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Evaluation of functional capacity in obese, overweight and normal dogs using six-minute walk test

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Abstract
Obesity is a growing health concern in companion animals and is associated with reduced longevity, impaired quality of life, and increased risk of cardiovascular and respiratory dysfunction. The present study evaluated the effect of obesity on functional capacity and exercise-induced cardiac responses in dogs using the Six-Minute Walk Test (6-MWT) and electrocardiography (ECG). A total of 124 client-owned Labrador retrievers presented to the Teaching Veterinary Clinical Complex, SKUAST-Jammu were assessed. Dogs were categorized as normal, overweight, or obese based on body weight, body condition score, and body fat percentage. Functional capacity was assessed by measuring the distance walked during the 6-MWT, along with changes in heart rate, respiration rate, and ECG parameters before and after exercise. Obese dogs walked significantly shorter distances compared to normal dogs and exhibited higher post-exercise heart and respiration rates, indicating reduced exercise tolerance. Distance walked showed a significant negative correlation with body fat percentage, body weight, and body condition score. The study demonstrates that obesity markedly impairs functional capacity and alters cardiac responses in dogs, and validates the 6-MWT as a simple, reliable tool for assessing functional capacity in obese and cardiopulmonary-compromised dogs.

Keywords: Six-minute walk test, canine obesity, functional capacity

Introduction
There is an increasing trend in the incidence of obesity in the pet population (McGreevy *et al*., 2005) [20] with 25-35 per cent obese (Greco, 2002) [11] and up to 39 per cent overweighted dogs (Lund *et al*., 2006 and Courcier*et al*., 2010) [16, 7]. Obesity causes detrimental impact on dog's health, longevity and quality of life by reduction in median life expectancy by 15 per cent (2 years) in obese dogs (Hand *et al*., 2010) [13]Obese dogs generally present signs of constant panting, respiration distress, increased heart rate, struggles with stairs, lethargy and heat intolerance. One of the earliest and most significant consequences for both human and veterinary patients with chronic respiratory or cardiacdisease is the reduced ability to perform normal daily activities, also known as the functionalcapacity (FC) (Singh, 2007) [23]. The 6-Minute Walk Test (6MWT) performed by measuring the distance an individual can walk comfortably in 6 minute (Enright, 2003) [10] has also been evaluated in dogs (Agudelo and Schanilec, 2013) [1] and has been found to be able to discriminate between healthy dogs and dogs with cardiac and pulmonary disease. Despite the growing prevalence of canine obesity, limited information is available regarding its effect on functional capacity and exercise-induced cardiac responses. Therefore, the present study was designed to evaluate functional capacity in normal, overweight and obese dogs using the 6-MWT and to correlate walking performance with clinical, and morphometric parameters.

Materials and Methods
The study was conducted on 124 client-owned Labrador retriever dogs presented to the Teaching Veterinary Clinical Complex, SKUAST-Jammu. Dogs of different ages and gender were included. Animals with overt cardiac, respiratory, neurological or orthopaedic disorders were excluded.

Assessment of obesity
1. Body weight
The body weight of the dogs was measured using electronic weighing machine. The approximate body weight of Labrador retrievers was set as 65 to 80 lb (29.48-36.28 kg) for

males and 55 to 70 lb (25-31.75 kg) for females as per Burr *et al*. (2002) [5]. The dogs having body weight in excess of 10-15% of ideal body weight were considered as overweight whereas those having body weight in excess of 20-25% were considered as obese (Mawby*et al*., 2004) [19].

2. Body condition score

Body condition score of dogs was assessed by 5- point scale as described by Lund *et al*. (1999) [15]

3. Body Fat Percentage

Body fat percentage (BF%)of dogs was calculated using gender specific formula as given by Burkholder and Toll (2000) [4] and Mawby*et al*. (2004) [19].

A. Male body Fat (%) = -1.4 (HS) + 0.77 (PC) + 4
B. Female body Fat (%) = -1.7 (HS) + 0.93 (PC) + 5

PC (Pelvic circumference) and HS (Hock to Stifle)

The normal reference ranges for body fat percentage were set at 15%-22% for male (neutered/non-neutered) dogs and at 15%-25% for female (nonspayed/spayed) dogs. Body fat percentage exceeding 22% in males and 25% for females was considered overweight and obese (Li *et al*., 2012) [14].

Six-Minute Walk Test

Functional capacity was evaluated by performing six minute walk test (6-MWT) on dogs as described by Manens (2014) [17]. Before starting the 6-MWT, basal clinical heart rate, respiratory rate and ECG were obtained. After a few minutes of acclimatization, dogs were allowed to walk at their own pace for 6 min, along an unobstructed 18.6mt long hallway. Dogs were walked when there were no other people or animals around that could represent a potential distraction. Heart rate, respiration rate was recorded immediately after the test to assess the quality of life. The total walked distance was measured and reported in meters (mt).

Statistical Analysis

The mean values of heart rate and respiration rate of clinical cases at rest and after the 6-minute walk test was compared using student-t test. In survey dogs, one way analysis of variance and Tusky's HSD test was used to compare mean values of heart rate and respiration rate at rest and after 6-minute walk test.

Results and Discussion

Overall prevalence of obesity

Obesity in dogs was classified on the basis of body fat percentage (Table 1).

Table 1: Overall prevalence of obesity among surveyed dogs (n = 124)

Weight categories (BF%)	Number of dogs (n)	Percentage (%)
Normal dogs (15.73-27.96)	41	33.06
Overweight dogs (27.16-31.77)	20	16.13
Obese dogs (32.05-65.35)	63	50.81
Figure in parenthesis indicate range of body fat percentage		

Functional capacity test variables in dogs

Distance walked

In 6 MWT, the obese dogs (201.80±4.67 vs. 337.66±6.34 mt) (Table 2) walked much shorter distance as compared to the normal dogs. Similar finding was observed by Manens *et al.* (2014) [17] who recorded that obese dogs walked shorter distances than lean dogs (obese: 509 ± 35 m; overweight: 575 ± 36 ms; lean: 589 ± 36 m). Other workers observed that normal healthy dogs walked longer distance than dogs with cardiopulmonary dysfunctions [Boddy *et al*. 2004 (573 ± 85.5 vs. 526 ± 99.4 mt) [2], Swimmer and Rozanski, 2011 (522.7±52.4 vs. 384.8±41.0 mt) [24]]. The obese subjects exhibited slower gait speeds with shorter stride length, poor limb power test and poor endurance (Pataky *et al*., 2014) [22]. The changes in body conformation cause decrease in activity counts (Brown *et al*., 2010) [3] and a shorter distance walked was associated with several cardiovascular risk markers including higher levels of total cholesterol and LDL (Ekman *et al*., 2013) [9].

Heart rate and Respiration rate in functional capacity test

In the present study it was seen that the mean heart rate (107.48±1.98, 106.25±3.84 vs. 92.17±1.46 beats/min) of obese and overweight dogs was significantly ($P<0.01$) higher after 6-MWT as compared to normal dogs (Table 2) which coincided with the findings of Guyton and Hall (2004) [12]. A higher heart rate in dogs with cardiopulmonary diseases has been reported by others [Boddy *et al*., 2004 (150 ± 24.2 vs.133 ± 21.3 beats/min) [2]. Obese dogs showed panting more often in comparison to normal dogs, which may be attributed to decreased tidal volumes leading to a rapid and shallow pattern of respiration to maintain constant minute ventilation. The higher HR observed in obese dogs at rest as well as after walk test additionally indicates the chronic hormonal activation that accompanies heart disease (Di Thommazo-Luporini *et al*., 2012) [8]. The study further validates the simple and user friendly 6MWT that would represent a major addition to the armamentarium of clinical veterinary cardio-pulmonary function testing for pet dogs (Swimmer and Rozanski, 2011) [24].

Table 2: Functional capacity test variables

Parameters	Normal dogs (n=41)	Overweight dogs(n=20)	Obese dogs (n=63)	P value (within row)	P value (within column)
Distance walked (mt)	337.66 ± 6.34^{a} (223.20- 398.6)	246.53 ± 11.69^{b} (167.4- 372)	201.80 ± 4.67^{c} (111 - 16.20)	0.000	-
Heart rate at rest (beats/min)	79.92 ± 1.15^{ax} (70-102)	88.40 ± 2.85^{bx} (70 - 132)	89.30 ± 1.84^{cx} (68 - 145)	0.000	0.000
Heart rate after 6 -MWT (beats/min)	92.17 ± 1.46^{ay} (80 - 110)	106.25 ± 3.84^{by} (83-155)	107.48 ± 1.98^{cy} (84-175)	0.000	0.000
Respiration rate at rest (breathe /min)	35.93 ± 0.97^{ax} (24-48)	40.00 ± 3.13^{abx} (24-80)	40.81 ± 1.36^{bx} (21-70)	0.056	0.000
Respiration rate after 6 -MWT (breathe /min)	51.19 ± 1.29^{ay} (34-68)	55.25 ± 3.61^{aby} (38-102)	56.71 ± 1.33^{by} (36-82)	0.045	0.000

Figures in parenthesis range
Different superscripts $^{a, b, c}$ indicate significant difference at $P<0.05$within a row
Different superscripts $^{x, y}$ indicate significant difference at $P<0.05$ within coloumn

Correlation (r) between distance walked and morphometric parameters:

The present study revealed that distance walked showed a significant (P<0.05) negative correlation with BF% (r =- 0.310) and body weight (r =- 0.334) and body condition score (r = -0.459)(Table 3); which confirmed that the obese dogs had reduced functional activity expressed as exercise intolerance and worse performance of normal daily activities which has been reported in earlier studies (Singh, 2007) [23]. Chan *et al*. (2005) [6] and Weber (2011) [25] reported that body condition score was inversely correlated with physical activity. Generally obese dogs are less vigorously active than normal dogs (Morrison, 2015) [21]. Manens *et al.* (2012) [18] found that obesity negatively affects 6 MWT performances in dogs.

Table 3: Correlation (r) between distance walked and morphometric parameters

Morphometric parameters	Distance walked		
	Normal dogs (n=41)	Overweight dogs (n=20)	Obese dogs (n=63)
BF%	-0.041 (0.798)	-0.506* (0.023)	-0.310* (0.013)
BW	-0.098 (0.543)	-0.471* (0.036)	-0.334** (0.007)
MBMI	-0.070 (0.664)	-0.358 (0.121)	-0.223 (0.079)
WHSDR	0.124 (0.440)	-0.132 (0.578)	-0.127 (0.320)
WIWDR	0.065 (0.686)	0.197 (0.405)	-0.018 (0.886)
WTLR	-0.068 (0.672)	-0.221 (0.349)	-0.231 (0.068)
BCS	-	-	-0.459** (0.000)

**Significant correlation at the 0.01 level (2-tailed)
*Significant correlation at the 0.05 level (2-tailed)
Figures in parenthesis indicate P value

Conclusion

Abdominal obesity was significantly functional changes in the dogs. The 6- MWT was an effective method of screening for exercise intolerance and cardiopulmonary function with ability to perform daily activity in obese dogs.

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