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CURRENT TREATMENT STRATEGIES FOR OBESITY: PHARMACOLOGICAL AND NON-PHARMACOLOGICAL APPROACHES

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ABSTRACT

Obesity is a complex, chronic, relapsing, and progressive metabolic disease marked by abnormal or excessive adipose tissue accumulation that presents significant risks to health and longevity. Once underestimated, obesity has now reached epidemic proportions globally, with the World Health Organization estimating over 650 million adults affected. It is a major contributor to the development of non-communicable diseases (NCDs) such as type 2 diabetes mellitus (T2DM), cardiovascular disease, non-alcoholic fatty liver disease (NAFLD), certain cancers, and osteoarticular disorders, and is associated with increased all-cause mortality.

AIM OF THE STUDY:

To provide a comprehensive review of contemporary and emerging strategies for the management of obesity, a complex chronic disease with rising global prevalence. The study focuses on evaluating the efficacy of lifestyle interventions, pharmacotherapy, bariatric surgery, and the role of emerging technologies such as digital health platforms and precision medicine.

MATERIALS AND METHODS:

This narrative review synthesizes data from major clinical trials, meta-analyses, and guideline-based recommendations published between 2015 and 2024. Sources include PubMed, the New England Journal of Medicine, and official WHO/ADA/EASO and AACE guidance. Key focus was placed on randomized controlled trials evaluating GLP-1 receptor agonists, dual and triple gut hormone therapies, surgical outcomes, and digital intervention models.

RESULTS:

Lifestyle modification remains the foundation of obesity care, with hypocaloric diets and physical activity yielding 5–10% weight reduction. Pharmacologic therapies, including liraglutide, semaglutide, tirzepatide, and retatrutide, have demonstrated superior efficacy (8–24% weight loss) and metabolic benefits. Bariatric procedures such as Roux-en-Y gastric bypass achieve T2DM remission rates >60% and sustained cardiovascular improvement. Digital health interventions (e.g., AI-based coaching, remote CBT) and genomic-based personalization are expanding accessibility and long-term success. Combination therapies targeting neurohormonal pathways represent a paradigm shift in treatment.

CONCLUSIONS:

Obesity management requires a multidisciplinary, lifelong approach that integrates lifestyle counseling, pharmacologic innovations, surgical options, and emerging precision tools. Advances in gut hormone–based pharmacotherapy and digital health are reshaping the therapeutic landscape, offering personalized and scalable strategies to improve outcomes in 2024 and beyond.

Keywords: Obesity; pharmacotherapy; GLP-1; tirzepatide; bariatric surgery; digital health; precision medicine; gut hormones; behavioral therapy; weight management.

INTRODUCTION

The prevalence of obesity has tripled worldwide since 1975, with the World Health Organization (WHO) estimating that over 650 million adults are obese [1]. This alarming trend spans across all age groups and income levels, marking obesity as one of the most pervasive and rapidly escalating public health challenges of the 21st century.

Obesity represents an escalating public health issue in Poland, mirroring global trends but with distinct national implications. Recent data indicate that more than 25 % of Polish adults meet the criteria for obesity, highlighting a significant and growing burden on the healthcare system [2]. Furthermore, national surveys reveal that 62 % of adult men and 43 % of women are overweight, with 16 % of men and 12 % of women classified as obese based on BMI thresholds [3]. These figures underscore the urgent need for comprehensive prevention strategies and evidence-based interventions tailored to the Polish population.

The pathophysiology of obesity is notably complex and multifactorial, involving an interplay of genetic predisposition, neurohormonal dysregulation, epigenetic modifications, environmental influences, behavioral drivers, and the composition of the gut microbiota [4]. These interacting systems contribute not only to increased energy intake and decreased expenditure, but also to the persistence and relapse of weight gain, rendering obesity a chronic relapsing disease rather than a mere lifestyle issue.

Below is a summary table of the main obesity classification systems used in clinical research and practice.

Table 1. The main obesity classification systems.

Classification	Criteria/Basis	Subtypes/ Stages	Application
BMI-Based (WHO)	Body Mass Index (BMI ≥30 kg/m²)	Class I (30–34.9), II (35–39.9), III (≥40)	Epidemiology, basic diagnostic screening
Edmonton Obesity Staging System (EOSS)	Functional and metabolic consequences of excess adiposity	Stages 0–4 (from no complications to severe disability)	Risk stratification, prognosis, treatment planning
Phenotypic	Metabolic status, muscle mass, fat distribution pattern	MHO, MUO, sarcopenic, visceral, etc.	Individualized therapy, drug selection, metabolic risk assessment
Etiological	Underlying cause of obesity (exogenous, genetic, endocrine disorders)	Exogenous, monogenic, syndromic, secondary	Diagnostic clarification, genetic or endocrine evaluation

Fat Distribution Pattern	Anthropometric markers (waist circumference, waist-to-hip ratio)	Abdominal (android), gluteofemoral (gynoid)	Cardiovascular and metabolic risk evaluation

Obesity is a heterogeneous condition with distinct phenotypes that influence treatment response. These include:

- **Visceral (central) obesity**, associated with higher cardiometabolic risk;
- **Sarcopenic obesity**, characterized by loss of muscle mass alongside fat accumulation, often seen in older adults;
- **Metabolically healthy obesity (MHO)**, where individuals may have normal insulin sensitivity and lipid profiles despite elevated BMI;
- **Monogenic and syndromic obesity**, caused by rare genetic mutations (e.g., MC4R, LEPR) requiring targeted interventions such as MC4R agonists.
  Recognizing these phenotypes helps tailor therapeutic strategies and improve outcomes.

Despite being classified as a preventable and treatable condition, obesity remains significantly underdiagnosed and undertreated in clinical practice. One contributing factor is the reliance on simplistic anthropometric cutoffs such as Body Mass Index (BMI ≥30 kg/m²), which, although practical, fails to capture the heterogeneity of fat distribution, body composition, and metabolic risk.

A more nuanced diagnostic approach should include:

- Waist circumference and waist-to-hip ratio to assess visceral adiposity,
- Evaluation of body fat percentage when possible (e.g., via bioimpedance or DXA) [3],
- Screening for obesity-related metabolic comorbidities such as insulin resistance, hypertension, dyslipidemia, obstructive sleep apnea, NAFLD, and polycystic ovary syndrome (PCOS),
- Consideration of psychosocial impact, eating behaviors, and quality of life.

Obesity diagnosis and staging frameworks such as the Edmonton Obesity Staging System (EOSS) are increasingly advocated, as they move beyond BMI alone and stratify patients based on the functional and medical impact of excess adiposity, helping guide personalized treatment decisions and risk prediction [6].

METHODS

This narrative review synthesizes literature published between 2015 and 2024, sourced from databases including PubMed, Medline, NEJM, and official guidance from WHO, ADA, EASO, and AACE. Search terms included 'obesity treatment', 'GLP-1', 'tirzepatide', 'pharmacotherapy', 'lifestyle modification', and 'bariatric surgery'. Studies were selected based on relevance, quality, and clinical impact.

The following sections summarize key evidence and clinical insights from the reviewed literature, structured by therapeutic modality, including lifestyle interventions, pharmacologic options, surgical approaches, and emerging technologies.

CURRENT AND EMERGING TREATMENT STRATEGIES FOR OBESITY

Obesity treatment has evolved substantially in recent years, incorporating a wide range of lifestyle-based, pharmacologic, surgical, and technology-driven approaches. The following sections provide a structured overview of these modalities based on the latest clinical evidence.

1. LIFESTYLE MODIFICATION

Lifestyle intervention, including dietary changes, physical activity, and behavioral strategies, is the cornerstone of obesity treatment. Hypocaloric diets (energy deficit of 500–800 kcal/day) are associated with modest weight loss of 5–10% over six months, often sufficient to improve glycemic control and lipid profiles [7]. Structured programs emphasize increased consumption of plant-based foods, lean protein, and soluble fiber, while limiting saturated fats and ultra-processed foods. The Mediterranean and DASH diets are widely endorsed by clinical guidelines for cardiometabolic risk reduction.

Physical activity recommendations include 150–300 minutes of moderate-intensity aerobic exercise weekly, combined with resistance training to preserve muscle mass. However, adherence is often limited by

psychosocial and environmental barriers. Behavioral therapy, including cognitive behavioral therapy (CBT), motivational interviewing, and self-monitoring, enhances adherence and promotes sustained behavioral change [8,9]. Group sessions and digital interventions (apps, virtual coaching) have also shown efficacy.

2. PHARMACOLOGIC MANAGEMENT

Current clinical practice guidelines from the ADA (2023), EASO (2022), and AACE (2023) recommend early use of GLP-1 receptor agonists and dual/triple incretin-based therapies for chronic weight management, particularly in patients with cardiometabolic risk. [10, 11,12]

Pharmacologic therapy plays a key role in the long-term management of obesity, particularly for individuals who do not respond adequately to lifestyle interventions alone. According to current guidelines, anti-obesity medications are indicated for patients with a BMI ≥30 kg/m², or ≥27 kg/m² if accompanied by obesity-related comorbidities such as type 2 diabetes, dyslipidemia, or hypertension.

Among agents approved for long-term use, several have emerged with varying mechanisms of action, efficacy profiles, and tolerability:

2.1. Orlistat – Lipase Inhibition

Orlistat is a reversible gastrointestinal lipase inhibitor that reduces the hydrolysis and absorption of dietary fats by approximately 30% [13]. It is non-systemic and functions locally in the gastrointestinal tract. Orlistat is the only anti-obesity drug available over-the-counter in lower-dose form (60 mg).

- Efficacy: Clinical trials report modest weight loss (~3–5%), but it has also demonstrated improvements in LDL cholesterol and blood pressure.
- Limitations: Its use is often restricted by gastrointestinal side effects, including steatorrhea, fecal urgency, and flatulence, particularly in high-fat diets [13].

2.2. GLP-1 Receptor Agonists – Satiety and Glycemic Control

Liraglutide (3.0 mg daily, Saxenda)

A daily injectable GLP-1 receptor agonist, liraglutide enhances insulin secretion, delays gastric emptying, and promotes satiety. It is approved for chronic weight management and shares the mechanism with its antidiabetic counterpart, Victoza.

- Efficacy: Average weight loss of 8–10% has been observed in multiple phase III trials [14].
- Considerations: Side effects include nausea and vomiting, which are typically transient. It also offers benefits in glycemic control and cardiometabolic risk reduction.

Semaglutide (2.4 mg weekly, Wegovy) – Supported by the STEP clinical trial series and the SELECT cardiovascular outcomes trial [15,16]

Semaglutide is a long-acting GLP-1 analog administered once weekly. It demonstrated superior efficacy in the STEP 1 trial, where participants achieved mean weight loss of 14.9% over 68 weeks [17].

The SELECT trial (NEJM, 2023) further demonstrated semaglutide's benefits, showing a 20% reduction in major adverse cardiovascular events in adults with overweight or obesity and pre-existing cardiovascular disease, regardless of diabetes status.[16]

- Mechanism: Like liraglutide, it suppresses appetite and delays gastric emptying, but with longer half-life and improved tolerability.
- Impact: It represents one of the most potent non-surgical interventions to date, often considered a pharmacologic alternative to bariatric procedures in select populations [17].

2.3. Centrally Acting Agents – Appetite and Reward Modulation

- Naltrexone/Bupropion (Mysimba)

This oral fixed-dose combination works on both the hypothalamic melanocortin system (via bupropion, a dopamine/norepinephrine reuptake inhibitor) and the mesolimbic reward pathway (via naltrexone, an opioid antagonist) [18].

- Efficacy: Clinical trials report average weight loss of 5–9%.

- Benefits: Also offers potential support in patients with binge eating disorder or food-related compulsivity.
- Limitations: Includes risk of elevated blood pressure, nausea, and neuropsychiatric side effects in some populations [18].

2.4. Phentermine/Topiramate (Qsymia)

Approved in the United States, this combination comprises phentermine (a centrally acting sympathomimetic) and topiramate (an anticonvulsant with appetite-suppressing effects).

- Mechanism: Suppresses appetite, prolongs satiety, and may reduce hedonic drive to eat.
- Efficacy: Demonstrated average weight loss of 8–10% in pivotal trials.
- Concerns: Use is limited due to potential cardiovascular risks, teratogenicity, and regulatory restrictions in many countries [13].

2.5. Clinical Integration

While these agents provide clinically meaningful weight loss, none function as stand-alone solutions. Their effectiveness is maximized when integrated with:

- structured lifestyle modification,
- personalized nutritional planning,
- and ongoing behavioral support.

Drug selection should always consider individual comorbidities, preferences, cost, route of administration, and contraindications.

3. BARIATRIC AND METABOLIC SURGERY

For individuals with severe obesity—defined as BMI ≥40 kg/m² or ≥35 kg/m² with obesity-related comorbidities such as type 2 diabetes (T2DM), obstructive sleep apnea, or hypertension—bariatric surgery remains the most effective and durable intervention available. It not only leads to substantial and sustained weight loss, but also results in significant improvements in metabolic health, quality of life, and overall survival.

3.1. Most Common Procedures: RYGB and Sleeve Gastrectomy

The two most frequently performed bariatric procedures are:

- Roux-en-Y gastric bypass (RYGB): a combined restrictive and malabsorptive procedure that involves creating a small gastric pouch and bypassing a portion of the small intestine.
- Sleeve gastrectomy (SG): a purely restrictive procedure that involves the surgical removal of ~80% of the stomach, resulting in a narrow, sleeve-shaped gastric tube.
- Both procedures produce profound neurohormonal effects, including:
- ↓ Ghrelin (the "hunger hormone") due to resection of ghrelin-producing gastric fundus
- ↑ GLP-1 and PYY secretion, leading to enhanced satiety and improved glycemic control
- Altered gut-brain signaling that modulates appetite and energy expenditure [19]

3.2. Clinical Outcomes and Metabolic Remission

Multiple longitudinal studies have confirmed that bariatric surgery can induce remission of T2DM in more than 60% of patients, particularly following RYGB [20]. Moreover, surgery is associated with:

- Improved insulin sensitivity and beta-cell function
- Reduction or discontinuation of antihypertensive and lipid-lowering medications
- Significant reductions in cardiovascular events and all-cause mortality [20]

3.3. Safety Advances: ERAS Protocols and Minimally Invasive Approaches

The widespread implementation of Enhanced Recovery After Surgery (ERAS) protocols has optimized perioperative care and significantly reduced complication rates, hospital stays, and recovery time. In parallel, the use of laparoscopic techniques has made procedures less invasive and more accessible to broader patient populations [21].

Key ERAS components include:

- Early mobilization
- Multimodal analgesia (opioid-sparing)
- Preoperative nutrition support
- Early reintroduction of oral intake

Given the robust evidence base, bariatric surgery should be considered not as a last resort, but as an integral component of the multimodal obesity treatment continuum—particularly for patients with uncontrolled metabolic disease or failure of pharmacotherapy. Long-term follow-up, dietary support, and micronutrient monitoring remain essential.

4. NEW THERAPEUTIC ADVANCES

Recent breakthroughs in pharmacotherapy have led to the development of highly effective agents that replicate or amplify the physiological effects of gastrointestinal hormones involved in appetite regulation, satiety, insulin secretion, and energy homeostasis. These agents offer surgical-level efficacy in selected populations, marking a paradigm shift in the pharmacological management of obesity.

4.1. Tirzepatide: Dual GIP and GLP-1 Receptor Agonism

Tirzepatide is the first-in-class dual incretin receptor agonist, simultaneously activating glucose-dependent insulinotropic polypeptide (GIP) and glucagon-like peptide-1 (GLP-1) receptors. This dual action results in synergistic effects on insulin secretion, delayed gastric emptying, and appetite suppression.

In the pivotal SURMOUNT-1 trial, tirzepatide led to an average weight reduction of 21% in adults with obesity without diabetes over 72 weeks [22]. Additionally, significant improvements were observed in glycemic control, blood pressure, lipid profile, and waist circumference, positioning tirzepatide as one of the most potent non-surgical interventions to date.

4.2. Retatrutide: The Triple Agonist

Retatrutide, currently in phase 2 clinical development, targets three metabolic receptors: GIP, GLP-1, and glucagon receptors. This triple agonism enhances satiety, improves insulin sensitivity, and increases energy expenditure via glucagon-mediated thermogenesis and lipolysis.

Early clinical trial data reported mean body weight reductions of up to 24.2% over 48 weeks—comparable to or exceeding outcomes typically achieved through bariatric surgery [23]. In addition to weight loss, patients experienced significant improvements in markers of liver health (NAFLD), inflammation, and cardiometabolic risk.

4.3. Amylin Analogs and MC4R Agonists: New Mechanistic Pathways

The next wave of anti-obesity medications involves targeting neuroendocrine regulators beyond incretins:

- Amylin analogs (e.g., cagrilintide) mimic the satiety-promoting effects of amylin, a hormone co-secreted with insulin by pancreatic β-cells. When combined with GLP-1 receptor agonists, they exhibit additive effects on weight loss and appetite control [24].
- Melanocortin-4 receptor (MC4R) agonists act centrally to regulate appetite and energy balance. These agents have shown remarkable efficacy in patients with monogenic obesity syndromes (e.g., POMC or LEPR deficiency), and are being studied in broader populations [25].

These hormone-based therapies represent a shift toward personalized, mechanism-driven obesity treatment. For patients who are ineligible or unwilling to undergo bariatric surgery, these agents offer minimally invasive alternatives with substantial metabolic benefits. Importantly:

- Many of these drugs are well tolerated, with gastrointestinal side effects being the most common (and often transient).
- Long-term safety, cost-effectiveness, and real-world adherence remain active areas of investigation.

5. PRECISION AND DIGITAL MEDICINE

Modern obesity management is rapidly evolving through the integration of digital technologies and personalized

medicine, aiming to improve treatment precision, long-term adherence, and patient engagement.

5.1. Digital Platforms: Enhancing Adherence and Behavioral Change

Digital health innovations have significantly transformed the delivery of obesity interventions. These tools include:

- Telemedicine and remote consultations, increasing access to specialized care regardless of location.
- AI-powered mobile applications that track dietary intake, physical activity, sleep, and emotional triggers.
- Wearable devices (e.g., smartwatches and fitness bands) that continuously monitor metrics such as heart rate, steps, and energy expenditure.
- Virtual behavioral therapy platforms, which deliver cognitive-behavioral interventions and motivational coaching.

Programs like Noom and Klinio successfully integrate nutritional tracking, psychological support, and habit-building strategies, resulting in better user retention and sustainable weight outcomes [26].

5.2. Precision Medicine: Genomics and Gut Microbiome Modulation

Concurrently, precision medicine is emerging as a powerful tool in tailoring obesity treatments based on individual biological differences.

- Pharmacogenomics allows for treatment customization based on genetic variants. For instance:
  - The FTO gene (fat mass and obesity–associated gene) is linked to increased obesity risk and may affect response to lifestyle interventions.
  - Mutations in MC4R and LEPR genes influence satiety signaling and pharmacologic responsiveness [27].
- Gut microbiota modulation is gaining traction due to its role in energy balance, inflammation, and insulin sensitivity. Dysbiosis—a disruption in gut microbial diversity—is associated with obesity and metabolic syndrome. Approaches like high-fiber diets, prebiotics/probiotics, and fecal microbiota transplantation (FMT) may enhance treatment efficacy and reduce weight regain [28].

To provide a structured framework for the subsequent analysis, Table 2 provides a comparative overview of major treatment strategies discussed in this review, including their mechanisms of action, efficacy, and clinical considerations.

Table 2. Comparative Overview of Obesity Treatment Modalities

Treatment Modality	Mechanism of Action	Average Weight Loss	Key Advantages	Limitations / Risks
Lifestyle Modification	Caloric deficit, increased energy expenditure	5–10 %	Widely accessible, improves comorbidities	Limited long-term adherence
GLP-1 Receptor Agonists	Appetite suppression, delayed gastric emptying	8–15 %	Effective, improves glycemia and CVD risk	GI side effects, cost, injection route
Tirzepatide / Retatrutide	Dual/triple incretin effect, metabolic modulation	15–24 %	Near-surgical efficacy, multi-hormonal	Long-term safety under investigation
Bariatric Surgery (RYGB/SG)	Restriction, malabsorption, hormonal changes	25–35 % (EWL)	Durable remission of T2DM and CVD outcomes	Invasive, surgical risks, micronutrient deficiency

Digital & Precision Medicine	Behavior tracking, AI-guided support, genomics	5–10 % (adjunctive)	Personalized, scalable, supports adherence	Access, privacy, variable clinical validation

These insights enable the development of highly individualized treatment strategies, optimizing both clinical effectiveness and long-term outcomes.

RESULTS AND DISCUSSION

The following section synthesizes key findings from the reviewed literature and discusses their clinical implications. Results are organized by treatment modality to highlight comparative efficacy, safety, and applicability in different patient populations.

1. LIFESTYLE MODIFICATION

Randomized trials confirm that hypocaloric diets combined with physical activity yield an average 5–10% reduction in baseline body weight within 6 months, which is sufficient to improve glycemic control, lipid profiles, and blood pressure in many patients[29]. Behavioral therapy significantly improves adherence, with digital CBT platforms further enhancing long-term engagement and weight maintenance [30]

2. PHARMACOLOGIC INTERVENTIONS

Recent anti-obesity medications demonstrate clinically meaningful weight loss:

Liraglutide 3.0 mg (GLP-1 agonist): Mean weight loss of 8.0% at 56 weeks [31]

Semaglutide 2.4 mg: In the STEP 1 trial, adults with obesity lost 14.9% of body weight over 68 weeks [32].

The SELECT trial, conducted by Lincoff et al. (2023), confirmed semaglutide's cardiovascular benefit in adults with overweight or obesity and established cardiovascular disease but without diabetes, showing a 20 % relative reduction in major adverse cardiovascular events (hazard ratio 0.80; 95 % CI 0.72–0.90; $p < 0.001$). [16]

Tirzepatide 15 mg: Demonstrated 21.1% mean weight loss at 72 weeks in the SURMOUNT-1 trial, along with improvements in blood pressure, HbA1c, and waist circumference [33]

Retatrutide (GIP/GLP-1/glucagon agonist): In a Phase II trial, showed up to 24.2% weight loss over 48 weeks, with substantial metabolic improvements [34].

Combination agents such as phentermine/topiramate and naltrexone/bupropion show 5–10% weight loss, but with a higher incidence of central nervous system and cardiovascular side effects [35]

3. BARIATRIC SURGERY

Bariatric surgery remains the most effective intervention for severe obesity:

Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy (SG) achieve mean excess weight loss of 60–70% and type 2 diabetes remission in over 60% of patients [36]

Cardiovascular risk reduction, improved insulin sensitivity, and decreased use of antihypertensive and lipid-lowering medications are consistently reported.

Enhanced Recovery After Surgery (ERAS) protocols and laparoscopic techniques have reduced perioperative complication rates to under 5% [37]

4. EMERGING AND EXPERIMENTAL THERAPIES

Amylin analog cagrilintide, when combined with semaglutide, showed synergistic weight loss effects in early-phase trials [38]

Setmelanotide, an MC4R agonist, led to significant weight reduction in rare genetic obesity syndromes like LEPR or POMC deficiency [39]

5. DIGITAL HEALTH AND PRECISION MEDICINE

AI-powered mobile applications and wearable trackers have improved self-monitoring and adherence. Programs

like Noom and Klinio demonstrated increased user retention and a 5–7% average weight loss [39]. Microbiome-modulating interventions and pharmacogenomic profiling are enabling personalized obesity care, particularly in patients with monogenic traits or metabolic heterogeneity [40].

Taken together, the reviewed evidence highlights significant progress in obesity treatment across behavioral, pharmacologic, surgical, and digital domains. Despite these advances, long-term effectiveness remains dependent on individualized care, sustained adherence, and integration of emerging tools. These insights inform the following conclusions regarding future directions in obesity management.

CONCLUSION

Obesity is a chronic, multifactorial disease requiring sustained, multidisciplinary care. While lifestyle modification remains foundational, it is often insufficient alone. Recent pharmacologic advances, particularly GLP-1 receptor agonists, dual and triple incretin therapies, and agents like tirzepatide and retatrutide, have achieved efficacy levels approaching those of bariatric surgery. Surgical interventions continue to offer durable metabolic benefits in severe cases. Digital health tools and precision strategies such as pharmacogenomics and microbiome modulation are reshaping treatment personalization and accessibility.

Integration of these modalities into individualized care pathways will be critical to improving long-term outcomes. As obesity prevalence continues to rise globally, such innovations are essential for scalable, evidence-based management.

AUTHOR CONTRIBUTIONS

Conceptualization: Aleksandra Reda; methodology: Aleksandra Reda, Dorota Słupik; formal analysis:Aleksandra Reda, Magdalena Cyrkler; investigation: Aleksandra Śledziewska; resources: Aleksandra Giba; data curation: Aleksandra Reda, Aleksandra Zagajewska, Aleksandra Krygowska; writing - original draft:; Aleksandra Reda, Dorota Słupik, writing - review and editing: Aleksandra Reda, Kamila Sieradocha, Aleksandra Śledziewska, Dorota Słupik, Michał Wąsik, Aleksandra Zagajewska; Aleksandra Krygowska visualization: Kamila Sieradocha,; supervision, Aleksandra Reda, Aleksandra Śledziewska; project administration: Aleksandra Reda

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Artificial intelligence tools (e.g., ChatGPT, OpenAI) were used to assist in language editing, formatting suggestions, and structuring of the manuscript. The final content was critically reviewed and approved by the authors.

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