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Exploring obesity through Animal Models: Insights and innovations

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ABSTRACT

The rising incidence of obesity poses a major global health issue, shaped by a complex interaction of genetic, environmental, and behavioral elements. This review focuses on the important function of various animal models in the study of obesity, emphasizing their contributions to comprehending the underlying mechanisms of this intricate condition. Rodent models, especially genetically modified strains such as ob/ob and db/db mice, have revealed crucial insights into the hormonal and genetic pathways that govern energy balance. Furthermore, models of diet-induced obesity and new organisms like zebrafish and C. elegans present innovative methods for investigating the impacts of high-fat diets and genetic differences. The review also ad dresses the limitations of existing animal models, including their in ability to completely mimic the human experience of obesity due to gene-environment interactions and varying metabolic responses. By integrating findings from a range of animal models, this research seeks to deepen the understanding of the causes of obesity and aid in formulating specific therapeutic approaches, ultimately tackling the escalating obesity crisis.

Keywords: Obesity, Animal Models, Rodents, Zebrafish, Transgenic, Overweight, High-fat diet

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INTRODUCTION

Studying obesity using scientific methods has highlighted how complicated this global health issue is. A mix of genetic, environmental, and behavioral factors influences it. To grasp how people gain too much weight and develop related health issues, it is necessary to use suitable research methods. Animal models are important for studying obesity, giving useful information about the body's functions and genetic factors connected to this condition. This method enables researchers to look at obesity-related traits and treatments through controlled experiments and to study how different diets and medications affect weight gain. By using several animal models, such as transgenic mice and zebrafish, scientists can mimic human-like metabolic conditions and find possible treatment targets.

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The results from these studies help us understand obesity better and guide efforts to reduce its prevalence and associated health issues. In obesity research, animal models are important for understanding how genetics and the environment affect metabolic problems. Rodent models, especially genetically altered types, have greatly increased knowledge about how obesity works. For example, studies using ob/ob and db/db mouse models have shown the key role of leptin and its receptor in controlling energy balance, revealing important processes involved in weight management. (Pomp, 1999). Additionally, looking at gene activity in these models has helped identify pathways that are out of balance, which may lead to new treatment options. (Oka et al., 2010). While rodent models are the most common in research, other models like zebrafish are gaining attention because they are cheaper and breed quickly, which allows for fast testing of how genes and diet influence obesity. (Faillaci et al., 2018). The variety of animal models helps improve our understanding and encourages new treatment approaches. The strengths and weaknesses of these models are shown through methods that include visual assessments and metabolic measurements,
which improves how findings relate to human obesity studies. The complex history of obesity research shows a major change due to both social and scientific progress. Early studies mainly looked at the link between energy balance and weight gain, laying down basic ideas that are still important in today's research. The rise of genetic models, especially the discovery of mutations such as those in the leptin gene, marked a crucial turn, helping scientists to understand the molecular processes behind obesity and its inherited factors. (Pomp, 1999). During this development, animal models, especially rodents, have been very import- ant, giving insights into the genetic and physical features of obesity—insights that have been key in improving treatment methods. (Kleinert et al., 2018). As obesity rates have risen worldwide, research has increasingly included various disciplines, looking at environmental effects and behavioral trends, highlighting the need to view obesity not as a fixed state but as an ongoing interaction between genetics and lifestyle choices. The historical background prepares the way for further study into new models, like advanced zebrafish research, which shed light on these complex relationships. (Faillaci et al., 2018) Also, images like [placeholder] clearly show the differences in animal models, highlighting their importance in obesity research by connecting genetic traits and environmental factors.

The physiological and genetic basis of obesity

Obesity is a complicated issue with many causes, marked by too much body fat that negatively affects health. It occurrence has increased around the world, and it is estimated that by 2030, over half of the adult population in the United States will be considered obese. This issue is linked to var- ious health problems, like type 2 diabetes, heart disease, and some cancers because it plays a key role in creating insulin resistance and causing inflammation in the body. Genetic factors also play a role in obesity, with research showing that heritability is between 30% and 70%. Various animal studies have helped understand the genetic and physical reasons for obesity, providing information about how diet and the environment influence it (Pomp, 1999). These studies, especially those involving rodents, enable focused research into the biology behind obesity and `this public health issue. Moreover, the imaging methods dis- cussed provide useful information on fat distribution and metabolism in these studies, helping to deepen our under- standing. Studying obesity using animal models gives important insight into this complicated disorder. Rodent models, especially those with genetic modifications, have been key in discovering the genetic and physical causes of obesity. For example, research on ob/ob mice has shown how changes in single genes can greatly affect energy use and fat storage, reinforcing that there is a genetic factor in obesity (Speakman et al., 2007). Furthermore, dietary-in- duced obesity (DIO) models let scientists imitate human eating habits and evaluate the effects of high-fat diets on health (Oka et al., 2010). These models improve the under- standing of how obesity works and serve as a way to test possible treatments, like studies using zebrafish which demonstrate human metabolic responses (Faillaci et al., 2018). Thus, animal models not only highlight the genetic challenges of obesity but also create an important link to possible treatments for people.

Challenges in Obesity Research

Obesity research has many problems that make it hard to create effective treatments. One major problem is the complicated mix of genetic, environmental, and behavioral factors that lead to different obesity types in different groups of people. This issue is shown by the many genes involved in obesity, with more than 200 quantitative trait loci (QTLs) found in mouse studies. However, using these findings for humans is difficult because past efforts have not reliably found matching QTLs in people. (Speakman et al., 2007). Furthermore, ethical issues related to using animal models often limit the scope of research, causing a conflict between the need for various models and concerns about animal welfare. (Domínguez-Oliva et al., 2023). Visual methods, like those shown in, can help clarify the complicated aspects of obesity by better showing how fat is distributed and how metabolic processes work in different animal models, which can improve efforts to translate research into real-world applications.

Objectives of this review

The complex link between diet, genes, and obesity highlights the need for clear goals in this review. Mainly, the goal is to outline the different animal models used in obesity studies, focusing on how they relate to human metabolic diseases. Additionally, we will look at the value of genetic models—both polygenic and monogenic—in understanding genetic effects on obesity. This research is vital for creating specific drug treatments that might help with the worldwide obesity crisis expected to impact more than half of the U.S. population by 2030 (Kleinert et al., 2018). In conclusion, we aim to add valuable information to the discussion on metabolic health by combining insights from different models, influencing future obesity study methods, and improving treatment strategies, as discussed in.

Types of Animal Models Used in Obesity Research

Animal models are important in understanding obesity's complicated mechanisms, mainly divided into genetic models and dietary-induced obesity models. Genetic models have been key in finding hormonal pathways that control hunger and energy use, showing how certain mutations affect obesity traits. On the other hand, dietary-induced obesity (DIO) models help scientists mimic human obesity through controlled eating plans. For example, zebrafish are now often used because they breed quickly and have genetic similarities to mammals, offering a practical way to study the effects of high-fat diets (Faillaci et al., 2018). These different methods in obesity research highlight the importance of choosing the right models to investigate drug treatments and find possible therapeutic targets, aiding in the progress of understanding and treating obesity-related diseases effectively.

Rodent models (mice and rats)

Using rodent models, especially mice and rats, is important for studying obesity because of their ability to be genetically altered and their similar body functions to humans regarding obesity. These models help researchers look at the genetic and epigenetic aspects of obesity, with findings showing that body fat percentage has significant hereditary factors. (Lutz & Woods, 2012). Also, while traditional models have some drawbacks, like differences in how they react to diets, they serve as a basis for testing drug treatments aimed at lowering obesity-related health problems, such as type 2 diabetes. Analyzing rodent behavior and body reactions also provides an understanding of the complicated relationship between diet and genetics, highlighting the usefulness of these models in obesity studies (Table 1).

Non-human primates

To understand obesity's complexities, it is necessary to look beyond regular rodent models; non-human primates are very helpful because their physiology and genes are more like those of humans. Studies using these models show that obesity appears in similar ways in both groups, especially regarding insulin resistance and metabolic disorders, reflecting current human trends. Non-human primates enable long-term studies on how obesity develops, including how factors after birth affect body makeup and metabolism, which helps us learn about early actions that could lower obesity risk in humans. (Kleinert et al., 2018). Also, using them in drug testing, especially for treatments that may address both obesity and related issues like type 2 diabetes (Patel et al., 2013), improves our understanding of possible treatment options. While there are ethical and cost issues with using non-human primates, their input is vital for improving obesity treatments and advancing health strategies.

Canine Models

Using dogs in obesity research is useful because they have similar body structures and metabolism to humans, making them good for studying diseases linked to obesity. Dogs have a variety of genetic traits, which helps scientists look into the many genes that influence obesity, like what is seen in people. Also, some dog breeds naturally become obese, which allows for examining how genetics, environment, and diet affect body weight control, the different characteristics are described in Table 2. Research on dogs helps understand fat accumulation, energy use, and insulin resistance, which are important for obesity. These models also allow researchers to test how well medicines and diet changes work in situations similar to those in humans. (Ma & Zhang, 2010). Thus, using dogs in obesity research not only improves our understanding of how the disease works but also offers insights that could lead to better treatment options.

Porcine Models

Even though rodent models are common in obesity studies, pig models have important benefits because they are similar to humans in anatomy, genetics, and physiology. Pigs have a metabolism and body makeup that resemble those of humans, which is important for studying obesity related issues like type 2 diabetes mellitus (T2DM) and non-alcoholic fatty liver disease (NAFLD) (Renner et al., 2020). New developments in genetically modified pigs, especially those that show traits like human fat distribu-tion, have improved how useful pig models are in obesity research. These models, which reflect human eating habits and surroundings, allow for a closer look at how genet-ics and lifestyle interact, helping to better understand the biology of obesity.

Overall, using pig models to explore

the causes of obesity make them a useful tool for creating treatment methods for this worldwide issue, highlighting the need for effective strategies in managing obesity.

Zebrafish as a model organism

In the last few years, zebrafish have been recognized as a key model organism for studying obesity and related metabolic issues because of their useful features, such as their ability to be genetically manipulated and their relevant physiology. Their clear bodies during early growth enable direct observation of metabolic changes, which simplifies the study of fat buildup and dietary effects. (Russo et al., 2023). Additionally, zebrafish react to high-fat diets like mammals, leading to increased body mass index and triglyceride levels, effectively replicating significant aspects of mammalian obesity. (Russo et al., 2023). This model is useful for examining the effects of genetic and environmental elements on obesity traits, especially through the discovery of specific genes like PPARγ and cannabinoid receptor 1 (CB1R) (Reshma et al., 2023). Overall, the distinct biological features of zebrafish make them a valuable tool for understanding the complex processes related to obesity while also aiding in the development of new treatment strategies. For example, the visual methods used with zebrafish help researchers identify changes in fat tissue behavior that are relevant to human conditions, highlighting their important role in obesity research.

Drosophila (fruit flies)

Using Drosophila melanogaster as a model for obesity research gives important insights into genetic and physiological issues of metabolic disorders. These fruit flies are a great platform for changing genetics, letting scientists create transgenic lines that show human obesity traits. Their simple genome and quick reproduction cycles mean researchers can easily see the effects of diet changes and genetic alterations across generations. Research has shown that Drosophila shares many metabolic pathways with humans, helping to find genetic targets related to fat buildup and insulin response. (Musselman & Kühnlein, 2018). Additionally, keeping Drosophila in labs is inexpensive, making it viable for large-scale screening of possible anti-obesity drugs. This practical plus, along with results from similar biochemical models, makes Drosophila an important tool for enhancing our understanding of obesity and treatment methods.

C. elegans

Caenorhabditis elegans (C. elegans) has been considered a useful model organism in the study of obesity because it is simple, genetically tractable, and has conserved metabolic pathways. Although it is small in size and very simple in structure, a lipid metabolism pathway that is similar to higher organisms including humans has been conserved in C. elegans. This nematode is used by scientists to understand the genetic and molecular mechanisms behind fat storage and energy balance. C. elegans can be directly observed for lipid droplets with fluorescent markers, which allows for more detailed studies on fat accumulation and mobilization. In a study by Subhadra et al., worms raised on diets high in glucose and cholesterol exhibited notably increased intracellular triglyceride levels, and a decrease in both mean and maximum lifespan (Subhadra et al., 2024).

Comparison of different animal models

Many animal models give valuable insights into obesity research, each with their perks and downsides. Rodent models, especially mice, are widely used because they breed quickly and can be genetically altered, which helps in studying genetic factors related to obesity. (Kazura & Michalczyk, 2023). Although genetic differences like the ob/ob and db/db mutations show important hormonal pathways, their relevance to human obesity is not fully clear (Bourke et al., 2016). On the other hand, zebrafish models have become cheaper options that support extensive test- ing for metabolic issues, with research showing they can mimic human diets and show similar fat patterns. (Trinh & Boulianne, 2013). Despite their differences, both rodent and zebrafish models play important roles in understanding the complex nature of obesity, indicating that using both might provide the best insights into its causes and treatments. (Table 3).

Selection criteria for animal models

Choosing the right animal models for obesity research involves many factors, including genetics, physiology, and environment. The models should closely resemble how humans respond metabolically to be relevant; therefore, genetic similarity and the capacity to change genes are key elements. Rodent models, especially modified types like the leptin-deficient ob/ob mouse, provide valuable information about the genetic factors behind obesity due to their known roles in energy balance. (Speakman et al., 2007). Furthermore, specific dietary changes should be considered to understand how outside factors lead to obesity, which helps identify important metabolic pathways [125]. The best model also allows for long-term studies that look at the lasting impacts of weight change interventions, which is crucial for applying the results to humans. Importantly, zebrafish have become a budget-friendly choice because of their quick development and the capability to see metabolic activities through transgenic method. (Zang et al., 2018). Therefore, selecting animal models should involve different aspects to ensure strong and useful results in obesity research, ultimately supporting the search for effective treatment options.

Knockout and transgenic models

The complex link between genetic changes and studying obesity in animals has provided important knowledge about the biological processes behind this complicated issue. By using transgenic and knockout models, scientists have clarified several pathways related to energy management, such as discovering leptin and its receptor—an important finding from research on ob/ob and db/db mice that shows the genetic factors contributing to obesity (McNay & Speakman, 2013). These methods enable specific changes in gene expression, helping to analyze how single genes affect obesity traits. For example, employing quantitative trait loci (QTL) helps to locate genetic variations tied to fat buildup, which connects polygenic traits with their observable effects v(Vickers et al., 2011). Additionally, improvements in gene-targeting methods have changed our understanding of the inherited aspects of obesity, as noted by the creation of advanced polygenic and monogenic models (Barrett et al., 2016). Therefore, the careful use of genetic modifications in these animal models is crucial for finding targeted treatments to effectively tackle obesity, highlighting their key role in metabolic research. The making of transgenic models changed obesity studies a lot, giving new views on the genetic causes of this tricky illness. These models let scientists change certain genes related to metabolic functions on purpose, so they can see clear results about obesity and related health issues. For example, looking at gene changes like those in leptin has helped explain how appetite control and energy balance work, suggesting possible treatment options (Schachtschneider et al., 2017). Also, new methods in quality control and gene editing, like CRISPR-Cas9, make it easier to quickly create knockout models that can mimic human obesity better than older models. In short, transgenic models offer a detailed way to study the molecular aspects of obesity, connecting basic science to practical use in clinics.

By turning off specific genes, researchers can see the changes in traits and learn about the roles these genes have in maintaining energy balance. Knockout models are important tools that connect genetic research to practical uses in treating obesity, helping to identify new drug targets.

Role of gene editing technologies (CRISPR)

The rise of gene editing tools, especially CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats), has greatly changed genetic research, particularly studies on obesity. By allowing exact changes to specific genes, CRISPR helps scientists better understand the genetic causes of obesity compared to older techniques. This accuracy makes it possible to create animal models with specific genetic changes, like the removal of important genes involved in metabolic processes, which are then useful for examining obesity traits and potential treatments [134]. Additionally, CRISPR's flexibility lets researchers study complex traits, such as fat storage and energy use, in different animal models, helping to clarify gene-environment interactions. (McNay & Speakman, 2013). With advances in these technologies, their use in obesity research is expected to provide vital insights into the biological mechanisms of the obesity crisis, eventually leading to more effective treatment options. (Franco-Tormo et al., 2018). In this frame, visual aids showing CRISPR applications in obesity research offer useful insights into the mechanisms involved. Using images that illustrate the detailed processes of gene editing can help clarify how specific changes result in visible differences in animal models. It demonstrates how we can observe metabolic reactions on a molecular scale, aiding discussions on the relationships between genetics and the environment. In summary, the ongoing progress of CRISPR technology marks an important point in obesity research, as the chance for targeted genetic interventions opens up new ways to understand and possibly address this complicated issue. As scientists utilize CRISPR's features, creating advanced animal models will improve our understanding of the complex nature of obesity, enabling the examination of gene-environment interactions and the discovery of new treatment targets. Future research using CRISPR is likely to lead to a better understanding of the biological factors that influence obesity and its related conditions, laying the groundwork for new treatment methods. Such progress could reshape how we tackle the obesity crisis, marking a notable achievement in genetic research and health initiatives.

Genetic predisposition and epigenetics to obesity

The complex genetic structure that causes obesity shows how hard this disorder is to understand. Many genes and how they work together really affect energy balance, especially in how they control appetite and metabolism. Studies using rodent models have helped find these genetic factors, showing more than 200 quantitative trait loci (QTLs) linked to traits related to obesity. Important mutations, like those that change leptin and melanocortin-4 receptors, have highlighted key biological pathways that play a role in controlling weight and maintaining energy levels. Still, differences in genetic roles across various populations mean we need to carefully look at how these genes interact with environmental factors, such as diet and exercise (Pomp, 1999). Therefore, ongoing research into genetic risks using solid animal models, alongside modern genomic techniques, is crucial for understanding the inherited aspects of obesity and creating focused treatment options (Herrera & Lindgren, 2010). The diagram shown, which details common pathways important for metabolic health, improves our understanding of the genetic aspects of obesity, further proving the importance of these animal studies. The issue of obesity is not just about how much food a person eats or how much they move; it also includes epigenetic factors that might affect how easily someone gains weight. Studies show that things in the environment, like what people eat and the toxins they encounter, can cause changes in genes that do not change the DNA itself. This is very important when looking at obesity, as certain ways genes are controlled, like DNA methylation and changes to histones, are crucial in issues related to metabolism (Stoccoro & Coppedè, 2021) Research has shown that some of these changes can last for generations, which means that a mother's diet and health may put her children at risk for becoming obese. Knowing how these epigenetic factors work is essential for creating effective strategies to tackle obesity, as they might help point to medical treatments and lifestyle changes for those affected.

Dietary Interventions and Their Effects

The effect of diet changes on managing obesity is important, with many studies showing both short-term and long-term results. Typical methods of cutting calories have shown positive effects, especially in controlling weight and enhancing metabolic health. However, many people find it hard to stick to these diets due to compensatory actions that can reverse initial weight loss. (Kleinert et al., 2018). New research models, like zebrafish, have given valuable insights into how different diets affect body composition and metabolism. For instance, certain feeding methods in zebrafish can lead to specific obesity traits, similar to conditions seen in humans. (Reshma et al., 2023). These results support the idea that focused dietary plans can shift metabolic paths, helping to prevent or control obesity-related health issues. Also, high-fat diets are often connected to a rise in non-alcoholic fatty liver disease cases. (Tilg et al., 2021), highlighting the need to improve dietary strategies to reduce health risks. Additionally, a visual representation demonstrates the strong links between diet and metabolic changes that are relevant to current obesity research. The difference in weight change and biochemical parameters of specific treatments to animals is shown in Table 4.

High-fat diet (HFD) models

Using high-fat diets is a key method for studying obesity in labs. These diets show similar metabolic problems seen in human obesity, leading to outcomes like higher body mass index, bad cholesterol levels, and insulin resistance. Studies have found that rodent types on high-fat diets show clear changes in fat tissue and gene activity tied to fat processing, resembling features of human obesity. The general protocol to analyze the obesity effects in HFD rodents is illustrated in Fig. 1. Comparing gene activity shows that both high-fat diet models and obese animals have similar faulty pathways, highlighting important molecular processes related to fat build-up and inflammation (Kim et al., 2008). These findings underline the importance of these models for looking into new treatments for obesity. Therefore, high-fat diet models are vital tools for understanding the causes of obesity and for testing drugs that could help reduce its metabolic effects (Cho et al., 2012).

Caloric restriction studies

Research into caloric restriction, which is known to be a strong method for improving life span and lengthening lifespan, has sparked a lot of interest in obesity studies. Using different animal models, like mice and zebrafish, scientists have clarified the physiological reasons for these benefits. For example, research shows that caloric restriction not only helps lower body weight but also lessens negative metabolic issues tied to obesity, leading to better glucose metabolism and lower insulin resistance in models like the UCD-T2DM rat. (Spiegelman & Flier, 2001). Long-term caloric restriction has shown protective effects against kidney fibrosis and dysfunction, highlighting its overall benefits. (Russa et al., 2023). Moreover, the increasing evidence suggests common metabolic pathways, especially in gene regulation related to fat metabolism, highlighting the importance of caloric restriction across different species. This highlights the necessity for more research into the potential therapeutic uses of caloric restriction strategies for treating obesity in humans. (Halpern & Mendes, n.d.). In animal studies, like those using zebrafish to look at obesity from diet, looking at fat buildup and changes in macronutrients provided key information about how metabolism works and related genes, like PPARγ and cannabinoid receptor 1. Thus, knowing how various macronutrient mixes affect metabolic actions is crucial for creating useful eating plans and drug treatments to fight obesity (Paxman et al., 2008). This evidence highlights the need to carefully consider macronutrient types in treatments for managing obesity.

Gut microbiota and dietary influences

The complicated link between gut bacteria and diet is very important in causing obesity and related metabolic issues. The type of gut bacteria is greatly influenced by diet, particularly through complex carbs and fats. A good diet, full of fiber, helps support a varied microbial community that benefits metabolic health. In contrast, diets high in fat or sugar can cause an imbalance, where good bacteria decrease and harmful bacteria increase, leading to problems with energy metabolism and more fat storage. (Kazura & Michalczyk, 2023). Studies on animals, especially mice, help researchers see how specific diets affect gut bacteria and the related metabolic results. Understanding these connections is essential for creating focused dietary plans to fight obesity and enhance metabolic health outcomes successfully. It also shows the experiment design used to study these dietary effects on gut health, which is relevant to the larger discussion on obesity research. (De Vos et al., 2022).

Environmental enrichment and its effects

The role of environmental enrichment in obesity research shows it is important for changing behaviors and physical responses that affect metabolic results in animal models. By providing complex stimuli like social interactions, new objects, and different physical environments, enriched settings can boost thinking skills and lower stress levels, which could help with problems related to obesity. For example, research shows that environmental enrichment can lessen the negative impacts of high-fat diets by encouraging more physical activity and better emotional health in rodents. Additionally, using zebrafish for studies, researchers have seen that varied environmental stimuli lead to better lipid metabolism and less fat, similar to findings in mammalian research that point out the need for a stimulating environment to help manage weight. These results are hopeful, indicating that improving environmental conditions could be a useful additional strategy in treating and preventing obesity.

Influence of light and circadian rhythms

Circadian rhythms play a big role in several physiological and behavioral processes, being important for energy balance and metabolic health. Changes in light exposure and circadian timing can negatively impact eating habits, hormone control, and overall metabolism, leading to obesity. Research shows that unusual light conditions, like staying under artificial light for long periods at night, can cause a mismatch between the body's internal clock and outside signals, leading to more eating and less energy use. (Bray & Young, 2007). This connection affects how key metabolic genes and circadian proteins work, which are essential for keeping the body's balance. Additionally, studies with animals have revealed the complex link between circadian rhythms and metabolic processes, showing that changing light exposure can help reduce obesity symptoms. In the end, learning about the link between light, circadian rhythms, and obesity could help create new behavioral and drug treatments for the obesity crisis. (Arble et al., 2015)

Housing conditions and their relevance

The way animal models are kept is very important for obesity research outcomes. Factors in the environment like temperature, humidity, and social interactions can greatly affect how subjects behave and their metabolic responses. For example, studies show that temperature impacts the growth of metabolic syndrome in mouse models, making housing factors important in obesity research. (Chaudhary et al., 2024). Also, different genetic strains respond differently to diet-induced obesity depending on their housing, highlighting the link between genetics and external conditions. Understanding these factors can help researchers interpret data more accurately since both physical and social settings influence how models respond physiologically. Therefore, it's important to carefully control housing conditions in experiments to clarify how obesity works and to apply these findings to human health, which boosts the reliability of animal models in obesity studies. (Vickers et al., 2011). Well-structured models also support these ideas, as shown in, which visually summarizes how housing impacts metabolic measurements in rodent models.

Limitations of current animal models

Animal models have been widely used to study obesity, providing valuable insights into the mechanisms underlying this complex condition. However, these models have several limitations that researchers must consider. One of the primary limitations is that no single animal model can fully recapitulate the complexity of human obesity, which results from intricate gene-environment interactions (Barrett et al., 2016). While traditional monogenic models of obesity have been useful, they do not accurately represent the multifactorial nature of most human obesity cases. Additionally, the use of laboratory mouse and rat strains may not always translate directly to human physiology, as these animals have different metabolic rates and dietary habits compared to humans (Varga et al., 2010). Interestingly, some animal models, such as the Ossabaw and Göttingen minipigs, have shown promise in mimicking certain aspects of human metabolic syndrome, including obesity. However, even these models have their limitations and cannot serve all research needs. The challenge lies in finding a balance between model simplicity for experimental control and complexity to accurately represent human obesity. The composition of diets used to induce obesity in animals may not accurately reflect human dietary patterns (de Moura e Dias et al., 2021). Controlled laboratory environments do not account for the diverse environmental factors influencing human obesity, such as lifestyle, socio-economic status, and psychological factors as well as developing and maintaining animal models can be expensive and time-consuming, limiting the scope and scale of research (Kleinert et al., 2018). In conclusion, while animal models have contributed significantly to our understanding of obesity, their limitations must be acknowledged. Researchers should carefully consider the strengths and weaknesses of each model when designing studies and interpreting results. A complementary approach using multiple models may be necessary to address the complexities of human obesity and develop effective therapies.

CONCLUSION

The rise in obesity rates around the world is a big problem that requires more research to understand its many causes and to create effective solutions. The role of animal models in obesity research is very important, as they give useful information about the complicated biological processes behind this condition. Models like rodents, especially db/db or ob/ob mice, have been crucial in explaining the genetic and hormonal factors that control energy balance and body weight. Researchers can change genes and diets in these animals to closely imitate human obesity and related metabolic issues. Furthermore, zebrafish models provide special benefits for screening many samples at once, helping discover genetic and environmental influences on obesity. Recent research shows that the common disrupted pathways in zebrafish and mammals point to the useful potential of these models, strengthening their role in finding drug targets and testing new treatments for obesity-related illnesses. Overall, improving animal model research is key to understanding the complex interactions of genes, diet, and behavior in obesity.

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Conflict of Interest

The authors declare no conflict of interest.

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Table 1. Rodent models for obesity research

Rodent model	Obesity induction method	Average weight gain (g)	Source
db/db mice	Genetic mutation (leptin receptor deficiency)	30-40 g	(Bastard & Fève, 2012; Bastías-Pérez et al., 2020)
ob/ob mice	Genetic mutation (leptin receptor deficiency)	30-40 g	(Bastard & Fève, 2012; Bastías-Pérez et al., 2020)
Zucker rats	Genetic mutation	70-80 g	(Lutz & Woods, 2012)
Otsuka Long-Evans Tokushima fatty rat	Genetic mutation	30-40 g	(Martins et al., 2022)
C57BL/6 mice	High-fat diet	30-35 g	(Chalvon-Demersay et al., 2017)
Sprague-Dawley rats	High-fat diet	40-50 g	(Chalvon-Demersay et al., 2017)
MSG-induced obesity in rats	Chemical induction (Monosodium glutamate)	20-30 g	(Bastías-Pérez et al., 2020)

Table 2. Canine models used in obesity study

Breed	**Prevalence of obesity (%)**	**Average weight (kg)**	**Average lifespan (years)**
Labrador Retriever	35	30	12
Beagle	24	10	12
Golden Retriever	25	30	13
Dachshund	28	9	12
Bulldog	36	25	8
Boxer	32	27	10

Table 3. Comparison of different Animal models for Obesity

Model	Obesity type	Diet	Weight gain	Duration	Reliability
Zucker Rat	Genetic	Standard Lab Diet	Significant	6 weeks	High
Diet-Induced Obesity Mouse (DIO)	Diet-Induced	High-Fat Diet	Moderate to High	12 weeks	Very High
Leptin Receptor Deficient Mouse	Genetic	Standard Lab Diet	High	10 weeks	High
Golden Syrian Hamster	Diet-Induced	High-Fat Diet	Significant	8 weeks	Moderate
Non-Human Primate (Rhesus Monkey)	Diet-Induced	High-Fat Diet	Significant	16 weeks	High

Table 4. Dietary interventions and their effects on obesity in animal models

Intervention	Weight change	Glucose tolerance	Cholesterol levels
High-fat diet	+15%	Decreased	Increased
Caloric restriction	-20%	Improved	Decreased
Mediterranean diet	-5%	Improved	Decreased
High-protein diet	-10%	Improved	Stable
Low-carbohydrate diet	-8%	Improved	Decreased

Fig. 1. Research protocol for dietary effects on metabolic health in Sprague-Dawley rats.