

OBESITY AND ITS COMORBIDITIES: THE ROLE OF HEALTHY NUTRITION IN MAINTAINING NORMAL BODY COMPOSITION

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Obesity is among the most significant public health concerns worldwide. In combination with its co-morbidities, it contributes to serious health complications and, in severe cases, may result in mortality. This manuscript presents an overview of obesity and its most prevalent comorbidities. Furthermore, it discusses the role of healthy nutrition in maintaining a normal nutritional status. Electronic sources were systematically reviewed using keywords such as obesity, high energy intake, protein, fat, carbohydrates, high blood pressure, high cholesterol, type 2 diabetes, low-energy diet, and healthy diet. A total of 44 references were included, the majority of which are published in Q-rated journals. Obesity, a globally prevalent condition primarily resulting from an imbalance between energy intake and expenditure, is influenced by genetic, psychological, and social factors, and is typically diagnosed using Body Mass Index (BMI) alongside complementary anthropometric methods. Furthermore, the review summarizes key characteristics of energy intake and macronutrient composition, alongside essential aspects of detecting obesity associated with excessive nutrient consumption. The most common co-morbidities of obesity are also addressed. According to the literature reviewed in the manuscript, a rising trend has also been observed in obesity-related diseases, including respiratory disorders, musculoskeletal conditions, cardiovascular diseases, and metabolic syndromes. Emphasis is placed on the significance of a healthy diet and long-term lifestyle modifications in both the prevention and management of obesity. Sustained lifestyle changes, adherence to a healthy diet, and regular physical activity are identified as primary strategies for the treatment and prevention of overweight and obesity.

1. Introduction

Obesity is one of the most prevalent diseases globally. It is primarily caused by an imbalance between energy intake and expenditure. Genetic, psychological, and social factors also contribute to its development (Tóth, 2015). The body mass index (BMI; [kg/m²]) proposed by Keys and his colleagues is a diagnostic measurement for obesity, along with other anthropometric and body composition methods (Tóth and Suskovics, 2013). A BMI ≥ 30.0 (kg/m²) is considered obese (WHO, 2024). While a body mass index is useful for population-level statistics and individual risk estimation, it does not differentiate between body components such as bone mass, muscle mass, fat mass, and body water. Other methods, such as the

waist-hip ratio and the “Edmonton obesity staging system,” provide more detailed assessments. More accurate results can be obtained with a skinfold caliper, a method developed for the European race to measure subcutaneous fat (World Obesity Federation, 2024). The accuracy of the test is highly dependent on the practice of the person making the measurement.

Treatment of obesity primarily involves regular physical activity (Gaesser and Angadi, 2021), healthy nutrition (Romieu et al., 2017), and a comprehensive lifestyle change (Ruban et al., 2019). Obesity can lead to several comorbidities which has been formulated by experts in numerous manuscripts, including a strong correlation with complications from coronaviruses and respiratory diseases: Pulgaron and Delamater (2014) examined the rising prevalence of childhood overweight and obesity - conditions linked to increased risk of later obesity, type 2 diabetes, and metabolic syndrome - highlighting the importance of family-based behavioral interventions and calling for urgent research into prevention strategies, particularly among low-income and ethnic minority youth who are disproportionately affected. Fruh reviewed the health impacts of obesity and the benefits of even modest weight loss, emphasizing evidence-based weight-management strategies and highlighting the key role of nurse practitioners in supporting patients to achieve and maintain weight loss through realistic goals and consistent follow-up (Fruh, 2017). Klop and colleagues reviewed the mechanisms linking obesity to dyslipidemia and cardiovascular risk, emphasizing how obesity-related metabolic disturbances- such as insulin resistance, altered lipid metabolism, and pro-inflammatory processes - contribute to the development of metabolic syndrome, and discussing potential interventions to address obesity-related lipid abnormalities (Klop et al., 2013). An's study estimated the impact of COVID-19-related school closures and reduced physical activity on childhood obesity, finding that these disruptions significantly increased BMI and obesity prevalence - especially among boys and minority groups - and underscored the urgent need for public health interventions to promote active lifestyles in children (An, 2020). Sharma and Yadav discussed the mechanisms linking obesity-induced chronic inflammation to increased COVID-19 severity, aiming to enhance understanding of the disease process and guide the development of targeted clinical interventions for obese patients (Sharma and Yadav 2021).

In addition, diabetes mellitus and cardiovascular disease are the most debilitating chronic conditions, which can lead to complications involving multiple organ systems (Silva et al., 2018). Many individuals with obesity or related diseases exhibit a reduced immune response (Nieman, 2020).

2. State-of-the-art analysis

1. **Diagnostic Limitations:** Current anthropometric methods lack sufficient precision to accurately distinguish individual components of body composition, complicating the precise planning of personalized treatment.
2. **Lack of Population-Specific Interventions:** There is a shortage of effective obesity prevention and management programs tailored to vulnerable populations, which consider the unique characteristics, needs, and environmental, genetic, or lifestyle factors specific to these groups.
3. **Integration of Comorbidities and Immune Functions:** Although the association between obesity and its comorbidities is well-established, there is a pressing need for integrative approaches that address the interplay between metabolic disorders, immune responses, and the risk of infectious diseases.
4. **Personalized Nutritional Strategies:** While general dietary guidelines exist, the optimization of nutritional interventions customized to individual metabolic profiles and comorbidity risks remains insufficiently developed.

Paper goals: This manuscript aims to present obesity and its key comorbidities, along with dietary recommendations as a primary treatment option. The novelty of this thesis lies in its integration of the available knowledge. It addresses body composition analysis, the relationship with metabolic health, and the importance of immune function and personalized nutrition. The relevance of our work is justified by the increasing prevalence of obesity and its associated health risks, which demand more effective intervention strategies.

3. Materials and methods

On November 14, 2022, we conducted a literature search using Science Direct, PubMed, and Google Scholar databases with keywords including obesity, high energy intake, fat, carbohydrates, protein, high blood pressure, high cholesterol, type 2 diabetes, lifestyle change, and healthy eating.

We have included a total of 44 references in our publication, most of which are Q-rated. In addition to the articles, we have also used 1 book, 1 book excerpt, 1 volume of studies, 1 educational material, and 1 knowledge paper from a health innovation seminar. Of the 31 references with a Q rating, 18 are classified as Q1, 10 as Q2 and 3 as Q3. The presentation of the references is summarised in Figure 1 – excluding (OKOSTÁNYÉR, 2024a; OKOSTÁNYÉR, 2024b; WHO, 2024; World Obesity Federation, 2024).

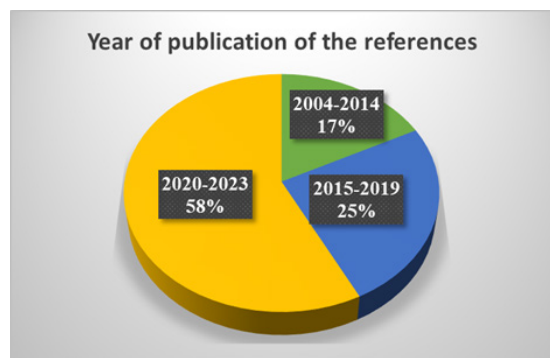


Figure 1: Literature used

4. Results

We have summarized our results in 3 main sections. These sections concern the relationship between obesity and energy and macronutrient intake, obesity and its comorbidities and the long-term importance of healthy nutrition and lifestyle changes.

4.1 The relationship between high energy and macronutrient intake and obesity

One of the most common causes of obesity is an unhealthy lifestyle (Tunkara-Bah et al., 2021), characterized by a lack of exercise and poor eating habits (Ellison and Prescott, 2021). Obesity results from consuming more energy than the body needs, with excessive intake of carbohydrates and fats playing a significant role (Fagunwa, 2021). In most cells, glucose is stored as rapidly mobilizable glycogen. The liver and skeletal muscle are the two most important glycogen stores. In addition, when glucose is converted into fatty acids, storage can also be in the form of lipids. Fructose is converted in the liver and viscera into triglycerides, which provide the most economical form of energy storage (Ádám, 2004).

Genetic, psychological, and social factors also contribute to obesity's development. Overweight and obesity negatively affect many organ systems. Obesity is associated with numerous comorbidities, such as high

blood pressure, high cholesterol, and type 2 diabetes, and increases mortality rates.

Body mass index (BMI) is one of the most commonly used methods to measure obesity, though it does not account for body composition differences. Lifestyle changes, regular exercise, and adherence to dietary recommendations (healthy eating) play a significant role in the treatment of obesity. Numerous manuscripts have reported on the treatment of obesity, some of which we would like to mention in our manuscript: Rizza and Federici concluded that disrupted sleep in night shift workers significantly increases the risk of obesity and metabolic disorders, and emphasized the need for interventions - such as improving sleep quality or using bright light therapy - to mitigate cardiometabolic risk without necessarily changing work schedules (Rizza and Federici, 2020). Moholdt and Hawley concluded that improving maternal metabolic health is crucial to preventing intergenerational cardiometabolic diseases, and emphasized that lifestyle interventions such as diet and exercise must begin before conception, with more effective strategies needed to enhance adherence among women of reproductive age (Moholdt and Hawley, 2020). Khanolkar and Patalay (2021) found that socioeconomic disadvantage is strongly and consistently associated with a higher risk of co-occurring overweight and mental ill-health across the life course, with the greatest inequalities seen in those with lower educational attainment, independent of sex or cohort. Novosad and colleagues reported that obesity is associated with a distinct asthma phenotype characterized by poor asthma control and increased severity, and highlighted the need for further research into underlying mechanisms - such as adipokines and oxidative stress - to inform targeted treatment strategies (Novosad et al., 2013). Andreoli and his research team concluded that early, personalized lifestyle interventions - particularly focused on diet and physical activity - play a crucial therapeutic and preventive role in managing newly diagnosed type 2 diabetes, potentially leading to remission and improved long-term outcomes, especially when supported by regular follow-up, interdisciplinary collaboration, and patient-centered education (Andreoli et al., 2020). Ahmed and colleagues highlighted that, although limited, existing studies consistently support the role of functional foods in preventing and reducing malnutrition, with some evidence suggesting they may also enhance quality of life (Ahmed et al., 2022).

4.2 Comorbidities of obesity: high blood pressure, high cholesterol, and type 2 diabetes

Obesity is a predisposing factor for several comorbidities:

- **High Blood Pressure:** Obesity is a major public health problem worldwide, causing the mortality of more than 7.5 million people every year. Such a high prevalence of the disease increases the risk of cardiovascular diseases such as high blood pressure (Nkosi et al., 2021). Childhood hypertension is rising due to lifestyle factors and family history (Yao, 2020).
- **Chronic Inflammation:** Obesity induces low-grade inflammation, with cytokines like TNF- α (Tumor necrosis factor alpha) and IL-6 (interleukin-6 cytokine) interfering with insulin signaling, promoting insulin resistance (Khanna et al., 2022).
- **Cardiovascular Diseases:** Both obesity and diabetes significantly increase the risk of heart disease, stroke, and hypertension (Brown et al., 2023).
- **Type 2 Diabetes:** A progressive disease where the body either cannot produce insulin or does not use it effectively. Environmental and genetic factors, including obesity, poor diet, and lack of physical activity, are the primary causes (Yeung et al., 2018).

In addition, hypertension in children is a growing concern with a global rate of 75-79 % between 2000 and 2015. Major risk factors include air pollution, lifestyle or dietary habits (high-calorie food consumption) and

low physical activity (Yao, 2020). Obesity predisposes children to hypertension as excessive body fat can lead to metabolic diseases (Silva et al., 2016). Epidemiological studies have shown correlations between serum lipid ratio, glycated haemoglobin (HbA1c), blood pressure, obesity, and lifestyle factors (Table 1).

Table 1: Epidemiological studies on hypertension, high cholesterol and type 2 diabetes

Name of diseases	Causes of diseases	References
Hypertension	Various lifestyle causes include smoking, alcohol consumption, genetic factors, or stress. 47 % of diabetics and 44 % of the hypertensive population have a BMI greater than 23, while the proportion in the non-diabetic population is 27 % and 25 % among the hypertensive population.	(Marbaninag et al., 2021)
	Consumption of fast food and sweets. The consumption of fast food and sweets significantly increases the blood count value. Drinking alcohol increases the risk of high blood pressure by 4 % compared to non-drinkers.	(Payab et al., 2015)
High cholesterol level	Lack of healthy life, high-fat diet. Among others, acteoside and isoacteoside have also proven to be effective in the treatment of obesity. Based on animal experiments, Acteoside and isoacteoside suppress lipid accumulation by inhibiting α -amylase and lipase.	(Joo et al., 2020)
	Predominance of other diseases (e.g. obesity, type 2 diabetes, high blood pressure) as co-morbidities. Significant correlations: • positive between serum triglycerides and visceral fat content • positive between fasting blood sugar and visceral fat content • negative between serum HDL-cholesterol and visceral fat content It was significantly higher in the male group than in the female group: • fasting blood sugar level • total serum triglycerides • the average level of LDL-cholesterol The mean serum HDL-cholesterol level was significantly lower in the male group than in the female group.	(Sukkriang, 2021)
Type 2 diabetes	Lack of physical activity or bad eating habits. A correlation was found between increased obesity and fasting blood sugar between 100 and 125 mg/dl: prediabetes. Exercise improves insulin action regardless of body weight and body composition. High-intensity aerobic training performed at a heart rate reserve greater than 80 % caused a significant decrease in body fat, fasting glucose, and insulin resistance.	(Faulkner and Michaliszyn, 2021)
	Other diseases associated with metabolic syndrome and obesity. Metabolic syndromes are accompanied by disruption of the redox balance of the tissues and circulatory system. Reactive oxygen species produced as a result of free radicals and endogenous oxidative stress are the cause and consequence of diseases.	(Korac et al., 2021)

The American Heart Association (AHA) recommends consuming fish once or twice a week to prevent high Low-Density Lipoprotein (LDL) levels and cardiovascular disease. Fish consumption increases high-density lipoprotein (HDL2) levels, which is considered “good” cholesterol due to polyunsaturated fatty acids (PUFA) (Tani et al., 2020).

Obesity and cardiovascular diseases are often associated with metabolic syndrome. Which can also lead to type 2 diabetes. Type 1 diabetes mellitus is an immune resulting in the destruction of the pancreatic beta cells, leading to little or no insulin production. In contrast, type 2 diabetes is a progressive condition where the body cannot produce sufficient insulin or utilize it effectively. Environmental factors (diet and lifestyle) and genetics, particularly obesity, poor diet, and lack of physical activity, are significant contributors to type 2 diabetes (Yeung et al., 2018).

Based on the European population’s 2009, 2014, and 2019 health surveys, involving 15844 European participants, being overweight or obese increases the likelihood of developing various diseases, as shown in Figure 2 (Pataki et al., 2023).

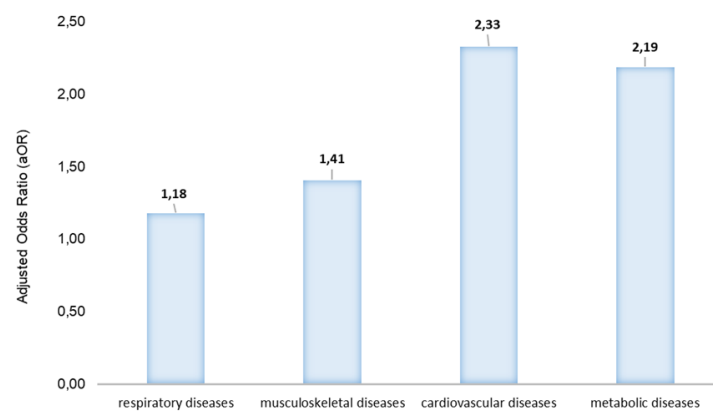


Figure 2: Increased risk of disease development in cases of overweight and obesity. Overweight or obesity as a risk factor in increasing the chance of developing diseases, after (Pataki et al., 2023)

4.3 The role of a healthy diet in maintaining a normal body weight

Acquiring nutrition knowledge is crucial as healthy eating supports normal growth, a healthy pregnancy, and maintain a healthy body weight, contributing to overall well-being (Ekesa et al., 2017). Recommendations for a healthy diet are available in various sources: Skerrett and Willet outline fundamental dietary strategies for women that promote health across all life stages, emphasizing nutrient-rich foods like unsaturated fats, whole grains, and fruits and vegetables, while limiting unhealthy fats, refined grains, and sugary drinks, complemented by multivitamin supplementation (Skerrett and Willet, 2010). Proscia discusses how the MyPlate educational tool, originally designed for the general public, has inspired the creation of a specialized version tailored to the unique and complex nutritional needs of patients with chronic kidney disease undergoing dialysis (Proscia, 2014). Szűcs emphasizes that strong scientific evidence supports the benefits of dietary diversity, advocating for a flexible combination of various food groups to achieve healthy eating without excluding any food category, while considering individual needs, preferences, and cultural traditions (Szűcs, 2016). Following these guidelines can lead to lifestyle changes that help treat obesity. The Hungarian smart plate (OKOSTÁNYÉR, 2024a), for example, emphasizes the consumption of vegetables, fruits, whole grains, and healthy protein sources (meat, fish, dairy, eggs). It also highlights the importance of drinking water, minimizing salt, sugar, and fat intake, and maintaining a varied diet and regular exercise (OKOSTÁNYÉR, 2024b).

5. Conclusions

Obesity is a major global public health issue, primarily caused by an imbalance between energy intake and expenditure. It compromises the immune system and, in severe cases, increases the risk of mortality. Acquiring knowledge about healthy nutrition and implementing long-term lifestyle changes are essential for both the prevention and management of obesity. To accurately determine individual nutritional requirements, it is recommended to consult a registered dietitian. There are now numerous approaches to promoting healthy eating. These include educational lectures, both verbal and written informational materials. Furthermore, many healthcare institutions emphasize health promotion and the management of obesity. Among their initiatives are programs that promote healthy foods, support groups focused on obesity-related topics, recipe exchanges for low-energy meals, physical activity programs, and health screenings. In addition to the essential contributions of medical specialists, a range of healthcare professionals - including dietitians or nutritionists, physiotherapists, and psychologists - also play a significant role in combating obesity. Each of these professionals has a crucial role in the effective treatment of obesity.

References

- Ahmed M.H., Vasas D., Hassan A., Molnár, J., 2022, The Impact of Functional Food in Prevention of Malnutrition. *PharmaNutrition*, 19, 100288. <https://doi.org/10.1016/j.phanu.2022.100288>.
- An R., 2020, Projecting the impact of the coronavirus disease – 2019 pandemic on childhood obesity in the United States: A microsimulation model. *Journal of Sport and Health Science*, 9, 302-312, <https://doi.org/10.1016/j.jshs.2020.05.006>.
- Andreoli B., Mantovani A., Andreoli C., 2020, Type 2 Diabetes, sarcopenic obesity and Mediterranean food pattern: Considerations about the therapeutic effect and the problem of maintaining weight loss and healthy habits. The outpatient experience of two clinical cases. *Journal of Clinical and Translational Endocrinology: Case Reports*, 16, 1-7, <https://doi.org/10.1016/j.jecr.2020.100061>.
- Ádám V., 2004, Orvosi Biokémia (Medical biochemistry). *Medicina Könyvkiadó Rt., Budapest*. 126, 143. ISBN: 9632429028.
- Brown O.I., Drozd M., McGowan H., Giannoudi M., Conning-Rowland M., Gierula J., Straw S., Wheatcroft S.B., Bridge K., Roberts L.D., Levelt E., Ajjan R., Griffin K.J., Bailey M.A., Kearney M.T., Cubbon R.M., 2023, Relationship Among Diabetes, Obesity, and Cardiovascular Disease Phenotypes: A UK Biobank Cohort Study. *Diabetes Care*, 46(8), 1531-1540, <https://doi.org/10.2337/dc23-0294>.
- Ekesa B., Johnson V., Kennedy G., Nabuuma D., Van den Bergh I., Ocimati W., 2017, A community Resource Persons' Training Guide: Improving Food and Nutrition Security through Banana-based Farming System and Foods. *International Society of Horticultural Science, Bioversity International*, 74 ps., ISBN: 978-94-6261-146-7.
- Ellison B., Prescott M.F., 2021, Examining Nutrition and Food Waste Trade-offs Using an Obesity Prevention Context. *Journal of Nutrition Education and Behavior*, 53, 434-444, <https://doi.org/10.1016/j.jneb.2020.11.005>.
- Fagunwa O.E., 2021, Child obesity prevention: Nigerian children and adolescents have fair knowledge of obesity. *Human Nutrition & Metabolism*, 23, 1-6, <https://doi.org/10.1016/j.hnm.2020.200117>.
- Faulkner M.S., Michaliszyn S.F., 2021, Exercise Adherence in Hispanic Adolescents with Obesity or Type 2 Diabetes. *Journal of Pediatric Nursing*, 56, 7-12, <https://doi.org/10.1016/j.pedn.2020.09.012>.
- Fruh S.M., 2017, Obesity: Risk factors, complications, and strategies for sustainable long-term weight management. *J. Am. Assoc. Nurse Pract.*, 29(S1), S3-S14, <https://doi.org/10.1002/2327-6924.12510>.
- Gaesser G.A., Angadi S.S., 2021, Obesity treatment: weight loss versus increasing fitness and physical activity for reducing health risks. *iScience*, 24(10), 102995, <https://doi.org/10.1016/j.isci.2021.102995>.
- Joo Y.H., Chung N., Lee Y.K., 2020, Anti-obesity effect of fresh and browned Magnolia denudata flowers in a high fat murine model. *Journal of Functional Food*, 75, 1-10, <https://doi.org/10.1016/j.jff.2020.104227>.
- Khanna D., Khanna S., Khanna P., Kahar P., Patel B.M., 2022, Obesity: A Chronic Low-Grade Inflammation and Its Markers. *Cureus*, 14(2), e2271, <https://doi.org/10.7759/cureus.22711>.
- Khanolkar A.R., Patalay P., 2021, Socioeconomic inequalities in co-morbidity of overweight, obesity and mental ill-health from adolescence to mid-adulthood in two national birth cohort studies. *The Lancet Regional Health-Europe*, 6, 1-9, <https://doi.org/10.1016/j.lanepe.2021.100106>.
- Klop B., Elte J.W.F., Cabezas M.C., 2013, Dyslipidemia in obesity: mechanisms and potential targets. *Nutrients*, 12;5 (4), 1218-1240, <https://doi.org/10.3390/nu5041218>.
- Korac B., Kalezić A., Peković-Vaughan V., Korac A., Janković A., 2021, Redox changes in obesity, metabolic syndrome, and diabetes. *Redox Biology*, 42, 1-17, <https://doi.org/10.1016/j.redox.2021.101887>.
- Marbaniang S.P., Lhungdim H., Yadav B., Yajurvedi V.K., 2021, Overweight/obesity risks and prevalence of diabetes and hypertension in North Eastern India: An analysis using seemingly unrelated probit model. *Clinical Epidemiology and Global Health*, 11, 1-8, <https://doi.org/10.1016/j.cegh.2021.100764>.

- Moholdt T., Hawley J.A., 2020, Maternal Lifestyle Interventions: Targeting Preconception Health. Trends in Endocrinology & Metabolism, 31, 561-569, <https://doi.org/10.1016/j.tem.2020.03.002>.
- Nieman D.C., 2020, Coronavirus disease -2019: A tocsin to our aging, unfit, corpulent, and immune-deficient society. Journal of Sport and Health Science, 9, 293-301, <https://doi.org/10.1016/j.jshs.2020.05.001>.
- Nkosi V., Shirinde J., Rathogwa-Takalani F., Voyi K., 2021, High blood pressure and exposure to dust from gold mine dumps among the elderly in South Africa: A cross-sectional study. Public Health in Practice, 2, 1-5, <https://doi.org/10.1016/j.puhip.2021.100146>.
- Novosad S., Khan S., Wolfe B., Khan A., 2013, Role of Obesity in Asthma Control, the Obesity-Asthma Phenotype. Journal of Allergy, 94, 1-9, <https://doi.org/10.1155/2013/538642>.
- OKOSTÁNYÉR, 2024a, Hungarian National Association of Dietitians. <https://www.okostanyer.hu/>, accessed 15.09.2024.
- OKOSTÁNYÉR, 2024b, OKOSTÁNYÉR https://www.okostanyer.hu/wp-content/uploads/2021/11/OKOSTANYER_felnott_A4_2021.pdf, accessed 08.07.2024.
- Pataki J., Hankovszki A.D., Szöllősi G.J., 2023, A túlsúly és elhízás előfordulási gyakorisága, illetve kockázati szerepe a nemfertőző betegségek kialakulásában az Európai lakossági egészségfelmérés adatai alapján. (The Prevalence of Overweight and Obesity and Their Role as Risk Factors in the Development of Non-Communicable Diseases Based on Data from the European Health Interview Survey.) University of Debrecen, Faculty of Health Sciences, Health Innovation Review, 2(1), 68-76.
- Payab M., Kelishadi R., Qorbani M., Motlagh M.E., Ranjbar S.H., Ardalan G., Zahedi H., Chinian M., Asayesh H., Larijani B., Heshmat R., 2015, Association of junk food consumption with high blood pressure and obesity in Iranian children and adolescents: the CASPIAN-IV study. Journal de Pediatria, 91, 196-205, <https://doi.org/10.1016/j.jped.2014.07.006>.
- Proscia A., 2014, MyPlate for Healthy Eating With Chronic Kidney Disease (MyPlate Education for Patients With Chronic Kidney Disease Receiving Hemodialysis and Peritoneal Dialysis Treatment). Journal of Renal Nutrition, 24, e23-e25, <https://doi.org/10.1053/j.jrn.2014.02.003>.
- Pulgaron E.R., Delamater A.M., 2014, Obesity and type 2 diabetes in children: epidemiology and treatment. Curr Diab Rep., 14(8), 508, <https://doi.org/10.1007/s11892-014-0508-y>.
- Rizza S., Federici M., 2020, Night shift work, obesity and cardio-metabolic risk. Endocrine and Metabolic Science, 1, 3-4, <https://doi.org/10.1016/j.endmts.2020.100069>.
- Romieu I., Dossus L., Barquera S., Blotière H.M., Franks P.W., Gunter M., Hwalla N., Hursting S.D., Leitzmann M., Margetts B., Nishida C., Potischman N., Seidell J., Stepien M., Wang Y., Westerterp K., Winichagoon P., Wiseman M., Willett W.C., 2017, Energy balance and obesity: what are the main drivers? Cancer Causes Control, 28(3), 247-258, <https://doi.org/10.1007/s10552-017-0869-z>.
- Ruban A., Stoenchev K., Ashrafian H., Teare J., 2019, Current treatments for obesity. Clin. Med. (Lond.), 19(3), 205-212, <https://doi.org/10.7861/clinmedicine.19-3-205>.
- Sharma J.R., Yadav U.C.S., 2021, COVID-19 severity in obese patients: Potential mechanisms and molecular targets for clinical intervention. Obesity Research & Clinical Practice, 15, 163-171, <https://doi.org/10.1016/j.orcp.2021.01.004>.
- Silva A.O., Silva M.V., Pereira L.K.N., Feitosa W.M.N., Ritti-Dias R.M., Diniz P.R.B., Oliveira L.M.F.T., 2016, Association between general and abdominal obesity with high blood pressure: difference between genders. Journal de Pediatria, 92(2), 174-180, <https://doi.org/10.1016/j.jped.2015.05.007>.
- Silva da J.A., Souza de E.C.F., Echazú Böschmeier A.G., Costa da C.C.M., Bezerra H.S., Feitosa E.E.L.C., 2018, Diagnosis of diabetes mellitus and living with a chronic condition: participatory study. BMC Public Health, 18, 699, <https://doi.org/10.1186/s12889-018-5637-9>.
- Skerrett P.J., Willett W.C., 2010, Essentials of Healthy Eating: A Guide. Journal of Midwifery & Women's Health, 55(6), 492-501, <https://doi.org/10.1016/j.jmwh.2010.06.019>.

- Sukkriang N., Chanprasertpinyo W., Wattanapisit A., Punsawad C., Thamrongrat N., Sangpoom S., 2021, Colleration of body visceral fat rating with serum lipid profile and fasting blood sugar in obese adults using a noninvasive machine. Heliyon, 7, 1-7, e06264, <https://doi.org/10.1016/j.heliyon.2021.e06264>.
- Szűcs Zs., 2016, OKOSTÁNYÉR – Új táplálkozási ajánlás a hazai felnőtt lakosság számára. (SMART PLATE - New dietary guidelines for the hungarian adult population), Új Diéta, 25(2-3), 20-23.
- Tani S., Matsuo R., Imatake K., Suzuki Y., Takahashi A., Matsumoto N., 2020, Association of daily fish intake with serum non-high-density lipoprotein cholesterol levels and healthy lifestyle behaviours in apparently healthy male over the age of 50 years in Japanese. Implication for the anti-atherosclerotic effect of fish consumption. Nutrition, Metabolism & Cardiovascular Diseases, 30(2), 190-200, <https://doi.org/10.1016/j.numecd.2019.09.019>
- Tóth G.A., 2015, Gyermekkori elhízás - állítsuk meg a lavinát! (Childhood Obesity – Halting the Growing Epidemic!) In: Módszertani irányok a pedagógusképzés fejlesztésében Nyugat-Dunántúlon, University of West Hungary, Regional Centre for Pedagogical Services and Research, Szombathely, 183-192, ISBN 978-963-359-054-6.
- Tóth G.A., Suskovics Cs., 2013, Iskoláskorú gyermekek testtömeg-indexének változásai (Körmend, Kaposvár), (Trends in Body Mass Index Among School-Aged Children) Conference: Cultural, Social, and Biological Factors in Public Education, at: Komárom – Komarno Volume: 1. Scientific Study Volume of the Department of Educational Sciences and the Department of Biology, Faculty of Education, J. Selye University, Komárno, Slovakia.
- Tunkara-Bah H., Badjan H.J., Senghore T., 2021, Dietary factors associated with being overweight and obese among school-going adolescents in Region One, The Gambia. Heliyon, 7(3), e06486, <https://doi.org/10.1016/j.heliyon.2021.e06486>.
- WHO, 2024, Body mass index (BMI). <https://www.who.int/data/gho/data/themes/topics/topic-details/GHO/body-mass-index>, accessed 15.09.2024.
- World Obesity Federation, 2024, Obesity Classification. <https://www.worldobesity.org/about/about-obesity/obesity-classification>, accessed 08.07.2024.
- Yao Y., Chen D-Y., Yin J-W., Thou L., Cheng J-Q., Lu S-Y., Li H-H., Wen Y., Wu Y., 2020, Phthalate expouse linked to high blood pressure in Chinese children. Environment International, 143, 1-8, <https://doi.org/10.1016/j.envint.2020.105958>.
- Yeung S., Soliternik J., Mazzola N., 2018, Nutritional supplements for the prevention of diabetes mellitus and its complications. Journal of Nutrition & Intermediary Metabolism, 14, 16-21, <https://doi.org/10.1016/j.jnim.2018.07.003>.