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ORIGINAL ARTICLE

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A Mobile Application Platform to Increase Physical Activity in Individuals with Type 2 Diabetes During the Coronavirus (COVID-19) Pandemic

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Abstract

Introduction: Mobile health applications for individuals with type 2 diabetes (T2DM) have the potential to improve physical activity (PA) during the coronavirus (COVID-19) pandemic; yet, there is a need to identify the *content* of a mobile application (app) in the light of conceptual framework and the delivery features to increase the usability of the app. The aim of this study is to improve the mobile application based on a framework that conceptually determines the needs of individuals with T2DM. At the same time, it is to determine the presentation features of the application to increase its usability for individuals and health professionals using it.

Methods: The content and delivery features of a PA app were determined using the Delphi method considering the diabetes core sets of the international classification of the functioning framework, including experts in the area of T2DM for the *app's content* and heterogeneous participants for the *delivery features* of the app. A mobile application was created according to the data obtained by this method after the application was created by this way.

Results: Delphi experts suggested 64 ideas for the content of the app, of which 46 reached sufficient agreement (72.5–100%). In the second step, participants generated 27 ideas, yet, the consensus was reached on 12 delivery features (70–100%). The application was created by transforming these ideas into app content.

Discussion and Conclusion: This study addressed the content-related limitations and usability challenges in the pre-existing studies. During the lockdown, the developed PA app can be implemented using different mobile devices.

Keywords: Coronavirus (COVID-19) pandemic; delphi techniques; mobile health application; physical activity; the international classification of functioning; type 2 diabetes.

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disease that is steadily increasing worldwide [1]. Its rising prevalence is linked to sedentary lifestyle, so adopting an active lifestyle is essential for preventing and managing T2DM [2]. However, individuals with T2DM are mostly not active and show poor adherence to long-term physical activity (PA) [3]. Following the coronavirus (COVID-19) outbreak, the governments of several countries launched national shutdowns, some of which are still ongoing [1]. This process aggravates a sedentary lifestyle. These lockouts

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force people to stay inside their homes save for essential duties in the event of an epidemic [2]. During the COVID-19 pandemic, there has been a rapid introduction and implementation of innovative solutions to health service delivery, especially for patients with chronic conditions such as individuals with T2DM [4].

Diabetes is a chronic disease progressively affecting different areas of the body. This, then, necessitates involvement in various exercise types targeting various body structures and functions. Until now, several apps have been developed to improve PA in individuals with T2DM, but the content of the developed apps is limited and lacks foundation [5,6]. This, in turn, challenges the validity and usability of the app in individuals with T2DM [6]. This involvement, however, should be done with the help of a conceptual framework and expert consultation to ensure the validity of the provided platform in the targeted population [7].

This study aims to develop a PA application in individuals with T2DM with the help of a conceptual framework and counseling approaches.

Materials and Methods

The Clinical Research Ethics Committee approved this study at Marmara University (Protocol No: 092017604). In this study, we have used Delphi techniques to identify the content (the information the app should contain) and delivery feature (the way the data should be presented) of the PA app. Delphi techniques consisted of two stages. In the first stage, we identified the exercise-related content of the mobile exercise platform through a modified Delphi process by seeking consensus among the experts. In the second stage, we formed the delivery method through a Delphi process to reach a consensus among a group of heterogeneous participants (i.e., individuals with T2DM and clinicians). The Delphi method is a technique for obtaining expert opinions in a structured manner [8]. It consists of an iterative multistage process to come to a group consensus. In this study, we used the traditional Delphi method and a modified version of the Delphi technique. The application was created by transforming these ideas into app content.

Content

The content of the PA app was developed by consulting with experts in T2DM, considering the ICF core attributes for diabetes [6]. An invitation letter and/or E-mail including brief information about the goal of the study and the roles of participants were sent to 30 experts who: (1) have, at minimum, a master's degree in physiotherapy and rehabilitation and (2) have at least 5 years of experiences in the field of diabetes as a clinician and/or researcher. All participants were provided with background information about the study by a research member before Round 1. In Round 1, experts were asked to generate ideas regarding the content of the PA app to improve PA levels in diabetes, considering the core sets of diabetes [8]. In Round 2, we asked to rate the relevance of each generated idea with "diabetes management and PA" using a 4-point Likert scale (strongly disagree, disagree, agree, and strongly agree). In Round 3, participants rerated the ideas on which there was no consensus in Round 2.

Delivery Features

The delivery method of the app was developed using a heterogeneous purposive recruitment strategy from three groups of individuals (individuals with T2DM, experts in the area of T2DM, and information technology (IT) technicians). It included one formative round to generate ideas and two rounds for rating. The four-point Likert scale was used for rating.

Delphi Rounds

- Delphi Round 1: In this round, participants were provided a brief presentation about the content of the mobile exercise platform by one of the researchers in the research team (ET). They were asked to generate new ideas about the content of apps to improve the adherence and usability of the app. Particularly, they were asked to generate some answers to the following question "What kind of features would you like the application to have to increase the usability of a medical application designed for T2DM."
- Between rounds (Mapping): We listed all the generated ideas regarding mobile exercise platform features in this round. Then, a statement corresponding to each idea was prepared (i.e., this mobile exercise platform should include X).
- Delphi Round 2: A list of statements (i.e., this mobile exercise platform should include X) was presented to all participants, and they were asked to rate the statements using a four-point Likert scale (strongly disagree, disagree, agree, and strongly agree). A blank comment area was provided for the participants if they would like to add new ideas during Round 2. The minimum agreement level was set as 70% [9].
- Between rounds (Analysis): The results of Round 2 were

summarized, and the frequency distribution was prepared. The items, in which there was no adequate consensus (%70), were documented with their frequency distribution and prepared to process into the following round.

- Delphi Round 3: In this round, participants were asked to rerate the statements (remaining), in which there was no consensus on it considering the response of other participants (frequency distribution of answer).
- Final round (Analysis): The frequency distribution of the remaining statements was presented. The statements in which 70% agreement was reached were not considered to design the delivery method of the mobile exercise platform.

Software Development

At this research stage, the generated content was converted to software, and the devices were tested. Modelling consisted of testing and evaluation steps for implementation. Software implementation was carried out with the Agile Methods Model [1].

In this approach, the quality of the software development process has been tried to be increased using the continuous integration method. Continuous integration separates the software development process into small parts and ensures continuous improvement. In the ongoing integration process, software developers usually combine the codes they write with the actual code daily. Each integration is validated with automated tests, ensuring that integration errors are found as quickly as possible (http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.848.5149&rep=rep1&type=pdf). The code that successfully passes computerized tests is distributed to alpha and beta users. Alpha users generally consist of people within the team, while beta users are general users of the application. After alpha users confirm that there are no errors in the application, the application is released to beta users. The application is published to all users if no errors are found after beta users. Possible errors found in the testing of alpha or beta users are immediately corrected, and the continuous integration process is repeated (Fig. 1).

At this stage, the software was created by an Endocrinology specialist, Public health specialist, a physiotherapist

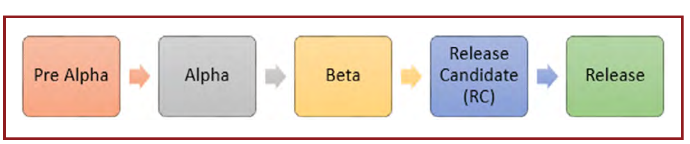

Figure 1. Software development process.

experienced in T2DM, a software engineer experienced in mobile health applications, and two females and two male patients with T2DM. The software, which was updated with the feedback received from the focus group, was reported with a SWOT analysis and revised again.

The software development process consists of two stages.

In the first stage, exercise videos were prepared for diabetes. The videos were recorded using the Canon EOS400D in front of a green background. Videos were edited using iMovie after recording. A green-screen effect has been applied to everyone to create a blue background. While exporting the videos, the following settings were used; 540 dp resolution, high quality, fast compression, and MP4 format. The size of the files has been adjusted to not exceed 5 MB in reducing the download time. After all the files were completed, they were uploaded to the data servers. Mobile, watch, and web applications were developed in the second phase. Firebase Real-Time Database controls data flow between mobile, watch, and web applications (https://firebase.google.com/docs/database/).

Mobile Apps

The FizyoTr mobile application has been developed for both Android and iOS platforms. OAuth 2.0 protocol was used for authorization on both platforms. This protocol constitutes an important step in securely sending user credentials to the remote server for login purposes for data security reasons. Platform-specific libraries and frameworks are described below.

Android App

Android Studio is used for development purposes. FizyoTr application for Android was developed using the Java programming language. Model-View-View Controller architecture is used according to Google's recommendation for Android apps (https://developer.android.com/jetpack/docs/guide#recommended-app-arch). View models separate the user interface from the business structure in this architectural model. This gives the app a chance to survive the configuration changes. Network interviews were conducted with the Retrofit open source library (https://square.github.io/retrofit/). Room Persistence Library was used to store Local Data. This framework is an abstraction layer over SQLite to allow more efficient database access (https://developer.android.com/topic/libraries/architecture/room). The sliding framework was used for image loading and caching (Https://github.com/bumptech/glide). The minimum supported API level for the application is 21. Xcode was used for development purposes. FizyoTr app for iOS was developed using Swift programming language. Model-View-Controller architecture was used. Network searches were done with the Alamofire open source library. (https://github.com/Alamofire/Alamofire). SQLite.swift library was used to store local data (https://github.com/stephencelis/SQLite.swift). The AlamofireImage framework has been used for image loading and caching (https://github.com/Alamofire/AlamofireImage). The minimum supported SDK level for application is 10.0 (Fig. 2).

Smart Clock Application

Currently, there are several clock operating systems such as WearOS, Tizen, and Apple Watch. The WearOS operating system was chosen for development because the apps developed for this platform can be used without the need for a phone. In other words, apps installed on a watch with WearOS can be used as a separate app or as an extension of the phone app. Android Studio is used for development purposes. FizyoTr application for WearOS was developed using the Java programming language (Fig. 3). Ticwatch E was chosen to be used for both development and testing. It has a pedometer, GPS, and heart rate sensor, all of which are used to calculate user actions.

Statistical Analysis

Responses were entered into Microsoft Excel and then analyzed. The percent agreement for all ideas was calculated as the proportion of the experts giving items a relevance rating of 3 or 4 [10]. The content analysis of the ideas was done by the research team to cluster them under some categories after Round 3. The stopping point for this study was achieving the 70% consensus (70% of experts must score 3 or 4 on the Likert scale) as suggested by Delphi guidelines[11].

Results

A total of 11 experts participated in and completed the Delphi process for the *content of the PA app*. Delphi experts suggested 64 ideas for the app's content, of which 46 reached sufficient agreements at the end of the third round (72.5–100%) (Supplementary file 2). The identified contents were clustered under three categories: (1) Exercise type and parameters, (2) health education, and (3) subsidiary contents (Table 1). To identify *the delivery features of the app*, seven participants completed the three rounds of the Delphi process. Out of 27 ideas generated in Round 1 (Supplementary file 2), there was a consensus on 12 delivery features (70–100 %) (Table 1).

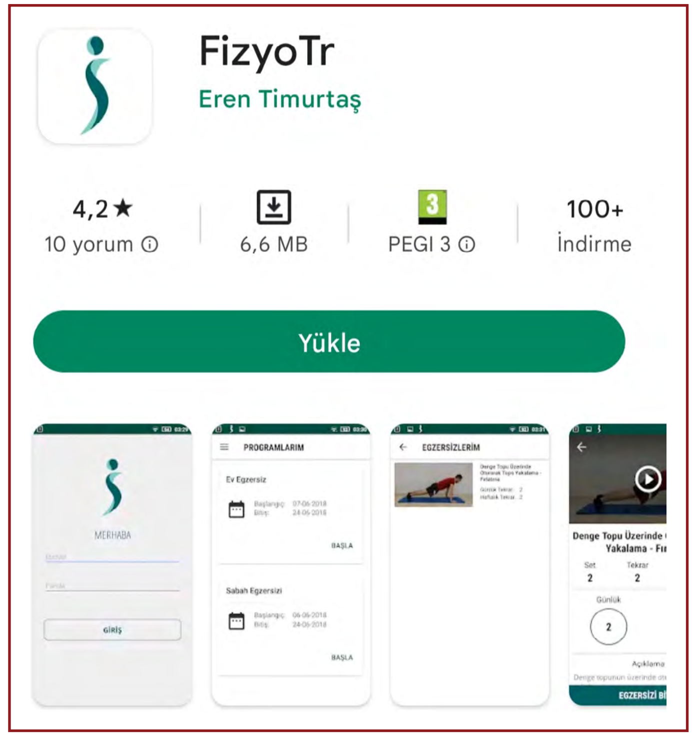

Figure 2. Mobile application interface.

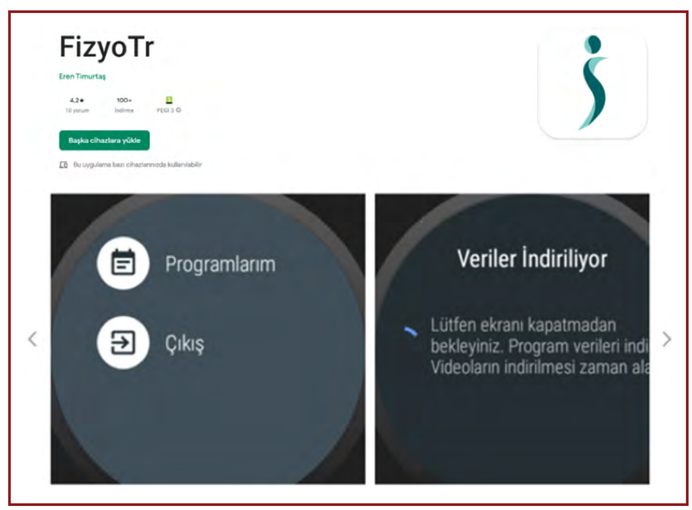

Figure 3. Smart clock application interface.

Discussion

The present study developed a mobile exercise platform solely invested in improving PA in individuals with T2DM using the ICF framework and consultation approaches. According to the expert feedback, different types of exercises (aerobic, stretching, strengthening, proprioception, coordination, and balance exercises) were included in the treatment program. All identified exercises were among those whose effectiveness has been repeatedly shown in managing T2DM [12,13]. Balance training has been included

Table 1. The ideas agreed by Delphi participants by the end of Delphi process

	Content of the mobile app		Delivery features of the mobile app
Exercise type and design	**Education**	**Subsidiary contents**	
1. Strengthening	1. Foot and skin care	1. Personal information registration	1. The exercise content should be presented as audiovisual video with written text
2. Coordination	2. Exercise education (goal setting)	2. Metabolic equivalent of task per exercise	2. The exercise performance should be presented as graphic
3. Stretching	3. Education for stress management	3. Heart rate and glucose monitor record	3. There should be a notification to remind patient to do exercise
4. Balance	4. General information about diabetes		4. There should be a warning when exercise is not appropriate for a patient (based on patient`s blood and cardiac parameters).
5. Coordination	5. Exercise nutrition interaction		
6. Aerobic exercise	6. Timetable of exercise		
7. Walking	7. Education for safe care activities of Daily Living		5. Exercise should be customized. 6. Clinicians should be able to send extra notification settings.
8. Exercise for activity of daily living	8. Exercise medicine interaction		7. Patient should be able to adjust notification settings.
9. Functional education	9. Tracking heart rate and glucose monitor		8. Both clinician and clinicians should be able to text to each other
10. Posture exercise	10. Step counting		
11. Proprioception	11. Education for the use of orthosis		9. Data security, back up, password protection
12. Gait training	12. Shoe type, proper choice of shoes		
13. Nordic poles	13. Education provided by local services		10. Exercise parameters should be presented just under the exercise video.
	14. Timing of exercise		
	15. Timetable of exercise		11. Data from pedometers should be visualized constantly.
	16. Charting and exercise follow-up charting		12. There should be educational tools for app.
	17. Information clinician- patient interaction		
	18. Occupational consideration		
	19. Usage of public transportation		
	20. Physical activity daily report		
	21. The means of transfers at Activity of daily living, usage of elevator or stairs.		
	22. Social interaction		
	23. Hobbies, routines		
	24. Useful link for diabetes and exercise		
	25. Updates about the content		
	26. Education for caregivers		
	27. Family education		
	28. Education for health care system		
	29. Education for non-governmental organisation		
	30. Data entry about the patient` characters diabetes related outcome (value)		

in the content to promote safe and efficient ambulation in the targeted population since individuals with T2DM are more likely to fall and vulnerable to fall-related injuries than healthy individuals [14,15].

On the other hand, aerobic exercises target to improve and control blood glucose levels [16]. The identified content also contains a walking training, where participants can adjust their walking speed based on physiological signals such as heart rate and glucose level through instant feedback and notification. The recent studies interviewing individuals with T2DM documented that self-monitoring of vital signs during PA increases their motivation to do exercises [17]. Moreover, embedding a pedometer into walking training has also been considered. Another motivator is promoting exercise and increasing PA [18].

Educational context, including information about PA and potential exercise-related complications, was also suggested to promote a healthy lifestyle and avoid possible adverse effects [19]. In the next step, various delivery features to increase interaction with health professionals, boost motivation, and improve adherence to exercise and satisfaction levels in individuals with T2DM that can address the challenges that arose from current epidemic situations were identified by Delphi experts. We identified several delivery methods to improve the usability of the mobile exercise platform, considering the efficiency and effectiveness of the exercise platform and the satisfaction of users in consultation with patients, clinicians, and IT technicians. For example, presenting contents in an audiovisual video format, allowing to set a notification for daily exercise, providing a warning for an inappropriate exercise choice, and graphical representation of performances hourly or daily were chosen with sufficient level of agreement among Delphi participants to foster the ability of users to learn exercise-related contents, promote regular exercise adherence,[20] and facilitate a safe and customized exercise program concerning vital signs, physiological signals, and glucose dynamics, and boost the motivation of users, respectively [21].

Finally, an exercise platform with different types of exercises, informative content, and other specified features was created. The epidemic has seriously affected individuals with T2DM with insufficient PA since they were isolated at home [22]. Due to quarantine measures, patients with T2DM diabetics have had difficulty accessing health care systems and professionals [23]. According to a recent survey, the conventional face-to-face mode of medical care is not preferred by patients in an epidemic situation, and telerehabilitation is urgently needed [24]. The developed PA app can be implemented under lockdown life using various technological devices, including smartphones, tablets, and smartwatches that can allow communication with health professionals instantly. However, further studies are required to investigate the feasibility of implementing the developed exercise app during the pandemic.

Ethics Committee Approval: This study was approved by Clinical Research Ethics Committee at Marmara University (Protocol no: 092017604).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: E.T., E.Ç., N.K., Y.S., M.G.P.; Design: E.T., E.Ç., N.K., Y.S., M.G.P.; Data Collection or Processing: E.T., N.K.; Analysis or Interpretation: E.T., E.Ç.; Literature Search: E.T., E.Ç., N.K.; Writing: E.T., E.Ç., N.K., Y.S. M.G.P.

Conflict of Interest: None declared.

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