an important factor contributing to the quality of life of both the dog and the owner, especially taking into consideration that obese dogs are more likely to be owned by obese owners.
10. Engagement in physical activity, either by walking the dog for a longer time each day, introducing interactive activities more often, or gradually increasing to a more vigorous type of physical activity together, has a significant positive impact

on health-related quality of life and even the mental health of the dog and the owner.

Finally, the overall conclusion is that weight loss and weight management are better achieved using the combination of both caloric restriction and physical activity.

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## 5. SUMMARY

Multifactorial approach in canine obesity management- challenges and opportunities

Adaya Kela

Canine obesity is a growing concern in the veterinary field, with around 33% of adult dogs worldwide reported to be obese. Obesity is a multifactorial condition, with the main factor being excessive caloric intake coupled with inadequate energy expenditure. In addition, obesity has both genetic and environmental influences, such as breed, sex, age, geographical location, and owner behavior. Canine obesity is associated with a variety of diseases, including metabolic dysfunctions, respiratory distress, exercise intolerance, OA, orthopedic injuries, dermatological diseases, neoplasia, anesthetic complications, and decreased longevity. Treatment and management of obesity requires an individualized approach, taking into consideration the health status of the patient i.e., comorbidities and capability, the current diet, and the owner's participation. Owner compliance is essential to a weight loss protocol and its success and can pose a challenge to the veterinarian while treating an obese patient; thus, continuous monitoring and guidance with good communication between the owner and the veterinary practitioner is key and needs to be emphasized. Restriction in caloric intake has been shown to be successful by itself. However, the integration of PA in weight loss protocols in different forms and intensities, either by increasing the distance of the daily walk, interactive playing activities, or by applying PT tailored modalities such as hydrotherapy, demonstrated to be beneficial in weight loss, preservation of LBM, and improvement in the QOL.

Key words: obesity, weight loss, caloric restriction, physical therapy, physical activity, canine.

# 6. SAŽETAK

Multifaktorijalni pristup pretilosti u pasa - izazovi i prilike

Adaya Kela

Pretilost u pasa postaje sve veći problem u veterinarskom polju, pri čemu udio odraslih pasa koji su pretili iznosi 33%. Pretilost je multifaktorijalna patologija, pri čemu je glavni čimbenik nastanka pretjeran unos kalorija uz nedostatan energetski deficit. Osim toga, na pretilost će utjecati genetski i okolišni čimbenici, poput pasmine, spola, dobi, geografske lokacije i ponašanja vlasnika. Pretilost u pasa povezana je s raznim bolestima, uključujući metaboličke poremećaje, respiratorne bolesti, netoleranciju za vježbanje, ortopedske i dermatološke patologije, neoplazije, komplikacije pri anesteziji i smanjenje životnog vijeka. Provedba protokola gubitka tjelesne mase zahtijevaju individualni pristup, uzimajući u obzir zdravstveno stanje pacijenta, tj. prisutnost drugih bolesti, ograničenja u vidu prehrane i motiviranost vlasnika. Sudjelovanje vlasnika je ključno za uspješnost protokola gubitka tjelesne mase te može predstavljati izazov za veterinara koji liječi pretilog pacijenta; stoga je kontinuirano praćenje i komunikacija između vlasnika i veterinara od ključnog značaja. Restrikcija unosa kalorija pokazala se uspješnom kao samostalna intervencija. Međutim, integracija tjelesne aktivnosti u protokol mršavljenja u različitom obliku i intenzitetu, povećavanjem udaljenosti dnevne šetnje, interaktivnim igrama ili primjenom prilagođenih metoda fizikalne terapije kao što je hidroterapija, pokazala se korisnom za protokol gubitka tjelesne mase, očuvanje mišićnog tonusa i poboljšanje kvalitete života.

Ključne riječi: pretilost, protokol mršavljenja, kalorijska restrikcija, fizikalna terapija, fizička aktivnost, pas.

## 7. BIOGRAPHY

Adaya Kela was born on March 30th, 1992, in Tel-Aviv, Israel.

She graduated high school in 2010, and the same year she enlisted in the Israeli Defense Forces, serving for 2 years in the Air Force as a coordinator Integrating underprivileged soldiers into the system. After discharging from her service, she traveled for 8 months in Central America. In 2015 she decided that veterinary medicine is the path to take and enrolled in a pre-medicine course.

In 2016, Adaya enrolled in the Faculty of Veterinary medicine of Zagreb as a part of the 1st generation of the English program.