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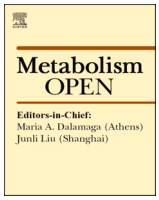

Effectiveness of a hybrid approach in integrating GLP-1 agonists and lifestyle guidance for obesity and pre-diabetes management: RWE retrospective study

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ABSTRACT

Aim: Emerging anti-obesity pharmacotherapy provides an option to correct maladaptive physiological and hormonal changes associated with obesity. One of the widely used medications in this context is glucagon-like peptide 1 (GLP-1) agonists. However, the misuse of these medications without any guidance and monitoring of lifestyle modifications can lead to unfavorable outcomes. The study aims to evaluate the effectiveness of a hybrid care model, incorporating GLP-1 and GLP-1/GIP agonist therapies, in managing obese patients with/without pre-diabetes. This study showcases the midway results of a 6-month program, which includes a multidisciplinary care team and digital technology for continuous engagement and monitoring of patients, both in-clinic and remotely.

Methods: In a retrospective observational study, 115 participants were treated with GLP-1s (semaglutide, tirzepatide, and liraglutide). Physicians, dietitians, and coaches worked together to support behavioral changes using a dedicated app provided to patients. At the care team end, an integrated portal enabled continuous data flow allowing for the care team to provide personalized care via chat at regular intervals. Data collected included food logs, continuous glucose monitoring (CGM), and digital biomarkers such as sleep and activity.

Results: At the midpoint of the program, participants exhibited statistically significant improvements in various metabolic parameters. Mean weight reduction was 8 %, with significant reductions in BMI, fat mass, and cholesterol levels. 24 (20.9 %) of patients lost ≥5 % of body weight, 55 (47.8 %) patients lost ≥10 % weight, and 36 (31.3 %) patients lost ≥15 % weight. Sub-analysis of pre-diabetic patients (n=36) demonstrated substantial improvements, including control of pre-diabetes in 80.6 % of cases and reduced HbA1c levels back to normoglycemia (5.39 ± 0.27).

Conclusion: The Zone.Health's program, which combines pharmacotherapy with continuous engagement and monitoring to enable sustainable lifestyle modifications, demonstrated significant improvements in weight, body composition, and metabolic markers. Pre-diabetes was also effectively addressed. It is necessary to conduct further research to assess the long-term sustainability and optimal adoption of such care models into clinical practice.

1. Introduction

Obesity, a growing global health concern, is characterized by a body mass index (BMI) equal to or greater than 30 kg/m^2 in adults [1]. In the United Arab Emirates (UAE), recent data indicates an overall obesity prevalence of 17.8 %, with the highest rates reported among women (21.6 %) and UAE nationals (39.6 %) [2]. Obesity is associated with multiple complications, including cardiovascular disease, type 2 diabetes (T2D), and osteoarthritis [3–5]. Weight loss of 5–15 % is recommended to improve many of the complications of overweight/obesity [5,6], with even modest weight loss of 5 % showing improvements in cardiometabolic risk factors, including reduced systolic blood pressure and plasma triglycerides concentration and increased multi-organ insulin sensitivity and b-cell function [5].

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Despite the benefits of weight reduction, there are many challenges in losing weight and maintaining long-term weight loss. Emerging anti-obesity pharmacotherapy provides an option to correct maladaptive physiological and hormonal changes associated with obesity [7]. One of the widely used medications in this context is glucagon-like peptide 1 agonists (GLP-1 agonists). Mechanistically, GLP-1 agonists operate through several pathways; they enhance insulin secretion in a glucose-dependent manner, suppress glucagon secretion under hyperglycemic or euglycemic conditions, slow gastric emptying to prevent postprandial glucose spikes and decrease appetite and food intake, which collectively contribute to weight loss [8,9]. Furthermore, they have differential impacts based on their acting duration, with long-acting variants having a more pronounced effect on fasting glucose levels and reducing cardiovascular risk factors [9]. Notably, recent research elucidates their central effects, including modulation of food preferences and intake without reducing energy expenditure, by directly interacting with GLP-1 receptors in the brain, particularly in areas involved in satiety and reward [8]. These multifaceted actions position GLP-1 agonists as a preferred option for managing obesity, offering a blend of glycemic control and weight management benefits [10]. These medications were originally used for treating T2D and, recently used in obesity management as adjunctive therapy for ongoing lifestyle changes [11,12].

Anti-obesity pharmacotherapy exists in different combinations and has varying mechanisms of action, adverse effects, and benefits. Still, they all promote weight loss by decreasing hunger and appetite while simultaneously increasing feelings of satiation, leading to reduced ingestion and absorption of calories [13]. Results from the STEP 5 trial have shown a mean weight loss of 15.2 % (vs 2.6 % with placebo) sustained at 104 weeks when using once-weekly semaglutide [14]. Moreover, findings from the SURMOUNT-3 trial using tirzepatide showed significant weight loss with an average weight loss reduction of 6.8 % at 12 weeks of the treatment and a further reduction of 21.1 % over 72 weeks [15]. Both studies used intensive behavioral change modification, in conjunction with pharmacotherapy, delivered entirely in an in-clinic approach, which can be limited in real-world settings.

Weight loss is a complex journey with behavioral change an important part of achieving sustainable long-term results. Behavioral modifications targeting diet and physical activity changes are the cornerstones of interventions for weight management in overweight and obese populations [16]. Weight loss using pharmacotherapy should go in parallel with lifestyle modifications and behavior change therapy; the use of these medications without any guidance and lifestyle changes leads to weight regain as seen in the STEP trial, where one year after withdrawal of semaglutide and lifestyle intervention, participants regained two--thirds of their prior weight loss [17]. Therefore, designing a holistic guided program is necessary for improving the overall use of these medications and to maintain and sustain long-term sustainable results. This study aims to measure the effectiveness of using an integrated multidisciplinary care team delivering continuous engagement in a hybrid manner (i.e. in-clinic and remotely) and to measure the effectiveness of such programs in managing obese patients with and without pre-diabetes.

2. Methodology

2.1. Zone.Health program overview

Zone.Health is a 6 month value-based, hyper-personalized, technology-enabled weight loss program introduced by meta[bolic] (www.metabolic.health) in 2023 which enables ongoing remote data monitoring and engagement and provides access to a multispecialty coordinated licensed care team. The term "value-based" refers to the program's commitment to effectiveness, offering a partial refund to patients who, despite meeting specified compliance metrics, do not achieve a minimum of 10 % weight loss within the program's duration. "Hyper-personalized" indicates the customization of the weight management strategy to each individual's unique physiological, behavioral, and psychological profile. This is achieved by integrating continuous glucose monitoring (CGM), activity and sleep tracking, and other digital biomarkers with personal health histories to dynamically tailor dietary guidance, exercise regimens, and medication dosages. Engagement with team members was a required metric of compliance from participants. Initial bi-weekly engagements were designed to be comprehensive, addressing the individual's progress, challenges, and needs, thereby ensuring impactful guidance, motivation, and plan adjustments. As participants progress, the frequency of engagement shifts to monthly sessions, aimed at reinforcing achievements, addressing any new challenges, and tailoring strategies for sustained success. This intensive, quality-focused engagement strategy is supplemented by an app that includes a team of coaches, sports scientists, nutritionists, physicians, and educators. Participants are also educated on food logging, the use of continuous glucose monitoring (CGM), and the syncing of digital biomarkers such as activity and sleep data, which are unified and time-synchronized in a single clinician portal for optimal patient monitoring and engagement. Data was unified and time-synchronized in a single clinician portal view allowing for patient monitoring and engagement. Medications were titrated monthly based on the assessment of fat vs muscle loss ratio, weight changes, and reported adverse effects. Data on anthropometric aspects of the members were collected both at the beginning of the study and quarterly. The effectiveness of the hybrid approach has been demonstrated before, specifically in the management of diabetes [18–21]. The participant journey is illustrated in (Fig. 1).

2.2. Study design

An observational, retrospective study was conducted on the medical records of individuals who had received GLP-1 or GLP-1/GIP medications following a comprehensive baseline evaluation. The study included 115 patients who completed the midway point of the 6-month program. Medications were initiated after 15 days of comprehensive evaluation and initial dietary assessment to ensure the eligibility of the participants. In this cohort, a significant proportion of subjects treated with GLP-1 receptor agonists presented a BMI of 27–30 kg/m^2. Consistent with established guidelines recommending the use of anti-obesity medications for individuals with a BMI $\geq$27 kg/m^2 in the presence of weight-related comorbidities, all subjects in this BMI range were carefully selected based on their medical histories. Documented comorbidities included prediabetes, hypertension, non-alcoholic fatty liver disease, metabolic syndrome, dyslipidemia, elevated liver enzymes, hypertriglyceridemia, and a history of diabetes or gestational diabetes. The physicians chose the medication based on clinical appropriateness, and the patients were treated with semaglutide, tirzepatide, or liraglutide. Tirzepatide was started with an initial dose of 2.5 mg, gradually increasing to either 5.0 mg, 7.5 mg or 10 mg by the three-month mark. Semaglutide started at 0.25 mg, escalating to 1 mg within the same timeframe, while Liraglutide was administered at a consistent dose of 6 mg. All the participants signed up for a value-based contract, which meant that they would receive a partial refund if they did not lose at least 10 % of their body weight by the end of the program. To qualify for the contractual guarantee, patients were required to meet specific compliance criteria focused on engagement and data sharing. These criteria included regular communication with the Zone.Health care team at least once every two weeks through the dedicated chat feature in the Zone.Health app, submission of at least one weight reading every 30 days throughout the program, provision of continuous glucose monitoring (CGM) data for a minimum of 14 days during the program, and the completion of food logs in the dedicated app at least three times weekly for the first three months, totaling a minimum of 36 food logs over the six-month program duration. All the participants complied with the criteria, resulting in the contractual guarantee of payment remaining

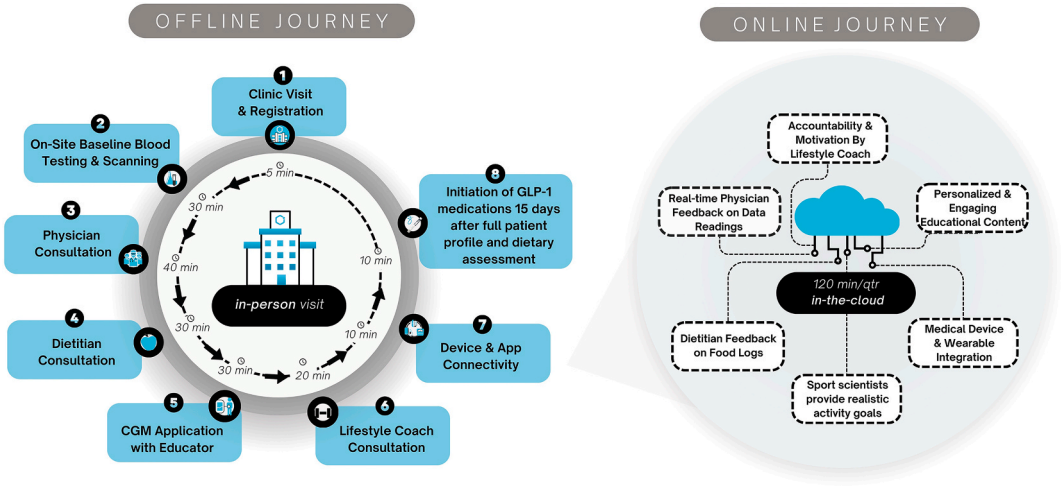

Fig. 1. Participant journey at Zone a hybrid approach, between offline and online journey.

active. All participants signed an informed consent in the beginning of their program. This study was conducted in strict adherence to the ethical standards of the Declaration of Helsinki. Informed consent was obtained from all individual participants included in the study. Clinical practices were regulated under the healthcare authority of the United Arab Emirates, which ensures compliance with international ethical standards for research involving human subjects. All procedures, including the collection and analysis of data, were performed with respect to the participants' rights and privacy.

2.3. Data collection and participants

The data was extracted from the physicians' patient records (at baseline and 3 months) using the Electronic Medical Record (EMR) (Diamond, Hicom, UK). Variables collected included: patients' gender, age, medications, weight, and BMI. Laboratory variables were also extracted including lipid profile (total cholesterol, low-density lipoprotein (LDL), high-density lipoprotein (HDL), and triglycerides), liver enzymes (alanine transaminase (ALT) and aspartate aminotransferase (AST)), and HbA1c. Fat mass and skeletal muscle mass were analyzed and collected using a Body Composition Analyzer (BCA). Liver stiffness and ultrasound attenuation parameter (UAP) were assessed using FibroScan, a special ultrasound technology that measures liver hardness and fatty changes in the liver.

2.4. Data analysis

Data was analyzed using SPSS software, version 29.0 (SPSS, Chicago, IL, USA). Continuous data like age, weight, and laboratory values were expressed as means and standard deviations (SD), and categorical data like gender and medication type were expressed as counts and percentages. The Paired T-test was used to compare variables at baseline and 3 months and to compare pre-and post-intervention outcomes. The P values at <0.05 were considered statistically significant.

3. Results

3.1. Basic demographics and characteristics

Table 1 presents the demographic and baseline characteristics of a total included patients in the program (n=115). The mean age of the participants is 43.13 ± 9.93 years. Gender distribution indicates that 41.1 % are male (n=46), while 58.9 % are female (n=66). The baseline weight of the participants was 95.6 ± 21.25 kg. Majority of participants (70.5 %) had a baseline BMI of >30 (kg/m^2). In terms of therapy, the majority of participants received tirzepatide (51.8 %, n=58), followed by semaglutide (46.4 %, n=52), and a smaller proportion received liraglutide (1.8 %, n=2). Fig. 2, represents the ratio of treatment

Table 1
Basic demographics and characteristics (n=115).

Variable	Mean ± SD or n (%) (n=115)
Age (mean ± SD)	43.09 ± 9.90
Baseline Weight (mean ± SD)	95.44 ± 20.92
Gender – n (%)	
Male	46 (40.0)
Female	69 (60.0)
BMI (kg/m^2) – n (%)	
<30 (kg/m^2)	35 (30.4)
>30 (kg/m^2)	80 (69.6)
Comorbidities in subjects with BMI 27–30 (kg/m^2) (n=35)	
Prediabetes	8 (22.9)
Fatty liver disease	8 (22.9)
Dyslipidaemia	20 (57.1)
History of Gestational Diabetes and/or Diabetes	2 (5.7)
Metabolic syndrome	4 (11.4)
Hypertension	2 (5.7)
Therapy – n (%)	
Semaglutide	51 (44.3)
Tirzepatide	60 (52.2)
Liraglutide	4 (3.5)

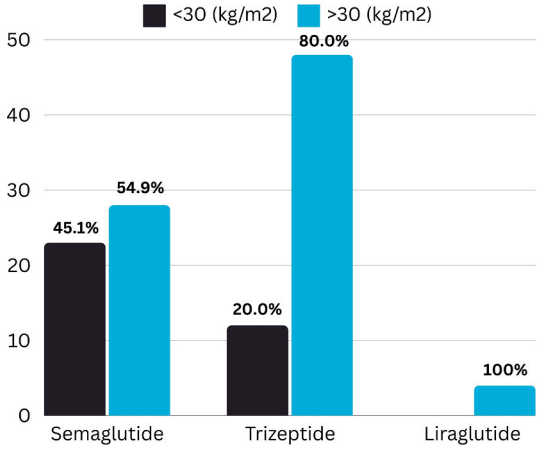

Fig. 2. Treatment ratios distirbution based on baseline BMI (kg/m^2).

distribution based on baseline BMI (kg/m^2).

3.2. Weight loss outcomes and body composition changes

Over 3 months, significant weight and fat mass reductions were observed across all groups (Table 2). Overall, participants experienced an average weight loss of 8.49 % ± 4.30 %, participants on semaglutide achieved a reduction of 8.27 % ± 4.02 %, and a slightly higher reduction for those on tirzepatide (8.78 % ± 4.65 %), and liraglutide exhibited the least reduction at 7.03 % ± 1.27 %. Fat mass reduction was most pronounced in the tirzepatide group (−15.46 % ± 9.75 %), followed by liraglutide (−13.86 % ± 7.30 %) and semaglutide (−12.53 % ± 11.64 %). In terms of achieving significant body weight reductions from baseline, tirzepatide had the highest proportion of patients achieving at least a 15 % reduction (36.7 %), followed by semaglutide (27.5 %) (Fig. 3). Overall, the majority of participants had at least 10 % reduction in weight at 3 months.

3.3. Overall improvement baseline vs. 3 months (n=115)

Table 3 presents the changes in metabolic health parameters midway through the program for a cohort of 115 participants. The baseline values and measurements at 3 months are provided for various parameters. The results show statistically significant improvements in several clinical risk factors. Significant reductions were also observed in cholesterol levels (16.69 mg/dL, $p < 0.001$), including LDL cholesterol (12.65 mg/dL, $p < 0.001$) and triglycerides (19.29 mg/dL, $p = 0.001$). Positive changes were seen in HbA1c (−0.25 %, $p < 0.001$). Additionally, improvements in liver function were noted, as evidenced by decreases in ALT (−4.27, $p = 0.034$), AST (−0.60, $p = 0.506$), and a decrease in liver UAP (−16.25, p= 0.001).

3.4. Sub-analysis of pre-diabetic patients

Table 4 focuses on the improvements observed in pre-diabetic patients (n=36) participating in the program. Notably, participants exhibited statistically significant improvements in HbA1c levels, with a mean reduction of 0.46 % ($p < 0.001$) leading to control of pre-diabetes and back to normoglycemia in 80.6 % of prediabetic patients (Fig. 4). Weight loss was also substantial, with a mean decrease of 7.52 kg ($p < 0.001$), accompanied by reductions in fat mass by 5.43 kg ($p < 0.001$). Furthermore, improvements were noted in total cholesterol levels, as evidenced by a mean decrease of 16.24 mg/dL ($p = 0.003$).

4. Discussion

In the context of obesity management, healthcare providers and specialists need to understand the mechanism of GLP-1 and GLP-1/GIP agonists. Despite their efficacy and safety in previous trials like SURMOUNT [15,22], and STEP [14], there remains a necessity for a comprehensive examination of these medications from an independent perspective. Guidelines recommend the medication to be used with intense behavioral modification such as a reduced calorie diet and increased physical activity. Further research is needed to determine the ideal content, amount of physical activity or lifestyle counseling when anti-obesity treatment is incorporated, and the best approach to deliver such services. The primary aim of this study was to evaluate the initial effectiveness of the program in real-world settings. Consequently, certain limitations such as the lack of a prospective design and absence of a control group are inherent to the study's retrospective nature.

The present study introduces a hybrid model that seamlessly integrates in-clinic and remote monitoring components within medicated obesity protocols that use personalized data from patients to enable gradual behavioral modifications. Integrating both online and offline care, the program allows for enhanced engagement collection of personalized data, the ability to derive insights and deliver these by the care team in near real-time for an outcome (i.e. behavior change) to be generated. This hybrid approach facilitates active participation with

Table 2
Weight loss and body composition outcomes across participants.

Changes at 3 months	Overall (mean ± SD %)	Semaglutide (mean ± SD %)	Tirzepatide (mean ± SD %)	Liraglutide (mean ± SD %)
Weight (kg)	−8.49 ± 4.30	−8.27 ± 4.02	−8.78 ± 4.65	−7.03 ± 1.27
BMI (kg/m^2)	−8.58 ± 4.57	−8.22 ± 4.18	−8.99 ± 4.99	−7.19 ± 1.48
Fat Mass (kg)	−14.13 ± 10.56	−12.53 ± 11.64	−15.46 ± 9.75	−13.86 ± 7.30
Muscle Mass (kg)	−4.59 ± 19.09	−1.59 ± 24.11	−6.35 ± 13.21	−14.36 ± 22.6

*Abbreviations: SD, standard deviation.

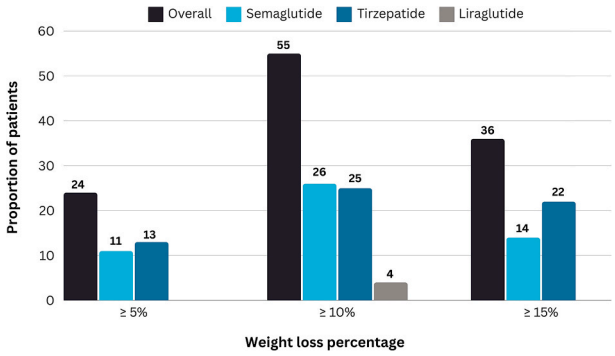

Fig. 3. Proportions of patients achieving bodyweight reductions of at least 5 %, 10 %, and 15 % from baseline.

Table 3
Metabolic health parameters improvement midway through the program (n=115).

Parameter	Baseline	3 months	Mean difference ± SD	p-value
Weight (kg)	95.46 ± 21.02	87.41 ± 20.21	−8.02 ± 4.17	<0.001[a]
BMI (kg/m^2)	33.41 ± 5.64	30.56 ± 5.53	−2.84 ± 1.52	<0.001[a]
Fat (kg)	40.28 ± 12.51	34.75 ± 12.13	−5.54 ± 3.60	<0.001[a]
Skeletal Muscle Mass (kg)	33.86 ± 13.33	32.08 ± 13.73	−1.78 ± 7.07	0.011[a]
Total Cholesterol (mg/dL)	197.53 ± 40.96	180.84 ± 36.28	−16.69 ± 33.1	<0.001[a]
LDL (mg/dL)	135.03 ± 41.61	122.37 ± 34.82	−12.65 ± 33.55	<0.001[a]
Triglycerides (mg/dL)	133.66 ± 80.55	114.36 ± 63.32	−19.29 ± 64.28	0.002[a]
HDL (mg/dL)	52.34 ± 15.05	48.63 ± 10.91	−3.71 ± 9.09	<0.001[a]
HbA1c (%)	5.40 ± 0.37	5.14 ± 0.33	−0.26 ± 0.32	<0.001[a]
ALT (U/L)	26.12 ± 20.21	21.77 ± 15.70	−4.27 ± 16.51	0.007[a]
AST (U/L)	21.01 ± 8.40	20.40 ± 9.19	−0.60 ± 9.86	0.525
Liver Stiffness (kPa)	6.71 ± 2.48	6.11 ± 2.48	−0.60 ± 2.65	0.085
UAP (dB/m)	295.81 ± 40.52	279.56 ± 40.90	−16.25 ± 36.69	0.001[a]

[a] The P-values <0.05 indicate the statistical significance of paired sample *t*-test. Abbreviations: HbA1c, glycated haemoglobin; ALT, alanine transaminase; AST, aspartate aminotransferase; UAP, ultrasound attenuation parameter; SD, standard deviation.

Table 4
Clinical improvements in obese pre-diabetic patients using GLP-1 and GLP-1/GIP (n=36).

Parameter	Baseline	3 months	Mean difference ± SD	p-value
HbA1c (%)	5.85 ± 0.18	5.39 ± 0.27	−0.46 ± 0.28	<0.001[a]
Weight (kg)	99.67 ± 19.39	92.15 ± 18.95	−7.52 ± 2.72	<0.001[a]
Fat Mass (kg)	42.12 ± 11.11	36.68 ± 10.26	−5.43 ± 3.23	<0.001[a]
Skeletal Muscle Mass (kg)	33.83 ± 13.9	32.21 ± 14.23	−1.63 ± 5.86	0.126
Total Cholesterol (mg/dL)	195.79 ± 41.95	179.53 ± 42.17	−16.24 ± 30.51	0.003[a]
LDL (mg/dL)	131.61 ± 52.41	123.41 ± 41.33	−8.19 ± 40.20	0.236
Triglycerides (mg/dL)	160.82 ± 101.51	141.61 ± 85.54	−18.89 ± 78.85	0.159
ALT (U/L)	28.48 ± 17.97	25.09 ± 15.82	−3.39 ± 13.98	0.161
AST (U/L)	21.63 ± 8.30	21.03 ± 7.96	−0.60 ± 7.55	0.643
Liver Stiffness (kPa)	7.87 ± 3.12	6.85 ± 1.92	−1.02 ± 3.59	0.246
UAP (dB/m)	299.72 ± 44.13	288.33 ± 44.56	−11.39 ± 36.49	0.203

[a] The P-values <0.05 indicate the statistical significance of paired sample *t*-test. Abbreviations: HbA1c, glycated haemoglobin; ALT, alanine transaminase; AST, aspartate aminotransferase; UAP, ultrasound attenuation parameter; SD, standard deviation.

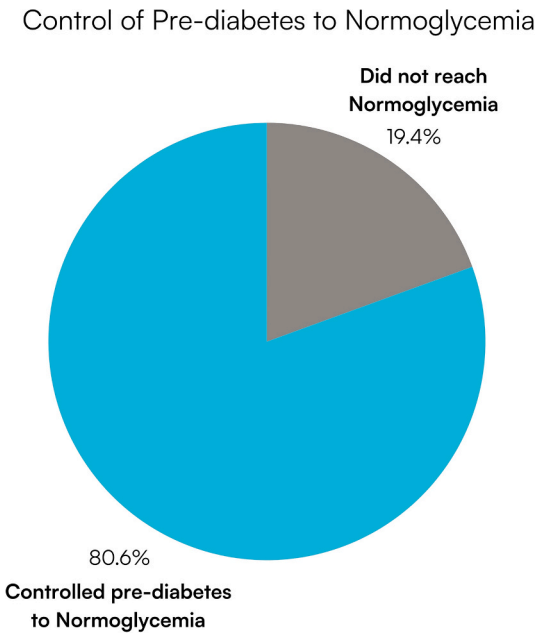

Fig. 4. Percentage of control of Prediabetes to Normoglycemia at 3 months of the program.

patients as there is no defined limit on the engagement with the care team, with an average of 120 min collectively spent managing a patient remotely per quarter. The relatively large sample size provided robust real-world evidence for analysis and showed significant improvements in various metabolic health parameters suggesting the effectiveness of the intervention. The absence of a control group and the midway period may limit the assessment of the long-term sustainability of the observed improvements. Overall, in 3 months, weight loss was 8 % from baseline mostly from fat mass (14 %) and only 5 % reductions in muscle mass. Weight loss interventions, as evidenced by various studies, exhibit a multifaceted impact on health parameters beyond numerical body weight reductions. In the current study, the effect of −8.49 % weight loss on other health parameters, −16.69 mg/dL in cholesterol levels, −18.89 mg/dL in triglycerides levels, and −12.65 mg/dL in LDL levels was significant. Ryan DH et al. [23] investigated the relationship between weight loss and comorbidities, demonstrating substantial improvements at different weight loss percentages, including 5 %, 10 %, 15 %, and beyond [23,24]. In the present study, majority of participants demonstrated a reduction in body weight of at least 10 %, with tirzepatide showing the greatest efficacy in terms of patients achieving a minimum of 15 % weight reduction (36.7 %), succeeded by semaglutide (27.5 %). This contrasts with findings from a real-world study by Alabduljabbar et al., which observed that a majority of patients on semaglutide who completed a 3-month follow-up achieved a weight loss of ≥5 % of their baseline body weight (65.5 %) [25]. Notably, in our study, only 21.6 % of patients on semaglutide exhibited a weight reduction of ≥5 %.

4.1. *Control of pre-diabetes using GLP-1 medications*

Weight loss is generally effective at reducing the incidence of pre-diabetes and progression to full diabetes. Intensive lifestyle modifications over 4 years in the Diabetes Prevention Program (DPP) study showed a 58 % risk reduction for diabetes incidence versus placebo [26]. In the present study, the sub-analysis of prediabetes patients highlights the efficacy of the hybrid Zone.Health care model in addressing pre-diabetes with a mean reduction of 0.4 % leading to a return to normoglycemia in 80.6 % of patients, reductions in weight (−7.52 kg), and improvements (lipid, fat mass) in key metabolic parameters are associated with the diabetes development.

4.2. *Hybrid health in weight loss management and obesity*

Hybrid care models have emerged as a transformative force in personalized and continuous patient monitoring, providing innovative solutions for metabolic dysfunction. The success of virtual disease management programs tackling metabolic health is well documented with HbA1c reductions ranging from 0.3 to 1.3 % points over a similar time period (12–26 weeks) [27]. Many of these studies have not reported other clinical parameter reductions due to the fact that such programs have not been part of the primary care providers' management plans, but act as an additional management/engagement tool used to assist patients [27]. Hybrid programs are managed end-to-end by the same provider, allowing for the same in-clinic care to provide real-time insights into patients' health journeys such as decision-making around food quantity, quality, and timing, delivery of regular bespoke exercise programs, glucose and sleep data interpretation, and gradual medication titrations based on results seen. In hybrid models, data collected from the online component becomes part of the patient's electronic medical record.

5. Conclusions

In conclusion, the study underscores the effectiveness of a hybrid care model that utilizes GLP-1 and GLP-1/GIP agonist therapies in improving various metabolic health parameters in patients with Obesity and Pre-diabetes. The integration of such hybrid solutions in the treatment protocol has been shown to significantly enhance the efficacy of the intervention, suggesting a promising approach for future obesity and pre-diabetes management strategies. Further, while this study has provided a preliminary understanding of educational interventions within the Zone.Health program, it has also highlighted gaps in detailed outcome reporting. To bridge this gap, future research will focus on gathering and analyzing data on educational impact factors such as food logging fidelity, adherence to CGM usage, and the synchronization of digital biomarkers such as activity and sleep data. This approach will offer a more granular understanding of how such interventions

contribute to the management of obesity and associated metabolic conditions. Further research is needed to solidify these findings and expand our understanding of the long-term impacts and optimal approaches for integrating these therapies into clinical practice.

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CRediT authorship contribution statement

Hala Zakaria: Writing – original draft, Supervision, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Sheikha Alshehhi:** Writing – original draft, Investigation. **Milena Caccelli:** Writing – review & editing. **Cigdem Ozkan:** Writing – review & editing. **Judy Kattan:** Writing – review & editing. **Zeinab Jafaar:** Writing – review & editing. **Remie Laborte:** Data curation. **Sofia Aleabova:** Data curation. **Noah Almarzooqi:** Writing – review & editing, Investigation. **Ali Hashemi:** Writing – review & editing. **Ihsan Almarzooqi:** Writing – review & editing, Validation, Conceptualization.

Declaration of competing interest

The following authors declared the following potential conflicts of interest: The following authors are full-time employees/interns at GluCare: Hala Zakaria, Sheikha Alshehhi, Milena Caccelli, Cigdem Ozkan, Zeinab Jafaar, Judy Kattan, Remie Laborte, and Sofia Aleabova. The following author is an intern at GluCare: Noah AlMarzooqi. The following authors have affiliations with organizations with direct or indirect financial interest in the subject matter discussed in the manuscript: Ali Hashemi, Ihsan AlMarzooqi.

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