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INTEGRATING ARTIFICIAL INTELLIGENCE INTO OBESITY MANAGEMENT: A COMPREHENSIVE CLINICAL OVERVIEW

KEY WORDS: Obesity management, Artificial intelligence, Digital therapeutics, Machine learning (ML)

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ABSTRACT

Artificial intelligence (AI) is transforming obesity management in India by shifting healthcare from reactive treatment to predictive, precision prevention. The emergence of artificial intelligence (AI) technologies, particularly machine learning and deep learning algorithms, has opened new frontiers for transforming obesity prevention, diagnosis, and management strategies. Traditional obesity management approaches, including dietary interventions, physical activity programmes, pharmacotherapy, and behavioural therapies, face significant limitations in scalability, personalisation, and long-term adherence rates. Artificial intelligence has emerged as a transformative force in healthcare, offering unprecedented opportunities to revolutionise obesity prevention, diagnosis, and management through data-driven, personalised, and scalable interventions. AI is transforming obesity care by moving medicine from population-based treatments to highly individualized metabolic management. AI algorithms analyze vast datasets—including genetic profiles, gut microbiome composition, electronic health records (EHRs), and wearable telemetry—to predict weight trajectory, optimize treatment, and enhance long-term health outcomes. Artificial intelligence (AI) is transforming the landscape of obesity diagnosis, management, and dietary tracking in India. The integration of Artificial Intelligence (AI), machine learning (ML), and generative AI offers a transformative approach to precision obesity medicine, enhancing diagnostic fidelity, therapy optimization, predictive risk stratification, and patient engagement

INTRODUCTION

Current approaches to obesity management encompass a multifaceted strategy involving dietary modification, increased physical activity, behavioural therapy, pharmacological interventions, and in severe cases, bariatric surgery (1)

However, these traditional interventions face substantial limitations that impede their effectiveness and scalability. Dietary counselling and lifestyle modification programmes, whilst forming the cornerstone of obesity treatment, often suffer from poor long-term adherence rates, with studies indicating that fewer than 20 % of individuals maintain significant weight loss beyond two years (2)

Obesity should be considered a chronic progressive disease resulting from abnormal and/or excessive fat accumulation (3,4).

Cardiovascular disease (CVD) is the primary cause of death linked to obesity. (5)

Type 2 diabetes (T2D) , chronic renal disease, metabolic dysfunction associated with steatotic liver disease, hypercholesterolemia, and many kinds of cancer are the most prevalent consequences of obesity (6,7)

The prevalence of obesity has nearly tripled since 1975 and is projected to increase to 1.02 billion (18% of adults) by 2030. Nearly two billion adults, children, and adolescents, in other words, 24% of the world's population, are projected to be living with obesity by 2035 (8,9)

There are many reasons leading to obesity, such as over consumption of highly palatable, energy-dense foods and increased sedentary behavior [10].

Moreover, commercial determinants of health, including increased food availability, marketing, pricing, portion sizes, energy density, ultra-processing of foods, and prioritizing profitable by-products, as well as other societal and environmental changes, such as insufficient sleep, elevated stress, and exposure to endocrine-disrupting chemicals, are some of the hypothesized causes of increased food consumption [11].

Therefore, the fundamental reasons for the rise in obesity are multifaceted and include interactions between environmental, behavioral, social, genetic, and economic factors as well as human biology [12,13].

Many organ and tissue functions are disrupted by excess adipose accumulation, such as venous stasis; increased oxygen consumption; restricted diaphragmatic movement; pharyngeal collapsibility, which results in respiratory insufficiency and obstructive sleep apnea; increased abdominal pressure that causes gastroesophageal reflux disease; and increased wear and damage to weight-bearing joints that cause osteoarthritis, pain, and impaired mobility [14].

Depression and obesity frequently coexist and are correlated, as obesity increases the risk of depression and depression is a risk factor for obesity. People with obesity frequently have a lower quality of life; those with a higher BMI report lower physical and mental quality of life [15].

The one-size-fits-all approach employed by many conventional interventions fails to account for individual differences in metabolism, genetics, psychological, cultural factors, and social determinants of health, resulting in suboptimal outcomes for many patients(16)

Furthermore, the chronic nature of obesity necessitates long-term monitoring and support, which places additional strain on already overburdened healthcare systems and highlights the need for automated, intelligent solutions that can provide continuous care without overwhelming human resources(17)

AI technologies, encompassing machine learning, deep learning, natural language processing, and computer vision, possess the capability to analyse vast amounts of heterogeneous data from multiple sources, including electronic health records, wearable devices, mobile applications, and medical imaging, to generate actionable insights and personalised recommendations (18)

The integration of AI in obesity management represents a paradigm shift from reactive, episodic care to proactive, continuous, and precision-oriented approaches that can adapt to individual needs and circumstances in real-time(19)

Despite the growing interest and investment in AI-powered obesity management solutions, there remains a significant gap in comprehensive reviews that synthesise the current evidence, identify key challenges, and provide strategic directions for future development. The problem lies in the fragmented nature of existing research, with studies focusing on isolated applications of AI without considering the broader ecosystem of obesity management or the interconnected challenges that must be addressed for successful implementation (20)

Obesity

Obesity poses a significant global health challenge due to its association with various morbidities (21,22)

Despite being commonly measured by body mass index (BMI), obesity is a complex condition influenced by genetic, behavioral, and environmental factors. Obesity is a leading cause of preventable mortality, necessitating significant social resources in both high- and low- to middle-income countries (23,24)

In 2014, the World Health Organization (WHO) reported that approximately 1.9 billion individuals were overweight and over 600 million were obese. By 2030, projections indicate that 2.16 billion individuals will be overweight and nearly 1.2 billion will be obese. Therefore, a substantial portion of the global population faces increased risks of various health complications associated with excess weight (25,26)

Numerous research studies have highlighted the multifaceted nature of obesity, indicating that it is not simply a matter of excess weight but rather a complex health issue influenced by a variety of factors. These factors include individual factors such as genetics, learned behaviors, and broader societal and cultural influences such as unhealthy eating habits. While genetic and epigenetic factors contribute to obesity, lifestyle choices are a major contributor (27,28)

Factors such as low physical activity and poor dietary habits are known to heavily influence the development and progression of obesity (29)

Moreover, obesity is intricately linked to the exacerbation of pre-existing health conditions and the onset of new health-related issues. Various forms of obesity, including abdominal obesity, have been associated with an increased risk of chronic diseases such as asthma, cancer, diabetes mellitus, hypercholesterolemia, and cardiovascular diseases. Furthermore, obesity impacts several organ systems, including the cardiovascular, endocrine, central nervous, and gastrointestinal systems [30].

AI model identifies obesity risk factors beyond BMI for better precision

The research in *Decision Analytics Journal* highlights BMI's limitations and emphasises the need for comprehensive data like diet, activity, and regional factors. Obesity can lead to several lifestyle diseases. Reducing weight to the optimum level can help prevent several diseases. Once someone becomes obese, it is tough to lose weight. If someone knows about the risk of becoming obese, they can take corrective measures. Woxsen University Researchers, along with US scientists, developed an AI-based prediction model to detect what they call 'Obesity Risk'. (31)

Diagnostic support

The application of computer vision and deep learning techniques to medical imaging has transformed body composition assessment, providing more precise and clinically relevant measurements than traditional anthropometric indicators such as body mass index (32)

Convolutional neural networks trained on magnetic resonance imaging (MRI), computed tomography (CT), and dual-energy X-ray absorptiometry (DEXA) scans can automatically segment and quantify different adipose tissue compartments, including visceral adipose tissue, subcutaneous adipose tissue, and ectopic fat deposits in organs such as the liver and pancreas (33)

The integration of AI with portable and accessible imaging technologies has expanded the potential for widespread body composition assessment beyond traditional clinical settings. Smartphone-based applications utilising computer vision algorithms can estimate body fat percentage and muscle mass from standard photographs, though with lower precision than medical imaging modalities (34)

1. How AI Can Improve Diagnosis

Standard diagnostic metrics such as BMI fail to distinguish between fat mass and lean muscle tissue, nor do they reflect visceral fat distribution or individual metabolic risk. AI enhances diagnostic precision through:

- **Multimodal Phenotyping:** ML algorithms integrate electronic health record (EHR) data, metabolic panels, genomic profiles, and imaging to classify obesity into distinct biological and behavioral sub-phenotypes (e.g., "hungry brain," "hungry gut," or "emotional eating").
- **Advanced Imaging & Body Composition:** Computer vision models analyze DEXA scans, CT, or abdominal MRI images to accurately quantify visceral adipose tissue (VAT), subcutaneous adipose tissue (SAT), and ectopic muscle fat infiltration, replacing crude anthropometric measures.
- **Early Risk Identification:** AI systems scan primary care EHRs to identify subclinical metabolic dysfunction, enabling early screening for individuals at high risk before significant weight gain occurs.

2. Medication Management

Anti-obesity medications (AOMs)—including GLP-1 receptor agonists and dual GIP/GLP-1 receptor agonists—show variable efficacy and tolerability across patient populations.

AI optimizes pharmacological management by:

- **Precision Prescribing & Response Prediction:** Machine learning models evaluate baseline clinical markers, pharmacogenomics, and metabolic profiles to predict which patients will respond optimally to specific classes of anti-obesity medications.
- **Dose Titration & Tolerability Monitoring:** Dynamic algorithms analyze real-time patient-reported outcomes (e.g., gastrointestinal side effects, satiety scores) to suggest personalized, step-wise dose escalation schedules, maximizing compliance and minimizing side-effect related discontinuations.
- **Adherence Tracking & Refill Prediction:** Predictive models monitor pharmacy fill patterns and digital logbooks to flag non-adherence early, allowing healthcare teams to intervene proactively.

3. Predictive Analytics: Complications and Disease Progression

AI-driven predictive analytics enable a shift from reactive care to proactive, disease-modifying interventions:

- **Cardiometabolic Complication Risk:** Algorithms evaluate longitudinal health records to forecast individual risks of developing type 2 diabetes, non-alcoholic fatty liver disease (MASLD/MASH), obstructive sleep apnea, and cardiovascular events.
- **Bariatric Surgery Outcomes:** Predictive models evaluate preoperative clinical parameters to forecast post-bariatric weight loss trajectories, surgical complication risks, and probability of long-term weight regain.
- **Hospitalization & Resource Utilization:** Machine learning models identify high-risk patients with obesity-related comorbidities who are at elevated risk for unplanned acute care visits or hospital readmissions, directing care-management resources effectively.

4. Patient Education and Lifestyle Modification

Sustainable long-term weight management relies heavily on continuous behavioral modification and dynamic patient support:

- **AI-Enabled Behavioral Coaching (AIBC):** Chatbots powered by Large Language Models (LLMs) provide continuous, 24/7 personalized coaching, offering evidence-based nutritional guidance, physical activity reminders, and cognitive-behavioral strategies tailored to daily patient habits.
- **Real-Time Wearable Integration:** AI algorithms process continuous glucose monitoring (CGM) and wearable activity data to provide instant feedback on postprandial glucose spikes, sleep patterns, and daily energy expenditure.
- **Personalized Micro-Interventions:** Deep learning models analyze temporal patterns to deliver targeted, high-yield behavioral prompts right when patients are most susceptible to cravings or sedentary behavior.

5. Three Key Take-Home Points for Physicians

1. **Beyond BMI to Precision Stratification:** AI enables clinicians to move beyond simple BMI cutoffs toward multimodal phenotyping, allowing for individualized treatment plans based on fat distribution, metabolic profile, and underlying etiology.
2. **Enhanced Pharmacotherapy Efficiency:** Machine learning tools aid in selecting the right anti-obesity medication and optimal titration schedule, reducing adverse effects and improving long-term medication persistence.
3. **Scalable Continuous Care:** AI-driven behavioral coaching and wearable monitoring extend physician reach, providing adaptive, real-time patient support between clinical encounters without increasing clinician burnout.

-AI could democratise nutritional advice, but safety and accuracy must come first

AI uses large language models (LLMs) and machine learning not only to identify words in text but also to understand their order and context, producing human-like responses to text-based prompts. Search online to see how people are using artificial intelligence (AI) tools such as ChatGPT; you will quickly find that food requests are popular. More specifically, users are seeking help with menu planning to meet their personal dietary goals. But how effective is this technology in providing dietary advice? In a consumer poll, over three out of five consumers agreed they would like to eat a healthier diet. Some 73% felt it was important to buy food that has a low environmental impact. A substandard diet is a leading cause of chronic disease and death around the world. Additionally, a third of all human-caused greenhouse gas emissions are linked to food.

CONCLUSION

Obesity is a complex, chronic, and relapsing multi-system disease. Traditional models of obesity management—reliant on episodic clinical encounters and body mass index (BMI) thresholds— often fall short of capturing heterogeneous disease phenotypes or providing continuous behavioural support. The integration of Artificial Intelligence (AI), machine learning (ML), and generative AI offers a trans-formative approach to precision obesity medicine, enhancing diagnostic fidelity, therapy optimization, predictive risk stratification, and patient engagement

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