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The Interrelation between Obesity Management and Climate Change in Greece

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ABSTRACT: Two major global problems of our era are climate change and obesity. Both are interlinked and interconnected having undesired social, economic, environmental impacts as well as harmful impacts on human health. The rate of obesity and overweight in children and adults in Greece is high compared to other EU countries causing many health, social and economic problems. Climate change is foreseen to have severe and harmful impacts in Greece as well as in other Mediterranean countries altering the climate conditions. Obesity and its treatment mitigate climate change, mainly due to the change in the dietary pattern of the treated patients. The proposed diets for managing obesity, based on Mediterranean dietary patterns, have less GHG emissions and lower climate footprint. Climate change makes more difficult the treatment of obesity, mainly due to the rising temperatures. Climate change has undesired and harmful impacts on obesity treatment in Greece while obesity treatment results in the mitigation of climate change in the country. Future policies for climate change mitigation and managing obesity in Greece should take into account their mutual interconnections and interlinkages in order to maximize their effectiveness in treating these two severe pandemics in the country.

KEYWORDS: climate change, diet, Greece, health, obesity

1. INTRODUCTION

Obesity and climate change consist of two important contemporary global problems threatening the prosperity of mankind. Both have severe economic and social impacts in the developed and developing countries while obesity is now one of the most important chronic health problems in the world. A lot of research has been implemented worldwide as well as in Greece regarding the management of overweight and obesity [1], [2], [3]. The environmental and climate impacts of diets related to obesity treatment, like Mediterranean diet, have been also investigated [4], [5], [6], [7]. Several researchers have studied the relation between obesity treatment and achieving the United Nations (UN) Sustainable Development Goals (SDGs) [8], [9]. The impacts of obesity and its treatment on climate change in Greece have been also studied [10] while the results from various programs related to overweight and obesity treatment in the country have been reported [11]. It has been indicated that obesity and climate change are interrelated and interconnected while obesity treatment has positive impacts on climate change mitigation [12], [13].

The aim of the current work is the investigation of the linkages and the interrelations between obesity management and climate change in Greece.

The text is structured as follows: After the literature survey the problem of obesity in Greece as well as its impacts on climate change in the country are analyzed. Next, the interrelation between obesity and climate change is mentioned as well as the impacts of obesity and its treatment on climate change. In the following sections the impacts of obesity treatment on achieving the UN SDGs as well as the impacts of climate change on obesity and its treatment in Greece are discussed. The text ends with discussion of the findings, the conclusions drawn and the citation of the references used.

The present work is novel filling an existing gap related with the interconnection and the interrelation of obesity treatment with climate change in Greece. It could be useful to policy makers, to public authorities and researchers as well as to those who develop new methods for managing overweight and obesity in Greece. The current work might help them to have better understanding of the co-benefits of obesity treatment and climate change mitigation in the country.

2. LITERATURE SURVEY

The environmental impacts after one year of promoting a Mediterranean Diet (MD) have been studied [14]. The environmental parameters studied were: greenhouse gas emissions, land use, energy used, acidification and eutrophication. The authors stated that after one year of intervention all the factors analyzed were reduced while meat products had the greatest environmental impacts in

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all the parameters analyzed. The environmental footprint of the Mediterranean and the western diet has been calculated [4]. The authors stated that the use of Mediterranean diet in Spain reduces several environmental parameters like Greenhouse Gas (GHG) emissions by 72%, land use by 58%, energy consumption by 52% and water consumption by 33%. They also mentioned that the western dietary pattern increases the abovementioned environmental parameters by 12% to 72%. The environmental footprint associated with the MD and the EAT-Lancet diet has been estimated [15]. The environmental impact was evaluated using the land, water and carbon footprint per unit of several agricultural and food products. The authors stated that meat consumption contributed the most to land use, dairy products contributed the most to GHG emissions and fruits contributed the most to water use. The sustainability dimension of the Mediterranean diet has been reviewed [16]. The authors examined several indicators including ten environmental indexes to assess the Mediterranean diet. They mentioned that Mediterranean diet had a lower environmental impact than the western diets showing a carbon footprint between 0.9 $kgCO_2$ and 6.88 $kgCO_2$ per capita per day, a water footprint between 600 and 5,280 m^3 per capita per day and an ecological footprint between 2.8 and 53.42 m^2 per capita per day. The water footprint of the recommended Italian diet has been calculated [8]. The author stated that it is necessary to shift towards diets which are both nutritious and sustainable with low environmental impacts achieving the United Nations Sustainable Development Goals regarding food security (SDG2) and water security (SDG6). She mentioned that the proposed Italian diet guidelines have a low water footprint while its reduction by replacing animal food with plant food is limited because the suggested consumption of animal food is already low. The positive climate impact of the MD has been examined [17]. The authors compared the GHG emissions associated with the dietary patterns in seven Mediterranean countries with the corresponding GHG emissions in 21 European Union (EU) countries in 2017. They stated that the GHG emissions associated with the ideal MD is 2.3 $kgCO_2$ per capita per day. They also mentioned that the GHG emissions related with the dietary pattern in seven Mediterranean (MED) countries were at 4.46 $kgCO_2$ per capita per day while in twenty-one EU countries at 4.03 $kgCO_2$ per capita per day. They concluded that meat overconsumption in the seven MED countries studied had increased the diet-related GHG emissions. The necessity to mitigate global obesity, undernutrition and climate change has been investigated [1]. The authors have tried to identify dietary and transportation strategies that reduce GHG emissions and obesity focusing on USA. They also mentioned that the report of Lancet Commission on obesity has suggested 18 actions to simultaneously mitigate obesity, malnutrition and climate change worldwide. They defined the “Sustainable diets” as “diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generation”. The catastrophic consequences of obesity, climate change and Covid-19 have been analyzed [18]. The authors examined the tri-directional relationship between them. They stated that obesity and climate change have challenged the world while the Covid-19 pandemic has imposed an additional stress on the planet. The climate co-benefits of obesity reduction have been assessed [12]. The authors used data for the fifty US states over the period 1997-2011 examining the relationship between the obesity rate and CO_2 emissions due to energy use. They mentioned that reversion of the obesity rates in 1997 levels, from the levels of 2013, in USA could reduce the annual CO_2 emissions due to energy use by 2.8% compared to total USA emissions. The authors evaluated the annual climate benefits regarding the social cost of carbon in the range of 5.7 to 8.9 billion $. The relation between climate change and obesity has been examined [5]. The authors stated there is a mutual relationship between obesity and global warming. With rising air temperatures people are less adaptive to thermogenesis, are less physically active and consume more energy for air-conditioning. Reducing obesity rates requires changes in the dietary pattern choosing “Mediterranean type dietary patterns” with lower meat consumption. MD reduces the GHG emissions by 72%, land use by 58% and energy consumption by 52%. The problems of obesity and overweight in adolescents in Greece have been studied [2]. The authors estimated the prevalence of overweight and obesity in a representative sample of young people eleven, thirteen and fifteen years living in Greece. They stated that overweight and obesity were positively associated with male gender, low family affluence, skipping breakfast and being on diet while it was inversely associated with age and being physically active. The dietary management of obesity has been reviewed [19]. The authors stated that obesity is a multifactorial disease and its prevention and management require knowledge of the complex interactions underlying it and adopting a holistic approach. They also mentioned that the framework behind the regulation of body weight and food intake are not well-understood. The MED diet and the diet of Greece have been reviewed [10]. The author stated that among MED countries the lower death rate and the longer life expectancy was occurring in Greece. She also mentioned that the Greek diet, before 1960, was consisted of high intake of fruits and local vegetables, nuts and cereals, olive oil, more cheese than milk and more fish than meat combined with moderate amounts of wine. The MD has been analyzed [20]. The authors stated that MD is originated from ancient civilizations lived around the Mediterranean basin. Its health benefits are universally recognized today by the medical

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community. However, they mentioned, it is difficult to promote the healthy MD dietary pattern in other territories and to keep it alive in traditional MD countries due to the adopted unhealthy eating habits. The Greek Orthodox fasting rituals related with the MD in Crete, Greece have been examined [21] The authors stated that the Orthodox Christian dietary regulations are an important component of Cretan diet characterized by low levels of fatty acids, high levels of fibers and folate and a high consumption of fruits, vegetables and legumes. The implications of food waste generation on climate change focusing in Greece have been examined [22]. The authors estimated the GHG emissions associated with food waste generation in the country. They stated that approximately 100 kg of food waste per person are generated annually while approximately 30 kg per person are avoidable. They also mentioned that the CO_2 emissions associated with food waste in Greece are at 5,672.5 Gg annually. The dietary management of obesity has been analyzed [23]. The author stated that the results of many studies have indicated successful weight loss with the help of MD. He also stated that for the majority of obese patients a lifestyle change associated with healthy dietary nutrition and regular physical activity can achieve a significant reduction of the body weight. The perspective of transition to plant-based diets has been examined [24]. The authors stated that there is little evidence to support the argument that a plant-based dietary pattern like a vegan diet will have major effects on body weight control. They also mentioned that a change to more plant-based diets may exert beneficial effects on the environment. The link between obesity and climate change has been investigated [7]. The authors stated that the impacts of obesity and obesity-related behaviors on rising GHG emissions are becoming increasingly clear. However, reducing global GHG emissions like reducing obesity is not an easy task. They also mentioned that knowing the link between environmental and health-related behavior helps in tackling two major world problems. The interplay between diets, health and climate change has been studied [13]. The authors, in order to understand better the interplay, compared eleven typical diets representing various dietary patterns all over the world. They stated that limiting the consumption of animal-source foods is an option for climate change mitigation which also reduces obesity and promotes a healthy lifestyle. The possibility of personal carbon trading for reducing obesity and mitigating climate change has been studied [25]. The author stated that obesity and climate change are two problems which currently challenge humanity. He mentioned that by increasing personal energy expenditure and decreasing energy-dense food intake consists of a "stealth intervention" for climate change mitigation. The health and climate change co-benefits of dietary change have been assessed [6]. The authors stated that recent research has highlighted the dual health and environmental benefits of reducing the fraction of animal sourced foods in our diets. They also mentioned that transitioning towards more plant-based diets could reduce global mortality by 6-10% and food-related GHG emissions by 29-70% compared with a reference scenario in 2050. The policies for obesity treatment and climate change mitigation in Australia have been reviewed [26]. The author stated that over 60% of adults and 25% of children are classified as overweight or obese in Australia. She suggested that policies which can tackle both these two problems are: a) policies which replace car use with low-emissions modes of transport, b) policies which improve diets and reduce emissions from the food system, and c) macro-level policies which reduce the over-consumption of food and fossil fuels. The necessary actions to prevent childhood obesity have been examined [27]. The authors, focused on USA, investigated how the concepts of individualism, freedom, free will, personal responsibility, freedom of speech and the principles of the marketplace can contribute in the promotion of public health policies to reduce childhood obesity. The traditional and indigenous food systems in the 21st century to combat obesity and climate change have been reviewed [28]. The authors stated that today the world faces a global syndemic of obesity, undernutrition and climate change. They also mentioned that development of food systems which promote the human health and the sustainability of the planet is required. The achievement of SDGs using the MD has been studied [29]. The authors analyzed the significance of a plant-based diet regarding its contribution in attaining the UN SDGs. They stated that MD emerges as the most suitable dietary option for achieving sustainable development. The MD model to achieve the 2030 agenda of SDGs has been examined [30]. The authors stated that the notion of "*Mediterranean diet*" is understood as "*eating well and stay well*". They also mentioned that MD is conceived as a peculiar Med life style, a specific modality of production and consumption of food and a unique relation between people and the environment. The required changes for the future survival of mankind have been studied [31]. The authors stated that three changes are necessary in the global food production and consumption system for eliminating malnutrition and famine. These include: a) the radical change of the current cultivation system, b) the change of our dietary pattern and, c) The minimization of food losses and wastes. A national e-health program for the management of obesity and overweight in Greece has been developed [32]. The authors evaluated 2,400 children and adolescents who followed a personalized multi-disciplinary management plan. They stated that in the end of the first year the prevalence of obesity was reduced by 32.1 % while of overweight by 26.7%. The points at which obesity is affected by the UN Sustainable Development Goals SDGs

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have been analyzed [9]. The authors stated that at least 14 out of 17 thematic SDG targets play a role in driving obesity epidemic including health, food, education, water quality, land and ocean quality, urbanization and employment. They also mentioned that obesity is a recuring theme and a pressing health crisis that the SDGs are well-placed to address. The vital role of obesity management in achieving several SDGs has been investigated [33]. The authors stated that obesity is a relevant and essential component of the global development agenda while SDGs offer a multi-faceted pathway to address obesity across multiple factors. The UN SDG targets related with the reduction of premature mortality from noncommunicable diseases (NCDs) through prevention and treatment promoting mental health and well-being has been analyzed [34]. The analysis stated that four main NCDs are associated with a cluster of common risk factors including tobacco and alcohol use, unhealthy diets, physical activity, hypertension, obesity, and environmental factors. It is also mentioned that at least 80% of the heart diseases, strokes and diabetes could be prevented by tackling these major risk factors. A "National registry for the prevention and management of overweight and obesity" in Greece has been developed [3]. The authors stated that the proposed system calculates a personalized therapeutic algorithm providing information on diet, physical exercise and sleep. They also mentioned that a pilot study in 1,270 children and adolescents resulted in a reduction in obesity rates by 30% and overweight rates by 35% within one year. A multidisciplinary management plan which was effective in reducing the prevalence of overweight and obesity in children and adolescents in Greece has been developed [11]. The authors stated that in Greece 30-35% of children and adolescents are overweight and obese. They implemented a pilot study with 1,000 children and adolescents who were receiving personalized advice on diet and exercise for one year. In the initial sample 57.9 % of the participants were obese, 29.5% overweight and 12.6% had normal Body Mass Index (BMI). They mentioned that after one year of treatment the prevalence of obesity among the participants was reduced by 16.8% while the prevalence of normal BMI was increased by 8.2%. The problem of obesity and its consequences in Greece have been analyzed [35]. The author stated that obesity is an acute phenomenon in Greece which ranks first among EU countries while it is also on top positions in adults' obesity. He also mentioned that obesity, which is the result of the body's positive energy balance, creates many severe health problems both in childhood and in adulthood while its social and economic consequences cannot be ignored. The consequences of climate change in Greece have been examined [36]. The author stated that for the vast majority of climate parameters the consequences of climate change in Greece are negative. He also mentioned that the average air temperatures will increase in the future as well as the number of annual days with heat waves. The impacts of climate change in Greece in the near future have been investigated [37]. The authors stated that the Mediterranean region is vulnerable to climate change particularly due to its sensitivity to droughts and rising temperatures while the climate conditions in Greece are expected to deteriorate in the future, during 2021-2050, compared to the reference period 1961-1990. They also mentioned that higher temperatures combined with higher humidity will increase the discomfort in urban areas while extreme rainfall episodes are expected to be more frequent. The impacts of climate change on the Greek economy have been studied [38]. The author stated that climate change is going to affect every aspect of human activity from tourism infrastructure and agricultural production to residents' health. He also mentioned that according to existing studies for every 1^{o}C temperature increase above 34^{o}C the daily mortality rate increases by about 3%. Taking into account that by 2050 1 out of 3 Greeks will be over the age of 65 the health of millions of Greeks will be in danger because of the rapid increase in the number of days with very high temperatures. The threats, challenges and solutions of climate change in Greece have been analyzed [39]. The author stated that climate change is a major threat to country's natural and human environment reducing the National Gross Domestic Product (GDP) by 2% annually. He also mentioned that the adoption of policies and technologies leading to a low-carbon Greece, in the context of European policies for climate change mitigation, can accelerate a transformation of the Greek economy that offers new opportunities for economic activity. The pandemics of obesity and climate change worldwide have been studied [40]. The authors studied a global sample over 40 years stating that obesity and climate change are co-existing pandemics which rarely have been examined together. They also mentioned that 1^{o}C increase in temperatures in developing countries is associated to a 2% increase in the BMI of children and women. The impact of weight loss on global warming has been investigated [41]. The authors estimated the reduction in CO_2 emissions that would occur with the theoretical global weight loss. They stated that a 10 kg weight loss of all obese and overweight people worldwide would result in a decrease of 49,560 Mt of CO_2 annually which equals at 0.2% of the CO_2 emitted globally in 2007. The global syndemic of obesity, undernutrition and climate change has been studied [42]. The report stated that these three pandemics – obesity, undernutrition and climate change – represent the global syndemic that affects most people in every country and region worldwide. It is also mentioned that the problem of obesity has four parts: a) the prevalence of obesity is increasing in every region of the world, b) many evidence-based policy

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recommendations to halt and reverse obesity rates have been endorsed in many countries but have not been translated in meaningful and measurable change, c) the enormous health and economic burdens caused by obesity are not seen as urgent enough to implement its effective treatment, and d) obesity has historically been considered in isolation from other major global challenges like climate change.

3. THE PROBLEM OF OBESITY IN GREECE

Obesity in children and adults is one of the most challenging health problems of the 21st century in Greece and worldwide. Obesity is essentially a result of the body's positive energy balance. If the energy we acquire is greater than what we consume, this extra energy is stored in the body as fat. It is estimated that more than 30%-35% of children and adults are overweight or obese in Greece [32]. The increasing prevalence of overweight and obesity in the country indicates that the current health policies are not effective. According to World Health Organization (WHO) data from 2019 37.9% of Greek adults are overweight and 24.9% are obese [35]. The rates of obesity in children seem to be higher in rural areas than in cities while smaller rates of obesity are observed in suburbs inhabited by high-income families than in suburbs inhabited by low-income families. It has been also observed that in Greece only 25% of adults consume the recommended amounts of fruits and vegetables while 68% of Greek adults do not exercise at all and do not engage in any sport, which is the largest percentage in EU [35]. Studies in Greece have indicated that the problem of obesity is multi-factorial while it is related to the lifestyle and personal choices made by families. The obesity rates in adults in Greece and Europe are presented in table 1. The cardiometabolic disorders and diseases associated with obesity in adulthood are presented in table 2.

Table 1: Obesity Rate In Adults In Greece And In Europe

	Greece (%)	Europe (%)
Overweight (BMI = 25-30)	37.9	35.4
Obese (BMI>30)	24.9	23.3
Total	62.8	58.7

Source: [35]

Table 2: Cardiometabolic Disorders And Diseases Associated With Obesity In Adulthood

Insulin resistance	Type 2 diabetes
Inflammation and dyslipidemia	Cardiometabolic diseases
Increased blood volume and high angiotensinogen	High blood pressure, high cholesterol level

Source: [35]

The increased number of obese and overweight people in Greece has significant economic impacts. According to OECD data from 2019, obesity is responsible for 9% of annual health expenditure. According to the same study, the annual Gross Domestic Product (GDP) in Greece during the period 2020-2050 will be 3% lower than otherwise, due to the economic consequences of obesity [35].

4. THE IMPACTS OF CLIMATE CHANGE IN GREECE

Greece like the Mediterranean region is vulnerable to climate change particularly due to its sensitivity to droughts and rising temperatures [37]. Climate change has undesired impacts on many human activities deteriorating human health. Unpleasant high temperature and relative humidity combined with aerosol pollution in atmosphere may increase the feeling of discomfort in citizens in large cities where the majority of the Greek population resides [36]. The city of Athens where a large percentage of the country's population lives is characterized by urban density, low natural aeration and low availability of green spaces. Athens will experience in various areas higher temperature rise due to the phenomenon known as "Urban Heat Islands" with hot spots up to +8ºC compared to neighborhood areas. Existing research indicates that the country is becoming increasingly warmer and dryer with extreme weather phenomena which will be more intense in the future, more frequent and longer lasting. Other studies have indicated that the temperature during 2046-2065 is expected to be, on average, 2.5ºC higher compared to the temperature in the period 1961-1990

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while regionally the temperature rise may reach up to 3.8ºC [38]. Additionally, the extreme weather events will be much more frequent while the days with temperatures above 35ºC are expected to increase by 15-20 annually. Some impacts of climate change in Greece are presented in table 3 while the impacts on Greek cities are presented in table 4.

Table 3: Some Impacts of Climate Change in Greece

Higher air temperatures
Increased number of days with heat waves
Reduction in the annual rainfall
Increased number of days with high risk of fire
More frequent extreme weather events
Rising sea levels
Reduction of biodiversity
Destruction of sensitive ecosystems
Adverse effects in the coastline

Source: [36]

Table 4: Impacts of Climate Change in Greek Cities

Climate risk	Primary effect	Secondary effect
Temperature rise	Depletion of ground water Water scarcity Draughts Intensification of heat waves	Urban heat islands Increased energy demand for cooling Increase in energy prices Impacts on population health
Extreme weather events	Floods Fires Landslides	Materials damage
Rising sea levels	Coastal floods	Materials damage

Source: [38]

Climate change is going to have undesired economic impacts in the Greek GDP in the coming decades while the combined impacts of climate change and obesity are going to be harmful in the country's economy [38], [39]. Under an inaction ("business as usual") scenario, the Greek GDP could fall by 2% annually by 2050 and even further by 2100, while the total cost to the Greek economy could reach a cumulative €701 billion by 2100. Efficient adaptation programs, necessary as a damage control measure, have been found to reduce the cost of climate change by almost 30% while they could provide a promising opportunity for Greece to boost its growth performance and competitiveness, while implementing climate mitigation and adaptation policies [39].

5. THE INTERRELATION BETWEEN OBESITY AND CLIMATE CHANGE

The links between obesity and climate change have been highlighted in several studies. Physical activity replaced by fossil fuels-based transportation and sedentary-based leisure activities combined with increased consumption of high-energy processed food and dietary patterns related with high embodied carbon have harmful impacts on climate change. Westernized diets related to obesity result in high GHG emissions while Mediterranean diets which are rich in fruits and vegetables result in lower carbon emissions. The linkages between obesity and climate change have contributed in the development of the concept of "*sustainable diets*". These are defined as "*diets with low environmental impacts which contribute to food and nutrition security and to healthy life for the present and future generations*". In parallel the concept of "*sustainable transportation systems*" has been also developed. These are defined as "*transportation systems with low environmental impacts which contribute to active and healthy transport for the present and future generations*". Currently both the agricultural and food systems as well as the transportation systems are unsustainable contributing to increased obesity and climate change. Several researchers have found that the MD has low impacts on climate change compared to western diets. The reduction in GHG emissions in MD compared to western type diets has been calculated at 72% [4],

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[5]. Other researchers have estimated that the GHG emissions associated with the ideal MD is at 2.3 $kgCO_2$ per capita per day while the GHG emissions related with the current dietary pattern in 28 EU countries is in the range of 4.0 to 4.5 $kgCO_2$ per capita per day [17]. The interrelation between obesity and climate change is presented in table 5.

Table 5: The Interrelation between Obesity and Climate Change

	Impact of obesity to climate change	Impact of climate change to obesity treatment
1	Obesity is related with unhealthy western-type diets resulting in significantly higher carbon emissions compared to Mediterranean dietary patterns	Climate change creates endocrine disruption to humans
2	Obesity is related with diets rich in meat. Cattle breeding results in high GHG emissions including CH_4 emissions	Increased air temperatures encourage obese people to use vehicles' transportation, instead of walking and biking, resulting in less physical activity, less energy consumption and increased obesity
3	Obesity is related with eating large quantities of processed food with high energy content resulting in higher GHG emissions	Increased air temperatures discourage obese people to be physically active, doing exercises and sports, resulting in less energy consumption and increased obesity
4	Obese people often use vehicle's transportation using fossil fuels and releasing CO_2	Climate change is related with droughts and extreme weather events which affect food production. This might affect people to adopt unhealthy dietary patterns
5	Since average temperatures are rising obese people will require more frequently air-conditioning resulting in higher energy consumption and carbon emissions	Rising air temperatures may increase the sedentary behavior of people which is related with less physical activity, low energy consumption and increased obesity

Source: own estimations

6. THE IMPACTS OF OBESITY AND ITS TREATMENT ON CLIMATE CHANGE IN GREECE

Obese and overweight people usually consume high-energy food products with increased embodied energy which is characteristic of the western type dietary patterns. Western type diets contain more meat than fruits and vegetables. However, meat production and cattle breeding are characterized by high GHG emissions including CH_4 emissions. Overweight and obesity management requires significant changes in the dietary pattern and increased physical exercise of the patients. Frequently, changes from the dominant western dietary pattern towards the Mediterranean type diet is required. Taking into account that Mediterranean type diet has 72% less GHG emissions compared to western type diets [4], [5] it is concluded that the change in the dietary pattern of the obese and overweight patients results in significant reduction in GHG emissions related with food intake. Additionally, the increase in the physical exercise of the obese and overweight patients results in less use of vehicle's transportation and less consumption of carbon-emitting fuels. Recent studies in Greece estimated that after one year of treatment the obese patients have been reduced by 16.8% to 32.1% while the overweight patients by 26.7% to 35% [3], [11], [32]. Therefore, the required changes in obese and overweight patients, related with food intake and mobility, reduce the GHG emissions mitigating climate change. Conclusively, the management of obesity and overweight in the country, apart from health benefits, contributes to climate change mitigation having positive economic impacts. The interactions among obesity, malnutrition, health problems and climate change are presented in table 6.

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Table 6: Examples of the Interaction among Obesity, Malnutrition, Health Problems and Climate Change

a) Obesity, stunting and food insecurity affect the same children and the same population b) Car use, transport-related GHG emissions and inactivity are related to obesity c) Cattle production, GHG emissions related to cattle breeding and high meat consumption are related to obesity, diabetes, colon cancer and cardiovascular diseases d) Overproduction and overconsumption of ultra-processed foods are related to obesity e) Increased GHG emissions, reduced crop yields and micronutrient content of crops are related to food insecurity and undernutrition

Source: [1]

7. THE IMPACTS OF OBESITY TREATMENT ON ACHIEVING THE UNITED NATIONS' SUSTAINABLE DEVELOPMENT GOALS

The Food and Agriculture Organization (FAO) of the United Nations has suggested that humanity requires "sustainable diets with low environmental impacts". Therefore, the shift to diets, like the Mediterranean diet, which are both nutritious and sustainable is needed to achieve the UN SDG2 on food security and SDG6 on water security [8]. Shift from western-type diets to Mediterranean dietary patterns contributes positively to obesity treatment. In fact, the management of obesity complies with the achievement of several SDGs [9], including: SDG1: end of poverty in all its forms everywhere, SDG2: end hunger, achieve food security and improve nutrition and promote sustainable agriculture, SDG3: ensure healthy lives and promoting well-being, SDG6: ensure availability and sustainable management of water and sanitation for all, SDG12: ensure sustainable consumption and production patterns, SDG13: take urgent action, to combat climate change and its impacts, and SDG15: protect, restore and promote sustainable use of terrestrial ecosystems, sustainable manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. Current studies indicate that there is a clear decline in EU in premature non-communicable disease deaths since the mid-2000s. In parallel the 17 UN SDGs are on the way to be achieved [34].

Table 7: Several Un SDGS Which Can be Easier Achieved with Obesity and Overweight Management

Sustainable Development Goal of United Nations	Goal
SDG1	End of poverty
SDG2	End hunger, achieve food security and improve nutrition and promote sustainable agriculture
SDG3	Ensure healthy lives and promoting well-being
SDG6	Ensure availability and sustainable management of water
SDG12	Ensure sustainable consumption and production patterns
SDG13	Combat climate change and mitigate its impacts
SDG15	Promote sustainable use of terrestrial ecosystems, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Source: several authors

8. THE IMPACTS OF CLIMATE CHANGE ON OBESITY AND ON ITS TREATMENT IN GREECE

Climate change is altering the climate conditions in Greece resulting in temperature rise, increased droughts and extreme weather events, water scarcity and more frequent heat waves. The changing climate conditions affect all human activities having adverse impacts in obesity and in the efforts for its treatment. Rising temperatures encourage obese people to use vehicle's transportation, to adopt sedentary behavior and discourage them to be physically active. Their changing behavior results in lower personal energy consumption which makes more difficult the reduction of their BMI. Additionally, the increasing temperatures might discourage obese people to adopt the required behavior for managing their obesity which presupposes increased physical activity delaying the decrease of their BMI. Extreme and frequent draughts as well as water scarcity in Greece are expected to reduce the agricultural

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production in the country resulting in lower food production associated with Mediterranean diet which facilitates the management of obesity. Temperature rise is expected to be higher in Athens where a large part of Greek population resides while Athen's residents have lower obesity rates than people residing in rural areas [36].

9. DISCUSSION

Climate change and obesity management are interrelated and interlinked. Obesity treatment mitigates climate change while climate change has adverse effects on obesity treatment. It has been stated that a 10 kg weight loss of all obese and overweight people worldwide would result in 0.2% reduction of the global CO_2 emissions [41]. Obesity treatment requires the change from the typical western dietary pattern to a new dietary pattern using more fruits and vegetables than meat and dairy products. It also requires the increased physical activity of obese patients who should avoid the frequent use of vehicles. The proposed new dietary pattern and life style of obese patients has positive impacts to climate change mitigation. On the other hand, the new climate conditions make more difficult the obesity treatment. Obesity and overweight management have positive impacts in the achievement of many UN SDGs. Treating overweight and obesity in Greece is related with the adoption of the traditional MED type dietary patterns and contributes to climate change mitigation. Mediterranean type diets reduce the GHG emissions by 72% compared to western-type diets [5]. It has been estimated [17] that the GHG emissions related with the ideal MD is 2.3 $kgCO_2$ per capita per day which is approximately half than the current emissions in several EU countries while it has been stated [16] that MD has a carbon footprint between 0.9 $kgCO_2$ and 6.88 $kgCO_2$ per capita per day. Rising temperatures in the future in Greece is foreseen to make obesity management more difficult since it will reduce the outdoor physical activities of the treated patients. Future work should be focused on quantitative estimations of GHG emission savings due to the proposed changes in the dietary pattern of obese patients in Greece.

10. CONCLUSIONS

Nowadays, obesity consists of a severe health problem in Greece having many undesired health, social and economic consequences. According to existing studies climate change, which is the most important global environmental problem, is going to alter the climate conditions in Greece having many harmful and undesired impacts in many sectors of the Greek society and economy including tourism, agriculture, natural ecosystems and the life in cities. Climate change has adverse impacts on obesity treatment, mainly due to rising temperatures, while obesity treatment contributes positively in climate change mitigation in Greece. This is mainly due to the replacement of western type diets with MED type diets which require reduced consumption of meat and dairy products and have lower environmental footprint. Managing obesity assists in the achievement of many UN SDGs. Therefore, climate change and obesity management are interlinked and interconnected and they should be mutually treated. The current study indicates that the efforts to manage and reduce obesity and to mitigate climate change in Greece affect positively both of them having many health, economic, social and environmental benefits in the country.

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