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NUTRITIONAL STRATEGIES FOR MODULATION OF THE RS 9939609 POLYMORPHISM OF THE FTO GENE IN THE PREVENTION AND TREATMENT OF OBESITY IN CHILDREN AND ADOLESCENTS

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Abstract: Goal: Study the nutrigenomic and nutrigenetic aspects involving obesity in children and adolescents, focusing on the rs9939609 polymorphism of the FTO gene, analyze the effects of this genetic variant on body fat gain and address possible nutritional strategies. **Methods:** This is a bibliographic review carried out in the electronic databases SCIELO, PUBMED, Google Scholar, LILACS, together with academic literature related to the subject, in Portuguese, English and Spanish. The key words were used: "nutrigenomics", "child", "adolescents", "obesity", "FTO Dioxygenase Dependent on Alpha-Ketoglutarate", "nutrigenomics", "adolescent", "child", "childhood", " obesity", "Alpha-Ketoglutarate-Dependent Dioxygenase FTO". **Results and discussion:** The daily value of lipids ingested, the type, especially saturated fatty acids, and the quantity showed an interaction with the rs939609 polymorphism of the FTO gene. In individuals carrying the risk allele (A) and with a higher intake of saturated fatty acids, they had a high BMI compared to homozygotes (TT). Studies regarding carbohydrates and proteins are scarce, hindering a conclusion about them. **Conclusion:** Lower daily intake of lipids and saturated fatty acids may be a possible nutritional strategy for managing the rs9939609 polymorphism in the FTO gene in children and adolescents. However, it is important to monitor future publications that may bring greater clarity and understanding about nutrients and their relationship with rs9939609 of the FTO gene.
Keywords: nutrigenomics; child; teenagers; obesity; "Alpha-Ketoglutarate-Dependent FTO Dioxygenase.

INTRODUCTION

Obesity is defined as excess fat accumulation that can harm health and well-being (WHO, 2000). It is an extremely complex condition, as it involves several factors such as genetic, environmental predisposition, socioeconomic, cultural and psychological conditions, which can influence weight gain, being considered a multifactorial disease (APOVIAN, 2016; MECHANICK, 2012; World Health Organization, 2000).

Children and adolescents are classified as overweight or obese using the body mass index (BMI) and also by other anthropometric indices such as height/age, weight/height, BMI/age and weight/age according to age and sex. The diagnosis is made using cutoff points in percentiles and z-scores, determined by the World Health Organization (WHO, 2006). Another measurement used to identify the amount of adipose tissue is the measurement of skinfolds (subscapular, suprailiac, biceps and triceps) which may indicate risk for metabolic diseases. (ANDAKI, 2017).

Furthermore, obesity is classified as a chronic non-communicable disease (NCD), which has become a global health problem as it affects a large part of populations, both Western and Eastern, without distinction of age group. The number of overweight individuals worldwide tripled between 1975 and 2016. Furthermore, during this period, the number of overweight and obese children and adolescents between the ages of 5 and 19 increased from 4% to 18%. In 2017, more than 4 million deaths were recorded per year related to overweight and obesity in adults (INCHLEY et al., 2020). According to the World Obesity Federation (2020), it is expected that by 2025, 1 in 5 adults will be obese.

The high incidence of obesity in the world population is due to the rapid dietary transition that has occurred since the industrial revolution, and has also reflected in a change in lifestyle, qualitatively and quantitatively altering the diet of populations, associated with economic, social and social conditions. demographics of the country. Consequently, chronic non-communicable

diseases such as diabetes, high blood pressure, cardiovascular diseases and cancers have also increased (WOF, 2020).

Thus, there was a change in eating behavior, in which the habits of consuming fresh foods such as vegetables, cereals, roots and tubers were replaced by a high consumption of ultra-processed foods, rich in saturated fats, sugars, sodium, trans fatty acids and food additives. There was also a decrease in the level of physical activity due to the industrialization and automation process, in addition to changes in leisure activities with increased screen time, that is, more time spent using television, cell phones and other electronic devices (LEE, 2018).

Furthermore, stress in the contemporary world plays a very important role in the development of obesity (MALAGRIS; FIORITO, 2006; PALOMINO-PÉREZ, 2020). Stress has a physiological effect that induces the individual to consume high-calorie foods, activating the reward system, thus generating a better sensation and helping the individual to deal with difficulties (PALOMINO-PÉREZ, 2020). Thus, for many, this becomes a cycle that can result in excess weight gain and the development of various comorbidities and eating disorders (COLLINS; BENTZ, 2007). In children, stress also plays a negative role, especially in those who are obese, as they tend to enter the reward system cycle (SAGAR; GUPTA, 2018).

According to Xavier et al. (2015), pregnancy, newborn classification and lactation influence the baby's metabolic programming, which can progress with the individual until adulthood, and can lead to obesity.

The socioeconomic factor has a great impact on the nutritional status of the population. Studies show that in developing countries, children with higher income are more overweight and obese, unlike in developed countries, where children with lower purchasing power are those who most suffer from the disease. This situation may be related to diet, physical activity, industrial marketing, low consumption of fruits and vegetables and high consumption of ultra-processed foods (ADAMS, 2020; BENTLEY; ORMEROD; RUCK, 2018).

Genetic predisposition is one of the major factors that lead to obesity and, since the Human Genome Project (PGH) was completed in 2003, we know that the genome is not static and can be modified by environmental factors, including diet. In this context, Nutritional Genomics emerged, an area of science that studies the interaction between genes and nutrients and how this interaction influences gene expression to manifest phenotypic results, such as obesity and other diseases (PENA, 2010).

One of the main genes linked to obesity is FTO (fat mass and obesity-associated), it was one of the first genes to show a well-established relationship with obesity in different populations and ages. The most studied polymorphism is rs9939609, which is responsible for increased adipogenesis, increased ghrelin levels and consequently hunger, among other factors, as well as strategies for modulating the expression of this polymorphism.

GOAL

Study the nutrigenomic and nutrigenetic aspects involving obesity in children and adolescents, focusing on the rs9939609 polymorphism of the FTO gene, analyzing the effects of this genetic variant on body fat gain, and addressing possible promising nutritional strategies to combat obesity.

MATERIALS AND METHODS

This is a bibliographic review carried out between October 2020 and March 2022, through the search strategy for articles in

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the electronic databases SCIELO, PUBMED, Google Scholar, LILACS, together with the consultation of academic literature related to the subject, in the languages Portuguese, English and Spanish. The Science and Health Descriptor (DECS) was used to determine the key words: "nutrigenomics", "child", "adolescents", "obesity", "FTO Dioxygenase Dependent on alpha-Ketoglutarate", "nutrigenomics", " adolescent", "child", "childhood", "obesity", "Alpha-Ketoglutarate-Dependent Dioxygenase FTO".

The articles were selected based on the inclusion criteria, which were: studies related to obesity and the fto gene, studies on the rs9939609 polymorphism, priority was given to studies on children and adolescents, but as it is an extremely specific and scarce topic, it was opened An exception was made for the inclusion of studies in the adult population, to collect some information and comparison and there was no restriction on the publication period. The exclusion criteria were: articles that were not related to the topic and studies that related obesity to other genes and polymorphisms.

RESULTS AND DISCUSSION

CHILDREN AND TEENAGERS

Childhood comprises a time of intense development, growth and different stages. This way, different bodies divide this moment of life into subcategories. The Brazilian Society of Pediatrics divides it into three phases, the first being infant (0 to 2 years old), preschool (2 to 4 years old) and school age (5 to 10 years old). The American Academy of Pediatrics understands that children aged 1 to 3 years are toddlers, or young children, 3 to 5 years old are preschoolers and school children are 5-12 years old. There are several different classifications for this group, but everyone understands the importance and care required at this stage of an individual's life.

Children's development goes far beyond biological progress, growth and the acquisition of skills, it involves maturation, learning and psychological and social aspects. This process is influenced by genetics, the environment in which they live, affection from caregivers, nutrition, attention, hygiene and basic sanitation, so each child has an individual and unique development (BRAZIL, 2002; MONTEIRO, 2016).

Growth is a continuous biological process that includes tissue renewal and physical and physiological maturation, influenced by genetic and environmental factors. During this period, children develop motor and sensory skills, with tactile development being notably accelerated. Brain development is shaped by social and cultural factors, and parental interaction plays a crucial role, influencing the child's emotional, social and psychological development, preparing them for independence and adolescence. (BRAZIL, 2002; MALIK, 2018; MONTEIRO, 2016).

According to the Child and Adolescent Statute (1990), individuals up to 12 years of age are considered children, thus adolescence includes individuals between 12 and 18 years of age. However, there are different understandings of the age that begins and ends adolescence, the WHO and Ministry of Health consider the period of adolescence to begin from 10 to 19 years of age (BRAZIL, 2005).

Adolescence, a stage in the life cycle between childhood and adulthood, is characterized by several psychological, social and biological changes (BRAZIL, 2005). These changes are influenced by genetic, environmental, nutritional and psychological elements (DE ANDRADE; MARQUES, 2010).

Puberty, distinct from but integrated with adolescence, encompasses biological and physiological changes such as body growth and sexual development, varying

individually in time and intensity. These physical transformations, together with brain maturation, encourage adolescents to make more complex decisions, although impulsivity and the feeling of omnipotence can lead them to risky situations. Furthermore, psychosocial changes include the development of abstract thinking, the appreciation of the immediate and the search for new experiences. (ALMEIDA, 2015; BRAZIL, 2005; CHIPKEVITCH, 2001; FERREIRA, 2010; GÜEMES-HIDALGO, 2017; SBP, 2012; DE ANDRADE; MARQUES, 2010).

With extensive development in childhood and adolescence, adequate nutrition is extremely important, as these are fundamental for proper growth and development (FERRIANI, 2001). Furthermore, during this period is where the development of eating habits that tend to remain until adulthood occurs, one of the main responsible for this formation are the parents. Acquiring healthy and appropriate eating habits from a young age can help alter the risk of chronic non-communicable diseases, such as obesity, diabetes and dyslipidemia in the future (BESERRA, 2020; CAMPOS, 2017; LOPES, 2016; SBP, 2012).

OBESITY IN CHILDREN AND ADOLESCENTS AND ITS PREVALENCE IN BRAZIL AND THE WORLD

The diet of children and adolescents has undergone major changes, a consequence of the rapid development of food industries and changes in eating patterns (BESERRA, 2020; LEE, 2018). In the past, food was only purchased in small quantities to improve a recipe (MOUBARAC, 2012), since contemporary times this practice has been modified and the purchase of ready-to-eat foods has been intensified and is easily accessible.

According to the Food Guide for the Brazilian Population, developed by the Ministry of Health (2014), foods are classified according to the type of processing as fresh or minimally processed foods, oils, fat, salt and sugar, processed foods and ultra-processed foods.

Fresh foods are taken from nature and can be of animal or vegetable origin and do not undergo modifications, while minimally processed foods are fresh foods that have undergone small changes, it is recommended to use these foods as the basis of your diet. The oils, fat, salt and sugar category are acquired through fresh foods and serve as ingredients in culinary preparations.

Processed foods are foods made in industries only with the addition of ingredients that improve the flavor and give longer shelf life; their consumption is recommended in small quantities. Ultra-processed foods are characterized as foods that go through various processes, with different ingredients added, such as sugars, salt, vegetable oils, many of them in excessive quantities, and artificial substances developed in laboratories. Furthermore, ultra-processed foods are low in fiber and abundant in calories, for these reasons the guide recommends people to avoid this type of food.

However, SISVAN WEB reports present data contrary to the recommendation. In the year 2021 in January, it was reported that of 14,914 adolescents of both sexes, including all ethnicities, people and community and education, 81% consume ultra-processed foods, with the consumption of vegetables being lower, adherence of 72% of the total number of adolescents monitored. In children aged 5 to 9 years, the percentage of individuals who eat ultra-processed foods is close to that of adolescents, being 85% of a total of 10,840 patients, while the percentage of vegetables was 68%. Therefore, we can observe that

the consumption of ultra-processed foods is predominant in relation to fresh foods, which must be the basis of our diet.

According to Sousa et al. (2020) and Pereira et al. (2018), studies indicate that most Brazilian adolescents do not consume the first meal of the day, breakfast, which is related to reaching the daily nutritional recommendations for calcium, phosphorus, thiamine, riboflavin, vitamin A, B6 and D, and a healthier and more balanced diet. Furthermore, if other foods were added to this meal, such as milk and dairy products, fruits and whole grains, the benefits would be much greater. Another factor observed is the replacement of meals with snacks, the most common meal being dinner, and the foods reported were soft drinks, chocolate drinks, tea, pizza, hamburgers, hot dogs, cookies, cakes and cold cuts sandwiches. Furthermore, the article shows that the dietary pattern of this group has worsened over the years and the consumption of fresh and minimally processed foods has been replaced by ultra-processed foods (SOUSA, 2020).

Children's diets are currently very similar to those of teenagers. Carvalho et al. (2015) states that the frequency of consumption of foods with high calorie content and low nutritional quality has increased, that is, diets have presented excess calories and micronutrient deficiencies. It was recorded that in 3,083 children the consumption of fried foods and artificial juices at least once a week was 60% and 82%, respectively. Furthermore, the daily consumption of foods such as biscuits, cookies, sweets and soft drinks is extremely common and has high adherence among Brazilian children (ALVES, 2006).

According to Lee (2018), one of the risk factors for developing obesity in children and adolescents is diet. A diet with a high consumption of sugary drinks, fast foods, ultra-processed foods, with high calorie content and low consumption of fruits and vegetables has shown a strong correlation with an increase in the number of obesity (ENES, 2010; LEE, 2018).

Obesity in childhood and adolescence increases the risk of mortality and causes the premature onset of high blood pressure, dyslipidemia, type 2 diabetes, cardiovascular diseases, non-fatty hepatic steatosis, cancer and psychosocial problems (LEE, 2018). Furthermore, obesity is portrayed as a phenotype for other diverse pathologies (GÜNGÖR, 2014).

Obesity in childhood and adolescence can be identified using the curves developed by the WHO. The curve used is the BMI by age for girls and boys. Individuals above the 95th percentile are considered obese, and those above the 99th percentile are severely obese (GÜNGÖR, 2014). In 1975, the global average BMI among children and adolescents (5-19 years) was 17.2 kg/m2 for girls and 16.8 kg/m2 for boys. After 42 years of study, they were able to observe that the BMI of these groups increased in all regions. The increase in BMI per decade was 0.32 kg/m2, that is, 18.6 kg/m2 for girls and 18.5 kg/m2 for boys. By 2022 worldwide, it is expected that the number of obesity cases will exceed the number of moderately or severely underweight children and adolescents (ABARCA-GÓMEZ et al., 2017).

Besides, according to Abarca-Gómez et al. (2017), the number of girls in the world with obesity increased from 5 to 30 million, and in boys there was an increase from 6 to 74 million, in just 41 years. Therefore, it is observed that the prevalence of obesity has grown disproportionately in recent years, surpassing adults (LEE, 2018).

In Brazil, at least 2.9 million children under 10 years of age are obese, and 3.4 million adolescents also have the disease. In 2020 it was reported that the state with the highest

percentage of obesity among children aged 0 to 2 years was Sergipe (11.6%), between 2-5 years old was Pernambuco (9.9%), between ages 5 to 9 years old it was Rio Grande do Sul (18.2%) and among adolescents aged 10 to 19, once again, Rio Grande do Sul (16.80%) stood out (CANELLA et al., 2020).

It is known that children and adolescents with obesity can present diseases early in adulthood, but some of them can present themselves during childhood and adolescence. One of the most common diseases that can develop is non-fatty hepatic steatosis, which is characterized as an accumulation of fat in at least 5% of hepatocytes. Diseases in the cardiovascular system were also detected. (KOHUT; ROBBINS; PANGANIBAN, 2019).

Furthermore, adolescents may have type 2 diabetes, due to insulin resistance developed as a result of the accumulation of fatty acids in the liver, adipocytes, skeletal muscle and pancreas. They may develop sleep apnea and skeletal muscle complications. (KOHUT; ROBBINS; PANGANIBAN, 2019).

ETIOLOGY

The prevalence of obesity has been growing throughout the world, and is currently one of the world's health problems (MEHRDAD; DOAEI; GHOLAMALIZADEH, 2020). Obesity is a complex disease that involves several factors, the most notable being genetic and environmental factors (QI, 2014). The combination of these can make the individual more vulnerable to developing obesity (SONESTEDT et al., 2009). Furthermore, obese individuals have a greater risk of chronic diseases, such as diabetes, cancer and cardiovascular disease. A recent study reported that obesity is 40 to 70% hereditary (GONZÁLEZ-MUNIESA, 2017).

Genetic factors can be characterized by three types, chromosomal changes, monogenic changes and polygenic changes. Chromosomal and monogenic changes are more serious and rare cases, affecting approximately 5% of the obese population. Polygenic changes are related to genetic variations, called polymorphisms, that predispose to obesity, however, the expression and development of the obese phenotype is influenced by biological factors and, mainly, by environmental factors (LOOS; YEO, 2021; MAHMOUD, 2022).

Studies have shown that there is a metabolic programming, which occurs from the moment of conception until 24 months after birth, a time in which the mother's nutritional and health status can permanently influence the health and development of diseases in the child. Excess weight during pregnancy, especially in the first 20 weeks, is a risk factor for the development of excess weight in childhood. The type and quality of nutrients ingested by the mother during pregnancy and lactation have been associated with the development of metabolic complications in adulthood. Longer breastfeeding duration was associated with a lower prevalence of overweight in old age (TRANDAFIR; TEMNEANU, 2016; WILLIAMS, 2014).

Furthermore, the risk of childhood obesity is also strongly related to the eating behavior of children and adolescents. These are increasing caloric intake and decreasing caloric expenditure. Dietary factors such as consumption of fast food, ultra-processed foods, skipping breakfast, eating while watching television, reducing meals with the family, reducing the intake of vegetables, fruits and vegetables have a high risk of obesity in childhood (KUMAR; KELLY 2017).

Socioeconomic, demographic and cultural factors are strongly associated with food quality. A study carried out in the city of São Paulo, in Brazil, with children between 8 and 10 years of age from public and private schools demonstrated that boys from public schools

have normal body fat percentage values, whereas in private schools the fat percentage is higher when comparing the values. However, the results of this study demonstrated the development of overweight and childhood obesity in children with greater purchasing power, negatively affecting their health status and potentially developing chronic diseases (MIRANDA et al., 2015).

According to Adams (2020), this situation is present in developing countries, such as Brazil. In developed countries, the prevalence of overweight and obesity is higher in children from low-income families, who have greater body mass. Children from families with greater purchasing power generally consume more fruits and vegetables and fewer sugary drinks, leading to a diet with lower cardiovascular risk. An American study associate's childhood obesity with lower purchasing capacity, highlighting the consumption of ultra-processed foods and the impact of food industry marketing, in addition to lower family availability for health care (BENTLEY; ORMEROD; RUCK, 2018).

Obesity in this population may also be associated with both the increased use of digital media, such as Instagram and YouTube, and the reduction in physical activity, with children spending more time in front of electronic devices. The internet, as the main marketing platform for foods high in saturated fats, sugars and sodium, and the increase in screen time, especially during the COVID-19 pandemic, contribute to this growing trend of obesity in childhood and adolescence. (CAMARGO; AÑEZ, 2020; COATES et al., 2019; KUMAR; KELLY, 2017; THE LANCET DIABETES & ENDOCRINOLOGY, 2022).

In childhood, psychosocial factors such as anxiety, stress and bullying have a profound impact, leading some individuals to eat excessively as a way of dealing with negative emotions. This contributes to overweight and obesity. Emotions directly influence the quality and quantity of food consumed, with studies showing that negative emotions increase food intake and overweight people tend to eat more when faced with negative emotions. (KUMAR; KELLY, 2017; PALOMINO-PÉREZ, 2020).

NUTRITIONAL GENOMICS

Genomics belongs to a field of biological science research called omics science, which began through the Human Genome Project (PGH) and encompasses technology and the in-depth study of the organism's intra and extracellular processes (HEINNER, 2015; GREEN; WATSON; COLLINS, 2015). This is the most explored area of omics science, and investigates the genome of organisms, understanding their function, structure, mapping and evolution (VAILATI-RIBONI; PALOMBO; LOOR 2017).

The Human Genome Project began in 1990 and was completed in 2003. It became a milestone in the history of humanity for obtaining the complete sequence of the human genome. The results of the PGH served as the basis for new studies and, in 2003, the sequence of the diploid genome was published containing information on each pair of chromosomes inherited from the parents, and it was possible to conclude that the genetic similarity between people is 99.5 % (NHGRI, 2012).

We can say that our phenotypic differences are determined by just 0.5% of our genetic sequence. Alternative genes are called alleles and genetic variations, when they occur in more than 1% of the population, are called polymorphisms. Thus, polymorphisms are understood as variations in the DNA sequence, which can result in modifications in protein synthesis or its functions (SCHMIDT; SODER; BENETTI, 2019). These variations are responsible for making each individual unique, who respond individually to the

environmental factors to which they are exposed, including food.

Nutritional genomics is a recent and multidisciplinary science, which encompasses nutrigenomics, nutrigenetics and nutritional epigenomics, in order to understand how nutrients and bioactive compounds interact with the human genome, presenting phenotypic results, including the risk of diseases (KAPUT, 2008).

Nutrigenetics, on the other hand, aims to understand how an individual's genetic makeup coordinates their response to food. Nutrigenetics studies the effect of genetic variation on the interaction between diets and diseases, incorporating the science of identifying and characterizing gene variants associated with differential responses to nutrients (KAPUT, 2008; MUTCH; WAHLI; WILLIAMSON, 2005).

Nutrigenomics studies how interactions between food components and the genome affect the pattern of gene expression and its consequences on health and disease, that is, how food influences different metabolic pathways and control of homeostasis (PENA, 2010).

Epigenetics is the area of science that studies the regulation of gene expression and through chemical modifications to DNA and chromatin, which result in reversible phenotypic changes, without any changes to the DNA. This regulation of gene expression is influenced by environmental factors, in addition to being hereditary. This means that the environment in which ancestors and progenitors lived can influence the way in which genes are expressed, however, unlike DNA, the epigenome can be altered, interfering with the behavior of the gene, this occurs through some epigenetic mechanisms, such as methylation and phosphorylation. Thus, it is known that nutritional epigenomics studies all epigenetic modifications in a cell caused by exposure to foods, nutrients and bioactive compounds. Epigenetic events, such as DNA methylation, are capable of promoting or harming health, through inducing gene expression or silencing (FRAGA et al., 2005; RINGROSE; PARO, 2004).

OBESITY AND NUTRIGENETICS

It is known that, with regard to obesity and genetics, the most common forms observed in obesity are of polygenic origin, that is, genetic variations present in several genes (MOSCA, 2012).

Genes and polymorphisms are selected for studies of the relationship with obesity, when they are found in chromosomal regions associated with the disease or when they are involved in metabolism (FRAYLING et al., 2007). Some genes that showed more relevance in the development of obesity are FTO, MC4R, NRXN3, POMC, among others.

The genes that were most frequently associated with obesity were evaluated in a study that observed the influence of polymorphisms present in these genes, involving the regulation of appetite, adipogenesis, energy expenditure, regulation of metabolism, insulin signaling and pathways inflammatory (FISCHER; EMMERLING; THER, 2008). In this sense, many studies are being conducted to understand the association of SNPs (single nucleotide polymorphisms) of these genes with the development of obesity, as well as the mechanisms involved in the development of the disease (CHURCH et al., 2009; CHURCH et al., 2010; MERKESTEIN; LABER; MCMURRAY, 2015).

FTO OVERVIEW

As it was previously stated, FTO was the first gene related to common obesity. It is located in chromosomal region 16q12.2. It has 9 exons and 8 introns and the most common variants are found in the first intron (FRAYLING et al.,

2007; SCUTERI et al., 2007). It is expressed in various human tissues, in greater quantities in the brain, more precisely, in the hypothalamus, a region involved in the regulation of energy balance.

The gene in question is responsible for encoding the protein demethylase dependent on 2-oxoglutarate and Fe (II), an enzyme capable of catalyzing the Fe (II) and 2OG-dependent demethylation of N6-methyladenine and 3-methyluracil, with concomitant production of succinate, formaldehyde and carbon dioxide (GERKEN et al., 2007).

N6-methyladenine (m6A) is found in mRNA, while 3-methyluracil is found in ribosomal RNA. m6A is the most abundant internal mRNA modification, and participates in the regulation of important cellular processes, such as transport, degradation and translation (HUANG et al., 2021; YEO, 2014).

Studies carried out in humans and animals show that the gene has an important role in regulating appetite, greater food intake, decreased satiety and greater adipogenic activity. Among the SNPs found, six are strongly linked to obesity, but only one seems to act more relevantly in determining the disease, rs9939609 (FRAYLING et al., 2007; RIVAS et al., 2018).

This polymorphism occurs in the first intron of the FTO gene. It presents a T>A risk allele, and can be AA homozygous or AT heterozygous (FRAYLING et al., 2007). Studies demonstrate that the presence of the A allele is associated with hyperphagia and reduced satiety in adults and children. It was also observed that people with the AA genotype have less postprandial suppression of ghrelin, the hormone responsible for the sensation of hunger, compared to people who have the TT genotype (CECIL et al., 2008; KARRA, et al., 2013).

KNOWN OBESOGENIC MECHANISMS

Studies demonstrate that FTO plays a fundamental role in the regulation of fat mass, adipogenesis and total body weight (FISCHER; EMMERLING; THER, 2008). Although the obesogenic mechanisms have not yet been fully elucidated, studies demonstrate that FTO significantly influences food intake behavior (CHURCH et al., 2009; CHURCH et al., 2010).

This occurs because, as previously stated, FTO is highly expressed in the hypothalamus, the region responsible for regulating body mass and composition, and directly influences the hormones leptin, ghrelin and insulin, which act in brain circuits, regulating hunger, satiety and blood levels. of adiposity (RIVAS et al., 2018).

A study carried out in 2013 showed that individuals carrying the risk allele of the SNP rs9939609 T/A, present greater expression of FTO, reduced methylation of ghrelin mRNA N6-methyladenosine (m6A) and increased expression of ghrelin, and had the attenuated postprandial appetite reduction (KARRA et al., 2013).

Increased ghrelin expression results in increased food intake and preference for energy-dense foods (KARRA et al., 2013).

Many studies have sought to clarify the mechanisms by which FTO interferes with adipogenesis, and evidence points to the fundamental role of m6A demethylation, mediated by FTO, in the regulation of adipogenesis. Adipose tissue acts as an endocrine organ, regulating energy metabolism through secretion and response to hormones, therefore, the expression of FTO in this tissue is very relevant. Studies have shown that m6A demethylation, caused by FTO, regulates mRNA splicing and plays a critical role in regulating adipogenesis. This occurs because the greater expression of FTO

interferes with cell differentiation, through the regulation of m6A levels around the splice site, thus regulating the exonic splicing of the adipogenic regulatory factor RUNX1T1 (ZHAO et al., 2014).

Merkestein, Laber and McMurray (2015) demonstrated that FTO regulates preadipocyte differentiation in vivo and further revealed that FTO increases the number of adipocytes during mitotic clonal expansion at an early stage of adipogenesis.

Another hypothesis that has been studied is the influence of FTO on the expression of the neighboring genes RPGRIP1L, IRX3 and IRX5, resulting in greater adipocyte production, appetite regulation and thermogenesis, however, the biochemical mechanisms still need further studies to be clarified (YANG et al., 2012; CLAUSSNITZER; HUI; KELLIS, 2016).

OBESITY AND NUTRIGENOMICS

Nutrigenomics studies the behavior of nutrients and bioactive compounds in genetic expression, that is, it understands how nutrients can influence the behavior of genes (RAMOS-LOPEZ et al., 2017; SANHUEZA, 2012).

One of the main objectives of nutrigenomics is to promote health and reduce the risks of NCDs, through an individual and personalized diet according to the genetic characteristics of each individual, as nutrients and bioactive compounds are capable of acting on several molecular targets (CONTI, 2010).

As obesity is one of the chronic non-communicable diseases (NCDs) very present in the current scenario and is a predictor for the development of other NCDs, this is one of the topics studied by nutrigenomics (BASTOS et al., 2009). From these studies, a high interaction was observed between the consumption of certain foods and genetic factors related to obesity, among them, sugary drinks which were associated with BMI and the high intake of fried foods which had a significant genetic influence on adipose tissue (HEIANZA, 2017; QI, 2014).

Furthermore, it was observed that fat intake has an important relationship with the FTO gene and the development of obesity (CASAS-AGUSTENCH, 2014). According to Phillips (2012), the consumption of saturated fatty acids resulted in a modulation between the waist circumference relationship and the FTO gene in the rs9939609 polymorphism. A greater measurement (waist circumference) was observed among individuals who carry the A allele than in those who are TT homozygotes for the FTO gene, where both consume saturated fatty acids.

Therefore, this study concludes that individuals who carry the risk gene, and who have a large intake of saturated fatty acids (greater than or equal to 15.5% of VET) or have a low intake of polyunsaturated fatty acids in relation to saturated ones, are at greater risk of having a BMI greater than or equal to 25 kg/m2 and developing central obesity when compared to homozygous TT carriers. Furthermore, the study reveals that when dieting is low in saturated fat, there is no relationship between the rs9939609 polymorphism and measures that indicate obesity.

In children and adolescents, results and conclusions similar to the study by Phillips (2012) were observed. In a study carried out with Spanish children and adolescents between the ages of 6 and 18, a statistically relevant interaction was found between the intake of saturated fatty acids, polymorphism and BMI. Individuals with the A allele and high consumption of SFA (greater than 12.6% of VET) had a higher BMI in relation to those carrying the T allele. Furthermore, for individuals with consumption of saturated fatty acids lower than 12.6%, the

polymorphism showed no changes in the BMI standard deviation score.

Moleres (2012), when making a relationship between polyunsaturated and saturated fatty acids, concluded that, if the ratio (PUFA: AGS) is less than 0.43, in carriers of the A allele, there is a 2.3 times greater risk of developing the disease. obesity compared to TT individuals, who consumed a higher ratio (AGPI: AGS).

Another European study, which is part of The Helena Study, carried out with adolescents between 13 and 16.99 years old, showed a relationship between the polymorphism and the percentage of energy ingested in the form of fat in central and total adiposity (LABAYEN, 2016).

The increase per risk allele in the percentage of body fat in adolescents who consumed diets in which fat represented 30% and 35% of total energy was +1.9%, and in those with consumption above 35% it was +2.8%. However, in individuals carrying the A allele who had consumption below 30%, they did not show any change in adiposity assessment indicators (BMI, BMI z-score, fat mass index, waist circumference and percentage of body fat) related to polymorphism. Labayen suggests that adolescents who have the A allele may benefit from a low-fat diet (LABAYEN, 2016).

Corella et al. (2011), also found that the high amount of lipids consumed during the day presented an unfavorable result for carriers of the A allele. This study was carried out with two different American populations, one identified as GOLDN and the second as BPRHS, considered high amount of lipid > or equal to 82 g/day and > or equal to 72.6 g/day, respectively. In both populations, high fat consumption resulted in higher BMI and excess SFA again stood out as it was linked to high BMI in carriers of the risk allele (AA). Polyunsaturated fats were not related to polymorphism and BMI, however monounsaturated fatty acids showed significant results. Furthermore, the article showed that there were no relevant interactions regarding carbohydrates.

In contrast, a Swedish study showed different results in relation to carbohydrates. It was observed that homozygous carriers of the risk allele when consuming a low-carbohydrate diet had a higher BMI than TT carriers, identifying an odds ratio of 3.11 for the increased risk of developing obesity for them. However, high carbohydrate consumption in AA carriers was not associated with higher BMI; the odds ratio for developing the disease in these individuals was 0.99. This study also commented on the interaction of high daily lipid consumption in AA carriers, which is a greater threat to obesity. Furthermore, no interaction was observed between protein, FTO and BMI. However, it was observed in this study that the FTO genotype and higher BMI were present in those who had high-protein diets (SONESTEDT et al., 2009).

A more recent study analyzed the effect of rs9939609 on weight loss and cardiovascular risks by comparing a high-protein diet (88.6 g/day), low in carbohydrates (86.1 g/day) and a diet hypocaloric pattern (1000 kcal/day), for 9 months, in obese patients carrying the polymorphism. Greater weight loss was noted in patients with the risk allele and the high-protein/high-glycemic diet had a greater impact on anthropometric measurements (weight, BMI, waist circumference and fat mass) in the different genotypic groups (TT vs AT + AA). The study confirms that in patients where the risk allele (A) was present, they had higher BMI, weight, waist circumference and fat mass before and after the intervention when compared to individuals carrying TT (DE LUIS et al., 2015).

CONCLUSION

The rs9939609 polymorphism of the FTO gene was shown to be related to the daily total, the type and amount of lipids consumed in the diet for individuals carrying the A allele. Furthermore, excessive consumption of saturated fatty acids showed an interaction with the rs9939609 polymorphism and resulted in higher BMI in these individuals.

Therefore, a possible promising nutritional strategy for managing the rs9939609 polymorphism in the FTO gene and obesity is a lower intake of total lipids and saturated fatty acids. It is not yet possible to recommend a specific amount, as studies are scarce and controversial.

Nutritional genomics has shown great promise in managing diseases and likely risks associated with food. New studies may better clarify the relationship between nutrients and rs9939609 of the FTO gene, enabling the use of effective and precise strategies for controlling obesity in childhood and adolescence.

REFERENCES

ABARCA-GÓMEZ, Leandra *et al.* Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128· 9 million children, adolescents, and adults. **The Lancet**, v. 390, n. 10113, p. 2627-2642, 2017. Disponível em: <https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(17)32129-3/fulltext>. Acesso em: 26 fev. 2021.

ADAMS, Jean. Addressing socioeconomic inequalities in obesity: Democratising access to resources for achieving and maintaining a healthy weight. **PLoS Medicine**, v. 17, n. 7, p. e1003243, 2020. Disponível em: <https://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1003243>. Acesso em: 05 out. 2020.

ALBRACHT-SCHULTE, Kembra *et al*. Omega-3 fatty acids in obesity and metabolic syndrome: a mechanistic update. **The Journal of Nutritional Biochemistry**, v. 58, p. 1-16, 2018. Disponível em: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7561009/>. Acesso em: 12 maio 2021.

ALMEIDA, Roberto Santoro. Adolescência e contemporaneidade-aspectos biopsicossociais. **Residência Pediatrica**, v. 5, n. 3 supl 1, p. 13-16, 2015. Disponível em: <http://residenciapediatrica.com.br/detalhes/159/adolescencia-e-contemporaneidade---aspectos-biopsicossociais>. Acesso em: 03 nov. 2020.

ALVES, Mabel Nilson; MUNIZ, Ludmila Correa; VIEIRA, Maria de Fátima Alves. Consumo alimentar entre crianças brasileiras de dois a cinco anos de idade: Pesquisa Nacional de Demografia e Saúde (PNDS), 2006. **Ciência & Saúde Coletiva**, v. 18, p. 3369-3377, 2013. Disponível em: <https://www.scielo.br/j/csc/a/VtchJf6pnPHGyvkRFrzK6dy/?lang=pt>. Acesso em: 09 abr. 2022.

ANDAKI, Alynne CR *et al*. Curvas de referência de dobras cutâneas e sua utilização na predição do risco de síndrome metabólica em crianças. **Jornal de Pediatria**, v. 93, p. 490-496, 2017. Disponível em: <https://www.scielo.br/scielo.php?script=sci_arttext&pid=S0021-75572017000500490&lng=pt&nrm=iso&tlng=pt>. Acesso em: 21 set. 2021.

APOVIAN, Caroline M. Obesity: definition, comorbidities, causes, and burden. **American Journal of Management Care**, v. 22, n. 7 Suppl, p. s176-85, 2016. Disponível em: <https://www.ajmc.com/view/obesity-definition-comorbidities-causes-burden>. Acesso em: 15 jun. 2021.

BASTOS, Deborah HM; ROGERO, Marcelo M.; ARÊAS, José Alfredo G. Effects of dietary bioactive compounds on obesity induced inflammation. **Arquivos Brasileiros de Endocrinologia & Metabologia**, v. 53, p. 646-656, 2009. Disponível em: <https://www.scielo.br/j/abem/a/cSRtQcqJygrLCFgTC5ct5Dr/?lang=pt>. Acesso em: 02 mar. 2021.

BENTLEY, R. Alexander; ORMEROD, Paul; RUCK, Damian J. Recent origin and evolution of obesity-income correlation across the United States. **Palgrave Communications**, v. 4, n. 1, p. 1-14, 2018. Disponível em: <https://www.nature.com/articles/s41599-018-0201-x>. Acesso em: 12 ago. 2021.

BESERRA, Jéssica Batista *et al*. Crianças e adolescentes que consomem alimentos ultraprocessados possuem pior perfil lipídico? Uma revisão sistemática. **Ciência & Saúde Coletiva**, v. 25, p. 4979-4989, 2020. Disponível em: <https://www.scielosp.org/article/csc/2020.v25n12/4979-4989/>. Acesso em: 21 jun. 2021.

BRASIL. Ministério da Saúde. Secretaria de Atenção à Saúde. Área de Saúde do Adolescente e do Jovem**.** Marco legal: saúde, um direito de adolescentes. Brasília: Editora do Ministério da Saúde, 2007. Disponível em: <https://bvsms.saude.gov.br/bvs/publicacoes/07_0400_M.pdf>. Acesso em: 03 ago. 2021.

BRASIL. Ministério da Saúde. Secretaria de Políticas Públicas de Saúde. Comitê da Primeira Infância. Políticas intersetoriais em favor da infância: guia referencial para gestores municipais – Brasília: Ministério da Saúde, 2002. Disponível em: <https://bvsms.saude.gov.br/bvs/publicacoes/0211pol_interset01.pdf>. Acesso em: 13 out. 2020.

BRASIL. Ministério da Saúde. Secretaria de Políticas de Saúde. Departamento de Atenção Básica. Saúde da criança: acompanhamento do crescimento e desenvolvimento infantil - Brasília: Ministério da Saúde, 2002. Disponível em: <https://bvsms.saude.gov.br/bvs/publicacoes/acompanhamento_crescimento_desenvolvimento_infantil_cab11.pdf>. Acesso em: 22 jun. 2021.

BUENO, Aline L.; CZEPIELEWSKI, Mauro A. A importância do consumo dietético de cálcio e vitamina D no crescimento. **Jornal de Pediatria**, v. 84, n. 5, p. 386-394, 2008. Disponível em: <https://www.scielo.br/j/jped/a/NM4xCDcZPWLGWmKFgpzhVzm/?lang=pt>. Acesso em: 02 mar. 2021.

CAMARGO, E. M.; AÑEZ, CRR. Diretrizes da OMS para atividade física e comportamento sedentário: num piscar de olhos. **Genebra: Organização Mundial da Saúde**, 2020. Disponível em: <https://apps.who.int/iris/bitstream/handle/10665/337001/9789240014886-por.pdf?sequence=102&isAllowed=y#:~:text=Recomenda%2Dse%20que%3A,atividade%20f%C3%ADsica%20deve%20ser%20aer%C3%B3bic>. Acesso em: 17 fev. 2021.

CAMPOS, Marina Linhares Bezerra *et al*. Dietary patterns of obese children: Maternal perceptions and experiences. **Revista de Nutrição**, v. 30, p. 197-207, 2017. Disponível em: <https://www.scielo.br/j/rn/a/RSHM5NpC6tPYNHXR8KphhnN/?lang=en>. Acesso em: 27 nov. 2020.

CANELLA, Daniela *et al.* Panorama da Obesidade em Crianças e Adolescentes – Rio de Janeiro: Instituto Desiderata, v.2, n.2, 2020. Disponível em: <http://desiderata.org.br/production/content/uploads/2020/10/7c2974ab485c2d97fd32ea8a7e6fdddb.pdf>. Acesso em: 04 mar. 2022.

CARVALHO, Carolina Abreu de *et al*. Consumo alimentar e adequação nutricional em crianças brasileiras: revisão sistemática. **Revista Paulista de Pediatria**, v. 33, p. 211-221, 2015. Disponível em: <https://www.scielo.br/j/rpp/a/tpJpvdBLB4TQdjMc6rMxJMq/?lang=pt&format=pdf>. Acesso em: 05 mar. 2021.

CASAS-AGUSTENCH, Patricia *et al*. Saturated fat intake modulates the association between an obesity genetic risk score and body mass index in two US populations. **Journal of the Academy of Nutrition and Dietetics**, v. 114, n. 12, p. 1954-1966, 2014. Disponível em: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4214897/#R7>. Acesso em: 07 mar. 2021.

CECIL, Joanne E. *et al.* An obesity-associated FTO gene variant and increased energy intake in children. **New England Journal of Medicine**, v. 359, n. 24, p. 2558-2566, 2008. Disponível em: <https://www.nejm.org/doi/full/10.1056/nejmoa0803839>. Acesso em:07 mar. 2021.

CHAUHDARY, Zunera; REHMAN, Kanwal; AKASH, Muhammad Sajid Hamid. The composite alliance of FTO locus with obesity- related genetic variants. **Clinical and Experimental Pharmacology and Physiology**, v. 48, n. 7, p. 954–965, 2021. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/33735452/>. Acesso em: 07 mar. 2021.

CHURCH, Chris *et al.* A mouse model for the metabolic effects of the human fat mass and obesity associated FTO gene. **PLoS Genetics**, v. 5, n. 8, p. e1000599, 2009. Disponível em: <https://journals.plos.org/plosgenetics/article?id=10.1371/journal.pgen.1000599>. Acesso em: 04 mar. 2022.

CHURCH, Chris *et al.* Overexpression of Fto leads to increased food intake and results in obesity. **Nature Genetics**, v. 42, n. 12, p. 1086-1092, 2010. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/21076408/>. Acesso em: 04 mar. 2022.

CIVIL, Casa. Lei nº 8.069, de 13 de julho de 1990. **Dispõe sobre o Estatuto da Criança e do Adolescente e dá outras providências. Brasília: Diário Oficial da União**, 1990. Disponível em: <https://www.unicef.org/brazil/estatuto-da-crianca-e-do-adolescente>. Acesso em: 06 jun. 2021.

CLAUSSNITZER, Melina; HUI, Chi-Chung; KELLIS, Manolis. FTO Obesity Variant and Adipocyte Browning in Humans. **The New England Journal of Medicine**, v. 374, n. 2, p. 192-193, 2016. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/26760097/>. Acesso em: 27 nov. 2020.

COATES, Anna E. *et al*. Social media influencer marketing and children's food intake: a randomized trial. **Pediatrics**, v. 143, n. 4, 2019. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/30833297/>. Acesso em: 27 nov. 2020.

COLLINS, Jennifer C., BENTZ, Jon E. Behaviorial and Psychological Factors in Obesity. **The Journal of Lancaster General Hospital**. v. 4, n. 4, p.124-127, 2007. Disponível em: <http://www.jlgh.org/JLGH/media/Journal-LGH-Media-Library/Past%20Issues/Volume%204%20-%20Issue%204/JLGH_Dec09bentz.pdf>. Acesso em: 15 abr. 2021.

CONTI, Aline de; MORENO, Fernando Salvador; ONG, Thomas Prates. Nutrigenônica: revolução genômica na nutrição. **Ciência e Cultura**, v. 62, n. 2, p. 04-05, 2010. Disponível em: <http://cienciaecultura.bvs.br/scielo.php?script=sci_arttext&pid=S0009-67252010000200002>. Acesso em: 15 jun. 2021.

CORELLA, Dolores *et al*. A high intake of saturated fatty acids strengthens the association between the fat mass and obesity-associated gene and BMI. **The Journal of Nutrition**, v. 141, n. 12, p. 2219-2225, 2011. Disponível em: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3223879/>. Acesso em: 16 fev. 2022.

DA FONSECA, Ana Carolina Proença; ABREU, Gabriella Medeiros; ZEMBRZUSKI, Verônica Marques; *et al*. The association of the fat mass and obesity-associated gene (FTO) rs9939609 polymorphism and the severe obesity in a Brazilian population. **Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy**, v. Volume 12, p. 667–684, 2019. Disponível em: <https://www.arca.fiocruz.br/handle/icict/42048>. Acesso em: 23 out. 2020.

DAVI, Tania Nunes *et al*. Inclusão de hábitos alimentares saudáveis na educação infantil com alunos de 4 e 5 anos. **Cadernos da FUCAMP**, v. 15, n. 24, 2016. Disponível em: <https://revistas.fucamp.edu.br/index.php/cadernos/article/view/932>. Acesso em: 25 out. 2020.

DE ALMEIDA CARVALHO, Elaine Alvarenga *et al*. Obesidade: aspectos epidemiológicos e prevenção. **Revista Médica de Minas Gerais**, v. 23, n. 1, p. 74-82, 2013. Disponível em: <https://ftp.medicina.ufmg.br/observaped/artigos_obesidade/ARTIGO_OBESIDADE_PUBLICADO_OFICIAL_24_09_2013.pdf>. Acesso em: 03 dez. 2020.

DE ANDRADE, Fábio; MARQUES, Maria Lucia. A Contribuição de "Grupos de Jovens" de Instruções Religiosas na Formação da Identidade do Adolescente. **Revista de Educação UNG**, v. 5, n. 2, p. 50-65, 2010. Disponível em: <http://revistas.ung.br/index.php/educacao/article/view/742>. Acesso em: 07 mar. 2021.

DE AZEVEDO, Fernanda Reis; BRITO, Bruna Cristina. Influência das variáveis nutricionais e da obesidade sobre a saúde e o metabolismo. **Revista da Associação Médica Brasileira (English Edition)**, v. 58, n. 6, p. 714-723, 2012. Disponível em: <https://www.scielo.br/j/ramb/a/fkfJLYTsZzj7tYfkq7qkpVN/?lang=pt>. Acesso em: 03 nov. 2020.

DE LUIS, Daniel Antonio *et al*. Effects of a high-protein/low-carbohydrate diet versus a standard hypocaloric diet on weight and cardiovascular risk factors: role of a genetic variation in the rs9939609 FTO gene variant. **Lifestyle Genomics**, v. 8, n. 3, p. 128-136, 2015. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/26457804/>. Acesso em: 18 de jun. 2021.

DENG, Xiaolan; SU, Rui; STANFORD, Savanna; *et al*. Critical Enzymatic Functions of FTO in Obesity and Cancer. **Frontiers in Endocrinology**, v. 9, p. 396, 2018. Disponível em: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6077364/>. Acesso em: 20 de fev. 2022.

DE OLIVEIRA, Denis William; DE OLIVEIRA, Evandro Salvador Alves. Sedentarismo infantil, cultura do consumo e sociedade tecnológica: implicações à saúde. **Revista Interação Interdisciplinar**, v. 4, n. 1, p. 155-169, 2020. Disponível em: <https://www.unifimes.edu.br/ojs/index.php/interacao/article/view/870/864>. Acesso em: 26 jan. 2022.

DINA, Christian; MEYRE, David; GALLINA, Sophie; *et al*. Variation in FTO contributes to childhood obesity and severe adult obesity. **Nature Genetics**, v. 39, n. 6, p. 724–726, 2007. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/17496892/>. Acesso em: 03 mar. 2022.

DI RENZO, Laura; CIOCCOLONI, Giorgia; FALCO, Simone; *et al*. Influence of FTO rs9939609 and Mediterranean diet on body composition and weight loss: a randomized clinical trial. **Journal of Translational Medicine**, v. 16, n. 1, p. 308, 2018. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/30419927/>. Acesso em: 04 abr. 2021.

DORLING, James L; CLAYTON, David J; JONES, Jenny; *et al*. A randomized crossover trial assessing the effects of acute exercise on appetite, circulating ghrelin concentrations, and butyrylcholinesterase activity in normal-weight males with variants of the obesity-linked FTO rs9939609 polymorphism. **The American Journal of Clinical Nutrition**, v. 110, n. 5, p. 1055–1066, 2019. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/31504106/>. Acesso em: 26 fev. 2022.

ENES, Carla Cristina; SLATER, Betzabeth. Obesidade na adolescência e seus principais fatores determinantes. **Revista Brasileira de Epidemiologia**, v. 13, p. 163-171, 2010. Disponível em: <https://www.scielo.br/j/rbepid/a/BrbTFHDPDmdf6sbnrxPwYRw/?lang=pt&format=html&stop=next>. Acesso em: 22 fev. 2022.

FAGERBERG, Linn et al. Analysis of the human tissue-specific expression by genome-wide integration of transcriptomics and antibody-based proteomics. **Molecular & Cellular Proteomics**, v. 13, n. 2, p. 397-406, 2014. Disponível em: < https://pubmed.ncbi.nlm.nih.gov/24309898/>. Acesso em: 08 jun. 2021.

FERRIANI, Maria das Graças Carvalho *et al*. Adolescência, puberdade e nutrição. **Associação Brasileira de Enfermagem: Compreender, Atuar, Acolher** Brasília (DF): ABEn, p. 77-92, 2001. Disponível em: <http://www.abennacional.org.br/revista/cap3.2.html>. Acesso em: 08 jun. 2021.

FISCHER, Julia; EMMERLING, Christian; THER, Ulrich. On the History of *Fto*. **Obesity Facts**, v. 1, n. 1, p. 43–44, 2008. Disponível em: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6444600/>. Acesso em: 07 abr. 2021.

FRAGA, Mario F. *et al*. Epigenetic differences arise during the lifetime of monozygotic twins. **Proceedings of the National Academy of Sciences**, v. 102, n. 30, p. 10604-10609, 2005. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/16009939/>. Acesso em: 07 abr. 2021.

FRAYLING, Timothy M. *et al.* A common variant in the FTO gene is associated with body mass index and predisposes to childhood and adult obesity. **Science**, v. 316, n. 5826, p. 889-894, 2007. Disponível em: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2646098/>. Acesso em: 05 maio 2021.

FREDRIKSSON, Robert; HÄGGLUND, Maria; OLSZEWSKI, Pawel K.; *et al*. The Obesity Gene, FTO, Is of Ancient Origin, Up-Regulated during Food Deprivation and Expressed in Neurons of Feeding-Related Nuclei of the Brain. **Endocrinology**, v. 149, n. 5, p. 2062–2071, 2008. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/18218688/>. Acesso em: 05 maio 2021.

FURLAN, Aline da Silva; RODRIGUES, Lovaine. Consumo de polifenóis e sua associação com conhecimento nutricional e atividade física. **Revista Brasileira de Medicina do Esporte**, v. 22, p. 461-464, 2016. Disponível em: <https://www.scielo.br/j/rbme/a/NTNdcsH5xsspFYhVfbqvLMz/?format=pdf&lang=pt>Acesso em: 26 fev. 2021.

GERKEN, Thomas; GIRARD, Christophe A.; TUNG, Yi-Chun Loraine; *et al*. The Obesity-Associated *FTO*Gene Encodes a 2-Oxoglutarate-Dependent Nucleic Acid Demethylase. **Science**, v. 318, n. 5855, p. 1469–1472, 2007. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/17991826/>. Acesso em: 03 nov. 2020.

GONZÁLEZ-MUNIESA, P. *et al.* Obesity. vol. 3. **Nature Reviews**, p. 17034, 2017. Disponível em: <https://www.nature.com/articles/nrdp201734>. Acesso em: 21 mar. 2022.

GOODARZI, Mark O. Genetics of obesity: what genetic association studies have taught us about the biology of obesity and its complications. **The lancet Diabetes & endocrinology**, v. 6, n. 3, p. 223-236, 2018. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/28919064/>. Acesso em: 11 fev. 2021.

GREEN, Eric D.; WATSON, James D.; COLLINS, Francis S. Human Genome Project: Twenty-five years of big biology. **Nature**, v. 526, n. 7571, p. 29-31, 2015. Disponível em: <https://www.nature.com/articles/526029a>. Acesso em: 04 fev. 2021.

GÜEMES-HIDALGO, M.; CEÑAL GONZÁLEZ-FIERRO, M. J.; HIDALGO VICARIO, M. I. Desarrollo durante la adolescencia. Aspectos físicos, psicológicos y sociales. **Pediatría Integral**, v. 21, n. 4, p. 233-244, 2017. Disponível em: <https://www.pediatriaintegral.es/publicacion-2017-06/desarrollo-durante-la-adolescencia-aspectos-fisicos-psicologicos-y-sociales/>. Acesso em: 11 fev. 2021.

GULATI, Pawan; CHEUNG, Man Ka; ANTROBUS, Robin; *et al*. Role for the obesity-related *FTO* gene in the cellular sensing of amino acids. **Proceedings of the National Academy of Sciences**, v. 110, n. 7, p. 2557–2562, 2013. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/23359686/>. Acesso em: 07 abr. 2021.

GÜNGÖR, Neslihan Koyuncuoğlu. Overweight and obesity in children and adolescents. **Journal of Clinical Research in Pediatric Endocrinology**, v. 6, n. 3, p. 129, 2014. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/25241606/>. Acesso em: 29 out. 2020.

HAN, Zhifu; NIU, Tianhui; CHANG, Junbiao; *et al*. Crystal structure of the FTO protein reveals basis for its substrate specificity. **Nature**, v. 464, n. 7292, p. 1205–1209, 2010. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/20376003/>. Acesso em: 20 jul. 2021.

HEIANZA, Yoriko; QI, Lu. Gene-diet interaction and precision nutrition in obesity. **International Journal of Molecular Sciences**, v. 18, n. 4, p. 787, 2017. Disponível em: <https://www.mdpi.com/1422-0067/18/4/787/htm>. Acesso em: 22 jun. 2021.
HEINNER, Guio. Hacia la medicina personalizada: implicancias de las ciencias básicas y las" ómicas" en la práctica clínica. **Revista Peruana de Medicina Experimental y Salud Pública**, v. 32, n. 4, p. 629-632, 2015. Disponível em: <http://www.scielo.org.pe/scielo.php?script=sci_arttext&pid=S1726-46342015000400001>. Acesso em: 04 mar. 2021.

HUANG, Wei et al. N6-methyladenosine methyltransferases: functions, regulation, and clinical potential. **Journal of Hematology & Oncology**, v. 14, n. 1, p. 1-19, 2021. Disponível em: <https://jhoonline.biomedcentral.com/articles/10.1186/s13045-021-01129-8>. Acesso em: 25 mar. 2022.

INCHLEY, Jo *et al*. Findings from the 2017/2018 Health Behaviour in School-aged Children (HBSC) survey in Europe and Canada. **World Health Organization**, 2020. Disponível em: <https://www.researchgate.net/publication/342674634_FINDINGS_FROM_THE_20172018_HEALTH_BEHAVIOUR_IN_SCHOOL-AGED_CHILDREN_HBSC_SURVEY_IN_EUROPE_AND_CANADA_INTERNATIONAL_REPORT_VOLUME_1_KEY_FINDINGS_Spotlight_on_adolescent_health_and_well-being_Spotlight>. Acesso em: 17 abr. 2022.

JIA, Guifang; FU, Ye; ZHAO, Xu; *et al*. N6-Methyladenosine in nuclear RNA is a major substrate of the obesity-associated FTO. **Nature Chemical Biology**, v. 7, n. 12, p. 885–887, 2011. Disponível em: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3218240/>. Acesso em: 17 set. 2021.

JIANG, Yanrrui; MEI, Hao; LIN, Qingmin; *et al*. Interaction effects of FTO rs9939609 polymorphism and lifestyle factors on obesity indices in early adolescence. **Obesity Research & Clinical Practice**, v. 13, n. 4, p. 352–357, 2019. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/31402168/>. Acesso em: 05 set. 2021.

KAPUT, Jim. Nutrigenomics research for personalized nutrition and medicine. **Current Opinion in Biotechnology**, v. 19, n. 2, p. 110-120, 2008. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/18387295/>. Acesso em: 25 fev. 2022.

KARRA, Efthimia *et al.* A link between FTO, ghrelin, and impaired brain food-cue responsivity. **The Journal of Clinical Investigation**, v. 123, n. 8, p. 3539-3551, 2013. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/23867619/>. Acesso em: 25 fev. 2022.

KOHUT, Taisa; ROBBINS, Jennifer; PANGANIBAN, Jennifer. Update on childhood/adolescent obesity and its sequela. **Current Opinion in Pediatrics**, v. 31, n. 5, p. 645-653, 2019. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/31145127/>. Acesso em: 26 fev. 2021

KUMAR, Seema; KELLY, Aaron S. Review of childhood obesity: from epidemiology, etiology, and comorbidities to clinical assessment and treatment. In: **Mayo Clinic Proceedings**. Elsevier, 2017. p. 251-265. Disponível em: <https://www.sciencedirect.com/science/article/abs/pii/S000256196163059 5X>. Acesso em: 19 mar. 2021

LABAYEN, I. *et al*. Dietary fat intake modifies the influence of the FTO rs9939609 polymorphism on adiposity in adolescents: the HELENA cross-sectional study. **Nutrition, Metabolism and Cardiovascular Diseases**, v. 26, n. 10, p. 937-943, 2016. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/27514607/>. Acesso em: 07 nov. 2020.

LAN, Ning; LU, Ying; ZHANG, Yigan; *et al*. FTO – A Common Genetic Basis for Obesity and Cancer. **Frontiers in Genetics**, v. 11, p. 559138, 2020. Disponível em: <https://www.frontiersin.org/articles/10.3389/fgene.2020.559138/full>. Acesso em: 21 nov. 2020.

LEE, Eun Young; YOON, Kun-Ho. Epidemic obesity in children and adolescents: risk factors and prevention. **Frontiers of Medicine**, v. 12, n. 6, p. 658-666, 2018. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/30280308/>. Acesso em: 14 mar. 2021.

LOOS, Ruth J. F.; YEO, Giles S. H. The bigger picture of FTO—the first GWAS-identified obesity gene. **Nature Reviews Endocrinology**, v. 10, n. 1, p. 51–61, 2014. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/24247219/>. Acesso em: 06 set. 2021.

LOOS, Ruth J. F.; YEO, Giles S. H. The genetics of obesity: from discovery to biology. **Nature Reviews genetics**, v. 23, p. 120-133, 2021. Disponível em: < https://www.nature.com/articles/s41576-021-00414-z/>. Acesso em: 12 dez. 2021.

LOOS, Ruth J. F.; BOUCHARD, Chris. FTO: the first gene contributing to common forms of human obesity. **Obesity Reviews**, v. 9, n. 3, p. 246–250, 2008. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/18373508/>. Acesso em: 29 nov. 2020.

MAHMOUD, Ranim; KIMONIS, Virginia; BUTLER, Merlin. Genetics of Obesity in Humans: a clinical review. **Internacional Journal of Molecular Sciences**, v. 23, n.19, p. 11005, 2022. Disponível em: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9569701/>. Acesso em: 05 jan. 2022.

MALAGRIS, Lúcia Emmanoel Novaes; FIORITO, Aurineide Canuto Cabraíba. Avaliação do nível de stress de técnicos da área de saúde. **Estudos de Psicologia,** v. 23, p. 391-398, 2006. Disponível em: <https://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-166X2006000400007>. Acesso em: 04 abr. 2021.

MALIK, Fatima; MARWAHA, Raman. Developmental stages of social emotional development in children. 2018. Disponível em: <https://www.ncbi.nlm.nih.gov/books/NBK534819/>. Acesso em: 08 mar 2022.

MCCAFFERY, Jeanne M. *et al*. Obesity susceptibility loci and dietary intake in the Look AHEAD Trial. **The American Journal of Clinical Nutrition**, v. 95, n. 6, p. 1477–1486, 2012. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/22513296/>. Acesso em 18 abr 2022.

MECHANICK, Jeffrey I. *et al.* American Association of Clinical Endocrinologists' position statement on obesity and obesity medicine. **Endocrine Practice**, v. 18, n. 5, p. 642-648, 2012. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/23047927/>. Acesso em: 03 nov. 2020.

MEHRDAD, Mahsa; DOAEI, Saeid; GHOLAMALIZADEH, Maryam. Association of *FTO* rs9939609 polymorphism with serum leptin, insulin, adiponectin, and lipid profile in overweight adults. **Adipocyte**, v. 9, n. 1, p. 51–56, 2020. Disponível em: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6999843/> Acesso em: 02 out. 2021.

MEHRDAD, Mahsa; FARDAEI, Majid; FARAROUEI, Mohammad; *et al*. The association between FTO rs9939609 gene polymorphism and anthropometric indices in adults. **Journal of Physiological Anthropology**, v. 39, n. 1, p. 14, 2020. Disponível em: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7218491/>. Acesso em: 24 mar. 2021.

MERKESTEIN, Myrte; LABER, Samantha; MCMURRAY, Fiona. FTO influences adipogenesis by regulating mitotic clonal expansion. **Nature Communications**, v. 6, n. 1, p. 6792, 2015. Disponível em: <https://www.nature.com/articles/ncomms7792>. Acesso em: 07 jun. 2021.

MIRANDA, João Marcelo de Queiroz *et al*. Prevalência de sobrepeso e obesidade infantil em instituições de ensino: públicas vs. privadas. **Revista Brasileira de Medicina do Esporte**, v. 21, p. 104-107, 2015. Disponível em: <https://www.scielo.br/j/rbme/a/kdTfTLyPVmf46GQ78xDjwTD/?format=pdf&lang=pt>. Acesso em: 16 jun. 2021.

MOLERES, Adriana *et al.* Dietary fatty acid distribution modifies obesity risk linked to the rs9939609 polymorphism of the fat mass and obesity-associated gene in a Spanish case–control study of children. **British Journal of Nutrition**, v. 107, n. 4, p. 533-538, 2012. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/21798115/>. Acesso em: 03 fev. 2021.

MONTEIRO, Flávia Paula Magalhães *et al.* Crescimento infantil: análise do conceito. **Texto & Contexto Enfermagem**, v. 25, 2016. Disponível em: <https://www.scielo.br/j/tce/a/kV5kB4NrByxgtJ6SB87DKCq/?format=pdf&lang=pt>. Acesso em: 26 abr. 2021.

MOSCA, Paulo; SILVEIRA, Patricia; WERLANG, Isabel; GOLDANI, Marcelo. Obesidade e genética. **Revista HCPA**, v. 32, n. 3, p. 318-331, 2012. Disponível em: < https://lume.ufrgs.br/bitstream/handle/10183/157959/000873639.pdf/>. Acesso em: 28 dez. 2021.

MOUBARAC, Jean-Claude *et al.* Consumption of ultra-processed foods and likely impact on human health. Evidence from Canada. **Public Health Nutrition**, v. 16, n. 12, p. 2240-2248, 2013. Disponível em: <https://www.cambridge.org/core/journals/public-health-nutrition/article/consumption-of-ultraprocessed-foods-and-likely-impact-on-human-health-evidence-from-canada/22FD38DE1BB3B5CD42B843A36D9D8D25>. Acesso em: 28 abr. 2021.

MUTCH, David M.; WAHLI, Walter; WILLIAMSON, Gary. Nutrigenomics and nutrigenetics: the emerging faces of nutrition. **The FASEB Journal**, v. 19, n. 12, p. 1602-1616, 2005. Disponível em: <https://faseb.onlinelibrary.wiley.com/doi/full/10.1096/fj.05-3911rev>. Acesso em: 07 mar. 2022.

NATIONAL HUMAN GENOME RESEARCH INSTITUTE. Nhgri Fy 2012 Congressional Justification, 2012. Disponível em: <https://www.genome.gov/nhgri-fy-2012-congressional-justification>. Acesso em: 25 nov. 2020.

PALOMINO-PÉREZ, Ana María. Rol de la emoción en la conducta alimentaria. **Revista Chilena de Nutrición**, v. 47, n. 2, p. 286-291, 2020. Disponível em: <https://scielo.conicyt.cl/scielo.php?script=sci_arttext&pid=S0717-75182020000200286>. Disponível em: 26 fev. 2021.

PENA, Sérgio Danilo Junho. Medicina genômica personalizada aqui e agora. **Revista Médica de Minas Gerais**, v. 20, n. 3, p. 329-334, 2010. Disponível em: <http://rmmg.org/artigo/detalhes/365>. Acesso em: 26 fev. 2021.

PEREIRA, Jaqueline L. *et al.* Prevalence of consumption and nutritional content of breakfast meal among adolescents from the Brazilian National Dietary Survey. **Jornal de Pediatria**, v. 94, n. 6, p. 630-641, 2018. Disponível em: <https://www.scielo.br/j/jped/a/rKqvTKtDqbsTYkZswZFZxhc/?lang=en>. Acesso em: 03 jul. 2021.

PHILLIPS, Catherine M. *et al*. High dietary saturated fat intake accentuates obesity risk associated with the fat mass and obesity–associated gene in adults. **The Journal of Nutrition**, v. 142, n. 5, p. 824-831, 2012. Disponível em: <https://academic.oup.com/jn/article/142/5/824/4630756?login=false>. Acesso em: 03 nov. 2020.

PINHEIRO, Karina Aragão de Paula Nobre. História dos hábitos alimentares ocidentais. **Universitas: Ciências da Saúde**, v. 3, n. 1, p. 173-190, 2005. Disponível em: <https://www.publicacoesacademicas.uniceub.br/cienciasaude/article/view/553>. Acesso em: 03 nov. 2020.

QI, Qibin *et al.* Fried food consumption, genetic risk, and body mass index: gene-diet interaction analysis in three US cohort studies. **British Medical Journal**, v. 348, 2014. Disponível em: <https://www.bmj.com/content/348/bmj.g1610.short>. Acesso em: 04 mar. 2021.

RADOMINSKI, Rosana Bento. Aspectos epidemiológicos da obesidade infantil. **Revista da Associação Brasileira para o Estudo da Obesidade e da Síndrome Metabólica**, v. 11, n. 49, 2011. Disponível em: <https://abeso.org.br/wp-content/uploads/2019/12/49.pdf>. Acesso em: 11 abr. 2021.

RAMOS-LOPEZ, Omar *et al.* Guide for current nutrigenetic, nutrigenomic, and nutriepigenetic approaches for precision nutrition involving the prevention and management of chronic diseases associated with obesity. **Lifestyle Genomics**, v. 10, n. 1-2, p. 43-62, 2017. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/28689206/>. Acesso em: 13 abr. 2021.

REIS, Caio Eduardo G.; VASCONCELOS, Ivana Aragão L.; BARROS, Juliana Farias de N. Políticas públicas de nutrição para o controle da obesidade infantil. **Revista Paulista de Pediatria**, v. 29, n. 4, p. 625-633, 2011. Disponível em: <https://www.scielo.br/j/rpp/a/8KSy3yMP9DV6ZCc6Z5gmktd/?lang=pt>. Acesso em: 26 fev. 2021.

RINGROSE, Leonie; PARO, Renato. Epigenetic regulation of cellular memory by the Polycomb and Trithorax group proteins. **Annual Reviews in Genetics**, v. 38, p. 413-443, 2004. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/15568982/>. Acesso em: 26 fev. 2021.

RIVAS, Ana Maria Obregón *et al.* Association of the FTO fat mass and obesity–associated gene rs9939609 polymorphism with rewarding value of food and eating behavior in Chilean children. **Nutrition**, v. 54, p. 105-110, 2018. Disponível em: < https://pubmed.ncbi.nlm.nih.gov/29778907/>. Acesso em: 12 maio 2021.

ROBINSON, Thomas N. *et al.* Screen media exposure and obesity in children and adolescents. **Pediatrics**, v. 140, n. Supplement_2, p. S97-S101, 2017. Disponível em: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5769928/pdf/nihms931685.pdf>. Acesso em: 03 fev. 2022.

SAGAR, Rajesh; GUPTA, Tanu. Psychological aspects of obesity in children and adolescents. **The Indian Journal of Pediatrics**, v. 85, n. 7, p. 554-559, 2018. Disponível em: <https://link.springer.com/article/10.1007/s12098-017-2539-2>. Acesso em: 12 maio 2021.

SANHUEZA, Julio; VALENZUELA, Alfonso. Nutrigenómica: revelando los aspectos moleculares de una nutrición personalizada. **Revista Chilena de Nutrición**, v. 39, n. 1, p. 71-85, 2012. Disponível em: <https://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0717-75182012000100008&lang=pt>. Acesso em: 02 abr. 2022.

SCAGLIONI, Silvia *et al.* Factors influencing children's eating behaviours. **Nutrients**, v. 10, n. 6, p. 706, 2018. Disponível em: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6024598/>. Acesso em: 01 jun. 2021.

SCHMIDT, Leucinéia; SODER, Taís Fátima; BENETTI, Fábia. Nutrigenômica como ferramenta preventiva de doenças crônicas não transmissíveis. **Arquivos de Ciências da Saúde da UNIPAR**, v. 23, n. 2, 2019. Disponível em: <https://pesquisa.bvsalud.org/portal/resource/pt/biblio-996722>. Acesso em: 27 out. 2020.

SCHUCH, Ilaine *et al*. Excess weight in preschoolers: prevalence and associated factors. **Jornal de Pediatria**, v. 89, p. 179-188, 2013. Disponível em: <https://www.scielo.br/j/jped/a/QLbK9XVbXNCnMP3bDhcYFBd/?format=pdf&lang=en>. Acesso em: 16 jun. 2021.

SCUTERI, Angelo; SANNA, Serena; CHEN, Wei-Min; *et al.* Genome-Wide Association Scan Shows Genetic Variants in the FTO Gene Are Associated with Obesity-Related Traits. **PLoS Genetics**, v. 3, n. 7, p. e115, 2007. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/17658951/>. Acesso em: 05 mar. 2021.

SOCIEDADE BRASILEIRA DE PEDIATRIA. Manual de orientação para a alimentação do lactente, do pré-escolar, do escolar, do adolescente e na escola. Departamento de Nutrologia, 3ª. ed. Rio de Janeiro, RJ: SBP, 2012. 148 p. Disponível em: <https://www.sbp.com.br/fileadmin/user_upload/pdfs/14617a-PDManualNutrologia-Alimentacao.pdf>. Acesso em: 12 mar. 2021.

SONESTEDT, Emily *et al.* Fat and carbohydrate intake modify the association between genetic variation in the FTO genotype and obesity. **The American Journal of Clinical Nutrition**, v. 90, n. 5, p. 1418-1425, 2009. Disponível em: <https://academic.oup.com/ajcn/article/90/5/1418/4598172?login=true>. Acesso em: 03 nov. 2020.

SOUSA, Suzy Ferreira de *et al.* Frequency of meals consumed by brazilian adolescents and associated habits: systematic review. **Revista Paulista de Pediatria**, v. 38, 2020. Disponível em: <https://www.scielo.br/j/rpp/a/pnKjbcKZSkDFX8mkxthnNqF/?lang=en#>. Acesso em: 09 fev. 2021.

THE LANCET DIABETES & ENDOCRINOLOGY. Childhood obesity: a growing pandemic. **The Lancet Diabetes & Endocrinology**, v. 10, issue 1, p. 1, 2022. Disponível em: <https://www.thelancet.com/journals/landia/article/PIIS2213-8587(21)00314-4/fulltext#articleInformation>. Acesso em: 05 abr. 2022.

TRANDAFIR, L.M; TEAMNEANU, O.R. Pre and post-natal risk and determination of factors for child obesity. **Journal of Medicine and Life**, v. 9, n.4, p. 386-391, 2016. Disponível em: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5141399/>. Acesso em: 20 fev. 2022.

VAILATI-RIBONI, Mario; PALOMBO, Valentino; LOOR, Juan J. What are omics sciences? In: **Periparturient Diseases of Dairy Cows**. Springer, Cham, 2017. p. 1-7. Disponível em: <https://link.springer.com/chapter/10.1007%2F978-3-319-43033-1_1>. Acesso em: 26 jan. 2022.

WANDERLEY, Emanuela Nogueira; FERREIRA, Vanessa Alves. Obesidade: uma perspectiva plural. **Ciência & Saúde Coletiva**, v. 15, p. 185-194, 2010. Disponível em: <https://www.scielo.br/j/csc/a/cxTRrw3b5DJcFTcbp6YhCry/?lang=pt>. Acesso em: 12 abr. 2021.

WANG, Dong; WU, Zhihong; ZHOU, Jun; *et al*. Rs9939609 polymorphism of the fat mass and obesity-associated (FTO) gene and metabolic syndrome susceptibility in the Chinese population: a meta-analysis. **Endocrine**, v. 69, n. 2, p. 278–285, 2020. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/32303904/>. Acesso em: 26 fev. 2021.

WILLIAMS, Christine; MACKENZIE, Kusaynyonon; GAHAGAN, Sheila. The effect of maternal obesity on the offspring. **Clinical Obstetrics and Gynecology,** v. 57. N. 3, p. 508-515, 2014. Disponível em: < https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4862374/>. Acesso em: 27 jan. 2022.

WORLD HEALTH ORGANIZATION. Obesity: preventing and managing the global epidemic. 2000. Disponível em: <https://apps.who.int/iris/handle/10665/42330>. Acesso em: 29 out. 2020.

WORLD HEALTH ORGANIZATION. WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development. World Health Organization, 2006. Disponível em: <https://www.who.int/publications/i/item/924154693X>. Acesso em: 10 abr. 2021.

WORLD OBESITY FEDERATION. Obesity: missing the 2025 global targets. Trends, Costs and Country Reports – Londres: World Obesity Federation, 2020. Disponível em: <https://data.worldobesity.org/publications/WOF-Missing-the-2025-Global-Targets-Report-FINAL-WEB.pdf>. Acesso em: 07 nov. 2020.

WU, Ruifan; LIU, Youhua; YAO, Yongxi; *et al*. FTO regulates adipogenesis by controlling cell cycle progression via m6A-YTHDF2 dependent mechanism. **Biochimica et Biophysica Acta (BBA) - Molecular and Cell Biology of Lipids**, v. 1863, n. 10, p. 1323–1330, 2018. Disponível em: <https://www.researchgate.net/publication/327007474_FTO_regulates_adipogenesis_by_controlling_cell_cycle_progression_via_m6A-YTHDF2_dependent_mechanism>. Aceso em: 03 nov. 2020.

XAVIER, JLP *et al.* Programação Metabólica: Causas e Consequências. **Visão Acadêmica**, v. 16, n. 4, p. 33-41, 2015. Disponível em: <https://revistas.ufpr.br/academica/article/view/44138/27966 >. Acesso em: 02 set. 2021.

XIA, Longzheng *et al.* Role of the NFκB-signaling pathway in cancer. **OncoTargets and Therapy**, v. 11, p. 2063, 2018. Disponível em: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5905465/> Acesso em: 12 maio 2021.

YANG, Jian; LOOS, Ruth J. F.; POWELL, Joseph E. FTO genotype is associated with phenotypic variability of body mass index**. Nature**, v. 490, n. 7419, p. 267–272, 2012. Disponível em: <https://www.nature.com/articles/nature11401#citeas>. Acesso em: 24 fev. 2021

YANG, Qingyun; XIAO, Tiancun; GUO, Jiao; *et al*. Complex Relationship between Obesity and the Fat Mass and Obesity Locus. **International Journal of Biological Sciences**, v. 13, n. 5, p. 615–629, 2017. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/28539834/>. Acesso em: 26 fev. 2021.

YEO, Giles S.H. The role of the FTO (Fat Mass and Obesity Related) locus in regulating body size and composition. **Molecular and Cellular Endocrinology**, v. 397, n. 1–2, p. 34–41, 2014. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/25224490/>. Acesso em: 19 mar. 2021.

ZHANG, Meizi; ZHANG, Ying; MA, Jun; *et al*. The Demethylase Activity of FTO (Fat Mass and Obesity Associated Protein) Is Required for Preadipocyte Differentiation. **PloS One**, v. 10, n. 7, p. e0133788, 2015. Disponível em: <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0133788>. Acesso em: 25 mar. 2021.

ZHAO, Xu; YANG, Ying; SUN, Bao-Fa; *et al*. FTO and Obesity: Mechanisms of Association. **Current Diabetes Reports**, v. 14, n. 5, p. 486, 2014. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/24627050/>. Acesso em: 07 jun. 2021.

ZHAO, Xu; YANG, Ying; SUN, Bao-Fa; *et al*. FTO-dependent demethylation of N6-methyladenosine regulates mRNA splicing and is required for adipogenesis. **Cell Research**, v. 24, n. 12, p. 1403–1419, 2014. Disponível em: <https://www.nature.com/articles/cr2014151>. Acesso em: 18 set. 2021.

ZHAO, Yueshui *et al*. The beneficial effects of quercetin, curcumin, and resveratrol in obesity. **Oxidative Medicine and Cellular Longevity**, v. 2017, 2017. Disponível em: <https://www.hindawi.com/journals/omcl/2017/1459497/>. Acesso em: 03 fev. 2022.