

ORIGINAL ARTICLE

## Rationale and design of lifestyle intervention using mobile technology in patients with high cardiovascular risk: A pragmatic randomized clinical trial

### Mobil teknoloji desteğiyle yüksek riskli kalp hastalıklarında yaşam tarzı değişikliği: Pragmatik randomize klinik çalışma dizaynı

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#### ABSTRACT

Cardiovascular disease (CVD) is the leading cause of morbidity and mortality throughout the world and contributes a considerable burden to healthcare costs. Primary prevention strategies, particularly adopting healthy lifestyle habits, have great potential to reduce the risk of CVD. Patient compliance remains the major cause of the failure of primary prevention strategies. Telehealth interventions and gamification through mobile applications can increase adherence and reduce healthcare costs. The primary objective of this study is to compare the effect of lifestyle intervention using mobile technology plus usual care with usual care alone in patients with a high CVD risk.

The increasing prevalence of chronic diseases as a result of an aging population and concomitant bad lifestyle habits necessitates new approaches in healthcare systems, particularly in terms of patient self-monitoring and management of lifestyle interventions. Effective self-monitoring and appropriate lifestyle interventions have great potential to reduce the risk of cardiovascular disease (CVD), particularly in patients with a high risk, and to reduce the healthcare costs to hospitals and healthcare systems.<sup>[1]</sup> Preventable

#### ÖZET

Kardiyovasküler hastalıklar (KVH) tüm dünya genelinde morbidite ve mortalitenin başlıca sebeplerinde biridir ve sağlık sistemine yüksek maliyet getirmektedir. Sağlıklı yaşam tarzı alışkanlıkları KVH'dan primer korunma yöntemi olarak önemli bir potansiyele sahiptir. Ancak, hastaların sağlıklı yaşam tarzı değişikliklerine uzun dönemde uyum sağlayamaması en önemli sorundur. Tele-sağlık ve mobil telefonlardaki sağlık uygulamaları hastaların yaşam tarzı değişikliklerine olan uyumu artırarak sağlık sistemi üzerinde maliyeti azaltabilecek potansiyele sahiptir. Bu çalışmanın ana amacı KVH açısından yüksek riske sahip bireylerde birincil korunma yöntemlerine ek olarak mobil teknolojilerin kullanılması ile sadece geleneksel birincil korunma yöntemlerinin arasında herhangi bir fark olup olmadığının araştırılmasıdır.

causes of death, such as tobacco use, poor diet, physical inactivity, and alcohol abuse, have been estimated to be responsible for nearly 40% of total yearly mortality in the United States.<sup>[2]</sup> Recently, several studies have investigated possible tools to reach more people with lower healthcare costs through the Internet, remote monitoring, telephone support, and smartphone technologies. Adherence to medication use is another important factor in morbidity and mortality; it has been reported that only 50% of patients complied

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with persistent use of statins and drugs to reduce blood pressure at 1 year following an acute myocardial infarction (MI).<sup>[3]</sup> Telehealth interventions have significantly improved medical adherence in clinical scenarios.<sup>[4]</sup> In some countries, including the United Kingdom, current policy envisages that the use of telehealth and other technology-enabled approaches have the potential to transform the delivery of healthcare and to make the National Health Service sustainable for the future.<sup>[5]</sup> In the United States, the Veterans Health Administration enrolled more than 50,000 people in a home telehealth program, and in Europe, the Renewing Health consortium is evaluating telehealth programs in 9 countries.<sup>[6-8]</sup> Smartphone technologies give patients another means to participate in health-based educational processes and to find incentive for lifestyle changes through feedback, reminders, and motivational messages. In addition, these tools have great potential to improve both primary and secondary prevention strategies through monitoring patients' diet, physical activity, medication use, and cardiovascular risk parameters.<sup>[9]</sup>

The aim of the present study is to compare usual care alone with usual care plus intervention using mobile technology (IMT) in patients with a high risk of

#### Abbreviations:

ASCVD	Atherosclerotic cardiovascular disease
BMI	Body mass index
CVD	Cardiovascular disease
HbA1C	Glycated hemoglobin
IMT	Intervention using mobile technology
LIGHT	Lifestyle Intervention using mobile technology in patients with High cardiovascular risk: A pragmatic randomized clinical Trial
MI	Myocardial infarction

CVD. The study hypothesis is that the use of IMT in addition to usual care will demonstrate improved adherence to healthy lifestyle habits, reduce CVD risk, and improve secondary outcomes in this population in a 12-month follow-up period.

## METHODS

### Study design

Lifestyle Intervention using mobile technology in patients with High cardiovascular risk: A pragmatic randomized clinical Trial (LIGHT) is a single-center, randomized, controlled study comparing IMT plus usual care with usual care alone in patients with a high CVD risk. Patients in both arms of the study will be followed for 12 months. The study was approved by the ethics committee of Haydarpaşa Numune Training and Research Hospital (2017/78) and is registered with clinicaltrials.gov (NCT03397849). The trial protocol was designed and written by the academic investigators. No changes were made to the study design following the publication of study protocol.

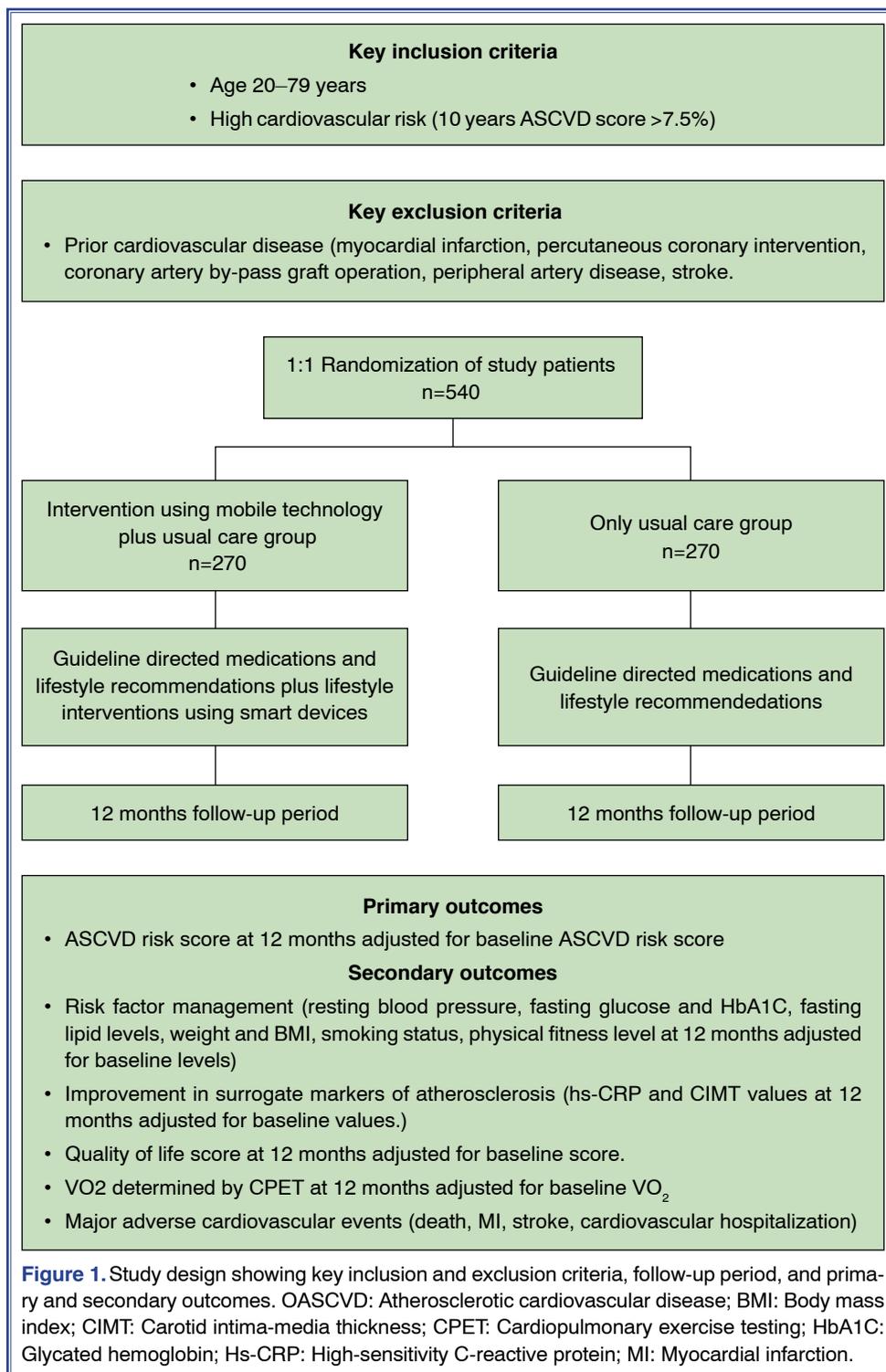
### Study population

Patients who present at the outpatient clinics of a tertiary hospital (Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Research and Training Hospital, Istanbul, Turkey) who are considered eligible according to the inclusion and exclusion criteria will be enrolled in the study (Fig. 1). The eligibility criteria are age between 20 and 79 years and at high risk for CVD [10-year atherosclerotic cardiovascular disease (ASCVD) risk score of  $\geq 7.5\%$ ]. Patients with an active infection,

**Table 1. Outcomes to be measured at baseline, 6 months, and 1 year**

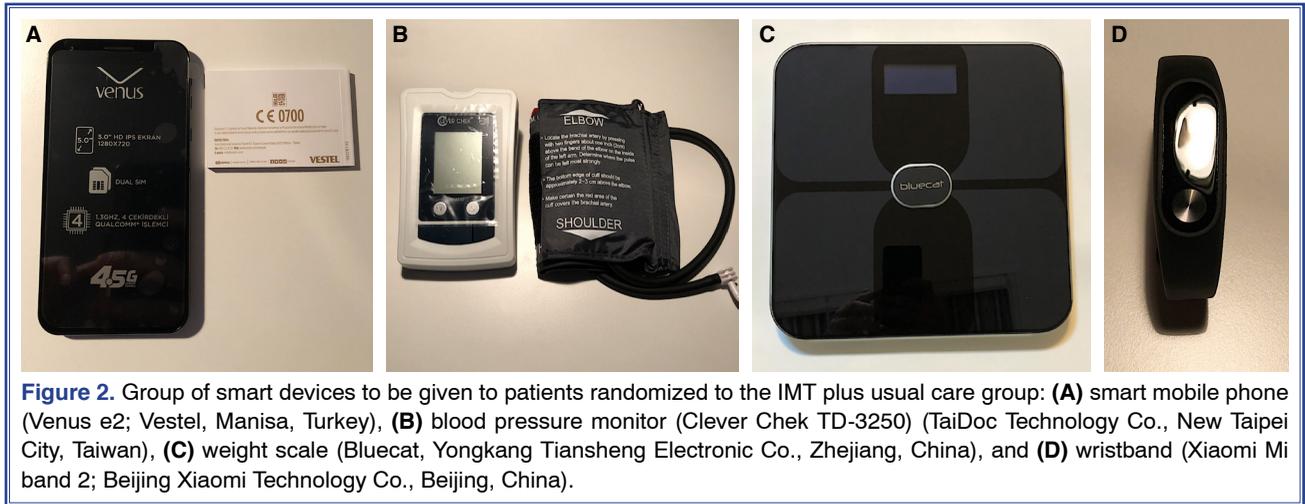
Outcome
Primary outcome
ASCVD risk score at 12 months, adjusted to baseline ASCVD risk score
Secondary outcomes
- Risk factor management (resting blood pressure, fasting glucose and HbA1C, fasting lipid levels, weight and BMI, smoking status, physical fitness level at 12 months, adjusted for baseline levels)
- Change in surrogate markers of atherosclerosis (hs-CRP and CIMT values at 12 months, adjusted for baseline values)
- Quality of life score at 12 months, adjusted for baseline score
- VO <sub>2</sub> determined by CPET at 12 months, adjusted for baseline level
- Major adverse cardiovascular events (death, MI, stroke, cardiovascular hospitalization)

ASCVD: Atherosclerotic cardiovascular disease; BMI: Body mass index; CIMT: Carotid intima-media thickness; CPET: Cardiopulmonary exercise testing; HbA1C: Glycated hemoglobin; Hs-CRP: High-sensitivity C-reactive protein; MI: Myocardial infarction.



inflammatory disease, prior CVD event (MI, percutaneous coronary intervention, coronary artery bypass graft operation, stroke, or peripheral artery disease), pregnancy, communication difficulty, severe neuropsychiatric problems, and chronic kidney disease

will be excluded from the study. Patients who are under anti-inflammatory treatment, anti-biotherapy, and/or statin therapy are also to be excluded. Finally, patients who are unable to use a smartphone phone will also be excluded.



**Figure 2.** Group of smart devices to be given to patients randomized to the IMT plus usual care group: **(A)** smart mobile phone (Venus e2; Vestel, Manisa, Turkey), **(B)** blood pressure monitor (Clever Chek TD-3250) (TaiDoc Technology Co., New Taipei City, Taiwan), **(C)** weight scale (Bluecat, Yongkang Tiansheng Electronic Co., Zhejiang, China), and **(D)** wristband (Xiaomi Mi band 2; Beijing Xiaomi Technology Co., Beijing, China).

After applying the exclusion criteria, patients who meet the inclusion criteria and give written consent to participate will be randomized to the IMT plus usual care or the usual care arm of the study.

Study enrollment will begin on February 1, 2018 and a total of 600 study participants will be randomized. The current treatment regimen of each patient will be recorded in order to examine the change during a follow-up period of 12 months.

### Intervention and control

Patients who are randomized to the usual care group will receive medications and lifestyle recommendations according to the guidelines. Cardiovascular risk management and compliance with medication and lifestyle recommendations will be assessed by 3 cardiologists in clinical visits performed at 6 and 12 months. When necessary, referrals to other specialties will be performed for smoke cessation and weight management.

Each study patient randomized to the IMT plus usual care group will receive a set of smart devices: a mobile phone (Venus e2; Vestel, Manisa, Turkey), a wristband (Xiaomi Mi band 2; Beijing Xiaomi Technology Co., Beijing, China), a scale (Bluecat, Yongkang Tiansheng Electronic Co., Zhejiang, China), and a blood pressure monitor (Clever Chek TD-3250) (TaiDoc Technology Co., New Taipei City, Taiwan) (Fig. 2).

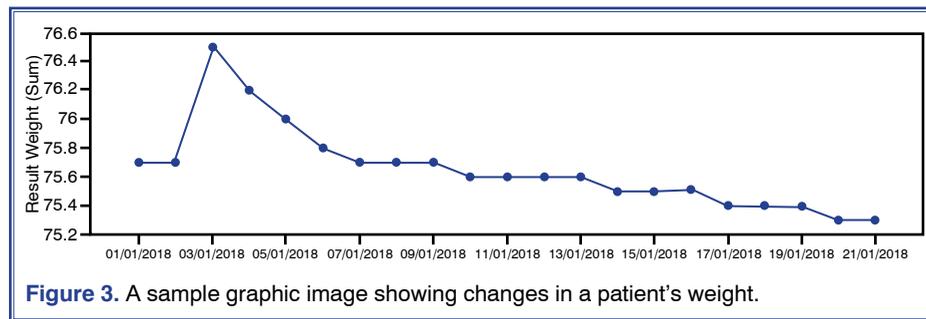
**A- Step counter (pedometer):** Smart wristbands use an accelerometer to calculate the number of steps. Parameters of the length of time spent walking and

step intensity can also be obtained. The step counter will launch automatically each morning to record all steps taken during the day. Data that are recorded in the wristband (number of steps, walking time, and step intensity) will be sent automatically to a remote server on a daily basis.

**B- Heart rate and blood pressure:** Heart rate and blood pressure measurements will be recorded using an electro-sphygmomanometer (a blood pressure monitor capable of performing both blood pressure and heart rate measurements). Measurement will be performed both in the morning and evening. Patients will be taught to measure their blood pressure properly by a specialized study nurse at the time of randomization. Data recorded in the blood pressure monitor (heart rate and systolic/diastolic blood pressure) will be sent automatically to a remote server on a daily basis.

**C- Weight measurement:** Weight measurements will be performed every morning before breakfast using an electronic weight scale. Data recorded in the weight scale will be sent automatically to a remote server on a daily basis.

**D- Dietary list:** Patients in the IMT plus usual care group will also be given a list of dietary recommendations, as shown in Figure 4. Nutrition and diet have an important role in primary prevention and the content of our dietary list was prepared according to the recommendations from the latest American Heart Association guideline on primary prevention of cardiovascular disease.<sup>[10]</sup> In addition, a recommendation to consume extra virgin olive oil was added based



on the recent scientific evidence in the PREDIMED (Prevention with Mediterranean Diet) study.<sup>[11]</sup>

**D- Smart mobile phone application:** We developed an application compatible with smart mobile phones for patients to be able to view their saved data (both numerical and graphical parameters) (Fig. 3). In addition, motivational messages will be delivered every day.

Both groups will be encouraged to adopt a dietary pattern that is recommended by American College of Cardiology (ACC) and the American Heart Association (AHA). The diet list to be provided to study participants is shown in Figure 4. Patients in the IMT plus usual care group will complete a dietary compliance form on a daily basis (A form that includes a check box for every dietary recommendation in Fig. 4) through the application in the smart mobile phone. This form will be recorded and delivered auto-

matically to a remote server every day. Patients who are considered to be noncompliant with their recommended diet will receive an educational/motivational text message.

Both groups will be encouraged to exercise regularly (30 minutes of moderate intensity aerobic activity at least 5 days a week) according to the AHA recommendations for physical activity in adults.

Patients who are randomized to the IMT plus usual care group will receive a text message asking about compliance with anti-hypertensive medication, diet, and exercise recommendations if they have a systolic blood pressure of >180 mmHg and/or a diastolic blood pressure of >110 mmHg 3 times or more in a week. If this condition persists in the following week they will receive a text message inviting them to an outpatient clinical visit. They will also receive a text message questioning compliance with exercise and diet recommendations if they perform ≤5000 steps/day at least 3 times in a week. If this condition persists in the following week they will be invited to an outpatient clinical visit.

In addition, patients will receive motivational text messages every day at 12:00 a.m. emphasizing the importance of adopting a healthy lifestyle and its impact on cardiovascular health. The heart team of the aforementioned center participated in developing the content of the messages. A message pool was created with topics related to medication adherence, increase in regular physical activity, adoption of healthy dietary measures, and smoking cessation (if appropriate). The messages will be randomly chosen and sent to the patients in IMT plus usual care group.

Heart rate, quality of sleep, and weight measurements will be assessed during clinical visits at 12 months. Patients will not be contacted or receive any text message related to these parameters.

LIGHT Dietary List	
<b>Recommended:</b>	
1. Extra virgin olive oil	> 4 spoon/day
2. Nuts	>3 meal/week
3. Fresh fruit	>3 meal/day
4. Fresh vegetables	>2 meal/day
5. Fish or seafood	>3 meal/week
6. Legumes	>3 meal/week
7. White meats (poultry)	Instead of red meat
<b>Not recommended:</b>	
1. Soda drinks	<1 meal/day
2. Processed beverages/products	<3 meal/week
3. Margarines	<1 meal/day
4. Red or processed meats	<1 meal/day

**Figure 4.** Dietary list to be recommended to the study patients.

## Outcomes

The primary outcome of this study is the ASCVD risk score at 12 months adjusted for the baseline ASCVD risk score (Table 1). The ASCVD risk score will be calculated for every study participant at randomization and the final visit at 12 months.

Secondary outcomes will be evaluated in the clinical visits at the baseline and 12<sup>th</sup>-month visits. Secondary outcomes are CVD risk factors, including smoking cessation, blood pressure, weight/body mass index (BMI), and blood lipid and glycated hemoglobin (HbA1C) levels, determined at 12 months and adjusted for baseline values. Other secondary outcomes are quality of life and peak VO<sub>2</sub> scores obtained from a cardio-pulmonary exercise test at 12 months adjusted for baseline scores. In addition, all-cause and cardiovascular mortality, MI, stroke, and hospitalization for cardiovascular diseases will be evaluated as secondary outcomes.

BMI will be calculated by weight (kg) divided by height in meters squared. A blood test will be performed at the baseline and at the 12<sup>th</sup> month to assess routine blood biochemistry and hemogram HbA1C, high-sensitivity C-reactive protein and troponin I, brain natriuretic peptide, and fasting glucose and lipid levels (following 12 hours of fasting). At each clinical visit, the patients' demographic details and medical history will be recorded and a physical examination will be performed. A quality of life questionnaire will be completed by each study participant at the baseline and 12<sup>th</sup>-month visit.<sup>[12]</sup>

## Devices

We developed a care model that can record and process cardiovascular rehabilitation services using mobile phones, the Internet, and communication technologies. This system is designed to be used by patients outside the hospital. Turk Telekom Inc. (Istanbul, Turkey) sponsored this effort. Data obtained from the mobile phones and other electronic devices will be synchronized to a remote server on a daily basis. The mobile phones have 4G web technology and patients will not pay fees for the data transfer. Outpatient clinical visits will be performed at the 12<sup>th</sup> month. Physicians will be allowed to access data recorded in the remote server for the purposes of the study.

## Sample size

The sample size of the present study was calculated

to provide sufficient data to make inferences about a larger population. A sample of 270 participants (135 per group) will be required to detect a minimal clinically important difference with 90% power at a level of 2-sided type I error of 0.05. We defined the minimal difference as a small effect size (0.2). To account for an estimated 20% loss to follow-up, at least 160 participants will be recruited in each group (total of 320 patients) (G\*Power 3.1 software; Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A.).

## Randomization

Patients who provide written consent will be allocated randomly in 1:1 fashion to the IMT plus usual care or only usual care groups. The randomization sequence will be generated by study statisticians using computer software and variable blocks (4 and 6). Given the nature of the intervention, the participants will be aware of the allocation. The ASCVD risk score, blood pressure, smoking status, and laboratory parameters, including cholesterol, fasting glucose, and HbA1C, will be recorded and evaluated at every clinical visit by a specialized study nurse who is aware of the allocation.

## Statistical analysis

The analysis will be performed by an independent trial steering committee and data monitoring committee in accordance with Consolidated Standards of Reporting Trials guidelines, as was the study design. The baseline characteristics of the allocated participants will be analyzed using descriptive statistics. The primary analysis will be response to care, which will demonstrate the variation in ASCVD risk scores between the 2 study groups. All evaluations will be performed using intention-to-treat analysis. Statistical analyses will be performed using R software, version 3.5.0 (R Foundation for Statistical Computing, Vienna, Austria).

## DISCUSSION

Advances in the healthcare, medications, and technology have reduced CVD mortality in recent decades. However, increased healthcare costs and the presence of chronic diseases continue to be challenges for physicians and government policymakers. Recent studies have focused on the optimal management of cardiac risk factors for primary prevention of CVD.

A reduced prevalence of cardiac risk factors is associated with a greater decrease in cardiovascular mortality compared with acute management and secondary prevention.<sup>[13]</sup> A new approach other than conventional clinical visits is needed in order to increase patients' motivation and education.<sup>[14]</sup> Mobile technologies have great potential to overcome this challenge.

The ASCVD risk score is frequently consulted in routine clinical practice to determine a 10-year risk of heart disease or stroke.<sup>[15]</sup> Various efforts have been made to help patients reduce their ASCVD score. Lifestyle modification (adherence to a heart-healthy diet, regular exercise habits, cessation of tobacco product use, and maintenance of optimal weight) remains a vital part of health promotion and ASCVD risk reduction. In our study, we will follow-up and compare the ASCVD risk score of patients to determine whether IMT can provide a significant effect on health promotion and risk reduction. In primary prevention, long-term follow-up periods are very helpful to discriminate the effect of the evaluated intervention in randomized trials. A 1-year period has recently been determined a satisfactory limit to test the effect of aspirin for primary prevention of CVD.<sup>[16]</sup> Similarly, our study design includes a 1-year endpoint to evaluate the effect of mobile health interventions in primary prevention.

Mobile technology-supported medical care has been compared with conventional medical care in several studies. Many results have favored the addition of mobile technology in terms of better management of weight,<sup>[17]</sup> hypertension control,<sup>[18,19]</sup> physical fitness,<sup>[20]</sup> smoking cessation,<sup>[21,22]</sup> and HbA1c levels in the diabetic population.<sup>[23,24]</sup> Nonetheless, these studies are still limited in number and additional comprehensive studies are needed to establish the role of mobile technology, particularly in CVD risk management. Primary prevention is at the fore of the modern-day, digitized medical era. There have been many attempts to evaluate the feasibility of mobile health technologies to increase the efficiency health sector, particularly in cardiology.<sup>[25]</sup> Mobile health intervention appears to be a promising modality to overcome barriers to preventive efforts and to provide a cost-effective approach in cardiology. In previous studies, telehealth systems were tested unilaterally in primary prevention. There has been research examining the use of text messages designed to aid in smoking ces-

sation.<sup>[21]</sup> Zhang et al.<sup>[26]</sup> used a mobile application that included modules related to risk factor modifications and healthy lifestyle practices. The program lasted for 4 weeks. Despite advances in cardiovascular disease knowledge in the study population, there was no significant difference in total coronary heart disease risk scores at the end of the study. In New Zealand, the Text4Heart trial was performed addressing behavior changes in patients with established coronary heart disease. The study showed positive effects at 3 months, but not at 6 months, which raises questions about the sustainability of mobile technology interventions.<sup>[27]</sup> A comprehensive effort uniting physical activity, dietary variables, weight control, and hypertension management in a single program and for a longer time period is necessary to more completely evaluate the effect of telehealth in primary prevention. A well-designed and patient-friendly application may be able to contribute to positive changes and answer questions about mobile health interventions after 1 year of follow-up.<sup>[28]</sup> Patients with high risk for CVD are a group that will promptly reflect changes in metabolic and cardio-pulmonary parameters based on the lifestyle changes presented by the defined application of IMT. One of the benefits of our study is the inclusion of multiple factors of lifestyle change in order to decrease the globally accepted risk score, the ASCVD. On the other hand, as in previous studies of such efforts, patient compliance may be a serious limiting determinant.

The objective is to evaluate the clinical efficacy and feasibility of IMT in patients with high risk for CVD in terms of cardiac risk factor management. The study has a unique design for recording data and intervening in several important lifestyle habit parameters through a digital technology system and a multi-functional digital health application.

There are some limitations to this study due to the nature of the design and the methodology. First, our study has a single-center design. Second, participant compliance will affect the results and may limit the statistical evaluation. Third, the study will rely on patient reliability and there may be misleading results if participants try to deceive the study team by entering inaccurate data. Patients will be informed in detail that the mobile intervention will be used to decrease their overall cardiovascular risk in an effort to ensure credibility. Fourth, a 1-year follow-up may limit the

change in ASCVD risk score in patients without cardiovascular disease in terms of primary prevention. Finally, the dietary list in this study is not externally validated for the Turkish population, though the content is evidence-based and recommended by major cardiology societies.

## Conclusion

Optimal management of cardiac risk factors is of utmost importance to reduce the mortality and health-care costs of CVD. Mobile technology-supported medical care has a potential role in CVD risk management. The LIGHT trial will provide insight for future cardiac risk management using mobile technologies.

**Ethics Committee Approval:** The study was approved by the ethics committee of Haydarpaşa Numune Training and Research Hospital (2017/78).

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**Authorship contributions:** Concept: İ.T, G.Ç; Design: İ.T, G.Ç, M.H.; Supervision: İ.T.; Materials: Y.S.Ö, Ö.Y, D.İ, E.G.V, K.E.P, G.Y, F.D, L.P.; Data: İ.T, G.Ç, M.H., S.Ö, Ö.Y, D.İ, E.G.V, K.E.P, G.Y, F.D, L.P.; Analysis: İ.T, G.Ç, M.H.; Literature Search: İ.T, G.Ç, M.H., S.Ö, Ö.Y, D.İ, E.G.V, K.E.P, G.Y, F.D, L.P.; Writing: İ.T, G.Ç, M.H.; Critical Revision: İ.T, G.Ç, M.H.

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- Keywords:** Cardiovascular disease prevention; digital health; mobile health; primary prevention.
- Anahtar sözcükler:** Kardiyovasküler hastalıklardan korunma; dijital sağlık; mobil sağlık; primer korunma.