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Data Collection and Analysis Methods for Smart Nudging to Promote Physical Activity: Protocol for a Mixed Methods Study

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Abstract. New digital technologies like activity trackers, nudge concepts, and approaches can inspire and improve personal health. There is increasing interest in employing such devices to monitor people's health and well-being. These devices can continually gather and examine health-related information from people and groups in their familiar surroundings. Context-aware nudges can assist people in self-managing and enhancing their health. In this protocol paper, we describe how we plan to investigate what motivates people to engage in physical activity (PA), what influences them to accept nudges, and how participant motivation for PA may be impacted by technology use.

Keywords. Personalized Nudge, Physical Activity, Activity Trackers, Data Analysis, Smart Watch

1. Introduction

A nudge is "any aspect of the choice architecture that alters people's behavior predictably without forbidding any options or significantly changing their economic incentives," according to Thaler and Sunstein's definition from 2008 [1]. Nudges were initially inves- tigated in offline decision-making, primarily focusing on financial or personal health choices. When the idea of nudging was applied to digital user interfaces in 2016, the term "digital nudging" was first introduced. Weinmass et al. [2] are credited with coin- ing the phrase and gave it the definition "subtle form of using design, information, and interaction elements to guide user behavior in digital environments, without restricting the individual's freedom of choice". Additionally, smart nudging was defined by Karlsen and Andersen [3] in 2019 as "digital nudging, where the guidance of user behavior is tailored to be relevant to the current situation of each individual user". A user profile with a large scope of connected data is necessary for smart nudging. Before a personalised nudge is created, the data is examined. In comparison to a non-personalized nudge, user acceptance of a customized nudge is

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more likely to succeed (i.e., the user accepts the nudge and follows the recommendation) [3]. Smartwatches, activity trackers, and smartphones can offer long-term, continuous behavioural data collecting. This comprises health-related data types like physical activity (PA), pulse, body temperature, stress levels, sleep, and contextual data (e.g., loca- tion by global positioning systems [GPS]) from which other data types can be inferred (e.g., weather). Thus, these devices offer a chance to create a continuous feedback loop to deliver timely cues, enabling people to better manage their own health and make wise decisions [4]. These devices may be able to provide insights into various demographic groups, with access to near real-time data collection and evaluation at the population level from a public health perspective, by gathering this type of data from a large portion of the population [5]. Understanding a person's context is challenging, and accurate smart device data are necessary to gain insightful knowledge [6]. Natural human conduct is influenced by several events occurring at once. People might be running, for instance, on running tracks, in the open air, and indoors [7]. In this circumstance, the geographic location information can help in determining the user's context. In this paper we present the protocol for an upcoming study, where the aim is to evaluate what motivates people to engage in physical activity and what influences them to accept nudges.

2. Methods

2.1. Study Context

This project is a part of High North Population studies (BiN). People living in Northern Norway are the primary population for this study. This study will help the high north residents to get relevant nudging to lead a healthy lifestyle. which aims to develop and test tailored nudges for people to increase physical activity to lead a healthy lifestyle. We have previously conducted a quantitative study on PA participation for such individuals [8,9]. The results from this study will be used in future smart nudging projects.

2.2. Participation Selection and Recruitment

Participants will be recruited by online invitation, posters, and by using convenience sampling. A minimum of 10 participants will be recruited for this study. All participants will be provided with an Apple watch series 8 and instructions will be provided for sharing their data to the researcher.

2.3. Inclusion and Exclusion Criteria

The inclusion criteria are: 1) resident of Northern Norway, 2) owning an Apple iPhone, 3) willing to wear an Apple watch for four weeks, 4) willing to share collected PA data, 5) willing to participate in one face-to-face interview, 6) age between 18 and 60 years, and 7) can provide written informed consent for participation prior to enrolment. The exclusion criteria are: 1) having an active gym subscription, 2) having a high level of PA, and 3) being unable to provide written informed consent.

2.4. Ethics Approval

The goal and methods of the study will be explained to each participant. Participants will be asked for written informed consent, as far as possible if the individual has the capacity to provide consent. The study description with a data management plan submitted for approval by the Regional Committees for Medical and Health Research Ethics in Norway and the data protection officer at UiT the Arctic University of Norway.

2.5. Data Collection

To access the data, we require participants to export the Apple Watch acquired data using the Apple Health application in their iPhone. Each participant's individual Extensible Markup Language (XML) file contains daily information on PA, workout specifics, and device information. The gathered information has combined a person's step count from their watch and mobile phone. We will not include steps taken from the mobile phone and only looks at step data from the watch. Using Python [10] with NumPy [11], we will extract primary variables from the original data and store in comma-separated value (CSV) files.
Daily variables for Active energy, Exercise minutes, Steps, and Distance will be kept in CSV files. Active energy is defined as the energy used by PA, expressed as Kcal. Light-, moderate-, and intensive PA minutes are combined to create exercise minutes. Distance is the sum of the running and walking distances, expressed in kilometres. The total number of daily steps recorded by the smartwatch is known as steps. Heart rate, heart rate variability (HRV), oxygen saturation (SpO2), peak oxygen uptake (VO2Max), stand minutes, and sleep information are additional variables [9]. We will collect this smart watch activity data from participants for a four week time period.

2.6. Qualitative Interview

After the 4-week data collection period, the recruited participants will be requested to take part in a 1-hour qualitative interview. The participant's home or other settings that are convenient for them, will be the site of a semi-structured interview [12]. We will prepare an interview guide that will be used during the interviews.
There will be two sections in the interview guide. Personal preferences and participant experiences with all areas of the study will be the main topics of Section 1. The influencing factors to improve PA levels will be the main topic of Section 2, along with practical challenges to nudging in everyday life and how the environment surrounding a person affects motivation for PA. All interviews will be recorded, verbatim transcribed, and anonymised.

3. Data Analysis

3.1. Quantitative Data

According to the nature and distribution of the data, appropriate quantitative statistical analysis will be carried out using Python (Python Software Foundation). The

descriptive statistics will be displayed as frequencies of categorical data, means with SDs or 95% CIs, and median (IQR) values. Estimates of effects utilising participant out- come measures will be investigated and published as estimates with 95% CIs without P values in accordance with the Consolidated Standards of Reporting Trials (CONSORT) 2010 extension [13,14]. We will also analyse the distributional characteristics of the variables. Additionally, we will do mixed analyses, where information from the qualitative content can be used to enhance quantitative data. The interviews can potentially help determine whether the outlying factors cause changes in activity data or if other causes are at play.

3.2. Qualitative Data

The interviews' transcripts will be examined using the tenets of systematic text condensation [15]. This analysis is conducted in two steps. Data on the viability of processes, expectations, and application use for PA, experiences with nudges, and motivation for acceptance of nudges to promote PA are provided through the qualitative approach. Clar- ity, explanation of minor themes, and a variety of cases will also be added to improve the conclusions' credibility and applicability. To ensure the greatest possible level of re- search quality in this pilot project, the consolidated standards for reporting qualitative research will be used [16].

4. Discussion

4.1 Expected Results and Findings

Enrolment will begin in January 2023 and when 10 participants have been included. Individual participant recruitment and intervention delivery will take place. This protocol's key contribution is a thorough explanation of a study that may reveal how people want themself to get motivated and whether they will accept being nudged to promote PA. This study will also investigate ways to persuade such people to adopt tailored nudging for a healthier lifestyle. This information can direct the creation of technology-based PA programmes in the future and enhance intervention studies that seek to raise PA levels. We anticipate that this study trial will reveal any potential issues with using technological tools and individual preferences for interventions meant to promote PA for those with low levels of exercise. This study will demonstrate how the application of technological use of data, like smart nudging, can be examined in personalized-context.

4.2. Limitation and Implications

There will be numerous restrictions on this investigation. The limited sample size will have an impact on how representative the quantitative results are. If data saturation is attained, a sample of 10 participants for the qualitative data is anticipated to be of high quality. The findings of the study could have significant effects on people. The research will be presented at conferences and released in reputable, peer-reviewed international journals.

5. Conclusion and Future Work

This study will assess the PA-influencing elements and acceptability of tailored nudges. The result from the study can be used to address problems with feasibility, enhance study methods, and calculate the effectiveness of the study's metrics. In addition, this paper investigates how technology with personalization can affect PA motivation in order to better inform and direct future technology-assisted PA interventions. To ensure improved health and a higher quality of life, it is crucial to investigate novel approaches to improve PA for individuals. We will use the data and outcome of this study to develop the machine learning-based future activity suggestion model for the same participants. We will use those outcomes to design and provide smart nudges for a larger population.

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