Original Article

Finnish 6-Month Digital Intervention to Promote Health-Related Lifestyle Changes in Pre-Diabetics and Type 2 Diabetics Adults: A Preliminary Study

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Abstract

Background: Lifestyle modification that involves changing both diet and activity habits is essential in the treatment and prevention of type 2 diabetes. There is evidence that the digital health-related lifestyle interventions can improve diabetes control, healthcare utilisation and healthcare costs. However, the effectiveness of new digital interventions should be studied.

Aims and objectives: The study aimed to assess the effectiveness of a single 6-month digital intervention to promote health-related lifestyle change in pre-diabetics and type 2 diabetics using a quasi-experimental study design.

Methodology: The applied intervention was a 6-month digital service pathway for holistic lifestyle change. It consisted of various lifestyle themes, progress monitoring and support and guidance from a nurse or doctor. At the beginning and end of the intervention, self-reported weight, height, and waist circumference were collected via a digital questionnaire for pre-diabetics (n=23) and type 2 diabetics (n=33). Similarly, data on physical activity, dietary habits and perceived health status were collected from pre-diabetics (n=26) and type 2 diabetics (n=26). Changes were assessed using non-parametric analyses.

Results: During the intervention, the participants in the study lost on average 3.0 (-6.0, -1.0) kg ($p < 0.001$, their BMI dropped by 0.90 (-2.02, -0.10) kg/m2 ($p < 0.001$) and their waist circumference decreased by 4.0 (-7.0, 0.0) cm ($p < 0.001$). Perceived health status ($p < 0.001$), dietary habits ($p < 0.001$) and physical activity habits ($p < 0.001$) improved by 0 (0, 2), 1 (0, 3) and 2 (0, 4), respectively. Dietary habits improved among those who had two visits with a nurse ($p = 0.003$). The changes during the intervention did not differ between prediabetics and type 2 diabetics.

Conclusion: These preliminary study results may suggest the effectiveness of intervention in managing BMI and weight and improving dietary and physical activity habits among pre-diabetics and type 2 diabetics.

Keywords: diabetes mellitus; diet, diabetic; internet-based intervention; lifestyle, telemedicine; questionnaire

Introduction

Lifestyle modification is essential procedure for preventing type 2 diabetes in people with pre-diabetes and in treating type 2 diabetics (Fritsche et al., 2021; Laine et al., 2021). Over the past two decades, studies have demonstrated that lifestyle interventions are effective in preventing diabetes. A diet rich in vegetables, fruits, whole grains, and dairy products has been associated with a lower risk of pre-diabetes and type 2 diabetes (Pestoni et al., 2019). Moreover, the preventive effect of physical activity on the progression of type 2 diabetes in high-risk populations is widely recognised (Smith et al., 2016; Sahin et al., 2021).

The link between being overweight and a higher risk of diabetes is well established, leading many interventions to focus on weight loss. Previous lifestyle interventions for people who are at high risk of diabetes have achieved an estimated 3–6 kg of weight loss. (Feldman et al., 2017) Studies have demonstrated that nutrition and physical activity-based interventions can have beneficial effects on weight, blood glucose and other cardiometabolic factors such as blood pressure and cholesterol levels, as well as on the incidence of type 2 diabetes (e.g. Feldman et al., 2017; Hemmingsen et al., 2017; Pestoni et al., 2019).

After the expansion of mobile technology to all population groups, its use to support diabetes self-management has increased. Technologies have provided a platform for the rapid development of person-centred diabetes interventions and self-management support (Greenwood et al., 2017). Studies have suggested that digital interventions can improve diabetes control, healthcare utilisation and healthcare costs (Komkova et al., 2019; Gershkowitz et al., 2021; Legaard et al., 2023), and provide benefits similar to in-person or telephone-based interventions (Gershkowitz et al., 2021). Some studies suggest that digital interventions offer a promising solution to address the rapid increase in diabetes prevalence, because they can treat many people in different geographical locations (Gershkowitz et al., 2021). In digital interventions, interaction, real-time feedback, and service accessibility can help diabetics to take care of their health and increase treatment adherence (Greenwood et al., 2017).

Studies have also reported that digital lifestyle-based interventions can effectively treat type 2 diabetes (Bretschneider et al., 2017; Christensen et al., 2022; Rajkumar et al., 2023). An intervention study demonstrated that an eHealth intervention reduced weight, hyperglycemia remission rate, Body Mass Index (BMI) and hip and waist circumference after six months of lifestyle counselling (Christensen et al., 2022). Similarly, a small preliminary study without a control group, demonstrated that a 3-month digital lifestyle intervention reduced long-term blood glucose levels, improved metabolic parameters, perceived quality of life, dietary habits and increased physical activity (Bretschneider et al., 2017). Furthermore, a study comparing telehealth and in-person lifestyle intervention on type 2 diabetics demonstrated that telehealth provided comparable outcomes for blood glucose and weight loss with lesser follow-ups and fewer visits (Rajkumar et al., 2023).

In Finland, studies have compared the effectiveness of traditional and digital interventions (Kaasalainen & Neittaanmäki, 2018). A study of 2907 participants in the *StopDia* project at the University of Eastern Finland demonstrated that a 1-year lifestyle intervention based on multiple behaviour change theories, using both digital and group-based face-to-face delivery, improved diet quality and tended to reduce abdominal adiposity, thus preventing an increase in insulin resistance (Lakka et al., 2023). Self-determination theory (SDT) is a broad psychological framework use d in the intervention to support participants' intrinsic motivation and perceived competence in self-monitoring, goal setting and health behaviour planning (Lakka et al., 2023; Ryan & Deci, 2000). SDT suggests that by supporting an individual's ability to act in agreement with their own values and interests, their experience of being able to effectively act and their need for relatedness, optimal motivation and well-being can be promoted (Ryan & Deci, 2000). The use of SDT in digital health interventions has increased (Ryan, 2023), including in the treatment and prevention of chronic diseases such as type 2 diabetes (Mathiesen et al., 2023).

Improving the efficiency and effectiveness of lifestyle interventions for diabetes prevention is important (Laine et al., 2021). Furthermore, new digital solutions provide evidence-based benefits and thus genuinely support healthcare (Jääskelä et al., 2022). Regarding the effectiveness and efficiency of such interventions, the development of a holistic approach to diabetes care, defined as focusing on the diabetic's overall health and well-being (Jaam, 2017), is extremely relevant and critical. Recently, in addition to obesity, physical inactivity and high-fat and low-fibre diets, the understanding of factors contributing to diabetes has been expanded to include new environmental and lifestyle factors such as stress, smoking, depression and low levels of rest and sleep. To summarize, holistic health promotion that reduces exposure to all predisposing factors is an important and cost-effective preventive measure. (Costa & Mestre, 2019).

To address this requirement, we are evaluating the effectiveness of a Finnish 6-month digital intervention to promote health-related lifestyle changes in pre-diabetics and type 2 diabetics adults. This is the first study to assess the effectiveness of this new intervention using a small sample size and can, therefore, be considered a preliminary study. The research questions were as follows:

1) What was the change in weight, BMI and waist circumference of pre-diabetics and type 2 diabetics who responded to the questionnaire before and after measurement?

2) What was the change in perceived health status, dietary habits and physical activity of pre-diabetics and type 2 diabetics who responded to the questionnaire before and after measurement?

3) Which background variables of pre-diabetics and type 2 diabetics were associated with changes in weight, BMI, and waist circumference?

Methods

Design: The preliminary study applied a pre-post quasi-experimental design without a control group.

Intervention description: The digital intervention used, *Terve Päivä*, is a Finnish digital service pathway for holistic lifestyle change (Terve Päivä, 2024). It has been developed by a multidisciplinary team of healthcare professionals, including physicians, diabetes nurses, nutritionists, physiotherapists, and psychotherapists, by transferring traditional lifestyle counselling to a digital platform and designing the content of the counselling in a more user-friendly and empathetic format. The content of the intervention is based on the Finnish Current Care Guidelines (Current Care Guidelines, 2020) and the latest research results. The intervention is based on the SDT approach, which supports the autonomous motivation and perceived competence of diabetics by focusing on their freedom of choice and their existing knowledge, skills, and healthy habits as a basis for lifestyle change (Ryan & Deci, 2000).

The developed digital pathway provides a 6-month intervention that supports improved lifestyle choices and, thus, either the prevention of common lifestyle diseases or general lifestyle improvement. It comprises six themes, progress monitoring and evaluation, and two remote appointments with a nurse or one with a physician (an endocrinologist). The themes were based on lifestyle medicine: motivation, diet, exercise, daily rhythms, sleep and rest, and prevention and substance use (Jaqua et al., 2023). Themes were addressed in 24 weekly sectors, with baseline goal-setting and regular progress follow-ups during the intervention.

Participants and data collection: Inclusion criteria were people living in Satakunta who were over 18 years of age, had prediabetes or type 2 diabetes and were reported to require lifestyle intervention and enrolled for the intervention by public healthcare professionals.

The study collected data using questionnaires that were administered before and after the 6-month intervention, which was conducted between May 2022 and February 2023. Data were collected through two questionnaires, which were implemented within the digital intervention platform itself. The first questionnaire collected information on self-reported anthropometric parameters before and after the 6-month intervention, whereas the second questionnaire collected data on physical activity, dietary habits and perceived health status. The respondents' digital-care pathways included either two remote appointments with a nurse or one with a physician (an endocrinologist). In addition to questionnaires, data on the following demographic variables were collected: gender, age, diabetes type and intervention type.

Anthropometric parameters: The questionnaire for anthropometric parameters collected data related to self-reported weight, height and waist circumference from the participants at baseline and end of the intervention. BMI was calculated as follows: BMI = (weight (kg) / (height (m))^2. The self-reported weight obtained from mobile health applications has been found to be a valid method of collecting anthropometric measurements of type 2 diabetics during lifestyle interventions (Imeraj et al., 2022).

Lifestyle and perceived health parameters: Perceived health status, activity habits and dietary habits were determined using a 5-point Likert-scale questionnaire, which was completed by participants at baseline and end of intervention. Physical activity was determined using three questions about perceived physical condition, the regularity of physical activity and having regular exercise as a hobby. Dietary habits were determined using two questions about the regularity of meal rhythm and whether meals met Finnish nutritional recommendations (i.e., the plate model) (National Nutrition Council, 2014). Each participant's responses were summed to generate a combined value for the overall change in physical activity and dietary habits.

Statistical methods: The Kolmogorov–Smirnov test demonstrated that the distributions of all anthropometric and health status variables were skewed; therefore, non-parametric tests were performed for this analysis (Otsu & Taniguchi, 2020; Van Buren & Herring, 2020). Median and interquartile ranges were determined for all items. Moreover, demographic variables were described using frequencies and percentages. The association between demographic variables and median scores for changes in health status and anthropometric parameters was examined using a Mann–Whitney U test for two-paired independent samples and a Kruskall–Wallis H test for >2 independent samples (Van Buren & Herring, 2020). Differences in pre- and post-values for anthropometric and health status variables were tested using the Wilcoxon signed-rank test. If differences in pre-post values significantly differed between the groups (e.g., pre-diabetics and type 2 diabetics), the responses were separately analysed for each group using **Bonferroni-adjusted post-hoc tests:** A non-response bias analysis was performed comparing demographic variables and baseline measures between those who responded to the follow-up questionnaire and non-respondents. Statistical analyses were performed using the chi-squared test for categorical variables and the Mann-Whitney U test for continuous variables. A P-value of <0.05 was considered to be statistically significant. Analyses were performed using the statistical software SPSS for Mac (Version 27.0, IBM Corporation, Armonk, NY).

Ethical considerations: Informed voluntary consent was obtained from the study participants using the digital care platform applied for data collection and a 6-month intervention (Finnish National Board on Research Integrity, 2019). As per Finnish guidelines, this study did not require ethical permission because it was based on company records without the data security risks that are associated when data are combined from several sources (European Commission, 2021). The anonymised data generated by the company were securely made available to researchers for research purposes.

Results

Demographics and baseline characteristics

A total of 157 participants participated in the anthropometrics questionnaire, of which 60 participants (38%) answered the questionnaire both at baseline and at the end of the intervention. Two participants had missing values; therefore, the anthropometric data comprised 58 before-and-after responses (Table 1). More than half of the respondents were male and had type 2 diabetes; their average age was 60 years (Q1, Q3: 54, 64). Slightly more than half of the respondents had two appointments with a nurse, in addition to the digital care pathway, while the remaining participants had one appointment with physician. At baseline, the participants, on average, weighed 92 kg, had a BMI of 32 kg/m^2 and a waist circumference of 109 cm.

A total of 127 participants participated in the anthropometrics questionnaire, of which 53 participants (42%) answered the questionnaire both at baseline and at the end of the intervention. One participant had missing values; therefore, the anthropometric data comprised 52 before-and-after responses (Table 2).

Of these respondents, most were women, of whom half were pre-diabetic and half were type 2 diabetic; their average age was 61(Q1, Q3: 54, 64). More than half of them attended two appointments with a nurse, while the remainder had one appointment with a physician. At baseline, their mean perceived health status was 2 on a Likert scale of 1–5, the average value for dietary habits was 7 on a scale of 2–10 and the average value was 9 on a scale of 3–15 for physical activity habits.

According to the non-response bias analysis, there were not statistically significant differences between those who responded to the follow-up questionnaire and non-respondents.

Impact of intervention on health-related lifestyle change

During the intervention, all anthropometric and health status variables demonstrated improvement (p < 0,001 for the difference between before and after measures for all parameters). On average, participants lost 3,0 kg (−6,0; −1,0), their BMI dropped by 0,9 kg/m^2 and their waist circumference decreased by 4,0 cm (−7,0; 0,0; Table 1). Perceived health status, dietary habits and physical activity habits improved by 0 (0, 2), 1 (0, 3) and 2 (0, 4), respectively (Table 2).

Age was associated with changes in weight (p = 0,036) and BMI (p = 0,028); however, after Bonferroni correction, only changes in BMI were reported to show statistically significant differences between age subgroups. Moreover, BMI decreased more for 55–65-year-old people than for <55-year-old people (p = 0,049). However, BMI decreased in all age groups, in the under-55-year-old group (p = 0,003), in the 55–65-year-old group (p = 0,003), and in the over-65-year-old group (p = 0,021). Dietary habits improved among those who had two visits with a nurse (p = 0,003) but not among those having one visit with a physician (p = 0,213; p = 0,025 for the interaction between the groups).

There were no other differences observed in the assessed parameters between genders, pre- and type 2 diabetics, intervention types or age groups (Tables 1 and 2).

Discussion

Our preliminary study suggested the beneficial effects of a Finnish 6-month digital intervention on health-related lifestyle changes in pre-diabetics and type 2 diabetics. Results showed that parameters such as self-reported weight, BMI and waist circumference reduced, whereas perceived health status, physical activity and dietary habits improved during the intervention.

The participants lost −3,0 kg (on average), which is consistent with the average weight loss achieved in previous lifestyle intervention studies on individuals at a high risk of diabetes (Feldman et al., 2017). Their BMI dropped by −0,9 kg/m^2, and their waist circumference decreased by −4,0 cm. Previous studies have reported reduced weight, BMI and waist circumference to be associated with a lower incidence of diabetes (Khader et al., 2019; Feldman et al., 2017), including among those with BMI values over 30kg/m^2; this value is similar to the BMI of the participants in this study.

Moreover, physical activity and dietary habits improved from baseline to the 6-month follow-up. The promoting effect of increasing physical activity is significant as a previous study of health behaviours in type 2 diabetics showed low levels of physical activity among diabetics, suggesting a lack of motivation or knowledge (Sahin et al., 2021). The result also agrees with previous studies on the effectiveness of similar dietary and physical activity interventions developed by health professionals in improving cardiometabolic health factors and reducing diabetes prevalence (Pronk, 2016). However, it is important to note that two-thirds of the interventions demonstrated an effect at 6 months, but only one-third at 12 months (Lakka et al., 2023). Therefore, additional trials with a larger dataset and a longer duration of interventions and follow-up time are required.

Participants' perceived health status improved during the 6-month intervention. Baseline health status was worse than that at intermediate but improved after the intervention. Perceived health status summarises several aspects of health and has been demonstrated to be a good predictor of mortality, functional capacity, institutionalisation, and health service use at the individual level (National Institute for Health and Welfare, 2024). One-third of the Finnish working-age population perceives their health to be intermediate or worse (National Institute for Health and Welfare, 2017). Therefore, the baseline measurement agreed with the average for the Finnish population.

Table 1. Medians and quartiles of anthropometric variables, and their relationship to demographic variables (P-value).

			Anthropometric variables											
			Weight (kg) Median (Q1, Q3)				**BMI** (kg/m²) Median (Q1, Q3)				**Waist circumference** (cm) Median (Q1, Q3)			
		n (%)	Baseline	After	Difference	P-value	Baseline	After	Difference	P-value	Baseline	After	Difference	P-value
	ALL													
		58	92.0 (82.8, 106.0)	88.5 (80.8, 101.3)	-3.0 (-6.0, -1.0)	***<0.001***[a]	31.8 (28.0, 37.6)	29.7 (26.4, 34.7)	-0.9 (-2.0, -0.1)	***<0.001***[a]	109.0 (100.0, 115.3)	103.5 (95.8, 113.0)	-4.0 (-7.0, 0.0)	***<0.001***[a]
Demographic variables														
Gender		58												
	Men	35 (60)	98.0 (90.0, 110.0)	95.0 (85.0, 110.0)	-3.0 (-6.0, -1.0)	*0.981*[b]	31.3 (28.4, 34.7)	29.8 (27.4, 34.0)	-0.9 (-2.4, -0.1)	*.737*[b]	112.0 (108.0, 120.0)	106.0 (99.0, 117.0)	-5.0 (-9.0, 0.0)	*.316*[b]
	Female	23 (40)	87.0 (77.0, 102.0)	83.0 (74.0, 94.0)	-3.0 (-6.0, -1.0)		32.2 (27.3, 39.3)	29.6 (26.2, 38.6)	-0.9 (-1.9, -0.1)		107.0 (98.0, 113.0)	102.0 (92.0, 111.0)	-4.0 (-6.0, 0.0)	
Age		58				**0.036**[c]				**0.028**[c]				0.252[c]
	> 55 year	16 (28)	97.0 (79.5, 137.3)	90.5 (76.3, 126.3)	-4.0 (-9.8, -2.3)		36.5 (27.5, 48.1)	33.0 (26.4, 45.0)	-1.6 (-3.3, -0.8)		113.5 (95.3, 134.0)	109.0 (95.5, 122.8)	-5.0 (-8.5, -2.5)	
	55–65 year	33 (57)	93.0 (83.0, 105.0)	89.0 (82.0, 100.5)	-2.0 (-4.0, 0.0)		31.3 (28.5, 34.9)	29.6 (27.3, 33.8)	-0.8 (-1.4, -0.1)		109.0 (100.5, 115.5)	105.0 (98.0, 114.0)	-3.0 (-6.0, 0.0)	
	< 65 year	9 (15)	90.0 (83.0, 96.5)	84.0 (81.0, 89.5)	-5.0 (-7.0, -2.0)		30.5 (27.2, 34.6)	29.5 (26.0, 31.9)	-1.6 (-2.4, -0.7)		105.0 (98.0, 109.0)	98.0 (93.5, 101.0)	-7.0 (-10.0, 0.0)	
Diabetes type		56												
	Pre-diabetes	23 (41)	94.0 (87.0, 110.0)	89.0 (83.0, 110.0)	-3.0 (-6.0, -1.0)	*0.828*[b]	31.8 (27.5, 39.3)	30.5 (26.2, 36.9)	-1.0 (-1.9, -0.1)	*0.868*[b]	108.0 (100.0, 113.0)	104.0 (95.0, 112.0)	-4.0 (-6.0, 0.0)	*0.993*[b]
	Type 2 diabetes	33 (59)	93.0 (82.5, 105.0)	89.0 (78.5, 101.5)	-3.0 (-8.0, -0.5)		31.8 (29.1, 36.8)	29.4 (27.3, 33.4)	-0.9 (-2.7, -0.1)		109.0 (100.5, 118.0)	103.0 (98.0, 116.5)	-4.0 (-8.0, 0.0)	
Intervention		56												
	Intervention and remote appointment with a nurse	31 (55)	94.0 (82.0, 109.0)	89.0 (79.0, 101.0)	-3.0 (-6.0, -1.0)	*0.579*[b]	31.3 (27.8, 38.2)	29.6 (26.2, 35.5)	-1.0 (-2.4, -0.3)	*.698*[b]	108.0 (99.0, 113.00)	104.0 (95.00, 112.00)	-4.00 (-6.00, 0.00)	*.630*[b]
	Intervention and remote appointment with a physician	25 (45)	93.0 (83.0, 108.5)	89.0 (81.0, 107.0)	-3.00 (-6.50, 0.0)		32.2 (28.8, 37.1)	29.80 (27.30, 35.3)	-0.9 (-2.2, 0.0)		109.0 (103.0, 123.50)	103.0 (99.0, 119.5)	-5.0 (-9.0, 0.0)	

Note: Statistically significant (*p*= <.0.05) results bolded [a]Baseline vs. After (Wilcoxon W) [b]Group difference in responses (Mann-Whitney U) [c]Group difference in responses (Kruskall-Wallis H)

Table 2. Medians and quartiles of the health status variables, and their relationship to demographic variables (P-value).

			Health status variables											
			Health status Median (Q1, Q3)				**Dietary habits** Median (Q1, Q3)				**Physical activity habits** Median (Q1, Q3)			
		n (%)	Baseline	After	Difference	P-value	Baseline	After	Difference	P-value	Baseline	After	Difference	P-value
	ALL	52 (100)	2.0 (2.00, 4.00)	4.0 (3.00, 4.00)	0.0 (0.00, 2.00)	***<0.001*** [a]	7.0 (5.0, 8.8)	8.0 (8.0, 9.0)	1.00 (0.0, 3.0)	***<0.001*** [a]	9.0 (5.2, 12.0)	12.0 (8.0, 13.0)	2.0 (0.0, 4.0)	***<0.001*** [a]
Demographic variable														
Gender		52												
	Men	15 (29)	2.0 (2.0, 4.0)	4.0 (3.0, 4.0)	0.0 (0.0, 2.0)	*0.572* [b]	6.0 (3.0, 8.0)	8.0 (7.0, 9.0)	3.0 (0.0, 4.0)	*0.287* [b]	8.0 (4.0, 11.0)	12.0 (10.0, 13.0)	4.0 (0.0, 7.2)	*0.360* [b]
	Female	37 (71)	2.0 (2.0, 4.0)	4.0 (2.5, 4.0)	0.0 (0.0, 2.0)		7.0 (6.0, 9.0)	9.0 (8.0, 9.0)	1.0 (0.0, 2.0)		9.0 (6.0, 12.0)	12.0 (8.0, 13.0)	2.0 (0.0, 3.0)	
Age		52				0.334 [c]				0.087 [c]				0.082 [c]
	> 55 year	14 (27)	2.0 (1.8, 4.0)	4.0 (2.8, 4.0)	1.0 (0.0, 2.3)		4.5 (3.0, 6.3)	8.0 (6.8, 9.0)	2.0 (0.0, 5.3)		8.0 (4.0, 10.3)	12.0 (9.3, 13.0)	3.5 (0.8, 4.0)	
	55–65 year	26 (50)	2.5 (2.0, 4.0)	4.0 (2.0, 4.0)	0.0 (0.0, 1.0)		8.0 (6.0, 9.0)	8.0 (7.0, 9.0)	0.0 (0.0, 2.3)		10.0 (5.5, 12.0)	10.0 (7.0, 13.0)	0.5 (-0.3, 2.0)	
	< 65 year	12 (23)	3.5 (2.0, 4.0)	4.0 (4.0, 5.0)	0.5 (0.0, 2.0)		7.5 (6.0, 9.0)	9.0 (8.3, 9.0)	2.0 (0.3, 2.8)		10.5 (6.5, 13.8)	13.5 (12.0, 14.8)	2.0 (0.3, 5.8)	
Intervention		52												
	Digital care pathway and remote appointment with a nurse	30 (58)	2.0 (2.0, 3.3)	4.0 (2.8, 4.0)	0.5 (0.0, 2.0)	*0.111* [b]	6.0 (3.8, 8.0)	8.0 (7.8, 9.0)	2.0 (0.8, 4.0)	***0.025*** [b]	8.0 (4.8, 12.0)	12.0 (8.0, 13.3)	2.0 (0.0, 4.0)	*0.117* [b]
	Digital care pathway and remote appointment with a physician	22 (42)	4.0 (2.0, 4.0)	4.0 (3.0, 4.0)	0.0 (0.0, 0.3)		8.0 (6.0, 9.0)	8.0 (8.0, 9.0)	0.0 (0.0, 2.3)		10.0 (6.8, 12.0)	12.0 (8.0, 13.3)	0.0 (-1.0, 4.3)	
Diabetes type	**Diabetes type**	52												
	Pre-diabetes	26 (50)	2.0 (2.0, 4.0)	4.0 (2.0, 4.0)	0.00 (0.0, 2.0)	*0.759* [b]	6.0 (4.0, 8.0)	8.5 (7.8, 9.0)	2.0 (0.0, 4.0)	*0.207* [b]	9.0 (5.5, 12.0)	12.0 (8.0, 13.3)	2.0 (0.0, 4.0)	*0.658* [b]
	Type 2 diabetes	26 (50)	3.0 (2.0, 4.0)	4.00 (2.0, 4.0)	0.0 (0.0, 1.3)		8.0 (5.8, 9.0)	8.0 (8.0, 9.0)	0.0 (0.0, 3.0)		9.5 (5.0, 11.3)	12.0 (8.0, 13.0)	1.0 (-1.0, 5.0)	

Note: statistically significant (p= <.0.05) results bolded [a]Baseline vs. After (Wilcoxon W) [b]Group difference in responses (Mann-Whitney U) [c]Group difference in responses (Kruskall-Wallis H)

Discusion Cont.

Age was associated with changes in weight and BMI; however, these changes were modest and mostly non-significant in post-hoc analyses. In a previous study, adults over 65 who were at a high risk of cardiovascular disease and diabetes were more likely to meet weight loss and exercise targets compared to those under 65 (Brokaw et al., 2015).

The study reported that adults over 65 had a higher self-monitoring rate and attended more intervention sessions than younger attendees, suggesting that higher weight loss among older people was related to their higher commitment to intervention. Other studies have also shown that older age is a significant predictor of adherence to lifestyle interventions (Burgess et al., 2017; DeLuca et al., 2020).

We found that the dietary habits of the participants improved more among those who had two remote appointments with a nurse than among those who had one remote appointment with a physician. Our results suggest that regular professional guidance, combined with a digital pathway, improves the effectiveness of the intervention. However, the difference was detected only in dietary habits; therefore, the overall effect of the applied lifestyle intervention did not considerably differ between those having one or two appointments. This result agrees with Lakka et al. (2023), who reported that habit-based digital lifestyle interventions may not be sufficient on their own and require support from health professionals and peers. A multi-national diabetes study emphasized that regular education, motivation, and professional support are essential for effective self-management of diabetes, suggesting that interventions designed to enhance patients' desire to reduce disease progression and incorporate appropriate technologies could improve outcomes (Adu et al., 2019).

Our study can provide valuable information on the effectiveness and efficiency of digital care, which is being widely implemented in Finland (Finnish Government, 2023). In addition to the effectiveness and cost-saving potential, improving the understanding of the impact of patient engagement alongside the provision of dignified and empathetic care is important to ensure that the technology is aligned with the principles and vision of nursing for the future (Juanamasta et al., 2017). The latest meta-analysis comparing the benefits and harms of SDT-based interventions with usual care in diabetics found no significant differences in quality of life, mortality, adverse events, diabetes-related distress, HbA1c, depressive symptoms, or motivation (Mathiesen et al., 2023). Instead, it found a high risk of bias among assessed studies and a requirement for additional high-quality trials. Alongside the effectiveness, future research should focus on user experience, interface design and exploring healthcare professionals' ability to engage and provide empathic care in a technology-mediated way, potentially influencing intervention effectiveness. This may require novel research and evaluation methods, including qualitative research methods, longitudinal research and other approaches, to understand the effectiveness of digital interventions on people's motivation, behaviour, and outcomes.

Strengths and limitations: A strength of our study was that it was designed to improve overall health and well-being using diversified lifestyle coaching developed by a professional multidisciplinary group. Our study provides new information on the effects of short-term lifestyle changes among people with pre-diabetes and type 2 diabetes. It was conducted in a real-life setting; therefore, it may provide valuable information about the effectiveness and appropriateness of the intervention. The response rate was 38% for the anthropometric data and 42% for the health status data, which may be considered adequate for a web-based questionnaire (Sammut et al., 2021). The non-response bias analysis indicated that the results can be generalised to the original sample, as there were no significant differences between respondents and non-respondents on demographic and baseline measures. However, it is important to consider possible unknown factors that may have influenced non-response and may affect the generalisability of the results. It is important to note that data were collected using self-reported questionnaires, which involve a generally recognised risk of bias. Social desirability bias may have affected the results. Moreover, the participants were not randomly selected, and there was no control group. However, the sample based on register data represents those pre-diabetics and type 2 diabetics who were advised to undergo the intervention as part of their normal clinical treatment; therefore, the results are applicable to the corresponding clinical settings. The study focused on the short-term effects of a relatively new intervention protocol in a small sample, which limits the generalisability of the results.

Regarding generalisability, there is a requirement for more robust evidence with larger datasets in different diagnostic and healthcare systems. Moreover, a longer follow-up period would have provided information about the long-term effects of the intervention, and larger samples could have demonstrated more differences in the observed changes related to factors such as age.

Conclusions: Our preliminary study may suggest that a Finnish 6-month digital lifestyle intervention supports managing BMI and weight and improves dietary and physical activity habits among pre-diabetics and type 2 diabetics. To ensure a robust understanding of the benefits of digital interventions in diabetes care, future studies applying a randomised controlled design and post-intervention follow-up studies are suggested. Moreover, it would be interesting to evaluate the effectiveness of the digital lifestyle intervention applied in our study in diverse populations, such as adults with cardiovascular disease and overweight adults without chronic disease.

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