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The Role of mHealth Application-Based Information Systems in Nutritional Interventions for Individuals with Overweight and Type 2 Diabetes Mellitus

ABSTRACT

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INTRODUCTION

Facing rapid technological progress and enormous pressure on healthcare systems, mobile-health (mHealth) applications, running on portable devices such as smartphones and wearables, are becoming essential tools for the management of chronic diseases. These technologies facilitate access to medical services, improve the efficiency of care, and promote healthy living, proving especially useful for monitoring type 2 diabetes mellitus (T2DM) and obesity.

The motivation for this research was the need for effective, easily implemented solutions that can modify behaviours associated with metabolic disorders. The topic is actual, and the study's originality lies in implementing an mHealth intervention adapted to Romania's clinical environment and evaluating its impact on multiple fronts: metabolic, behavioural, and subjective. Internationally, the use of mHealth apps for T2DM is endorsed by prestigious medical guidelines (ADA, WHO) and supported by multicentre studies. In Romania, research in this area is still limited, so the study meets an evident national need aligned with global trends.

The project takes an interdisciplinary approach, information technology, medicine, and behavioural sciences, aimed at assessing how mHealth applications influence the self-management of T2DM and obesity in the home setting. The study provides empirical evidence of the effectiveness of such interventions, supporting the integration of digital solutions into everyday clinical practice.

The central hypothesis is that mHealth use by patients with T2DM will show significant improvements in clinical and behavioural parameters, body weight, BMI, physical activity, glycaemic control, eating habits, stress, and sleep quality, while also enhancing motivation and quality of life.

Study objectives includes measuring clinical-metabolic changes, analysing users' behaviour, and their perceptions of the intervention. The design is a longitudinal observational study with baseline and six-month evaluations, supplemented by a SWOT analysis.

The thesis is organised into three chapters covering the theoretical foundation, methodology, detailed results, and their interpretation in light of the scientific literature, followed by general conclusions. The findings confirm both the efficacy and the scalability potential of the proposed intervention.

The research's interdisciplinary character merges internal medicine, clinical nutrition, health education, digital technology, and public health. Limitations noted include the short study period, absence of randomisation, and reliance on self-reported data. Even so, the work lays a solid groundwork for future controlled comparative studies and for incorporating its results into digital-health public-policy initiatives.

1. Theoretical Foundations of Metabolic Pathologies: Obesity and Type 2 Diabetes Mellitus

1.1. Overweight and Obesity

Obesity is a major global health problem, a complex, chronic, and progressive condition that significantly affects quality of life and mortality. It is characterized by excess adiposity and has multifactorial causes that are not yet fully understood (1-3). Recent research focuses on the brain mechanisms involved in regulating appetite and satiety, highlighting the role of gut hormones, the microbiota, and intestinal dysbiosis. Genetic and epigenetic factors also influence individual susceptibility to obesity and the development of associated complications (4-7).

1.1.1. Epidemiology and Prevalence

In March 2024 the WHO reported that about 35% of Romanian adults are obese, placing the country in the very-high-prevalence category. Projections indicate an annual increase in obesity prevalence of 2.1% in adults and 5.6% in children through 2035. According to Eurostat (2022), 59% of Romanians have a BMI over 25, exceeding the European average (8).

1.1.2. Pathophysiological Mechanisms

The pathogenesis of obesity is influenced by internal and external factors that interact in a complex way to drive the condition. The causes of obesity remain a topic of debate, but studies emphasize diet and energy balance (9), family history and lifestyle (10), the gut microbiome (11-13), and genetic factors (14).

1.1.3. Current Prevention and Therapeutic-Management Strategies

Lifestyle modification is essential for controlling obesity (15-17). Recently, pharmacological treatment has added FDA-approved therapies such as orlistat (18), liraglutide (19, 20), semaglutide (21), and tirzepatide (22), which are effective in reducing weight and comorbidities when combined with lifestyle changes. Tirzepatide provides results comparable to bariatric surgery and is a promising option for integrated obesity management.

1.2. Diabetes Mellitus

Type 2 diabetes mellitus (T2DM) accounts for nearly 90% of cases. Its pathophysiology is characterized by peripheral insulin resistance, progressive beta-cell dysfunction, and low-grade chronic inflammation, often precipitated by obesity, sedentarism, and excessive caloric intake (23, 24).

1.2.1. Epidemiology of Type 2 Diabetes

According to the International Diabetes Federation (IDF), 589 million adults (aged 20-79 years) live with diabetes worldwide and this is expected to reach 853 million by 2050. In Romania there are currently 1.3 million cases and the projection for 2050 remains 1.3 million (25).

1.2.2. Pathogenetic Mechanisms and Metabolic Interrelationships

Type 2 diabetes mellitus is a chronic progressive metabolic disorder (23). Over time, lipotoxicity, glucotoxicity, oxidative or endoplasmic-reticulum stress, and low-grade inflammation accelerate beta-cell apoptosis and dedifferentiation (26).

1.2.3. Therapeutic Options and Integrated Management

Evolution of Nutritional Recommendations in Diabetes Management: Key Principles from the ADA 2025 Report (27): Medical Nutrition Therapy (MNT); integrated weight-control strategies; healthy dietary patterns; avoidance of supplements without evidence; moderate alcohol intake; sodium restriction; water as the main source of hydration; malnutrition screening; cessation of tobacco and e-cigarettes. The ADA 2025 guidelines promote a holistic approach, prioritizing personalized care and long-term adherence.

Drug therapy for type 2 diabetes must be holistic and tailored, taking into account glycaemic and weight targets, risk of hypoglycaemia, comorbidities, and individual tolerability. Treatment choices should also consider factors such as cost, accessibility, regimen complexity, and support for self-management (e.g., glucometer, mobile apps) (27).

2. Innovative Nutritional-Medical Intervention Strategies for Lifestyle Modification in the Management of Obesity and Type 2 Diabetes Mellitus: Integrating Digital Technology with Conventional Methods

2.1 Conventional Approach to the Management of Diabetes and Obesity

Conventional nutritional-medical intervention is a fundamental pillar in the management of diabetes and obesity and can help prevent or delay the onset of complications such as retinopathy, neuropathy and cardiovascular disease (28).

2.2 Emerging Interventions for Lifestyle Optimisation

One of the most recent directions in the treatment of diabetes and obesity is the implementation of personalised diets. Another innovative area in lifestyle modification for patients with diabetes and obesity is the use of digital technologies.

2.3 Decision-Support Information Systems (DSS) in Nutrition and Diabetes

2.3.1 Mobile Health (mHealth) Information Systems as an Intervention Tool

According to the World Health Organization, mHealth is "medical and public-health practice supported by mobile devices, such as smartphones, patient-monitoring devices, personal digital assistants and other wireless systems" (29). From a functional perspective, the most important capabilities of mHealth platforms are continuous monitoring of physiological parameters (30, 31), facilitation of synchronous and asynchronous telemedicine (32), personalised educational support (33), and dynamic management of chronic diseases (34).

A growing number of randomised clinical trials and meta-analyses show that including mHealth interventions throughout the care continuum leads, on the one hand, to significant improvements in biological markers and, on the other, to a more efficient and cost-effective use of healthcare resources. These interventions have notable effects in the management of diabetes mellitus and other chronic diseases, in the prevention and management of cardiovascular diseases (35), and in promoting mental health and stress monitoring (36).

2.3.2 Integration of mHealth Applications as DSS in Medical-Nutritional Intervention

The combined advance of mobile technologies, secure wireless communication infrastructure and artificial intelligence has enabled a move from simple self-management apps to true mobile clinical decision-support systems (mCDSS). Extending these functions to mHealth platforms (smartphones, tablets, wearables) adds mobility, personalisation and scalability to interventions, with demonstrable impact on care quality and reduction of medical errors (37, 38).

2.3.3 Barriers and Facilitators to the Adoption of Digital Technologies (Mobile Health Technology – MHT)

Major advantages of mHealth applications functioning as clinical DSS (mCDSS): Continuous physiological monitoring and early intervention (39); Therapeutic personalisation (40, 41); Improved adherence and health literacy (42); Extended accessibility (43); Economic efficiency (44); Integration with telemedicine (41).

Limitations and challenges: Data quality and accuracy (45); Information overload and alert fatigue (46); Limited interoperability (47); Privacy and cybersecurity (48); Algorithmic bias and insufficient validation in sub-groups (49); Variable digital adherence (50).

The large-scale implementation of MHT faces a number of barriers that limit the efficiency and widespread adoption of these solutions. Identifying and understanding these obstacles is essential for optimising digital-health strategies (51, 52).

2.3.4 Medical-Nutritional Intervention Using App-Based MHT as DSS

Decision-support systems integrated into mobile applications use algorithms and databases to offer personalised dietary suggestions tailored to the user's needs and medical conditions (53).

2.3.5 Parameters for Assessing the Clinical Effectiveness of mHealth Systems

The evaluation of mHealth systems encompasses several essential dimensions: clinical effectiveness, user experience, data security and integration with existing healthcare systems.

2.4 SWOT Analysis of mHealth Systems Used as DSS in Medical-Nutritional Intervention

SWOT analysis provides a clear view of the strengths and limitations of these systems, helping to improve digital nutritional-intervention strategies (54). Strengths: accessibility and convenience; personalisation; real-time feedback; reduction of medical costs. Weaknesses: technological limitations; data reliability; lack of regulation. Opportunities: integration with electronic medical records (EMR); artificial intelligence and machine learning; nutritional education. Threats: privacy issues; dependence on technology; inequalities in access (55).

3. Usefulness of mHealth Information-System Apps in Nutritional Intervention for Individuals with Excess Weight and Type 2 Diabetes

3.1 Introduction

Although international clinical guidelines endorse personalised nutritional intervention and lifestyle modification as central pillars in the management of T2DM and obesity, patient adherence to these recommendations remains sub-optimal in the absence of continuous support (27, 56). Mobile applications can facilitate the adoption of a healthy lifestyle by offering personalised meal plans, automated reminders, real-time feedback and self-monitoring functions for weight, blood glucose and caloric intake (57).

The study rationale came from the growing burden of T2DM and obesity at the population level, both in terms of morbidity and the associated costs to the healthcare system (58). Conventional interventions often fail to sustain patient motivation in the long term. In contrast, mHealth apps provide continuous support, real-time feedback, personalised recommendations and easy access, thereby helping to overcome some of the limitations of traditional care (59).

3.1.1 Working Hypothesis

The primary aim of this study is to evaluate the effectiveness of a digitally assisted nutritional-behavioural intervention, delivered through an mHealth mobile application, in a cohort of patients diagnosed with type 2 diabetes mellitus and/or obesity within a clinical setting. The study seeks to determine the extent to which sustained use of the app contributes to improvements in metabolic parameters (body weight, body-mass index, blood glucose, glycated haemoglobin), lifestyle-related behaviours (physical-activity level, sleep quality, dietary habits) and the patient's active engagement in the therapeutic process.

In addition, the research explores the degree of adherence to app use, patient perceptions of its utility, and its potential to partially offset some limitations of conventional care.

Scientific hypotheses of the study

Primary hypothesis: The use of an mHealth mobile application within a nutritional-behavioural intervention leads to significant improvements in body weight, BMI, blood glucose and HbA1c in patients with T2DM and/or obesity.

Secondary hypotheses: Frequent app use is associated with increased physical activity and improved sleep quality. High digital adherence correlates positively with improvements in metabolic parameters. Patients perceive the app as a useful and motivating tool in the self-management of their condition. The digital intervention can compensate for certain deficiencies of conventional care by providing continuous and personalised support.

3.1.2 Study Objectives

Primary objective: To evaluate the impact of six-month sustained use of an mHealth mobile application on disease self-management and perceived health status in individuals diagnosed with type 2 diabetes mellitus, with or without associated obesity.

Secondary objectives:

1. To assess changes in anthropometric and metabolic parameters (weight, BMI, blood glucose, HbA1c) after six months of app use.
2. To analyse lifestyle behaviours (physical activity, sleep, diet) following the digitally assisted intervention.
3. To determine the level of adherence to the application and frequency of use among patients.
4. To investigate patients' perception of the app's utility and impact in supporting behavioural change.
5. To explore correlations between the degree of app utilisation and observed changes in metabolic and behavioural parameters.
6. To identify the advantages and limitations of the digital intervention through a contextual SWOT analysis.

3.2 Materials and Methods

3.2.1 Study Design

This was an observational, longitudinal study conducted in a clinical setting over a six-month period. Changes in metabolic, anthropometric and behavioural parameters were tracked before and after the use of the mHealth application.

Location and period. The study was carried out at the Department of Diabetes and Nutrition Diseases, "MetaMed Diabetes Centre" Clinic, Brașov, Romania, from May 2024 to January 2025. Patient enrolment took place over three months (May–July 2024). Selection, data collection and follow-up activities were conducted in accordance with ethical and professional standards.

3.2.2 Participant Selection Criteria

Inclusion criteria:

- Age between 18 and 75 years;

- Confirmed diagnosis of type 2 diabetes mellitus, with or without glucose-lowering therapy;
- BMI ≥ 25 kg/m² (overweight or obesity);
- Access to a smartphone and ability to use a mobile application;
- Signed informed consent to participate;
- Willingness to follow the nutritional-behavioural intervention for six months and to complete questionnaires at T0 and T1;
- Minimum literacy level (able to complete questionnaires and follow app instructions).

Exclusion criteria

- Type 1 diabetes or other secondary forms of diabetes;
- Previous or planned bariatric surgery;
- Recent injectable GLP-1 RA therapy;
- Pregnancy or breastfeeding;
- Severe psychiatric disorders or dementia that may affect compliance;
- Acute or unstable chronic conditions that could influence weight (e.g., active cancer therapy, stage IV/V renal failure);
- Concurrent participation in another clinical study.

Withdrawal criteria

- Non-use of the app for more than 30 consecutive days;
- Failure to complete the final assessment at T1;
- Voluntary withdrawal of informed consent.

Indicators and Assessment Methods

To evaluate the effectiveness of the digitally assisted nutritional-behavioural intervention, the following primary indicators were monitored:

- Anthropometric parameters: body weight (kg) and body-mass index (BMI, kg/m²) measured at baseline (T0) and study end (T1);
- Metabolic parameters: fasting blood glucose (mg/dL) and glycated haemoglobin (HbA1c, %);
- Behavioural parameters: physical-activity level (hours/week), sleep duration (hours/night) and dietary habits, assessed via standardised self-reports and periodic app entries;

- Digital-adherence indicators: app-use frequency expressed as the average number of days per week with active entries.

Intervention Method

All enrolled patients were trained to use a specialised mobile application for T2DM and lifestyle management. The app allowed monitoring of dietary intake, weight, blood glucose and physical activity. Participants were encouraged to enter data daily and to follow the recommendations generated by the application.

3.2.3 Description of the Mobile Application Used in the Nutritional Intervention

The mobile application used for the personalised nutritional intervention is designed to support patients in monitoring nutritional and metabolic status and in adapting dietary behaviour, based on clinically validated algorithms. A closed-beta version 1.0, developed by Shellix 2021-2024, was employed. Access to the app was granted by the developers specifically for this study.

Functionalities: Assessment of weight and metabolic status: BMI, resting metabolic rate estimation, ideal-weight estimation; Interactive functionalities and nutritional personalisation: longitudinal weight-trend graph, dietary patterns; Diabetes-specific features: blood-glucose values, graphs and alerts; Educational component and development outlook: educational blog, tele-consultations.

3.2.4 SWOT-Analysis Method

Each SWOT dimension (Strengths, Weaknesses, Opportunities, Threats) was completed inductively by identifying relevant factors supported by data and the scientific literature (e.g., ADA, WHO, recent studies from PubMed and Web of Science). The tools employed were descriptive matrices (SWOT table), clinical assessment, self-reported feedback via the application and integrative interpretation by an interdisciplinary team.

Ethics. The study was approved by the Ethics Committee of the MetaMed Diabetes Centre Clinic, Brașov. All patients signed informed consent prior to participation. Data were collected and stored in accordance with personal-data-protection legislation.

3.3 Results

The six-month nutritional-behavioural intervention assisted by an mHealth application, carried out with 107 adults diagnosed with type 2 diabetes and/or obesity, generated statistically significant improvements ($p < 0.05$) in most of the analysed parameters. The results are detailed below by category—clinical, metabolic and behavioural indicators.

1. Anthropometric parameters

Body weight: mean decrease of −3.3 kg (85.2 ± 10.5 kg → 81.9 ± 9.8 kg). Forty-six percent of participants lost ≥3 % of baseline weight and 22 % lost >5 %.

Waist circumference: mean decrease of −3.7 cm (102.4 ± 8.3 cm → 98.7 ± 7.9 cm). The >105 cm category shrank from 16 to 3 participants, and the 96–105 cm range from 36 to 16.

Body-mass index (BMI): prevalence of morbid obesity (BMI > 40) decreased from 21 % (23 participants) to 11 % (12 participants), while the overweight group (25–29.9 kg/m²) increased from 7 to 33 participants.

2. Metabolic control

Glycated haemoglobin (HbA1c): mean absolute reduction of −0.8 percentage points (8.1 ± 1.2 % → 7.3 ± 1.1 %). Participants with HbA1c < 6.5 % rose from 12 to 30, whereas those with HbA1c > 8 % fell from 5 to 0.

Hyperglycaemic episodes (blood glucose > 200 mg/dL): the proportion with >5 episodes/month declined from 89 % (95 participants) to 49 % (52 participants).

Hypoglycaemic episodes (blood glucose < 70 mg/dL): mean monthly frequency dropped from 3.4 ± 1.7 to 2.1 ± 1.2 episodes.

3. Blood pressure

Mean values fell from 138/85 ± 12/8 mmHg to 130/80 ± 10/7 mmHg.

Participants with BP < 120/80 mmHg increased from 10 to 18; those with BP > 140/90 mmHg fell from 18 to 2.

4. Glycaemic events and therapy adherence

Medication adherence: rose from 68.3 ± 15.2 % to 82.6 ± 13.8 %; 93 % (100 participants) report an adherence score of 4–5.

Frequency of glucose logging: increased from 54.2 ± 18.7 % to 76.4 ± 16.1 %.

Self-reported ability to adjust treatment (score 4–5/5): up from 71 to 83 participants.

5. Behavioural parameters

Dietary compliance (score 4–5): 83 % (89 participants).

Physical activity (≥150 min/week, score 4–5): 65 % (70 participants).

Smoking: 40 % reduced cigarette number; 11 % quit entirely.

6. Psychology and quality of life

Overall well-being (score 5): increased from 23 to 48 participants.

Daily energy level and positive mood scores rose significantly ($p < 0.05$).

Fear of hypoglycaemia (score 1–2): declined from 70 to 55 participants.

7. App adherence

82 % of participants used the platform ≥5 days/week.

74 % awarded the app the maximum ease-of-use score; 98 % would recommend it.

3.4 Discussion

The findings of this study support the hypothesis that the use of an mHealth mobile application can exert a significant positive impact on the metabolic and behavioural status of patients with type 2 diabetes mellitus and obesity. This discussion places the results within the context of international literature, evaluates methodological robustness and identifies avenues for improving mHealth-based interventions for diabetes and obesity.

The mean reduction of 0.8 percentage points in HbA1c and the weight loss of more than 3 kg are consistent with recent meta-analyses that report HbA1c reductions of 0.3–0.8 pp and weight losses of 2–4 kg through mHealth interventions (60-62). A noteworthy aspect is the improvement in sleep duration and quality—often overlooked in classical interventions yet essential to metabolic regulation and weight maintenance. The positive perception of the app, expressed by over 75 % of patients, confirms its user-friendly and motivational character (63). Effectiveness is attributable to just-in-time adaptive-intervention (JITAI) design elements, personalised feedback and gamification, all of which can enhance patient self-efficacy.

SWOT analysis:

Strengths: high digital adherence (>82 %), significant reductions in weight and HbA1c, intuitive interface, positive user feedback.

Weaknesses: absence of a control group, self-reported data, limited six-month duration.

Opportunities: integration into national programmes, expansion to other chronic diseases, combination with AI and wearable technology.

Threats: digital heterogeneity, data-security concerns, lack of eHealth regulation.

Potential sources of bias

Selection bias: participants were motivated and had technology access, limiting sample representativeness.

Reporting bias: behavioural parameters were self-reported, subject to recall error and social desirability.

Performance bias (Hawthorne effect): behaviour may be influenced by awareness of monitoring.

Loss to follow-up: results reflect compliant participants, not the entire cohort.

Confounders: lack of a control group does not exclude the influence of external therapeutic changes.

Younger participants or those with higher digital literacy may interact more effectively with the app, potentially skewing perceptions of its usefulness across the general T2DM/obesity population.

Clinical and public-health implications

Integrating mHealth applications into routine care could lessen the burden of T2DM/obesity by facilitating continuous monitoring and early intervention.

Connecting applications to electronic health records and developing a robust legislative framework for data protection are recommended.

Limitations and future research directions

Key limitations include the absence of randomisation and the relatively short study duration.

Future work should involve randomised controlled trials lasting ≥12 months, exploration of complementary indicators (waist-to-hip ratio, continuous glucose monitoring) and large-scale cost-effectiveness evaluations.

3.5 Conclusions

This study validates the hypothesis that mobile mHealth applications, when embedded in nutritional-behavioural interventions for patients with type 2 diabetes and obesity, can lead to significant improvements in clinical, metabolic and behavioural parameters.

The mHealth intervention produced meaningful improvements in these parameters, confirming the working hypothesis. High adherence (>82 %) and user satisfaction (98 % recommendation rate) demonstrate the acceptability and feasibility of the digital approach.

mHealth applications constitute a scalable tool capable of complementing conventional care by supporting self-regulation and fostering an interactive therapeutic relationship.

Nationwide implementation will require interoperability standards, data-security regulations and digital-literacy programmes.

Future research should incorporate longer RCTs, integration of AI, continuous glucose monitoring and advanced body-composition indicators to further optimise personalised interventions.

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