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Obesity-Related Dyslipidemia in Domestic Cats: A Comparative Analysis of Lipid Profile Alterations

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Gabriela Dal'Agnol Lara[1], Verônica Lordello Gulin[2], Gilberto Serighelli-Júnior[1], Ester Hanna de Pauli Flaksberg[2], César Jun Hironaka Nakao[1], Gabriellye Tavares de Abreu[3], Rosângela Locatelli Dittrich[3]

[1]*Department of Veterinary Medicine, Federal University of Paraná (UFPR), Curitiba, Brazil, State of Paraná, Brazil. ORCID 0009-0002-9527-6765 (G.D.L); 0000-0002-0979-7939 (G.S.J); 0000-0002-5971-4943 (C.J.H.N)*
[2]*Undergraduate Veterinary Medicine, Federal University of Paraná (UFPR), Curitiba, Brazil, State of Paraná, Brazil. ORCID 0009-0009-7622-9411 (E.H.F); ORCID 0009-0003-0008-4099 (V.L.G)*
[3]*Laboratory of Clinical Pathology, Federal University of Paraná (UFPR), Curitiba, Brazil, State of Paraná, Brazil. ORCID 0000-0001-5144-6422 (R.L.D); ORCID: 0009-0001-9261-1866 (G.T.A.)*

Author for correspondence: Gabriela Dal'Agnol Lara – gabrielalara@ufpr.br

Abstract: Feline obesity is a prevalent disorder that predisposes cats to metabolic diseases, but comprehensive data on its specific effects on serum lipid profiles are lacking. This study aimed to establish reference intervals for HDL cholesterol and a lipid profile in healthy, lean cats. It characterized serum concentrations of total cholesterol, HDL, VLDL, LDL, and triglycerides, and examined alterations across body condition scores, age groups, and between sexes. In a prospective cross-sectional study of eighty-five client-owned cats (25 lean, 60 overweight/obese), body condition was assessed using body weight and a 9-point BCS system. Biochemical analyses were performed using a Mindray® BS200 automated analyzer. Results established an HDL reference interval of 39.1–163.9 mg/dL for lean cats. Obesity was linked to a distinct dyslipidemia, characterized by a pronounced 58% increase in triglycerides and rising VLDL. Interestingly, while HDL levels increased with obesity, total cholesterol was up to 13% higher in overweight cats compared to lean cats, indicating a complex metabolic relationship. A significant finding was that 71.2% of young adult cats were already above ideal BCS, with the highest obesity rate (40%) in mature adults. A notable sex disparity was observed, with male cats showing a greater tendency toward higher adiposity.
Keywords: triglycerides; body condition score; overweight; HDL cholesterol.

1. Introduction

Obesity is a significant health concern in domestic cats, and it is estimated to affect over 35% of the global domestic feline population (Mori et al., 2016; Blanchard et al., 2025; Montoya et al., 2025). The relationship between being overweight and its associated metabolic diseases has been a growing concern in veterinary medicine. The definition of obesity is an excessive accumulation of triglycerides in adipose tissues, resulting from an energy imbalance where energy intake exceeds energy expenditure. Studies indicate that long-term obesity in cats leads to lipoprotein abnormalities similar to those in obese humans, including increased triglycerides and non-esterified fatty acids in the plasma (Mori et al., 2015). These changes are associated with insulin resistance, a typical progression in obese cats that can lead to type 2 diabetes.

Plasma lipoproteins in cats, including chylomicrons, VLDL, LDL, and HDL sub-classes (HDL1, HDL2, HDL3), play distinct roles in lipid transport and metabolism (Xenoulis and Steiner, 2010). Dyslipidemia, characterized by elevated triglycerides and non-esterified fatty acids, can also exacerbate other obesity-related health problems in cats, such as hepatic lipidosis or fatty liver disease (Valtolina, 2017; Pazak et al., 1998). The increased flux of non-esterified fatty acids to the liver, a hallmark of dyslipidemia, can overwhelm the liver's capacity for processing lipids, leading to fat accumulation and liver dysfunction, which is thought to be a factor in increasing the production and secretion of very-low-density lipoproteins (VLDL), which raises plasma VLDL concentrations. This condition can further impair metabolic regulation and overall health.

While previous studies (Bauer, 1996; Jordan et al., 2008) compared lean vs. obese cats, the gradation of lipid alterations across body condition scores (BCS 5–9) remains unclear. For instance, do mildly overweight (BCS 6–7) cats exhibit intermediate dyslipidemia, or is there a threshold effect? No studies have correlated VLDL and HDL with BCS in cats, despite their predictive value in human cardiovascular risk (Vekic et al., 2023; Liu et al., 2006). In the veterinary field, there are relatively few studies on the role of HDL and its relationship with complications of hyperlipidemia (Choi, 2024; Hoenig, 2007).

The objectives of this study were to: (1) establish reference intervals for HDL cholesterol in healthy lean cats; (2) characterize serum concentrations of total cholesterol, HDL, VLDL, LDL, and triglycerides across body condition scores (BCS 5–9); (3) assess the impact of overweight and obesity (BCS ≥6) on lipid metabolism alterations; and (4) assess lipid profiles across different age groups and between males and female cats. These aims address critical gaps in understanding the interplay between adiposity and dyslipidemia in cats, particularly the lack of BCS-stratified lipid data.

2. Material e Methods

2.1. Animals and Sample Size

This study was approved by the Ethics Committee (Comitê de Ética no Uso de Animais do Setor de Ciências Agrárias, CEUA-SCA) at the Federal University of Paraná (Protocol No. 063/2024), adhering to the Brazilian National Council for Animal Experimentation Control (CONCEA) guidelines. Sample size was estimated a priori using G*Power 3.1.7 (Heinrich Heine University, Düsseldorf, Germany). HDL cholesterol was considered the primary outcome. Assuming a two-tailed α of 0.05, a power

of 80%, and defining a 20% difference in HDL concentration between groups as clinically significant, with a standard deviation of approximately 25 mg/dL based on pilot data and previous reports, a minimum of 22 cats per group was required. To account for potential exclusions and to allow subgroup analyses by BCS, age, and sex, 85 cats were ultimately enrolled.

2.2. Animal selection

This cross-sectional study was conducted with 85 client-owned cats from Curitiba between November 2024 and May 2025. All owners provided written informed consent, as required by CEUA-SCA, authorizing the collection of samples and the use of data for publication. Data collection Included Clinical history, physical examination, and owner questionnaires (specifically dietary/nutritional habits) to facilitate correlation with existing literature findings. Inclusion criteria: Female and male cats >1 year old, varying body condition scores (BCS). Exclusion criteria: Cats with any pre-existing medical conditions, current pharmacologic treatment with any drug, or a history of extended medication use, with specific emphasis on agents known to induce obesity. All cats underwent hematologic screening to exclude those with anemia or other blood-related abnormalities.

2.3. Body Condition Assessment

Body condition was evaluated by using Body weight and the 9-point Body Condition Score (BCS) (Laflamme, 1997; Teng et al., 2018). A BCS of 6-7 constituted overweight, and a BCS of 8-9 constituted obesity. To eliminate inter-observer variability, the same clinician performed all assessments. Photographic documentation (lateral and dorsal views) was obtained for potential retrospective validation. Participants were stratified by age according to the AAHA/AAFP Feline Life Stages (Quimby et al., 2021): Young Adult (1–6 years), Mature Adult (7–10 years), and Senior (>10 years).

2.4. Blood Samples

Patients underwent an 8 to 12-hour fasting period to minimize the risk of pre-analytical lipemia. Using cat-friendly handling techniques (Rodan et al., 2011), 3mL blood was collected via cephalic or jugular venipuncture. Sample handling: EDTA tubes for complete blood count (CBC) and clot activator tubes for biochemical analysis. Clot activator tubes for biochemical analysis. All samples were promptly transported to the UFPR Veterinary Clinical Pathology Laboratory, with processing completed within 6 hours of collection to ensure sample integrity.

2.5. Laboratory Analysis

Biochemical analyses were performed by an automated analyzer (Mindray® BS200). The samples were centrifuged at 5,000 rpm for 5 minutes to separate the serum. Analyzed parameters: Total cholesterol, Triglycerides, and HDL (Bioclin® direct HDL) were analyzed using the enzymatic colorimetric method; VLDL and LDL were calculated by the Friedewald equation (Friedewald et al., 1972): (LDL-C) = (total cholesterol) - (HDL-C) - (triglycerides)/5.

2.6. Statistical Analysis

Statistical analyses were performed using GraphPad Prism version 10 (GraphPad Software, San Diego, CA, USA). The normality of data distribution was assessed using the Shapiro–Wilk test. Parametric data were expressed as mean ± standard deviation (SD) and compared by one-way ANOVA with Tukey's post hoc test. Nonparametric data were reported as medians and interquartile ranges (IQRs) and compared using Kruskal–Wallis tests with Dunn's correction. Correlations between variables were assessed using Spearman's rank correlation coefficient (ρ). Threshold effects across BCS categories were explored using segmented regression models. Reference intervals for HDL cholesterol in lean cats were established using the nonparametric percentile method (2.5th–97.5th percentiles) in accordance with CLSI guidelines. A p-value < 0.05 was considered statistically significant.

3. Results

3.1. 3.1. Age and gender lipid profiles

The study evaluated 85 client-owned cats (45 females, 40 males), all of which were neutered. Our population consisted of 60 (70.5%) overweight cats and 25 (29.4%) lean cats. Age distribution followed the 2021 AAHA/AAFP Feline Life Stage guidelines. The results are presented according to age range and body condition score (Table 1).

BCS	Young Adult (YA)	Mature Adult (MA)	Senior	Female Cats (%)	Male Cats (%)
5	17	6	2	20 (44,4%)	5 (12.5%)
6	19	3	0	9 (20%)	13 (32.5%)
7	8	2	4	8 (17.7%)	6 (15%)
8	11	2	5	4 (8%)	14 (35%)
9	4	2	0	4 (8%)	2 (5%)
Total	59	15	11	45	40

Table 1 – Body Condition Score (BCS) Distribution Across Age Groups and Gender Distribution of 85 cats.

Consistent with feline primary-care populations (Quimby et al., 2021), our cohort's age distribution (69.4% Young Adults, 12.9% Seniors) aligns with expected demographic patterns. The Mature-to-Senior ratio (1.5:1) exceeds the minimum recommended (1:1) for comparative analyses.

Our study revealed differences in how male and female cats distribute across weight categories (Table 1). Healthy-weight cats (BCS 5) were predominantly female (80%), while obese cats (BCS 8) were overwhelmingly male (77,7%). Female cats showed a U-shaped distribution, appearing most frequently at both weight extremes (healthy BCS 5 and severely obese BCS 9). In contrast, males dominated the middle ranges (BCS 6-8).

To comprehensively evaluate how obesity affects feline lipid metabolism, we conducted our analysis in two key phases: We first examined how lipid values (cholesterol, HDL, LDL, VLDL, and triglycerides) vary across different life stages (Table 2). After building on these age-related findings, we then analyzed how lipids changed across the full spectrum of body conditions (Table 3). This way, we can establish normal age-related variations before assessing the effects of obesity, allowing us to distinguish actual weight-related changes from the effects of aging.

Parameter	Life Stage	n	Reference Intervals (mg/dL)
TRIG (mg/dL)	Young Adult	55	47.40 – 108.0
	Mature Adult	13	33.75 – 78.50
	Senior	8	38.78 –127.0
TC (mg/dL)	Young Adult	58	69.92 – 237.48
	Mature Adult	14	24.92 – 263.68
	Senior	11	63.96 – 169.04
HDL (mg/dL)	Young Adult	55	64.16 – 136.44
	Mature Adult	10	37.52 – 179.68
	Senior	10	54.26 – 127.04
VLDL (mg/dL)	Young Adult	58	9.66 – 23.57
	Mature Adult	14	6.75 – 15.70
	Senior	9	8.51 – 24.67
LDL (mg/dL)	Young Adult	46	14.76 – 43.0
	Mature Adult	12	7.26 – 32.11
	Senior	6	5.77 – 20.80

Table 2 – Triglyceride (TRIG) mg/dL, Total Cholesterol (TC) mg/dL, High-Density Lipoprotein Cholesterol (HDL) mg/dL, Very Low-Density Lipoprotein (VLDL) mg/dL and Low-Density Lipoprotein (LDL) mg/dL Distribution by Feline Life Stage.

Triglycerides varied significantly by life stage, with the mean value being lowest in Mature Adults (51.30 mg/dL) and highest in Seniors (90.80 mg/dL). The considerable inter-quartile range (IQR) in the Senior group (46.33-198.6) indicates substantial variability within this group. While some senior cats maintain levels similar to younger adults, a significant portion exhibit moderate to severe hypertriglyceridemia. Total cholesterol demonstrates a consistent and progressive decline with advancing age. There is a steady decrease in mean total cholesterol levels with advancing age, with seniors exhibiting lower mean levels (116.5 mg/dL) compared to young adults (151.4 mg/dL).

High-Density Lipoprotein (HDL) cholesterol follows a decline parallel to that of Total Cholesterol. Young adults have a robust mean HDL level of 113.0 mg/dL, which slightly decreases in mature adults to 108.6mg/dL. The most pronounced drop is observed in seniors, who have a mean HDL of 90.8 mg/dL. The median VLDL in young adults is 13.54 mg/dL, which correlates well with their median TRIG of 64.7 mg/dL. The value dips slightly in mature adults to a median of 10.26 mg/dL, consistent with their lower mean triglycerides. Notably, VLDL levels rebound in the senior group to a median of 14.0 mg/dL, with an upper IQR bound of 28.30 mg/dL.

Low-density lipoprotein (LDL) exhibits a significant age-related decrease in all parameters. The median concentration decreases from 25.48 mg/dL in young adults to 16.46 mg/dL in mature adults, and finally to just 10.99 mg/dL in seniors.

Parameter	Group	n	Reference Intervals
TRIG (mg/dL)	Lean	23	6.51 – 107.35
	Overweight	29	6.69 – 137,45
	Obese	21	24.07 – 149.23
CT (mg/dL)	Lean	24	48.3 – 217.9
	Overweight	36	62.12 – 263.48
	Obese	24	70.08 – 215.72
HDL (mg/dL)	Lean	21	39,1 – 163,9
	Overweight	34	66.3 – 169.4
	Obese	24	67.6 – 150.8
VLDL (mg/dL)	Lean	23	3.16 – 23.56
	Overweight	30	6.02 – 37.74
	Obese	21	8.64 – 28.30
LDL (mg/dL)	Lean	22	8.125 – 43.09
	Overweight	27	18.48 – 45.98
	Obese	16	4.43 – 46.24

Table 3 – Comparative Lipid Profiles of Triglyceride (TRIG) mg/dL, Total Cholesterol (TC) mg/dL, High-Density Lipoprotein Cholesterol (HDL) mg/dL, Very Low-Density Lipoprotein (VLDL) mg/dL and Low-Density Lipoprotein (LDL) mg/dL in Lean (L) vs. Overweight (O) and Obese Cats.

3.2. Body condition score lipid profiles

The data demonstrate an increase in serum triglyceride concentrations that correlates with body condition score. The lean group presented a mean of 56.9 mg/dL, which rose to 72.07 mg/dL in overweight cats and further to 86.65 mg/dL in the obese cohort.

The total cholesterol values reveal a non-linear relationship with body condition. While the obese group showed an expected elevation (142.9 mg/dL) compared to the lean group (133.1 mg/dL), the overweight group exhibited the highest mean concentration (162.8 mg/dL). Contrary to the typical pattern observed in humans, HDL cholesterol levels were higher in overweight (117.9 mg/dL) and obese (109.2 mg/dL) cats compared to the lean reference group (101.5 mg/dL).

The VLDL concentration exhibited an ascending trend from the lean (11.39 mg/dL) to the overweight (14.40 mg/dL) to the obese (17.33 mg/dL) groups. The data for VLDL corroborates the triglyceride levels. The median VLDL concentration is over 50% higher in overweight and obese cats (15.88 mg/dL) compared to lean cats (10.04 mg/dL). LDL cholesterol levels in the obese group (16.86 mg/dL) were significantly lower compared to both the lean (30.55 mg/dL) and overweight (37.35 mg/dL) groups.

A Spearman correlation analysis was performed to assess the relationship between feline body condition score (BCS) and serum triglyceride levels. The study revealed a statistically significant, moderate positive correlation between body condition score and triglyceride concentration ($p < 0.001$).

The HDL cholesterol values for the population of lean cats in the current study are presented in Table 3. The mean ± SD HDL concentration was 101.5 ± 31.20 mg/dL, with a range of 39.1 to 163.9 mg/dL. These values demonstrate strong agreement with those previously reported in the literature for lean cats (Table 4), despite differences in analytical methodology, supporting the establishment of a reference interval of approximately 40 to 164 mg/dL for this population.

Parameter	Current Study	Muranaka et al. (2010)	Jordan et al. (2008)	Pazak et al. (1998)
Mean ± SD	101.5 ± 31.20	96.8 ± 28.3	108.6 ± 24.1	94.7 ± 26.8
Minimum–Maximum	45.0–168.9	52.0–155.0	67.0–148.0	49.0–162.0
Sample Size	21	24	18	22
Methodology	Enzymatic (Mindray®)	Electrophoresis	Ultracentrifugation	NMR Spectroscopy

Table 4 – HDL Cholesterol Reference Values in Lean Cats and Comparative Previous Studies.

4. Discussion

The pronounced concentration of young adults (n = 59, 69.4% of the cohort) across all BCS categories underscores this life stage as a critical period for initiating weight gain. In our study, a significant proportion of young adult cats were already above optimal weight, with 45.8% classified as overweight (BCS 6-7) and 25.4% (15/59) as obese (BCS 8-9). A study by Montoya et al. (2025) found that cats aged 3–6 years had a prevalence of 47.2% being overweight and 13.9% being obese. In our study, cats in the 7–10 year age group had a prevalence of 33% being overweight and 26% being obese. In mature adults, while a notable segment (40%) maintained an optimal body condition score (BCS 5), the majority (60%) were in a condition above the ideal. This group showed a progression into higher BCS categories, with 20% (3/15) in the overweight range (BCS 6-7) and 40% (6/15) in the obese range (BCS 8-9). The presence in BCS 6 indicates the establishment of an overweight status. At the same time, the higher prevalence in the obese categories suggests a significant portion of this age group has experienced progressive weight gain. Senior Cats: 36% were overweight, and 45% were obese. These findings indicate that while the prevalence of overweight cats' peaks during the adult stage, the prevalence of obesity is highest during the mature stage, suggesting a progression from overweight to obesity as cats age. This age-related risk pattern, peaking in middle age, is consistent with previous studies (Courcier et al., 2012; Russell et al., 2000).

Nearly half of the female cats (44,4%) are in the leanest category (BCS 5). Most male cats are classified as BCS 6 and 8 (32.5% and 35%, respectively), indicating a trend toward moderate to high adiposity. This reinforces the data found on previous studies (Bjornvad et al., 2014; Merenda et al., 2021), that female cats tend to be leaner, while male cats are more distributed toward higher BCS values, because of both higher lean mass and higher fat mass. While neutering is a standard and routine procedure for pet cats, it significantly increases the risk of obesity and related diseases (Larsen, 2017; Phungviwatnikul et al., 2020; Bjornvad et al, 2019). Considering that the entire population of this study is neutered, it is crucial to understand that the procedure itself is not the direct cause of weight gain, but rather the catalyst for a necessary change in dietary management, typically associated with reduced energy expenditure and a tendency for owners to practice ad libitum feeding.

Dyslipidemia in obese individuals is typically characterized by hypertriglyceridemia, a reduced high-density lipoprotein (HDL) cholesterol level, and an elevated number of small, dense low-density lipoprotein (LDL) particles (Vekic et al., 2023; Liu et al., 2006). Triglyceride levels exhibit a non-linear trend across the life stages. Young adults display a median level of 64.70 mg/dL, which serves as a baseline for this population. Interestingly, mature adults show a slight decrease, with a mean of 58.77 mg/dL, suggesting a period of stable metabolic efficiency. However, the most notable change occurs in the senior group, where the median triglyceride level rises to 90.80 mg/dL. While some senior cats maintain levels similar to younger adults, a significant portion exhibit moderate to severe hypertriglyceridemia. This elevation is a clinically relevant finding, as it can be associated with common age-related pathologies in cats, including diabetes mellitus, pancreatitis, and hepatic disease (Quimby et al., 2021).

Total cholesterol demonstrates a consistent and progressive decline with advancing age. The reduction in variability, as seen by a slight standard deviation in the senior group, suggests this is a common and predictable age-related change rather than a sporadic finding (Choi, 2024). High-Density Lipoprotein (HDL) cholesterol follows a decline parallel to that of Total Cholesterol. The most pronounced drop is observed in seniors, and this downward trend suggests an overall reduction in the capacity for lipid mobilization

and recycling from tissues back to the liver. In other species, low HDL is a risk factor for vascular disease; however, its significance in age-resistant feline physiology is less clear.

In our study, LDL levels decreased considerably with age. This steep decline, a reduction of over 50% from young adults to seniors, is the primary driver behind the falling total cholesterol (TC) levels. Studies have shown that hepatic low-density lipoprotein receptor expression decreases with age, leading to reduced clearance of LDL cholesterol from the bloodstream (Song et al., 2023). However, the absence of atherosclerosis in cats despite high VLDL suggests protective mechanisms, such as differences in LDL particle composition (Blanchard et al., 2025).

A study performed by Chala et al. (2021) found that the concentrations of LDL and VLDL exceeded those of healthy cats. Another study (Hoenig et al., 2012) found that obese cats showed an increase in nonesterified fatty acids, VLDL, and plasma triglycerides, primarily originating from VLDL. The median VLDL concentration in our study is over 50% higher in overweight cats compared to lean cats. This phenomenon is a classic feature of obesity and is primarily driven by insulin resistance. Insulin resistance in fat tissue triggers a constant release of fatty acids, which the liver converts into triglycerides and packages into VLDL particles, resulting in elevated blood levels of TRIG and VLDL (Valtolina et al., 2017). In our study, overweight cats exhibit a pronounced hypertriglyceridemia, with a mean value 58% higher than that of lean cats. This elevation is not only significant in its central tendency but also in its variability, as indicated by the much larger standard deviation in the overweight group. This suggests that while some overweight cats maintain triglyceride levels close to normal, a substantial number experience severe elevations.

Overweight cats also display significantly higher concentrations of Total Cholesterol and HDL Cholesterol. This pattern might seem counterintuitive, as in humans, obesity is often associated with low HDL. However, in cats, HDL is the major cholesterol carrier (Karkamo et al., 2025). The increase in both TC and HDL is likely a direct consequence of the overall state of lipid excess and heightened metabolic activity associated with larger body mass. The liver increases the production of all lipoproteins, including HDL, in response to the increased flux of dietary and mobilized fatty acids.

In contrast to the other parameters, LDL levels showed no meaningful difference between lean and overweight cats. It is also important to note the progressively smaller sample sizes (n) for LDL calculations, which could suggest that calculating this value via the Friedewald formula became less reliable in cats with higher triglyceride levels. The Friedewald equation tends to underestimate LDL in high-risk subjects, such as those with hypertriglyceridemia and hypo-HDL-cholesterolemia (Lee et al., 2018). For the accurate assessment of LDL-C in these individuals, various methods are crucial.

This study identified distinctive features of a feline-specific dyslipidemia pattern, considering hypertriglyceridemia, elevated VLDL, and HDL. This profile aligns with features of metabolic syndrome observed in other species but is distinguished by feline-specific lipid responses (Figure 1). The dyslipidemia observed in obese cats has significant implications for the management of feline obesity, emphasizing the importance of considering lipoprotein subclass concentrations and particle size, in addition to total lipoprotein levels. These findings suggest that monitoring lipid profiles in obese cats is crucial, as dyslipidemia can serve as an early indicator of metabolic dysfunction (Choi, 2024). Early detection allows for timely interventions, such as dietary modifications and weight management strategies, to prevent the progression to more severe conditions like diabetes mellitus.

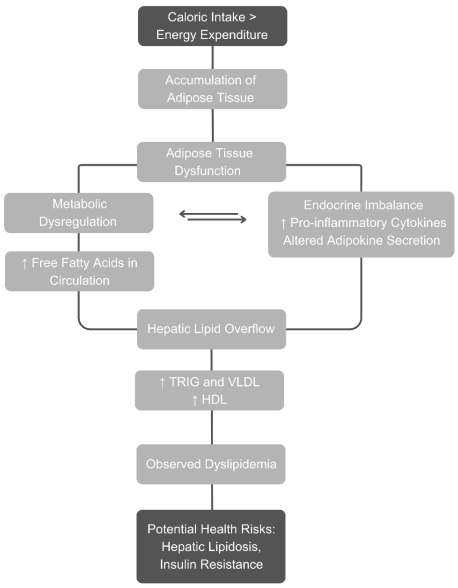

Figure 1 – Flowchart presenting a possible mechanism of feline obesity related dyslipidemia and its metabolic consequences.

This study has several limitations that warrant consideration. First, the cross-sectional design precludes the determination of causal relationships between body condition and lipid alterations, restricting interpretation to associations rather than temporal progression. Second, all cats were neutered, which standardizes reproductive status but limits extrapolation to intact populations. Third, LDL concentrations were calculated using the Friedewald equation, which may underestimate values in hypertriglyceridemic

states; future studies employing direct quantification methods are needed to validate these findings. Fourth, although the sample size was adequate for detecting differences in HDL, subgroup analyses (e.g., sex and age-stratified comparisons) were based on smaller numbers and may have been underpowered. Longitudinal studies incorporating direct dietary monitoring, advanced lipoprotein profiling, and functional assessments of insulin sensitivity will be essential to further elucidate the pathophysiology of obesity-related dyslipidemia in cats.

5. Conclusion

The present study determined HDL values for lean, overweight, and obese cats. The results showed that feline obesity is linked to a distinct dyslipidemia, marked by a pronounced increase in triglycerides and VLDL that escalates with body condition score. While HDL also rises with obesity, total cholesterol elevation is up to 13% higher in overweight cats compared to obese cats, revealing a complex relationship between adiposity and cholesterol metabolism and distinguishing feline lipid regulation from that of humans, where obesity typically reduces HDL levels. This study showed a high prevalence of overweight and obesity across all life stages, with weight gain initiating early in life. A significant finding was that 71.2% of young adult cats were already above optimal weight. While overweight was most prevalent in young adults, the highest rate of obesity was found in mature adults (40%), suggesting a progression from overweight to obesity with age. Furthermore, a distinct sex-based disparity was observed: nearly half of female cats were lean, whereas male cats were predominantly distributed in higher body condition scores, indicating a trend toward moderate to high adiposity.

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Briefing notes: This study was approved by the Ethics Committee (Comitê de Ética no Uso de Animais do Setor de Ciências Agrárias, CEUA-SCA) at the Federal University of Paraná (Protocol No. 063/2024), adhering to the Brazilian National Council for Animal Experimentation Control (CONCEA) guidelines. Informed written consent was obtained from the owners of all client-owned animals.

Conflicts of Interest: The authors declare that they have no conflicts of interest.

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