AGRICULTURAL UNIVERSITY OF ATHENS
DEPARMENT OF FOOD SCIENCE & HUMAN NUTRITION
LABORATORY OF CHEMISTRY & FOOD ANALYSIS

PROGRAMME OF POSTGRADUATE STUDIES
FOOD, NUTRITION & HEALTH

MSc thesis

Average consumption of total sugar and added sugar and their correlation with different anthropocentric assessment criteria in children, adolescents, and adults

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ATHENS 2022

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Abstract

In general lines, the accumulation of fat in the body can be characterized as obesity.Obesity is very common and in some cases has taken the form of an epidemic. A form of obesity is the child obesity which can be found both in developed and developing countries. Obesity, especially, the last 30 years has been increased considerably, and it constitutes a high priority for the World Health Organization. There is a consensus among experts of the field that the reason obesity can be described as an energy imbalance between the calories that are consumed and the calories that are expended, respectively.

However, the recent trends regarding obesity research have clearly shown that obesity is connected to a number of biological and environmental factors as well as lifestyle. More particularly, increased sugar consumption is linked with a number of side-effects such as excessive gain weight, obesity, metabolic syndrome, type 2 diabetes, hypertension and other cardiovascular disorders with a greater emphasis in children.

In the current thesis, there is an analysis about the prevalence in obesity across various countries – including Greece – and population, its pathogenesis, management, and treatment. Moreover, it is shed light on the effect of foods with natural as well as added sugars on overall health and its association with children obesity.

Scientific area: Obesity

Keywords : obesity, children, sugar, added sugar, epidemiology, diseases, children obesity

Μέση κατανάλωση συνολικών σακχάρων και προστιθέμενης ζάχαρης και η συσχέτιση τους με διαφορετικά ανθρωπομετρικά κριτήρια αξιολόγησης σε παιδιά, εφήβους και ενήλικες

ΠΜΣ Τρόφιμα, Διατροφή & Υγεία
Τμήμα Επιστήμης Τροφίμων & Διατροφής του Ανθρώπου
Εργαστήριο Χημείας & Ανάλυσης Τροφίμων

Περίληψη

Σε γενικές γραμμές, η συσσώρευση λίπους στο σώμα μπορεί να χαρακτηριστεί ως παχυσαρκία. Η παχυσαρκία είναι πολύ συχνή και σε ορισμένες περιπτώσεις έχει πάρει τη μορφή επιδημίας. Μια μορφή παχυσαρκίας είναι η παιδική παχυσαρκία η οποία συναντάται τόσο στις αναπτυγμένες όσο και στις αναπτυσσόμενες χώρες. Η παχυσαρκία, ειδικά, τα τελευταία 30 χρόνια έχει αυξηθεί σημαντικά και αποτελεί υψηλή προτεραιότητα για τον Παγκόσμιο Οργανισμό Υγείας. Υπάρχει ομοφωνία μεταξύ των ειδικών του χώρου ότι ο λόγος της παχυσαρκίας μπορεί να περιγραφεί ως μια ενεργειακή ανισορροπία μεταξύ των θερμίδων που καταναλώνονται και των θερμίδων που καταναλώνονται, αντίστοιχα.

Ωστόσο, οι πρόσφατες τάσεις όσον αφορά την έρευνα για την παχυσαρκία έχουν δείξει σαφώς ότι η παχυσαρκία συνδέεται με διάφορους βιολογικούς και περιβαλλοντικούς παράγοντες καθώς και με τον τρόπο ζωής. Πιο συγκεκριμένα, η αυξημένη κατανάλωση ζάχαρης συνδέεται με μια σειρά από παρενέργειες όπως η υπερβολική αύξηση του βάρους, η παχυσαρκία, το μεταβολικό σύνδρομο, ο διαβήτης τύπου 2, η υπέρταση και άλλες καρδιαγγειακές διαταραχές με μεγαλύτερη έμφαση στα παιδιά.

Στην παρούσα διπλωματική εργασία γίνεται ανάλυση σχετικά με τον επιπολασμό της παχυσαρκίας σε διάφορες χώρες - μεταξύ των οποίων και η Ελλάδα - και πληθυσμούς, την παθογένεια, τη διαχείριση και τη θεραπεία της. Επιπλέον, ρίχνεται φως στην επίδραση των τροφίμων με φυσικά αλλά και πρόσθετα σάκχαρα στη συνολική υγεία και στη συσχέτισή τους με την παιδική παχυσαρκία.

Επιστημονικός τομέας: Παχυσαρκία

Λέξεις κλειδιά: παχυσαρκία, παιδιά, ζάχαρη, πρόσθετη ζάχαρη, επιδημιολογία, ασθένειες, παιδική παχυσαρκία

ACKNOWLEDGMENTS

First of all, I would like to express my heartfelt appreciation to my supervisors, Antonis Zampelas and Emmanuella Magriplis, for the invaluable help and support they provided me during the preparation of my diplomatic work.

This endeavor would not have been possible without my parents who have supported me in every way throughout this time.

Finally, I also thank my colleagues for their cooperation during the journey towards my Master's degree.

Thank each and everyone of you.

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Figures/tables

1. Introduction

Obesity can be described as a disease, that is caused, as we said in the introduction of this thesis, by the excessive accumulation of fat in the body. Although, research hasn't concluded which is the ideal percentage of fat in adults to be healthy (Navalpotro et al., 2012). The prevalence of obesity has increased to a great extent in the last 30 years, resulting in body fat indices that today are five times higher in comparison to the past (Bray, 2014). Moreover, it is worth mentioning that obesity can cause even mortality in underweight people (Mbogori et al, 2020). In addition, obesity increases the possibility of early-onset diseases during childhood and can lead to an increased mortality rate. Just to give some examples of such comorbidities are the development of diabetes mellitus Type 2, cardiovascular and kidney diseases, metabolic syndrome, fatty liver disease, obstructive sleep apnea, cholesterol disorders, metabolic syndrome, and mental disorders. The most common mental disorder is depression which can be present throughout adulthood if it is not healed early (Swinburn et al, 2011).

The occurrence of obesity but also its prevalence are associated with many different factors including biological, lifestyle, and environmental ones. As said earlier, childhood obesity negatively affects the physical and mental health of children and has an impact on their later adult life with very serious consequences or in some cases can result in premature death. To go a step further, obesity is recognized as a major threatening factor for Non-Communicable Diseases (NCDs), such as cardiovascular diseases, cancer, and diabetes, accounting for >70% of premature death globally (WHO, 2017). Therefore, it is not a disease that affects simply the physical condition of children but mainly has an impact on their health in so many ways. Childhood obesity is thereby perceived as a scourge for the developed world, which needs to be addressed immediately (Navalpotro et al., 2012); Therefore, it is a high priority for the WHO, as one of the core objectives of the Global Action Plan for the Prevention and Control of Non-Communicable Diseases 2013–2020 (WHO, 2016).

In childhood and adolescence, the percentage of fat differs in so many ways. To be more specific, the fat differs not only amongst boys and girls but also depending on the age and physical maturity of each child and this difference turns almost impossible for scientists to set clear limits to define the ideal percentage of fat. Factors that affect not only the body weight but also the distribution of fat in the human body should be sought in a mix of environmental influences and

genetic factors, and even in cultures with similar lifestyles, body weight, and fat percentages can be varied, as well (Poskitt & Edmunds, 2008).

An important part of the study of obesity and its treatment includes the determination of the amount and distribution of adipose tissue. Next to that, the distribution of body fat is also crucial and can act as an indication of the subsequent risks of obesity. Indeed, intra-abdominal fat, which is more common in men, is more detrimental to health in comparison to the fat that is accumulated in the glutes, which is more common in women. Therefore, determining the distribution of fat is an indication of further health effects for both adults and children (Poskitt& Edmunds, 2008). Relating to our study, the WHO provides a definition of obesity and overweight amongst children aged 5-19 as follows: for someone to be overweight, the BMI-for-age must appear one standard deviation above the WHO Growth Reference Median and for obesity, it needs to be greater than 2 standard deviations (WHO, 2021).

Existing guidelines on combating obesity are related to an energy imbalance between consumed and expended calories. Nevertheless, approaches targeted at weight loss– decreasing energy consumption and increasing expenditure in most cases fail (see Blüher, 2019). Instead of targeting only the responsibility of the individual, it is more feasible for the obesogenic (and preventative) behaviors to occur as a result of environmental, societal, as well as biological factors acting in tandem (e.g., Franco et al., 2013; Flores-Dorantes et al., 2020; Loos & Yeo, 2022)

The disproportionate consumption of sugar on health and disease constitutes a very active area not only of scientific but also of policy debate. The influence of WHO guidelines is apparent and therefore a great number of countries are implementing regulations or are taking public health policy measures that are based on reducing sugar intake in their population, especially in children. These concerns are justified by current research which has concluded that excessive consumption of sugar can have an impact on dental caries, overweight and cardio-metabolic risk factors, and mortality. For instance, Moynihan (2016) highlights that even decreasing sugar intake greatly reduces but again does not eliminate dental caries. Another recent report has shown that individuals with dental caries display a much higher mortality rate (Liu et al., 2022).

What is more, numerous studies showed that many causes can lead to obesity, and among them are genetic, epigenetic, and environmental factors. For instance, scientists concluded that some people struggle with food cravings which are regulated in the individual's brain. Moreover,

gut microbiota can play a huge role in controlling someone's appetite. Finally, all the above factors are regulated by an organ in the brain known as the hypothalamus with the secretion of hormones. Thus, if there is an impairment in that very important organ then it can cause multiple disorders and one of those disorders can be obesity (Singer-Englar et al, 2019).

Additionally, genetic factors play a huge role in metabolism regulation. Recent epigenetic studies showed that specific genes in the human genome can regulate and determine the body's metabolism. This can also be explained by taking into account the family's clinical history to determine the obesity risk (Dubern, 2019).

There can be used various methods that give trustworthy results to measure the percentage of fat in the body and its distribution. For this particular reason, several factors are taken into account at least in adults. Some of these factors are the following: height, weight, BMI, age, and sex of an individual (Comizio et al., 1998); the definition for children has already been cited above. There are different measurements used in studies for calculating obesity. However, those measurements are very accurate and cannot be widely used in comparison to measurements based on anthropometry which is more economical and easier to use (Burniat et al., 2006).

In the next section, the discussion is going to revolve around the prevalence of obesity including childhood obesity, across different countries, its pathogenesis, management, and treatment. In addition, the discussion will refer to the impact of foods with added and natural sugars on health along with its potential consequences .

2. Pathogenesis of obesity

At its core, obesity is the result of an imbalance between excessive consumption and little expenditure of calories (e.g., Camacho & Ruppel, 2017). From an evolutionary perspective, it is plausible that early genotypes which favored overconsumption and little energy expenditure could tolerate higher bouts of famine or under nutrition, leading to a higher likelihood of reproductive success. Such overeating can have detrimental effects, and more particularly there are several people today that are dying because of overweight and obesity (WHO, 2016).

Although not yet fully elucidated, biomedical science has made substantial leaps in the etiology of obesity. For instance, neurobiological approaches (e.g., animal studies) have identified

key brain regions regulating body weight, such as the hypothalamus whereby damage to it – amongst others – results in abnormal food-seeking behavior and obesity (e.g., Anand &Brobeck, 1951; Farooqi, 2014; Park et al., 2020; Raji et al., 2009). In addition, a seminal finding from murine investigations showed that a mutation in the *ob*gene (encoding for the hormone leptin) resulted in severe obesity in *ob/ob*mice (Coleman & Hummel, 1969; Zhang et al., 1994). Moreover, it is now understood that gaining abnormal weight from obesogenic diets also largely depends on unique genotypes which are more accommodating to such overeating behaviors (Li et al., 2020).

Not surprisingly, observations from twin studies have indicated that obesity can also be the result of an inherited disorder, while the heritability rates of BMI are estimated at 40-70% (Borjeson, 1976; Herrera & Lindgren, 2010; Stunkard et al., 1990). Although these rates do pinpoint an evident environmental contribution, it is probably best to view obesity as a condition driven by both genetic and environmental factors acting in synergy. Nevertheless, it is now generally understood that most – if not all causes – of obesity, whether they are monogenetic, polygenic, or environmental, converge on key brain pathways regulating body weight (Table 1; see Loos & Yeo, 2022). However, monogenetic causes of obesity are usually rare and difficult to detect, further corroborating the search for multidisciplinary interventions (Bluher, 2019). Understanding these biological pathways can promote the design of behavioral, environmental (e.g., exercising), and pharmacological interventions aimed at modulating pathways to suppress obesogenic mechanisms.

According to a recent article Obesity in Children by Steven M. Scharz, professor of pediatrics at Children's hospital in Downstate of New York has also shown that the dysfunction of the ghrelin and leptin hormonal pathway may be a factor affecting 10% of obese individuals and particularly those with familial obesity. Multiple reports have shown that in these families, replacement therapy for leptin deficiency leads to weight loss.

However, despite the claims that genetic predisposition and hormonal disorders play a role, they do not explain the excessive weight gain. Although most obese and overweight children have a form of family obesity with 1 or 2 obese parents, weight gain is also influenced by genetics as well as environmental factors.

Table 1

*Overview of genes implicated in the pathogenesis of obesity (*adapted from Loos & Yeo, 2022).

Gene	Species	Expression	Role	Reference
ADCY3	Human	Cell cilia	Influence energy balance in neurons	Siljee et al. (2018)
AGRP	-	Hypothalamus	Increases food intake	Cowley et al. (1999)
BDNF	Humans	Brain	Synaptic plasticity	Kernie et al. (2000)
LEP	Humans/mice	Fat	Regulates neuroendocrine system during starvation	Ahima et al. (1996)
MC4R	Humans/pigs/ cavefish	CNS	Mediates appetitive behavior	Cowley et al. (1999); Greenfield et al. (2009)
MRAP2	Humans	Mostly brain	Trafficking of *MC4R* to cell surface	Asai et al. (2013)
POMC	Humans/dogs	Hypothalamus, pituitary, adrenal glands	Processed into melanocortin peptides that signal to MC4R in brain	Krude et al. (1998); Bertagna (1994)
SH2B1	Humans	Wide expression	Signalling molecule downstream of leptin receptor	Doche et al. (2012)
SIM1	Humans	Hypothalamus, kidneys, fat	Transcription factor important for development of PVN, thus crucial for MC4R expression	Michaud et al (2001)

ADCY3, adenylate cyclase; *AGRP*, agouti-related protein; *BDNF*, brain-derived neurotrophic factor; *LEP*, leptin; *MC4R*, melanocortin 4 receptor; *MRAP2*, melanocortin receptor accessory protein 2; *POMC*, pro-opiomelanocortin; *SH2B1*, SH2B adaptor protein 1; *SIM1*, SIM Bhlh transcription factor 1; PVN, paraventricular nucleus

3. Prevalence of obesity

3.1. Globally

The superiority of weight problems in adults has doubled since 1980. More than one-third of the population around the world is considered to be overweight or obese. Moreover, it was found that the obesity rate has increased in both males and females with older people having a higher prevalence of obesity (Ataey et al., 2020). At a global level, it is estimated that between 1980-2015, children's obesity increased from 3.9 to 7.2% in boys and from 3.7 to 6.4% in girls aged 2–4 years (Di Cesare et al., 2019). Moreover, the prevalence of obesity is also related to socioeconomic status. That means that countries and families with a low income are more vulnerable to becoming obese than those with a high income. In the beginning, obesity was considered an issue that characterizes high-income countries, but recent surveys have shown that the rate and the prevalence of the disease have decreased dramatically (Chen et al, 2019). On the contrary, in low-income countries, the obesity rate is increased especially in urban areas. Particularly, a study which was conducted in China, for more than 22 years, showed an increased prevalence of obesity in both sexes from 2.8% to 13.2% in females and from 1.45% to 15% in males. (Chen et al, 2019).

Furthermore, it was discovered that in the USA obesity prevalence among pediatric patients is above 18% which means that if interventions are not implemented, then today's children are going to be obese as adults. What is more, studies suggest that a child which is overweight during early years has an increased risk of becoming obese in their adulthood. Furthermore, consequences of childhood obesity can include the onset of illnesses like asthma, diabetes Type 2, mobility problems, bone disorders as well as mental disorders due to the stigma (Deal et al, 2020).

The changes that occur in the percentages of overweight and obese children between different countries differ significantly due to their age, gender, place of residence, and their socio-economic level. In this respect, it has been found that at a global level, more than 22 million children, under the age of 5, are overweight while it seems that 1 out of 10 children is overweight. These global average prevalence rates indicate a range of disparate values of overweight and obese children, with the prevalence of overweight being around 10% in Africa and Asia, with over 20% in the United States and Europe. The percentage of children with an above-normal BMI was projected to double by 2010 based on existing data from the 1990s to 2010 (Kosti & Panagiotakos,

2006). Generally speaking, according to recent trends in global BMI values based on body weight and height data from 128.9 million children, adolescents, and adults, it was found that the prevalence of obesity has increased in every country between 1975 – 2016 (Abarca-Gomez et al., 2017).

Even though, the primary focus of this thesis is on children, it is vital to recognize that obesity is a serious problem for adolescent and adult populations; As a matter of fact, obesity prevalence has significantly increased worldwide in children and adolescents from 0.7% to 5.6% in boys and 0.9% to 7.8% in girls covering a period from 1975 to 2016 (Abarca-Gomez et al., 2017). In addition, between almost the same period (1975-2014), the same prevalence has increased from 3.2% to 10.8% in adult men and from 6.4% to 14.9% in adult women; In the year 2014, 0.64% of men and 1.6% of women exhibited morbid obesity (i.e., BMI >40kg/m^2) (NCD-Risc, 2016). Geserick et al. (2018) have shown that most rapid weight gain can occur between 2 and 6 years of age and can lead to serious risk of obesity, as more children who were obese at these specific ages were also obese in adolescence; gauging from the above findings, it is speculated that adult obesity might also stem from this childhood risk.

In the USA, the occurrence of childhood obesity rose from 5% to 13% in boys and from 5% to 9% in girls between 1966 - 1970 and 1988-1991 (Kosti & Panagiotakos, 2006) while for the years 2009 -2010, it was noticed a rapid increase in girls (33.2% overweight & obese) and boys (35.1%) (IOTF, 2004; 2005). In North America, the rates of overweight children aged 6-11 increased from 15% in 1963 to 22% in 1991, while the rates for obese children were 5% and 11% in the same years (Troiano et al., 2000).

It is noteworthy to be underlined that in the United States of America in 1991 only 4 states had a prevalence of obesity of 15-19% while in 2004, 7 states had a prevalence of 15-19%, had 20-24% and 9 had an obesity rate of more than 25%. In the United States during the years 1971-1974 and 1988-1994 in children aged 6-18 years, the prevalence of overweight and obese children had increased by 15.4% during the years 1971 -1974, to 25.6% in the years 1988-1994 without significant differences between boys and girls while it was discovered a larger increase in individuals found in the lower socio-economic strata. It was also observed that the prevalence of overweight and obese children was higher for the ages of 10 -18 years compared to the solar group

6-9 years, which did not appear to be in other countries (Brazil, China, Russia) (Deckelbaum and Williams, 2001).

In the period 1999-2004, the increase in overweight and obese children, targeting the 95th percentile of America's growth curves, increased from 13.8% in 1999-2000 to 16% in 2003-2004 for girls and from 14% to 18.2% for boys in those years (Ogden et al., 2006).

The data of the National Health and Nutrition Examination Survey or also known by the abbreviation NHANES from surveys of children aged 2 to 19 in the United States compared to NHANES data from 1971-1974 (CDC) found them to be obese. The data mentioned above are discouraging if someone looks at the rates of childhood obesity in other countries, which range from 4% to 15% while the rates of overweight children are twice or three times higher than the rates of obese (Ogden et al., 2002).

In Canada, there was a 2003 study of height and weight in children under the age of 18 which found, by taking into account the IOTF criteria, that the prevalence of overweight children was 33% (41% for boys and 25.7% for girls), while the prevalence of obese children was 14.9% (15.9% for boys and 13.9% for girls) (Neovious et al., 2006). Moreover, across Canada, the prevalence of obesity climbed significantly for a period between 2005 and 2017/18, from 22.2% to 27.2% with the prevalence among adults aged 40–69 years exceeding 30% (Lytvyak et al., 2022).

In Mexico, it was found that the prevalence of overweight/obese children aged 6-13 over 30 years, while during the years 1968 - 1978, the percentages of overweight/ obese children were small, in 2000 these percentages were at 5.1% and 7.6% for overweight boys and girls respectively, while the prevalence of obese children was 1.1% for both boys and girls (Malina et al., 2007). Di Bonaventuraet al. (2017) showed that in a sample of 2511 Mexican adults, 38.3% were overweight while 24.4% were obese with increasing BMI linked to the expected risk for cardiovascular and metabolic impairment.

For the year 2010, girls were at 29% and boys at 28.1% (IASO). In Seychelles, the prevalence of overweight children aged 6-12 according to the CDC criteria was twice as high in 7 years, as it increased from 4% to 6% in 1998 to 9.4% in 2004, an increase corresponding to 0.8% per year. This increase in the prevalence of obesity coincided with rapid socio-economic growth, a finding that was also present in other developing countries, such as Brazil.

In Brazil, it was discovered that the prevalence of overweight/obese children, aged 6-18, tripled between 1974 and 1997 as the rate increased from 4.1% to 13.9% for those years (Bovet et al., 2006).

3.1.1 Europe

Over the last few decades, several surveys have taken place in various European countries to estimate the proportion of overweight but also of obese children. The studies concluded that the prevalence of childhood obesity varies from very low levels, in the countries of Central and Eastern Europe to quite high in the southern countries of Europe and particularly in countries that are not classified into the so-called eastern bloc. Childhood obesity in European countries has reached an alarming level, especially in many southern countries of Europe, with ranges from 20% –40% while in countries of the north, these rates range from 10% –20% (Lobstein & Frelut, 2003).

In 2002, one in four children in Europe could be considered overweight or obese. In Europe, the prevalence of childhood obesity stood at 24% in 2002 and has exceeded greatly the expected growth rate based on data from the 1980s, while it is much higher than expected for the year 2010 (IOTF, 2004). The annual change in the prevalence of overweight and obese includes 400,000 children, which is added to the already 14 million overweight children each year, including 3 million children who can be classified as obese (IOTF, 2005).

In Sweden and always following the IOTF criteria, the prevalence of overweight and obese children aged 6-12 years was 16.6% and 3.8% for boys and 19.1% and 3.7% for girls respectively in the year 2000 (Zimmermann et al., 2004), while it amounted to 1.7% for boys and 2.7% for girls (Woringer&Schütz, 2003). In 2001, a survey in one of Sweden's largest cities came to the result that many children aged 6-13 were facing problems with obesity. In particular, 26.3% of girls and 20.2% of boys were overweight and 6.9% of girls and 2.8% of boys were obese (Neovius et al., 2006). In 1990, the rates of overweight and obesity for adult men were 34.5% and 6.6%, while for women 31.2% and 13.1%, respectively (Kuskowska-Wolk&Rossner, 1990); a study by Hemmingsson et al. (2020) showed that between 1995 and 2017, the prevalence of severe obesity increased by 153%, compared to obesity (+86%) and overweight (+23%) in adult (18-74) populations.

In Switzerland, a survey of children aged 5-16 years showed that 14% of girls and 15.5% of boys were overweight in relation to the IOTF criteria. Furthermore, the corresponding rates for obese children were 3% for girls and 2% for boys (Schutz &Woringer, 2002). In Italy, the rates of childhood obesity range from 13% in the central and northern regions to 23% in the southern regions of the country. In the year 2008, there was a sharp increase with the rate for girls reaching 34.7% and for boys at 37.2%.

Finally, another meta-analysis that was conducted in Europe, measured the BMI of children aged between 6 and 9 years old and measured the obesity prevalence using the worldwide guidelines from World Health Organization (WHO). This study was carried out from 2007 to 2017 and involved 11 European countries. It is interesting the fact that the total number of children, which eventually participated in this study was estimated at around 300000. Moreover, the results showed that the prevalence of obesity decreased in Southern Europe compared to Northern and Eastern EU countries where the prevalence was rather high. The same study also observed that the obesity prevalence in the boys' population decreased in countries like Portugal from 40% in 2007 to 28% in 2017. A similar path follows Greece, where obesity in the pediatric population decreased from 30% in 2009 to 22% in 2017. On the other hand, Lithuania was the only EU country, in which there was a high increase in overweight from 24.8% to 28.5%, and obesity from 9% to 12%. Moreover, the above data were identical between boys and girls. To conclude, it was observed that when the EU countries promoted policies to fight obesity, the epidemic of obesity was reduced (Buoncristiano et al., 2021).

3.1.2 Greece

Firstly, a recent meta-analysis took place in Greece regarding the pediatric population who suffers from the problem of obesity. Particularly, the existence of obesity was investigated in children of primary and secondary education schools. The total amount of participants was around 3500 students and their ages varied between 10 and 16 y/o while they were residents of Western Greece. Furthermore, all the necessary demographic characteristics, including socioeconomics, physical activity, and dietary patterns were collected, via the distribution of a questionnaire. The results that came out from this study revealed that 19% of this population was overweight and the other 12% was obese using the criteria that are provided by the Centers for Disease Control (CDC).

Furthermore, when the IOTF criteria (International Obesity Taskforce) were used, the results revealed that 20.9 of them were overweight and 7% were obese. Another finding was that the children were often consuming food during school hours and a large number of sweets when they were at home. To conclude, this meta-analysis demonstrated that the obesity rate in Greece remains pretty high and the risk factors that are related to the disease can be used to develop prevention strategies (Kostopoulou et al., 2021).

Based on another study which again was conducted in Greece, it was found that obesity among children increases the risk of metabolic syndromes and is associated with nutrient deficiencies which could lead to the development of anemia. Therefore, this study aimed to assess the consumption of nutrients compared to the worldwide dietary guidelines among children and adolescents who suffer from the problem of obesity in Greece. Interestingly, the results showed that the consumption of vegetables, fruits, and fish was lower compared to the national recommendations, while the consumption of meat was very high compared to the national recommendations. What is more, it was also shown that children in Greece tend to consume more unhealthy food and beverages that contain high amounts of sugar. Therefore, the study found that the majority of obese children and adolescents follow an unhealthy diet and therefore the key recommendation was to apply measures that not only can prevent but also treat obesity and more importantly change the behavior of these individuals **(**Georgiou et al, 2022**).**

Childhood obesity has increased rapidly in the last decade as recent data have shown; specifically, 1 in 4 Greek children aged 7 to 10 years display issues with obesity and overweight as well. In the past decade, there has been a serious issue of malnutrition, based on current data that came out from new research conducted by the Department of Nutrition and Dietetics of ATEI Thessaloniki and the Hellenic Medical Society for Obesity with the COSI program of the World Health Organization for childhood obesity. This program started after an agreement between the Ministers of Health of Europe and was attended by 15 countries of the European Union and Greece and is going to be repeated every two years.

In this research for Greece, which started in November 2010 until March 2011, 150 schools took part, ie a total of 5,679 students of the second and fourth grades of primary school, aged 7-8 and 9-10, in which their weight, height and waist circumference were measured. At the end of the study, results for elementary school students showed that 23.03% of children could be described

as overweight and 13.65% of them were obese. In boys, the percentage of overweight was 21.85% and of obese at 14.18% while in girls, the percentages were 24, 26%, and 13.09%, respectively. In the second group of fourth graders, the rates of obesity increased, as 28.87% of students were found as overweight while 13.42% were considered obese. Boys had larger percentages, as 29.88% are overweight and 14.04% obese compared to girls where the percentages are 27.96% and 12.87%, respectively. In comparison to the above research, previous studies have discovered a marked increase in the prevalence of childhood obesity compared to current data. At this point, it important to be underlined that the studies that were concerned with the prevalence of childhood obesity in Greece in the past (Mamalakis & Kafatos, 1996; Krassas et al., 2001; Karayannis et al., 2003) included a large sample of children.

Going even deeper, in a study conducted by Krassas et al. (2001), the participants were 2458 children aged 6 to 17 years from Thessaloniki. The results showed clearly that 25.3% of children aged 6-10 years were overweight, while 5.6% were obese and 19% of children aged 11-17 years were discovered as overweight, while 2.6% were found as obese. Still, 19.1% of all girls were overweight while 3.2% were obese. As for the boys, it was found that 25.9% of them were overweight, while 5.1% were obese. Finally, 22.2% of all children were found once more as overweight, while around 4.1% of them were obese.

In the study of Mamalakis and Kafatos (1996), 1046 children aged 6-12 years participated from the Greek island of Crete. The criterion for classifying children as overweight and obese was the 85th and 95th percentiles of growth curves, respectively. The result was similar to the previous studies because 24% of boys were found as overweight and 8.2% were considered obese. As for the girls, the outcomes discovered that 19.2% of them were overweight and 5% could be characterized as obese.

Karagiannis and his colleagues estimated the prevalence of obesity and overweight in a representative sample which included around 4299 children aged 11-16 years from all over Greece. The results were based on self-reported height and weight data. The IOTF BMI limit values showed that 9.1% of girls and 21.7% of boys surveyed were overweight, while 2.5% of boys and 1.2% of girls were overweight. Based on the CDC 2000 BMI limit values, the rates for the overweight are 18.8% for boys and 8.1% for girls, while 5.8% of boys and 1.7% of girls were

obese (Karayiannis et al., 2003). To finish, the research concluded that the BMI of Greek children has been rising at a fast pace.

Farajian et al. (2013) in their research revealed the socio-demographic effects of obesity in Greece. Therefore, they studied 2,315 children aged 10-12 years from all Greek regions. At these ages, the percentage of overweight and obese boys was 29.9% and 12.9%, while for girls it was 29.2% and 10.6%, respectively. The results concluded that the percentage of overweight and obese children was pretty higher compared to the findings of other Greek surveys. Looking at the gender aspect, the results agreed with those of other European countries, and more precisely boys had higher prevalence rates of obesity than girls. Only 3% of children followed the principles of the Mediterranean Diet. Children with a high KIDMED score had a healthier diet because they eat more fruits, vegetables, dairy, fish, bread, and nuts, while at the same time, they had higher levels of physical activity.

It is noteworthy to be said that, they tended to consume red meat more often than the recommendations of the Mediterranean model suggest. The explanation for that was that Greek parents coerce their children to eat more red meat during the week to keep their iron levels at the right level. From 2001 to 2004, it was discovered that the prevalence of overweight and obesity was 53% and 20% in adult men and 31% and 15% in adult women (Panagiotakos et al., 2004). In addition, the same study showed that the prevalence of obesity was even higher as the age factor was increasing especially for men older than 40 and women between 50 and 59; What is more, the prevalence was linked to unfavorable lifestyle choices, low education, and so on. Koukoulis et al. (2010) in their research found that the rates of overweight and obesity were quite high (39.4% & 26.6%, respectively) in individuals aged 18-79 who lived in Thessaly, which constitutes a large region found in Central Greece. A recent study in older Greek adults (i.e., >65yo) also found that there is a connection between osteoporosis in these populations and obesity and reduced muscle mass and strength, phenomena which result in a lower lifetime functionality (Keramidaki et al., 2019).

The Toy-Box research indicated that a variety of family factors could determine the eating habits of preschool children. Specifically, the factors that affect the daily consumption of snacks by children are a) the educational level of their parents and b) how often the parents themselves consume snacks on a daily basis. Regarding the first factor (parent's level of education) the high

educational level of parents or guardians is positively related to the daily consumption of snacks by children. In particular, children whose parents had completed more than 14 years of education were 2.04 times more likely to consume daily snacks. Similarly, the eating habits of parents or guardians, and more precisely the daily consumption of snacks, are also positively associated with the appearance of the same eating behavior by children. This is due to the mimetic behavior that children have towards their parents and also children at this age perceive their parents as a role-model.

Significant differences in children's eating habits were observed in Germany and Belgium. In those countries, children reduced the unhealthy savory and sweet snacks respectively. The implemented intervention seemed to have an impact on increasing the amount of water and reducing the number of other beverages (packaged juices and beverages with added sugar) in the entire sample of children. However, the changes observed in the previous two parameters didn't bring the expected results, especially in reducing significantly the number of children who were obese or overweight in the countries surveyed (Manios et al., 2012).

4. Effects and complications of obesity

The existence of weight issues in childhood is a multifactorial disease, which can cause devastating results. The effects of childhood obesity can be short-lived, but can also occur after adulthood (Ebbeling et al., 2002). The overweight effects do not differ so much between children and adults, while it is crucial to recognize the problem of being overweight as soon as possible and ideally in childhood (Shils & Shike, 2006).

4.1. Short-term effects

These effects occur within the duration of pre-early life and youth. These effects affect systems such as the respiratory, cardiovascular, musculoskeletal, endocrine, gastrointestinal, and neurological, but mainly, the psychological field (Ebbeling et al., 2002; Dietz and Robinson, 2005).

4.2. Long-term effects

Studies have shown that being overweight during adolescence is a very good indicator of adult obesity. Preschool children aged 4-6 have a 50% chance of becoming obese in adulthood, at a rate of 70-80% (WHO, 2000). In the USA, the Bogalusa Heart Study found that this risk increases with a child's BMI, and as he or she grows older, so does the risk of obesity in adulthood. The study found that increased BMI between children of 2-5 years old, is associated with adult obesity (Freedman et al., 2004).

4.3. Childhood obesity and diabetes

Insulin resistance is the key risk for developing type 2 diabetes. The reason for being so important is that over 25% of obese or overweight children may develop insulin resistance (Sinha et al., 2002). In addition, the racial or ethnicity criterion to which the child or adolescent belonged, according to a study by the American Diabetes Organization, seemed to play a role, as there were different rates of juvenile type 2 diabetes in adolescents of different races and nationalities, ranging from 6% for non-Hispanic whites up to 22% for Native Americans. At the same time, regardless of racial groups and nationalities, more than 90% of cases of type 2 diabetes were overweight or obese (Ogden et al., 2007).

Moreover, recent studies showed that the medical consequences in pediatric patients also entail the appearance of type 2 diabetes. Furthermore, the prevalence of diabetes varies depending on how serious is the problem of obesity and on the age of the child. Additionally, individuals who get type 2 diabetes during adolescence showed to have worse glycaemic control and many health complications like hypertension and dyslipidemia (Fitzgerald et al, 2019). However, all health issues related to childhood obesity are fully reversible if they are treated nonetheless some continue to have negative health consequences during their adulthood (Fitzgerald et al, 2019).

4.4. Childhood obesity and cardiovascular diseases

Studies show that obese children have an increased risk of cardiometabolic syndrome which included increased blood pressure, low levels of high-density lipoprotein, and high levels of triglycerides. Furthermore, echocardiographic findings show hypertrophy of the left heart

chamber or ventricle and an increase in left ventricle artery diameter. These can result in the dysfunction of diastolic and systolic blood pressure (Corica et al., 2018).

Furthermore, weight loss could benefit the cardiovascular system by decreasing all the risk factors. Also, studies found that weight loss decreases a lot the risk of CVD mortality by 40% even after 20 years of that weight loss (Li, et al, 2014).

One of the epidemiological studies related to serious risk factors of cardiovascular disease in childhood and overweight is the conducted Bogalusa Heart Study, which was conducted in the USA (Freedman et al., 2004). According to it, it was found that 204 children who died from various causes displayed atherosclerotic lesions in the aorta and coronary arteries. This means that the risk of heart disease started at a much younger age (Must &Strauss, 1999).

Prospective research went a step further by discovering that the levels of serum lipids and lipoproteins in young adults are almost the same as in childhood and thus allow them to observe these levels for later adulthood (Boutelle et al., 2007). Relatedly, Ebbeling et al. (2002) showed that English overweight adolescents had more chances (almost twice as likely) to find death from an ischemic attack after the age of 57.

4.5. Childhood obesity and hormonal disorders

In young girls and adolescents, the problem of obesity along with other weight issues have been related to the early onset of menstruation. There is an inversely proportional relationship between weight and menstrual age, as the heavier the weight, the later the onset of menstruation (Freedman et al., 2003; Daniels et al., 2004). Another side-effect of obesity that developed at a very young age is polycystic ovary syndrome, whose prevalence, like childhood hypertension, seem to increase to a great extent with the rise in obesity rates in children. Sex hormone disorders especially in girls who deal with obesity issues and adolescents could lead to a premature onset syndrome linked directly with hyperandrogenism and conditions such as amenorrhea or irregular menstrual cycles (Dietz &Robinson, 2005).

Weight gain is found to be associated with endocrine disorders in pediatric patients. Particularly, food that contains a significant amount of sugar has also a higher glycaemic index which results in much faster insulin secretion, a hormone that has a known anabolic impact (Liberali et al., 2020). Moreover, a meta-analysis showed that most pediatric patients, who have endocrine disorders, present a tendency to gain weight and have hypogonadism. Finally, endocrine

disorders can lead to weight gain which also can be caused either by the use of endogenous or exogenous corticosteroid treatment (McKelvey et al, 2019).

4.6. Musculoskeletal problems

Studies show that obese children population can have serious musculoskeletal issues, which affect negatively their health and cause impairment to individual's mobility. It has also been shown to cause bone fractures, low back pain as well as joint pain (Lin and Li, 2021).

Musculoskeletal problems are related to being overweight and obese since they cause complications and problems in the muscles, tendons, and bones. The joints absorb more pressure, especially those of the lower extremities because they are responsible for supporting the whole body (Ebbeling et al., 2002).

4.7. Psychosocial effects

Children who suffer from obesity issues have more chances to develop psychological and psychiatric problems than those of normal weight. Girls who are both overweight and obese, have more chances to develop mental problems than boys and this risk increases with age (Cole et al., 2000; Kumar et al, 2016). In developed countries, the psychosocial effects of childhood obesity could affect negatively the social future and social interactions of those children. Aside from the difficulties in the social milieu, obese women who were obese in their childhood or while they were adolescents, had few chances to pursue pursuing higher education after finishing basic school education (Strauss and Pollack, 2003).

5. Management and treatment

5.1. Dietary control

Besides the pharmacological treatment, lifestyle modifications are still strongly recommended for weight loss even in pediatric patients. Specifically, obese patients but also children can reduce up to 10% of their body weight if they follow a diet pattern, which will be supported with physical activity and behavioral therapy. Furthermore, if the diet is controlled, it

can be rather beneficial to the loss of weight (Nguyen and Clements, 2017). Undoubtedly, the final choice of food is determined by the individual, therefore every State needs to implement laws, which limit access to unhealthy food. In that way, access to healthier food would be more difficult. Such policies could also aim to reduce the development of foods that contain sugar and fat. Finally, advertisements should promote and educate citizens about healthier food choices, which can help the loss of body weight and improve the cardiovascular system (Lal et al, 2020).

Obese and overweight children are recommended to follow a diet that can assist them to maintain the appropriate weight in accordance with their age. In extreme cases when children can be classified as third-degree obesity and have developed serious health problems, then a hypocaloric balanced diet can be the solution. However, all dietary interventions suggest several corrections in eating habits and calorie reduction. Diets usually suggest the reduction of fat intake and the increase of fiber intake. Also, when children are in the process of development, their diet must be balanced because it remains important to provide kids with the necessary calories and nutrients for their development. An important intervention used by many experts in the field is the so-called traffic light diet, which was invented by Epstein and his colleagues. It is a diet in which foods are proposed to be divided into three colors: red means "stop", yellow means "continue carefully", while green means "go ahead", depending on their content of fat and simple carbohydrates. Thus, the number of portions that children eat for each light color is calculated and the calories consumed are calculated (Epstein et al., 1998). However, undesirable outcomes of such diets need to be taken into account; for instance, low-calorie diets with high protein content could cause weight loss but can subsequently lead to vitamin deficiencies with tremendous consequences for the health of the child (Zampelas, 2003).

5.2. Physical activity

Moreover, life modifications have been proven to be beneficial for the patient. Particularly, integrating long-term physical activity showed that in many cases the loss of body weight can confine significantly the possibility of cardiovascular diseases (Nguyen and Clements, 2017).

In parallel, researchers suggest long-term systematic exercise programs, so that there are noticeable changes in daily activities (e.g., walking, playing, cycling, taking the stairs, dancing). Lifestyle changes can bring effective improvements, particularly for children are effective for children because usually are more easily applicable in their lives. Within this framework,

interventions should target reducing sedentary activities. Reducing these kinds of sedentary activities like watching the TV or playing computer games, is more desirable in children because children need to invest their time differently for instance to do a sport or another physical activity (Epstein et al., 1994; Wyszyńska et al., 2020). Furthermore, physical activity can reduce excessive body mass in the pediatric population.

Moreover, studies show that less than 20% of children and adolescent worldwide population participates in physical activity. Given this, it is rather obvious that decreased physical activity contributes to obesity among children. Quite recently (2016), it was found that almost 40 million children aged 5 y/o were suffering from obesity. What is more, a meta-analysis in Southern Europe found that around 40% of children aged 10 y/o and 10% in the Northern EU were obese which was caused by not exercising (Wyszyńska et al., 2020).

5.3. Behaviour Modification / Behavioural Theory

Studies underline the key role of parents who can change dramatically their children's behavior and prevent obesity. Such behavioral interventions from parents involve nutrition education and parenting strategies that promote physical activity and provide their children with a balanced diet. Furthermore, a study showed that children have a higher risk of becoming obese if their parents are obese too (Ash et al, 2017). Therefore, the majority of intervention strategies emphasized parents since their habits have a greater impact on their children (Ash et al, 2017).

The purpose of behavioral therapy is to enable obese people to understand how they behave not only when they have to follow a diet but also when they need to exercise. A key aspect in the whole process is the mental ability of those individuals to resist as much as possible to the impulsive consumption of. Behavioral therapy is based on the principle of learning. Since the 1960s, behavior therapy has been a preferable treatment for obesity in the United States. Initially, it included the recording of dietary habits and several techniques for controlling the eating behavior of the individual. Compared to the past, the new programs pay attention to the nutritional training of the overweight as well as to the strengthening of their physical activity. The same programs also include multiple ways of social support and cognitive behavioral techniques designed for obese individuals to maintain the goal of weight loss over a long time. Behavioral therapy offers significant help when there are behavioral disorders.

At this point, there will be a very brief analysis of the most important techniques used to change behavior and applied in obesity treatment protocols which are in grosso modo: mobilization, setting realistic goals, monitoring, reinforcement/reward, stimulus control, problem-solving, alternatives, relapse prevention, angle. Behavioral therapy strategies include the recording of dietary habits (self-monitoring), nutrition education, nutritional behavior control techniques (stimulus control), cognitive therapeutic techniques, and social support for the obese (WHO, 2000).

5.4 Body mass index

Body mass index (BMI) is an indicator of the percentage of fat in the human body and is calculated in kg/m^2. The BMI can find application not only at the individual level but also at the population level. It is pointed out that using only the body mass index to categorize a person about his/her weight is extremely unsafe and requires special attention. Therefore, BMI should not be used as an individual diagnostic method. It is, however, the first indication that provides basic information regarding a person's weight. Given this, it is important to evaluate the information obtained from the BMI with certain other characteristics to draw a safer conclusion. Furthermore, BMI is calculated by dividing someone's weight by their height. It also provides a reasonable indication regarding someone's health (Mbogori et al, 2020).

Moreover, BMI is associated with fat mass and this fat mass is measured via a very specific method in the general population. However, it needs to be stressed here that the BMI can be sometimes unreliable at the individual level. This can be better explained when two individuals with the same BMI can appear a very different fat mass. Therefore, a value that is above or below the standard value may not define their normality; for example, in children, overweight and obesity are calculated by comparing individual BMIs to reference values. Thus, mistakes can occur such as someone can overrate fat mass in a young person while for an older person to underestimate his/her fat mass. Another example that can be seen is the case of an athlete who can maintain a high BMI but low-fat mass and at the same time can be considered obese (Cui et al, 2016).

At the population level, however, BMI is a relatively reliable and extremely low-cost indicator regarding the classification of individuals as underweight, normal, overweight, and obese, respectively. BMI is an indicator for calculating obesity in adults, adolescents, and children. This method considers both height and weight and is suitable for measuring overweight and its

limits, as defined by the International Obesity Task Force (IOFT). BMI is obtained when someone divides the weight of a given person measured in kilograms by the square of his/her height which is also measured in meters: BMI = WEIGHT (kg) / HEIGHT X HEIGHT (m). The BMI of a given person is then compared to the BMI distribution for children aged 2-20, to be finally characterized as underweight, healthy, overweight, or obese.

The use of BMI is a simple and easy process for categorizing risk children – and adults – into various categories such as underweight, normal weight, overweight and obese. Moreover, the same formula applies to both men and women. BMI is an economical method, which can be repeated several times to determine the validity of the result. The disadvantage is that the aforementioned method does not provide data regarding the distribution of fat that exists in the human body. Thus, the values that experts have in their hands by BMI vary considerably in children, as the height of children is constantly changing (Poskitt& Edmunds, 2008).

BMI for children but also adolescents aged 2-20 is measured with the usage of the same mathematical formula used for adults, but the results are interpreted differently. More specifically, children are not classified according to the BMI value per se, but the value of a child's BMI is compared to the BMI values of other children who are found of the same age and sex. Children are then classified into percentiles based on BMI which has been substantially standardized for gender and age (Status, 1995; Longe, 2008); according to the CDC: underweight is considered a kid found in less than the 5th percentile, healthy weight is considered a kid found in the 5th percentile to less than 85th percentile, overweight is a kid who is found in the85th percentile to less than 95th percentile, and finally obese is a kid who equals to or greater than 95th percentile.

In this way, using the various percentages is a possible way to compare the weight of a child with the population of children who have the same sex and age. According to the World Health Organization, the categories in which children are classified are the following: underweight children: BMI <5 cm, normal children: 5 cm ≤ BMI <85 cm, overweight children: 85 cm ≤ BMI <95 cm, obese children: BMI ≥ 95 percent. Classifying children in percentiles based on BMI has been substantially standardized for gender and age to assess whether a child is overweight or obese is not only a reliable, economical, and non-invasive method but also provides an internationally-recognized definition of childhood obesity. This is very important, as it allows the comparison of the results of different studies on childhood obesity (Status, 1995).

The anthropometric assessment of children is a more complex process than that of adults, because changes in body composition (height, weight), which are constantly changing in childhood, must be considered. One of the indicators for evaluating body composition in children is BMI. As said before, this indicator is a rather simple, inexpensive, reliable, and safe indicator, used in epidemiological and clinical research. For its interpretation, care is required for parameters such as age, sex, and race of the population group, so that the categorization of children based on body fat gives reliable and valid results. In essence, BMI constitutes a valuable screening tool, which recognizes potential weight problems in children but is not a diagnostic tool. Thus, if a child has a high BMI for his/her age and gender, additional assessments should be made to determine if body fat is a problem, such as skin thickness measurements, dietary assessments, physical activity, and family history.

For the classification of children into the four categories of underweight, normal, overweight, and obese, reference criteria have been used, such as a) the reference percentages which were based on the NHANES I study and recommended by WHO, b) the CDC growth curves for the USA which are aimed exclusively at American population groups, and c) development charts, which present international BMI limit values for boys and girls aged 2-18. Percentages are the most commonly used indicator for assessing children's development. After calculating the BMI, the values are represented graphically in the growth curves for boys and girls, which acquire a percentage ranking. The percentages indicate the relative position in respect of a child's BMI value among other children of the same sex and age, while growth curves express the categories of body weight (fat, normal, overweight, obese). Growth Curves for ages 0-18 are used to assess the growth rate of infants, children, and adolescents. Growth curves show us if certain growth variables (weight, height, or BMI) of the child move in normal frames. These are graphs that summarize quickly the changes in the weight or height or BMI of a particular population depending on its age and refer to percentages of a specific weight or height for a certain age. Normal values for a certain age are extracted from the growth curves and are based on a specific price range. Each country has its unique growth curves which are following the growth rate of its population.

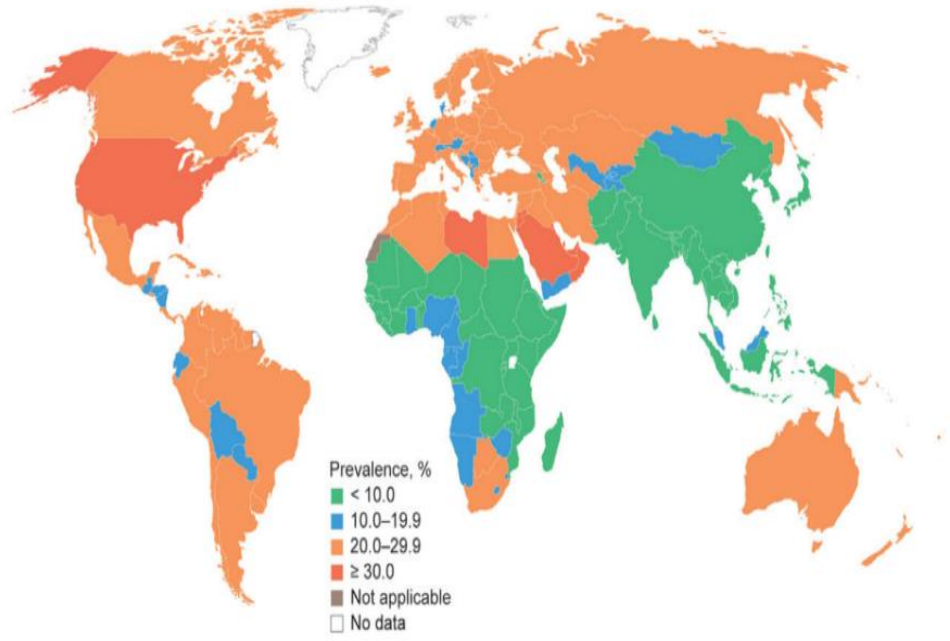
In the development curves of the BMI regarding children and adolescents (2-20 years old), as already outlined, the CDC has added the 85th position as a limiting point for identifying people at risk ("at risk") to become overweight. When a child has a BMI with values between the 85th and 95th percentile should be treated carefully for reaching the secondary complications of obesity,

such as hypertension and dyslipidemia. When we look at children older than 7 years and their BMI is between 85 and 95 given that they do not have secondary complications of obesity then prolonged weight maintenance can be an achievable goal. Nevertheless, weight loss is suggested for children of the above age with a BMI between the ages of 85 and 95, who do not have severe secondary complications of obesity. The same applies to children of the above age group, who display a BMI of 95 percent or more. A child with a bigger BMI (BMI>) from the 95th percentile of the same age and sex is characterized as "obese", while with a BMI bigger (BMI>) from the 85th percentile is characterized as "overweight" (Cole et al., 2007, 2000; Zampelas, 2003; Kuczmarski, 2002; Barlow & Dietz, 1998).

In Greece, height, weight, and BMI growth curves for boys and girls, aged 6-16 years were analyzed by Kafatos et al. (1997). Although the latter research reached an underestimation of the real prevalence of overweight and obesity in children (average age 11.42 ± 3.51 years), in comparison with the international IOTF and CDC BMI limit values for overweight and obese children. Both used standards of IOTF and CDC, which are independent of each other, detected an increased number of children who were overweight and obese. Under any circumstances, the above standards are appropriate for early diagnosis and intervention in clinical medicine (Christoforidis et al., 2011).

WHO as an Organization has defined obesity as the condition in which there is a very high-fat accumulation. This accumulation can cause numerous serious health consequences (WHO, 2016). According to studies, in the year 2015, it was reported that the rate of obesity in the U.S.A. was over 30% (Yang and Colditz, 2015). Moreover, a meta-analysis showed that people in the USA started gaining weight when they were found at a very young age. Finally, children with obesity demonstrate around 50% greater risk of being obese when they will be adults in comparison to 10% of children who had normal weight (Yang and Colditz, 2015).

Figure 1



Summary regarding the prevalence of the phenomenon of obesity in Europe during the period 1991-2003

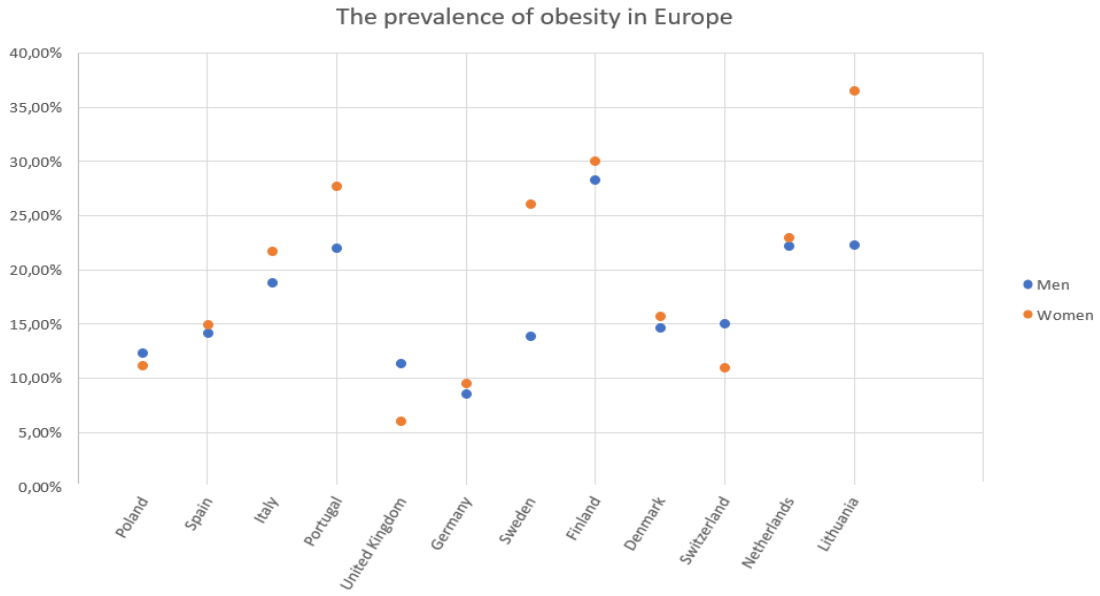


Figure 2

*U.S. obesity prevalence(2015.)**Source**. Figure adapted from Centers for Disease Control and Prevention (CDC). Retrieved from https://www.cdc.gov/obesity/data/prevalence-maps.html.*

6. Food and health

6.1. Nutrition

During the last few years there is a rush for a low-fat diet has resulted in the shelves being filled with products "unloaded" from fats but loaded with sugar. Each of us ends up consuming unbelievable amounts of "hidden" sweeteners, as a result of which the consumer becomes addicted to these flavors. It is impossible to taste a product when it is deprived of some of its basic substances such as fats. But it is possible to flavor a product by adding sugar and artificial sweeteners. The more the consumers look for sweetened foods, the more the food industry adds sugar to processed products and the problem swells. Many children are growing up creating facing a massive problem of obesity thus possibly increasing the rates of diabetes and heart disease.

Sugar is the best-known representative of oligosaccharides. It is contained in sugar cane, sugar beets, and fruits. When isolated from its sources and consumed in the form offered by modern industrial production, it does not give the body a trace of minerals (potassium, calcium, sodium, iron, magnesium, phosphorus) and vitamins, unlike unprocessed sugar, such as is brown or brown sugar, which contains traces of them. Sugar mainly provides the body with energy (calories). 1 teaspoon of sugar contains 25 calories. Consistent with the American Heart Association, there is advice for children aged between 2-18 years, to eat less than 25 grams, or approximately 6 teaspoons of added sugar each day. All the previous recommendations are grounded on the examination of the effects that added sugars cause on children's health and more precisely on cardiovascular function, blood pressure, diabetes, obesity, and NAFLD (non-alcoholic-fatty liver disease). Undoubtedly, people's preference for sweet taste has encouraged industries to design and produce a wide range of sweeteners, such as xylitol, mannitol, sorbitol, cyclamate, saccharin, and aspartame. These sweeteners have replaced sugar in a wide range of products, giving them a sweet taste, while providing 0-4 calories per gram to the body.

According to research, extremely tasty foods, which include huge quantities of fat, sugar, and salt, encourage the mind to secrete dopamine. Dopamine has a direct connection with the pleasure middle, and the feelings of well-being, and for that reason, tasty foods become almost "irresistible". There is a tendency to turn to sugar substitutes, to satisfy the desire for a sweet taste. In consequence, artificial sweeteners are used and they bring about an increase in an individual's,

weight. Although they add a sweet taste without many calories and are found in many light products and assist the gain weight.

There are such sweet substances, causing more cravings for the foods that contain them, but also for various other sweets, in the effort of one to appease this strong desire for sugar. Although they do not contain many calories, in this case, more insulin is produced and affects bodily systems (e.g., the brain; Avena et al., 2008). Foods contain in addition to the known sugar and hidden sugar (Blum et al, 2014). There is no way to hide the truth: the modern individual is eating more and more sugar now. Today, many people prefer low-fat foods and because it is common to consume a lot of products without or with little fat, we do not know that in many of these products, sugar is a substitute for fat and, in fact, "we exchange fat for sugar".

Mainly processed foods contain hidden sugar, depending on the amount contained in the food, in descending order. This means that the ingredient contained in the largest quantity (has the highest weight) is listed first and the one with the lowest weight is listed last. Sugar may be referred to by another name, while the product may contain another sweetener (fructose, glucose, sucrose, fructose, glucose, sucrose). Some of the foods that contain hidden sugar are 1. Cooking tomato juice, 2. Ketchup with 4 gr. sugar, 3. Two tablespoons of barbecue sauce contain 10 g. sugar, 4. Almost all canned foods, 5. Many of the pre-cooked foods,6. Low-fat yogurts with fruit flavor (found to contain up to 7 teaspoons of sugar in a cup of standard yogurt), 7. Soft drinks such as cola, lemonade, orange juice, and liqueur, 8. Processed cereals, 9. Yogurt desserts, 10. It is used as a preservative in compotes, juices, 11. Frozen foods, 12. The syrup, 13. The concentrated fruit juice, 14. Some medicines (Linet et al., 2018).

Moreover, obesity can be prompted by the increased consumption of high-energy food and beverages which is a very common phenomenon, especially among children. As usual, factors such as social and economic state that are related to food supply can destroy a balanced diet (Yoo et al., 2018). Also, genetic factors that are associated with the susceptibility to fat accumulation, seem to increase the risk of getting obese, even if the diet is controlled. In addition to this, advertisements tend to promote not only foods, but also drinks that include a high amount of sugar and fats, and they tend to impact negatively the human body and mind function.

What is more, for clinical physicians, it is important to know which factors affect their patient's health, metabolism, and energy regulation. All these are needed for the effective management of obesity, especially in early age onset. Having all these data available in addition

to the patient's clinical history, a physician can give the appropriate diet advice to their patient (Obri et al., 2019).

Additionally, another factor that was studied and seems to contribute to the phenomenon of childhood obesity is snacks (chips, candies, and baked foods), which are preferred by children. Furthermore, studies suggest that this type of food contributes to childhood obesity as it tends to increase the total intake of energy. The same studies also found that portion size contributes significantly to childhood obesity. In particular, the combination of high-calorie food and a huge portion of it can drastically increase weight gain (Sahoo et al, 2015).

6.2. Sweeteners in the diet

Sweeteners can take various forms (aspartame, potassium acesulfame K, cyclamic acid, and sucralose), and they can be found in a large number of foods and beverages since they replace sugar and provide few or no calories. Depending on the type of product and the desired sweetness, taste and other organoleptic ingredients (such as texture and sense of "volume"), different sweeteners or combinations of them can be traced. Just to provide some indicative examples, in products such as soft drinks, aspartame, cyclamic acid, and acesulfame-K are traditionally used, while in ice creams, biscuits, baked goods, and products in which sugar traditionally offers volume along with sweet taste, polyols (mannitol, sorbitol, xylitol). Given that, the exact amount of sweetener used in each product is not listed for commercial reasons while it is rather impossible to measure the total amount of sweetener consumed daily from different sources.

In this respect, European legislation has considered quantities and frequency of consumption of products with specific sweeteners, even by vulnerable groups of the population (children and pregnant women) or populations with high consumption of such products (diabetics). The labeling of sweeteners in the products that contain them is mandatory by law, to ensure adequate information on behalf of consumers. Also, products containing aspartame should state clearly that they are a "source of phenylalanine", because people with inherited disease phenylketonuria cannot metabolize it, while those containing polyols should state clearly that "excessive consumption may have a laxative effect".

The European Food Safety Authority (EFSA) is the body responsible for assessing food safety and advising the European Commission on all matters of food safety and consumer health. At regular intervals, EFSA re-evaluates the safety of additives (Świąder et al., 2019). In this way,

European citizens can feel somehow protects and can be aware of the products that they consume, after all.

6.3. Nutrient sweeteners

6.3.1. Sugars

In this category belong monosaccharides and disaccharides, which offer 4 calories/gram. More specifically, the following sugars are contained: glucose, fructose, galactose, sucrose, maltose, corn syrup, and agave nectar (derived from agave, a cactus plant) (Fitch and Keim, 2012).

6.3.2. Polyols

Polyols offer an average of 2 calories/gram, however, the energy they provide varies due to differences in digestion and absorption. In nature, there are many polyols, but there is also the possibility to be produced bymonosaccharides or polysaccharides. To this category belong the polyols derived from monosaccharides: sorbitol, mannitol, xylitol, erythritol, D-tagarose. Polyols derived from disaccharides: isomaltitol, lactitol, maltitol, isomaltulose, trialose. Polyols derived from polysaccharides: starch hydrolysates, maltitol syrup, sorbitol syrup (Fitch & Keim, 2012).

6.3.3. Non-nutritive sweeteners

Non-nutritive sweeteners are also called high-intensity sweeteners and include substances with a sweetness many times stronger than that of sugar (sucrose). These include acesulfame-K, aspartame, saccharin, steviol glycosides (stevia), and sucralose, ingredients that are 150 to 600 times sweeter than sugar, as well as neotame, which has a sweetening ability (7,000 to 13,000 times larger). Their sweetening power depends on their inherent sweetening ability and the amount in which they are used. Their caloric content ranges from zero to 4 calories (kcal) per gram, but in reality, all these sweeteners give practically very few calories because they are added to the products in minimal quantities. Non-nutritive sweeteners can be included in a wide range of products, such as soft drinks, dairy products, confectionery, desserts, and chewing gum. Most are still available in the form of table sweeteners which are put in drinks like tea and coffee or in other foods which are consumed widely such as cereals and fruit. The European Food Safety Authority

(EFSA) is charged with the evaluation of non-nutritive sweeteners while sets also the level of acceptable intake on a daily basis and more broadly examines emerging data on issues affecting their health (Gardner et al., 2012).

Moreover, non-nutritive sweeteners are perceived as healthy substitutes of sugar that can regulate glycaemic index and prevent diseases like type 2 diabetes. They can be an ideal solution for those who want to achieve weight loss by reducing their total calorie intake. However, studies showed that non-nutritive sweeteners can trigger hunger via the ingestion process. In that way, they can indirectly contribute to weight gain. This can be explained as the sugar substitute gets ingested, then it releases hormones that enhance the glucose transport in the intestines thus there is a secretion of insulin. Therefore, glucose concentration is reduced in the bloodstream and the feeling of hunger can be activated. So the individual can gain weight (Fernstrom, 2015).

According to the official position of the American Academy of Nutrition and Dietetics concerning non-nutritive sweeteners (Fitch & Keim, 2012), the most commonly used substances are Acesulfame-K which is a substance that combines organic acid and potassium. It is discharged almost intact (95%) in the urine. In that way, it does not give any energy and does not affect the potassium balance, while it is stable at baking temperatures.

Aspartame constitutes a methyl ester of the dipeptide of aspartic acid and phenylalanine. Aspartame gives 4 calories/gram, while the amount of sweetness it offers, allows the usage of a minimal amount to achieve the desired levels of sweetness. Aspartame is hydrolysed to aspartic acid, methanol, and phenylalanine. However, because aspartame is hydrolysed to phenylalanine in the gut, its use should be avoided in some cases, such as in people with phenylketonuria. All aspartame product packages must bear the warning that "it contains a source of phenylalanine". In dry conditions, aspartame remains stable but in solutions, it can degrade with the necessary heating. The pace of degradation depends on pH and temperature.

Cyclamic acid and its salts, sodium, and calcium, are powerful sweeteners (WHO, 2010). The use of cyclamic acid is acceptable in Europe, but not in the US, as one study showed that the saccharin / cyclamic acid mixture was associated with the development of tumors in rats.

Saccharin is the oldest sweetener accepted for use in food and beverages. However, it is not metabolized in the body. It is widely used, often in combination with other sweeteners.

Steviol glycosides are derived from the plant Stevia rebaudiana. They have a sweet taste in the usual amounts; however, they may have a bitter taste in larger ones. They are stable and more

stable than aspartame or acesulfame-K. Steviol glycosides also offer the advantage of being exclusively plant-based. Finally, they could serve as a phenylalanine-free sweetener for people with phenylketonuria.

Sucralose is a disaccharide. About 85% of the sucralose taken up by the body cannot be absorbed and is discarded almost intact in the faeces. The same applies when it is absorbed, it is also discarded unchanged in the urine. Finally, it is heat stable while baking and cooking.

6.4. The price of Acceptable Daily Intake

Under European law, the food and beverage industry is required to use only approved sweeteners. The legislation also determines the products in which each sweetener can be used, as well as the maximum amount of each sweetener per product category. The evaluation of their safety, as for any food additive, is based on the available toxicological data. An essential part of the evaluation process is the determination of an Acceptable Daily Intake (ADI) value for each sweetener, which is the maximum amount of the specific additive that one can take each day and for the rest of his/her life without his/her health to be endangered. The ADI value, which is unique for each supplement, is expressed in mg of the supplement per kilogram of body weight per day (mg/kg/day). It covers the population including groups, such as pregnant women, diabetics, and children, and appears to have a large margin of safety. Consumption studies in European countries discovered that the consumption of sweeteners is much lower than the corresponding ADI values even in populations with the highest consumption. In general lines, sweeteners used in the EU and all food additives, have been evaluated and approved by the global body responsible, namely the Joint Committee on Food of the World Health Organization and the Food and Agriculture Organization (JEFCA WHO / FAO) (Abdel Rahman et al., 2018).

6.5. Health

Sugars, like starch, are carbohydrates. Sugars are found in various forms, such as sucrose, fructose, lactose, and glucose. All forms have a sweet taste. Sucrose is a common table sugar, a product of industrial production from sugar cane and beets, and is used in beverages, baked goods, and the confectionery industry. Fructose is found in fruits and honey, while lactose is found in milk. Glucose is the simplest form of sugar and is a component of other sugars. Table sugar, for

example, is made up of glucose and fructose. Glucose is also the building block of starch. Starch is the main source of carbohydrates found in bread, pasta, potatoes, rice, and cereals. Glucose is the form of sugar that circulates in the blood. It is often referred to as "blood sugar" and supplies the body with energy. Frequent exposure of teeth to sugar in large quantities, and for a long time, increases the risk of tooth decay in children. Typical sugar sources are soft drinks, sweets, candies, and juices. Foods that are rich in added sugar are excessive in calories and low in other nutrients such as protein, vitamins, minerals, and fiber. That is, they contain "empty calories" and replace other more nutritious foods in the daily diet. Also, the sweet taste causes pleasure, and as a result, individuals seek even greater consumption (Wang et al, 2015).

Overconsumption of sugar can lead to overweight and obesity, only if the calories we consume are more than what we "burn". Foods that are rich in sugar and beverages contain a high amount of calories and fat, so we run the risk of exceeding our recommended intake. In particular, people who are in favor of sugary drinks, usually tend to overeat because they cannot control their appetite. Consumption of such drinks contributes to childhood obesity. Many people believe that overeating sugar can lead to diabetes. This is not right. Diabetes is not the result of a single factor but it appears due to a mix of genetic and environmental factors. Nevertheless, if someone is overweight, then he/she is more exposed to type 2 diabetes. People who suffer from any type of diabetes should abstain from sugar because its rapid absorption by the digestive tract can cause a very quick rise in blood sugar. This sharp rise cannot be controlled by people with diabetes. A great number of studies have concluded that people without diabetes who consume many sweets, tend to present a higher value concerning body mass index and waist perimeter.

In a similar vein, people who consume a lot of sugary soft drinks have increased insulin levels, when they have eaten absolutely nothing. When an individual consumes food in the recommended quantities, there is no risk of overconsumption. There is a danger when an individual often consumes in large quantities foods that contain added sugar. Examples of such foods are sweets and pastes, candies, soft drinks, juices (when they are not 100% natural), but also jams, and jellies. Sugar, when consumed in moderation, can be part of a balanced diet. Special attention must be paid to food labels because only in that way the individual will be able to avoid consuming products that contain large amounts of sugar. When the sugars in the food are more than 15% of the total carbohydrates, then the food at hand is rich in sugar. When it is below 5%, then the food at hand contains low sugar. It is also important to control the overall amount of food consumed.

Thus, foods that are rich in sugar, it is good to be consumed in small quantities. Some examples of sugars on food labels are the next ones: glucose, dextrose, fructose, corn or inverted syrup, raw or brown sugar, sweet syrup glucose syrup, maltose, hydrolysed starch (Razzaque, 2020).

6.6. Natural Sugars vs Additives

Classic table sugar is often added to processed foods (added sugars) to improve the taste. The scientific name for sugar is sucrose. After consumption, it is rapidly broken down into glucose and fructose, without being accompanied by the release of beneficial nutrients. So, foods that are rich in added sugars give "empty calories", the absorption is very fast by the body increasing the feeling of hunger, but also blood sugar. That is why the consumption of sugar increases body weight and the development of some diseases like cardiovascular diseases, diabetes, and so on. Natural sugars are contained in unprocessed foods. In simple carbohydrates, they are contained in fruit juices, honey, and syrups, while the more complex carbohydrates appear along with proteins, fiber, vitamins, minerals, and others. Complex carbohydrates are made up of large chains of sugar molecules and are broken down in the body at a slower rate. This means that they do not raise blood sugar sharply and give the feeling of satiety. Such foods are fruits and vegetables, milk and yogurt, legumes, and so on. These unprocessed foods are useful for our diet, because of their high nutritional value and beneficial effect on our health, even if they include (naturally) sugars.

The World Health Organization has set some recommendations to reduce the free sugar intake to 10% of daily energy. Equally, some other institutions, such as the European Society of Pediatric Gastroenterology, Hepatology and Nutrition (ESPGAN) suggested that the intake of added sugar should be lower under 2 years of age (Fidler et al.,2017).

Free sugars are simple carbohydrates, ie monosaccharides (e.g., glucose, fructose) and disaccharides (e.g., sucrose or sugar) and they are added to food and beverages (eg in our homes, from the food industry, confectionery workshops, etc) or are naturally contained in foods, such as natural fruit juices, honey, and syrups. By avoiding processed foods, beverages, and soft drinks, it is easier for someone to reduce the intake of free sugars. It is also critical to emphasize the consumption of natural sugars, which can be derived from fruits, vegetables, and legumes (Holistic Health, 2019).

A very large part of the general population does not cook at home and prefers to buy ready meals or standard foods. As a result, the daily intake of sugar is particularly high. In the United

States, added sugar in food reaches 17% of the total calories that adults receive, while in children arrives at 14%. However, the authorities are sounding the alarm to bring the number below 10%. The scientific community is certain that sugar consumption is responsible for obesity along with other chronic diseases, such as diabetes. At this point, there will be a summary of the basic problems that sugar causes to our health without realizing it. Obesity rates worldwide are growing. The added sugar found mainly in soft drinks and packaged sweets is one of the main culprits. Juices, cola drinks, iced tea, and energy drinks are loaded with fructose, a type of simple sugar. Fructose consumption assists in the opening of appetite for food, more than the consumption of glucose. Glucose is dominant in starchy foods (e.g., White, 2018). Moreover, the consumption of a high level of fructose may create resistance to the hormone "leptin", which regulates the individual's appetite and instructs the body to stop eating (Shapiro et al., 2008).

Simply put, sugary and soft drinks do not quench your hunger. Those drinks induce the individual to consume more calories (mainly in liquid form) and to gain weight. From various studies, it has become evident that individuals who buy and consume sugary drinks (soft drinks and juices) weigh much more compared to those who avoid those drinks. Consumption of sugary drinks is also associated with increased visceral fat in the middle zone and individuals have a great risk of developing diabetes and heart problems (Ma et al., 2014).

Foods in combination with beverages that contain added sugar have a high glycaemic index. When an individual consumes these products, he/she experiences an increase in blood sugar and insulin levels. However, the increase in energy levels is hard to pin down in products and foods that are full of sugar but they do not contain proteins, fats, or fiber and therefore they give instant energy and immediately after cause a rapid drop in blood sugar. A sudden drop in blood sugar has several side effects such as psychological transitions, intense hunger, cravings, and gluttony. Indeed, frequent fluctuations in blood sugar levels directly affect the energy levels of a given individual **(**Jocelyn et al, 2020).

Even high consumption of fructose via fruits can be the culprit for the development of metabolic syndrome such as obesity. This can raise a concern since fructose represents more than 50% of added sugar. Moreover, some studies endorse the view that free fructose can cause adverse effects on metabolism. However, it is crucial to be mentioned that those studies used a very high dose of fructose and this explains the detrimental results that they provided. On the other hand, moderate consumption of fructose does not harm someone's metabolism which leads to the

conclusion that fructose can only be detrimental to health if it is over-consumed (Evans et al., 2017).

A recent article published in April 2022 reviewed research on the effects of excessive intake of SSBs, noting that there are currently no available epidemiological and clinical studies in children that indicate only the effects of fructose because it is not consumed alone and is quickly removed from circulation, and cannot be properly evaluated. However, epidemiological studies have proven that the consumption of SSBs affects the consumption of fructose and glucose and acts synergistically to cause problems such as cardiovascular disease. (Giussani et al., 2022).

Another research, which was published in 2017 by the American Society of Gastroenterology regarding a population consisting of Latino and African-American children (aged 8-18 years) with obesity and metabolic syndrome since they consumed >15% sugar and >5% fructose, showed that the imposition of a short-term restriction had a positive effect on reducing liver fat, visceral adipose tissue, de novo lipogenesis and kinetics of insulin in obese children.(Schwarz et al.,2017).

Another pilot study in children 5-8 years found that a 12-week intervention to reduce completely fructose-sucrose-glucose, managed to decrease BMI and BMI-SDS by 0.68 kg/m2 and 0.21 at the end of the week, and BMI-SDS was lower than baseline, while only BMI decreased p=0.08. (Maier Ina et al., 2010).

In addition, the was also a very recent study (2017), which focused on the effect of restricting foods high in fructose corn syrup in 54 children (aged 6-11 years), who suffered from obesity in relation to metabolic markers and fatty liver showed that restricting foods high in fructose and the overall reduction in calorie and carbohydrate intake at 6 weeks did not result in weight loss, but reduced levels of triglycerides and hepatic steatosis. (Ibarra-Reynoso et al., 2017).

Other similar studies have compared the effects of natural sweeteners when those are consumed, compared to refined sugars. The results showed that the consumption of honey which is a natural sweetener can improve metabolism and reduce the risk of weight gain. Moreover, maple and agave syrup can improve the homeostasis of glucose compared to the consumption of sucrose (Nemoseck et al., 2011). Additionally, natural sweeteners contain other substances, which can be beneficial for metabolic health. Such molecules include minerals and polyphenols, which also have antioxidant effects (St-Pierre et al., 2014).

If an individual prefers to avoid this energy swamp, he/she should opt for sweet unprocessed carbohydrates that contain fiber such as fruit – but always in moderation (for a review, see Sharma et al., 2016). It would be good to never eat a dessert alone on an empty stomach. It would be good to eat something that contains protein. This will stabilize your blood sugar levels. One such example is the consumption of a simple apple with some almonds together. Such a snack will give the individual energy for a long time and a plethora of nutrients. Sugar may induce the risk of cardiovascular disease. A diet high in sugar is linked with the development of many diseases, such as cardiovascular disease and heart attacks. Research has shown that diets that include a high amount of sugar can easily help to gain weight or even become obese, diabetes problems, high blood pressure, chronic inflammation, and high triglycerides. The above are high-risk factors for cardiovascular problems.

An individual can have a can of cola that contains 52 grams of sugar. Those grams are equivalent to about 10% of the total calories, a person consumes in a diet of 2000 calories per day. In very simple terms, just one soft drink a day easily puts us in the high-risk group for cardiovascular problems. Consuming a large amount of sugar can increase the possibility of someone having diabetes. Globally, the number of diabetics has doubled in the last 30 years. There are several reasons for this, but the association between consuming extra sugar and type 2 diabetes is immediate. Obesity, which among other factors is linked directly with sugar and several processed carbohydrates, such as flour, constitutes still the strongest reason for the development of diabetes.

Consuming sugar for a long time leads to insulin resistance. This insulin resistance allows the increase in blood sugar levels and consequently increases the risk of diabetes. Based on a population study, which included data from 175 countries, it was discovered that the occurrence of diabetes increased by 1.1% for approximately every 150 calories of sugar taken. In brief, this is equivalent to a single can of soft drink. Other studies also concluded that individuals who drink soft drinks which contain added sugar (for instance commercial juices) have more chances to develop diabetes.

Apart from this, sugar is not so innocent because creates fat in the liver. Increased fructose consumption has in many cases been linked with the possibility to obtain a fatty liver. Unlike glucose and other simple carbohydrates utilized by several tissues in the body, fructose is completely metabolized in the liver. Afterward, fructose in the liver receives the form of energy

or is stored as glycogen. Still, it is easy to replenish liver reserves, which means that excess fructose is stored by taking the form of fat. The consumption of added sugar in the form of fructose has a detrimental effect on liver function and often leads to non-alcoholic fatty liver disease (NAFLD) in children, a situation in which fat accumulates in the liver organ (DiStefano & Shaibi, 2020).

What is more, sugar consumption is connected with the appearance of acne. A diet that contains a high amount of refined carbohydrates such as sugar and flour is associated with a higher risk of acne and pimples. Foods with a high glycaemic index like processed and packaged commercial sweets increase blood sugar to a great extent. This results in a sharp rise in blood insulin levels, which in turn lead to increased secretion of androgens, oiliness, and inflammation, which are directly related to acne. Studies have concluded that diets with a low glycaemic index are connected with lower rates of acne and high glycaemic index diets are associated with higher rates (for a review, see Meixiong et al., 2022). In this direction, a study of 2,300 teens found that individuals who consume added sugar regularly were 30% more likely to develop acne (Koku Aksu et al., 2011). In addition, it is important to say that several population studies have shown that in rural societies where processed foods and soft drinks are not consumed, the incidence of acne is almost negligible compared to that of large cities.

The results suggest that a diet that is fully processed foods, soft drinks, and commercial sweets directly affects the quality of the skin and could lead to the development of acne. It also increases the risk of developing depression. A diet that is full of nutrients with fruits, vegetables, and salads improves mood and psychology. Conversely, a diet high in sugar, flour, processed carbohydrates, packaged sweets, and ready-to-eat foods increases the risk of developing depression. Consumption of foods that are considered processed and with added sugar such as sweets, soft drinks, beverages, and ready-made juices seems to increase the probability of depression.

After all the conducted studies, it is currently known that eating fewer carbohydrates is associated with better skin quality and appearance. It can cause the aging of cells and tissues. Telomeres represent special structures that can be discovered at the end of chromosomes and contain all the germ material of each human being. Telomeres act as a "cap" preventing the alteration or destruction of chromosomes. As we get older the telomeres, following their nature, shrink and this leads to cellular aging and dysfunctions. This is a normal process; however, a bad lifestyle and a bad diet speed up the whole process. When we consume large amounts of sugar,

degeneration, and shrinkage of telomeres have been found to accelerate, leading to cellular aging. For instance, the report of Wojcicki et al. (2018) found that excessive consumption of sugary beverages in 2-3-year-old Latino children was associated with shorter telomere length and impaired immune function, possibly as a step before obesity.

If a person consumes sugar regularly irrespective of the form of it, he/she has more chance of developing various types of cancer. In principle, a diet that is consisted of high levels of sugary foods and beverages may cause obesity, and then there is an increase in the risk of cancer. Similarly, a diet high in sugar and processed carbohydrates causes chronic inflammation in the body and can cause insulin resistance. The above-described factors augment the risk of cancer; for instance, a recent study has shown that individuals who are below the age threshold of 18 years old were at high risk for presenting cancer when they were consuming higher amounts of sugar (Debras et al., 2020).

Of course, there are other serious problems and damages that sugar can create to health. Apart from the risks and dangers that were analyzed in detail previously, the consumption of sugar can cause damage in so many different ways. Research has shown that sugar can cause the following in children: dental health problems (Chi & Scott, 2019), increased risk of gout (Johnson et al., 2013), and deterioration in cognitive and brain function, especially during critical developmental windows (Cohen et al., 2018).

The need to reduce SSD consumption by children and adolescents has led several countries to various interventions. One of these interventions is the introduction of a sugar tax, with Denmark being the first country to implement it in 1930. In 2018, the UK also decided to introduce an SSB tax, while the USA implemented a tax on sodas >10% of the price. (Giussani et al., 2022).

7. Determinants

7.1 Meaning

Determinant is the characteristic (relative, environmental, or behavioral) of individuals on which the frequency of occurrence of the studied outcome depends (relates or depends). The outcome can be the appearance of a disease, healing, or death. The literature regarding the analysis of determinants that are critical for childhood obesity is extensive, but the persistence and increase of cases of obesity require further studies. Knowledge of these determinants and their proper

treatment can contribute decisively to reducing the very serious phenomenon of obesity that affects as we show not only the individual but also society, as a whole. The determinants that were identified as responsible for childhood obesity are many and the most important of them the demographic characteristics, spending too many hours in front of the TV, using very often a computer and gaming machines, existing eating habits, the presence of physical activity, sleeping habits and of course the support that exists from the family to change the unhealthy habits (Galanis & Sparos, 2012).

7.2 Demographic characteristics

The most important demographic characteristics which leave a kind of 'fingerprint' on childhood obesity are the parent's body mass index, the educational level of the parents, the socio-economic level, and the age of the mother. A parent's body mass index constitutes a very important factor to keep a child's normal weight. Obese parents have also children who are overweight or obese at a higher rate than parents with normal body mass index (Birbilis et al., 2013). In a study that took place in Greece by Farajian et al. (2013), it was argued that obese parents had 2.66 times more often obese boys and 4.13 times obese girls than parents with normal body mass index. In addition, the children who have children of obese parents are familiar with an environment that unfortunately seems to promote the consumption of high-fat foods. So children have more chances to develop childhood obesity (Burniat et al., 2006).

Additionally, other studies showed that high socioeconomic status during childhood leads to a lower risk of developing obesity. This is highly determined by their parent's occupation, education, and family income. Other factors can also contribute to the development of obesity and those include the family size and the care that the child receives from their parents. Paradoxically, a family with a low income is expected not to suffer from obesity. However, studies showed that these families tend to overconsume high-energy and processed food that is relatively cheap (Hruby et al, 2016).

The parent's educational level seems to play a role in the prevalence of childhood obesity. According to the body of literature, a negative link exists between the education of parents and the prevalence of obese children (Fernández-Alvira et al., 2013). Lien et al., (2007), conducted a study in Norway and they found that the educational level of parents is negatively connected with the gain of weight and the occurrence of obesity only in boys. Therefore, the higher the educational

level, the fewer the chances of childhood obesity. Studies have already investigated the relationship between the mother's educational level and the frequency of childhood obesity, and have concluded that increasing the maternal educational level reduces the prevalence of childhood obesity (Semmler et al., 2009). It is noted, however, that Duran-Tauleria et al., (1995) in their study in Britain found that as the mother's educational level increases, then there is also an increase in the prevalence of obesity in children. Moreover, Rona and Chinn (1982) found the opposite result, namely that the mother's educational level was not connected with obesity in children. Kromeyer-Hauschild et al. (1999) found that the father's occupation was linked to the development of childhood obesity. More specifically, when the father was having a manual occupation, then the development of childhood obesity increased. Lien et al., (2007) found that parents who exercise manual labor had more chances for their children to be overweight or obese, in comparison to the parent who had a position in the administration. Gnavi et al. (2000) found that childhood obesity occurs more often higher in families where the parents are unemployed or they are engaged in different types of manual work.

Studies in economically developed countries have found that the occurrence of childhood obesity is higher in areas with low socioeconomic status than in areas of higher socioeconomic status (El-Sayed et al., 2012). Kleiser et al. (2009) in their study which took place in Germany discovered that childhood obesity is more common in children from low socioeconomic backgrounds, even when the conditions in which they grow up are favorable, compared to children from high socioeconomic backgrounds, even if they grow up in non-ideal conditions. Navalporto et al. (2012), in another study conducted this time in Spain, supported the view that socioeconomic status is more related to the prevalence of obese children than overweight, a conclusion reached by Shrewbury and Wardle (2008). However, Sobal and Stunkard (1989) didn't manage to find a relationship between socioeconomic status and childhood obesity in developed countries. In addition, Dummer et al. (2005), discovered in their study that had as a place of conduct the city of Liverpool (England) the socio-economic level is not related to childhood obesity.

Farajian et al., (2012), found that in Greece the decrease in maternal age is associated with an increase in the occurrence of childhood obesity. This finding may be because older mothers are usually more aware of health issues. Older women are more responsive to the information they receive from health scientists about healthy eating and exercise and therefore have a positive effect on children in maintaining an ideal body mass index.

Manios et al. (2018), investigated the prevalence of obese children from 6 European countries by looking at the socio-demographics and the factors that exist in the family circle. Specifically, 7554 children of preschool age took place in the study together with their parents, the weight of the children was measured, while the parents only reported it, with the help of the questionnaires, and the data was recorded. The study showed that the prevalence ranges from 10.0% in Germany to 20.6% in Greece and is higher in children with two overweight or obese parents and low socio-economic status. Childhood obesity was higher in the countries of south and Eastern Europe.

7.3. Eating Habits

Firstly, meta-analysis underlines that dietary fat is the key reason for weight gain and can be developed as early as childhood. Particularly, energy intake from monosaturated and polyunsaturated fats is not related to obesity. Regarding now the intake of fats from meat and products that are rich in saturated fats is related to obesity. Other food consumption patterns that include nuts are also not associated with weight gain. The meta-analyses show clearly consumption of fast food, especially at an early age is strongly linked to the gain of weight and the development of childhood obesity. This phenomenon is more outstanding in families where both parents are working and their children visit their favorite fast-food store a dietary pattern that is both convenient and sometimes inexpensive (Pan et al, 2013).

Some studies explore the relationship between breakfast and childhood obesity and those studies have found that skipping breakfast can increase the occurrence of childhood and adolescent obesity (Van Lippevelde et al., 2013). Panagiotakos et al. (2008) found that frequent consumption of cereals at breakfast, as well as the consumption of breakfast on a daily basis, is negatively associated with the phenomenon of childhood obesity.

The frequency of meals is negatively linked to childhood and adolescent obesity (Cassimos et al., 2011). Fabry et al., (1966) were the first to search the relationship between the number of daily meals and childhood obesity and discovered that children who ate ≤3 meals a day were more prone to store fat in comparison to children who consumed 5 or 7 meals a day.

Kaisari et al. (2013) found that the most frequent daily meal intake was connected with lower BMI in children and adolescents and particularly in boys. Hammons and Fiese (2011) found that eating ≥3 meals a week with the family helps maintain the ideal BMI both in children and

adolescents. Lehto et al. (2012) found that eating meals with the family is connected with the maintenance of normal BMI in children or even reducing it. Interestingly, Sen (2006) in his research supports the opinion that the frequency of meals with the family is inversely linked to the occurrence of overweight adolescents who are white, while he did not find a relationship in black adolescents.

Valdes et al., (2013) held a systematic review, which contained articles published from 2005 to 2012 investigating the relationship between the frequency of family meals and the incidence of obesity both in children and adolescents. The results of the systematic review were that there is little relevance and therefore further studies need to be carried out. Taveras et al., (2005) concluded the same in a study conducted in the USA regarding children aged 9-14 years. Roos et al. (2014), in a study conducted in several European countries, found that eating breakfast or dinner with the family less than once a week and watching TV during meals increases the prevalence of childhood and adolescent obesity in northern European countries, while they found no connection in the countries of southern and eastern Europe.

Studies have found that daily consumption of sugar-containing beverages plays a very important role in the increase of childhood and adolescent obesity (Denova-Gutierrez et al., 2008). Taveras et al., (2005) came to the same conclusion and stated that a diet that contains t I beverages with added sugar leads necessarily to weight gain in children. Striegel-Moore et al. (2006), in a 10-year follow-up study that included girls aged 9-10 years, found that only an increase in soft drink consumption was related to an increase in BMI. Indeed, Sichieri et al. (2008) found that reducing the consumption of sugar-containing beverages has an impact on reducing BMI, especially in girls. Studies have also searched the relationship between soft drink consumption and the occurrence of childhood and adolescent obesity and have found that the often consumption of soft drinks can also cause an increase in BMI (James et al., 2004). Conversely, Nicklas et al., (2008) found that the consumption of natural juices is not linked with an increase in the incidence of obesity in children.

8. Results

The results of this thesis showed that obesity is a multifactor disease. The factors that trigger this disease can range from socioeconomic, environmental, and genetic. Particularly,

genetics can play a huge role in determining whether the kid will become obese or not. This can be assessed by receiving the family's clinical history. However, other factors can influence the gain of weight, and those can be traced to the family environment. Results from this thesis show that families with low income can affect negatively their children and make them have a higher risk of consuming saturated fat food that can lead to weight gain and thus early-onset obesity. Additionally, it was shown that parents who truly care about their children, provide their children with the appropriate nutrition which can lower the risk of gaining weight. Also, a home that embraces healthy food can help individuals improve their diet. Furthermore, environmental factors such as lifestyle and physical activities are also important for decreasing the gain of weight. Particularly, children with a low rate of psychical activity are at higher risk of gaining weight compared to their peers, who physically exercise more often.

Other factors are associated with the mental health of an individual. Undoubtedly, obese children are targeted by stigma and discrimination. This can influence them negatively by developing several mental, disorders including anxiety and depression. Furthermore, data from scientific reports suggest that overweight pediatric patients are at a higher risk of demonstrating low self-esteem and motivational disorders. Therefore, to overcome such negative mental consequences, parents need to support their children with enough care and provide them with the right amount of nutrition diet. What is more, the results from this dissertation showed clearly that behavioral therapies can also help pediatric patients to overcome the above mental issues by activating motivation and thus changing their behavior into achieving a healthier lifestyle. Moreover, strengthening the relationship between family members can also be very beneficial and the individual can decide more easily to lose weight. Treatments of obesity can also be affected by underlying diseases, such as cardiovascular diseases and type 2 diabetes. In addition to this, it was suggested that the consumption of natural sweeteners such as honey can ameliorate metabolic health compared to processed sugar.

9. Conclusions

Undoubtedly, the phenomenon of obesity is a huge health concern worldwide. Moreover, obesity can be a risk factor for the occurrence of other life-threatening disorders, which have a great impact on a patient's quality of life, especially in the early-onset period. If the problem of obesity is not treated soon then it can cause physical and mental impairments. Such

comorbidities include cardiovascular diseases, diabetes, and mobility problem. Additionally, it is reported that obese children have difficulties completing daily tasks. However, obesity is also associated with the development of mental disorders, which affect an individual's social life. This impact on the social life of individuals is less compared to that of physical function.

In parallel, evidence shows that weight loss is related to enhanced quality of life and benefits to mental health. Even the slightest weight loss from performing small life changes can be beneficial. In this direction, parents play a key role in supporting their obese children. Nevertheless, it is still questioned whether those benefits have a long-term effect or the opposite. Furthermore, weight loss can also prevent the development of type 2 diabetes and can protect the individual against cardiovascular disease. Furthermore, weight loss can also prevent comorbidities, including liver dysfunction, chronic obstructive pulmonary syndrome, joint pain, and even fertility.

Nonetheless, setting such goals can be difficult that's why it is important to consult professional healthcare givers, including psychologists who will provide the patient with the support and motivational techniques to achieve this goal. Particularly, such motivational approaches try to address the underlying issues and help patients change their behavior and integrate this change into their daily activities. Finally, family members have to assist their children by providing nutrition advice and applying a healthier diet.

All in all, obesity impacts an individual's life in multiple dimensions and must be considered a worldwide health priority. Therefore, further investigation is needed to develop new strategies and methods, which can prevent and also cure this pandemic.

Obesity has tripled since 1975, and today reached a pandemic rate (Abarca-Gomez et al., 2017; NCD-Risc, 2016). Obesity has put back tobacco usage as the primary lifestyle-related factor responsible for premature death (Bluher, 2019). This fact urged for stricter public health policies across the globe. It is intriguing to say that although added sugars are a likely culprit in promoting obesity, it is still not clear whether the form by which it is consumed (e.g., beverages, solid food) affects weight gain (Stanhope, 2015). Previous research on the Greek population has shown that adolescents differ from children in their consumption of added sugars; for instance, adolescents appear to endorse sugar-sweetened beverages compared to children (Magriplis et al., 2021). This makes sense as adolescence experience new stimuli without the constant supervision

of their parents –among which is the consumption of unhealthy food and drinks in the company of peers (e.g., at cafes).

Indeed, even though many foods contain sugar, sweetened beverages stand out as they increase sugar intake without feeding too many calories to children. Daily consumption of these beverages is over 50% of the population; studies have shown their consumption, especially during meal breaks, is connected with childhood obesity (Forshee et al., 2008; DuBois et al., 2007), especially for children under 12 (Frantsve-Hawley et al., 2017). Moreover, children who drink at least one "sweet drink" daily are twice as likely to be overweight after a year compared to children, who drink less of it (Welsh et al., 2005). Like any food, sugar is, of course, an essential part of a healthy diet, but the consumption of too much sugar can cause problems that affect overall health and well-being (Klurfeld, 2013). Increased sugar consumption – such as from the above beverages – is linked with excessive weight gain, obesity, metabolic syndrome, type 2 diabetes, hypertension, and other cardiovascular disorders in both children and adults (Malik et al., 2010; Raben et al., 2011; Yoshida &Simoes, 2018).

Consuming high-sugar fast food instead of family meals is one of the many conveniences of current life. Despite this, the increase in weight problems among adults and teenagers is a not neglectable situation. Restricting these meals to own family food can be a good manner to improve food consumption to lessen the risk of obesity (e.g, sweetened liquids). Healthcare experts assess and educate households on how to select healthier snacks and a way to prepare meals that might be healthy and nutritious. As described several times above, physical activity (e.g., aerobic, resistance training)– even at moderate levels – can cause significant benefits in terms of losing and maintaining appropriate weight (e.g., Jakicic et al., 2018; Kim et al., 2017); moreover, the individuals may emphasize more on the benefits of exercise rather than the negative aspects of restricting food intake – an approach which could become the focus of future campaigns (Waddington, 2019). In addition, Yoshida and Simoes (2019) have argued that higher taxation on sugar-sweetened beverages can provide a financial incentive in decreasing consumption. Although such approaches are likely beneficial in the long term, it is also important to realize that most studies treat sweetened beverages as being consumed holistically without showing asymmetrical rates of consumption; for instance, Pawellek et al. (2017) have reported higher consumption of sugar in children from younger mothers, while the sugar consumption from fruit merchandise was

decreasing in children from mothers with lower educational reputation and people with better birth order.

It is encouraging that recent reports have shown that sugar and energy consumption from the above beverages has significantly decreased from 2003 to 2016 in the USA (Marriott et al., 2019), although free sugar consumption *per se* still exceeds WHO recommendations (Perrar et al., 2019); this includes the substantial increase in sugar-sweetened beverages in decades before the 2000s and the sharp decline seen afterward (Della Notte et al., 2020). Indeed, a recent report by Schwimmer et al. (2019) has shown that adopting a diet low in free sugar improves the liver's condition in adolescent boys with nonalcoholic fatty liver disease (NAFLD), although the results are preliminary. It is, however, noteworthy to be said that a recent meta-analysis has shown that consumption of sugar-sweetened beverages may not be always linked with the incidence of obesity (Nissensohn et al., 2018). For instance, Sanghavi and Siddiqui (2017) have argued for the indirect role of oral health professionals (e.g., dentists) in combating childhood obesity by suggesting the avoidance of sugar-sweetened beverages, which are known to cause dental issues. In addition, Escalon et al. (2021) have reported that television advertising of products high in fat, sugar, and salt (HFSS) largely takes place during peak viewing hours and could be problematic for children and adolescents who are exposed to them.

Interestingly, a previous meta-analysis by Giske et al. (2010) has discovered that environmental, rather than purely dietary, factors – such as staying in a deprived area – can be a tremendous obesogenic reason. This is somewhat surprising, and paints a much more complex mechanism between obesity and food intake; this is not to say that low socioeconomic areas consume less added sugars – quite the opposite – but there may be a deeper synergy between sugar intake and lack of exercise (Thompson et al., 2009). For instance, it is possible that in low-income areas, there might be a lack of recreational facilities suitable for exercise (e.g., Keith et al., 2016), resulting in poor indices of physical activity; however, aerobic training (e.g., running) can still have substantial benefits in such areas. Future studies could, perhaps, aim to find the activity levels of participating individuals to draw meaningful associations between energy intake, sugar intake, and physical activity in maintaining a healthy body weight. Recognizing the issue of obesity as a multifactorial pathology can result in meaningful recommendations for fighting it such as campaigns for education, improved labeling, and advertisement restrictions (Fidler Mis et al., 2017).

In conclusion, it is important for individuals of all ages with a greater emphasis on vulnerable populations – to develop proper eating habits and introduce a more active lifestyle to prevent obesity and keep a healthy body weight for as long as possible. Healthier eating behaviors can be promoted – among others – via the reduction of added sugars, an increase in foods rich in fiber, and moderate physical activity. We expect future research to determine these important relationships to promote healthier lifestyles across the lifespan.

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