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User-centered design of a mobile app for physical activity advice in cancer care: preliminary study in Morocco at the National Institute of Oncology

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Abstract

Context Utilizing mobile apps to increase physical activity levels is now standard practice in cancer care. The study's objective was to provide patients with precise physical activity recommendations and/or initiate self-directed exercise programs.

Methods A multidisciplinary group directed the design procedure. We adhered to the self-determination approach, and accompanying behavior modification strategies, as well as international guidelines in the field of physical activity in cancer care. The design process was user-centered and involved three steps: Understanding the user and the context, conceptualization, and evaluation of the prototype. The testing was carried out by the beneficiaries, healthcare professionals, and two experts. Three criteria were evaluated in the designed solution: usability, quality, and potential for behavior change.

Results The evaluation results of the designed solution showed good perception by both beneficiaries and healthcare professionals. The average system usability scale score was 90.6 (SD: 7.33) for beneficiaries, and 92.75 (SD: 3.83) for healthcare professionals. The first expert received a mean overall quality score of 4.51 on the mobile app rating scale, while the second received a score of 4.27. The results of the app behavior change scale gave the first expert a score of 17/21 and the second a score of 15/21.

Conclusion Based on the criteria of usability, quality, and potential for behavior change, the designed app demonstrated positive results. This is a preliminary evaluation, which will be followed by additional, in-depth evaluations with larger sample sizes.

Keywords User-centered design, Physical activity advice, Physical exercise program, Mobile app, Cancer

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Introduction

In 2018, an estimated 18.1 million people were diagnosed with cancer and 9.6 million died from the disease, making cancer the second-highest cause of death worldwide [1]. Despite advancements in cancer patient survival, the oncological approach alone is still insufficient to address the functional impact of cancer on cancer survivors. The safety and the positive effects of physical activity (PA) on the physical function and quality of life of patients appear to be supported by strong scientific evidence [2].

Despite the expanding awareness of the importance of physical activity (PA) in cancer care among healthcare professionals (HCPs) internationally [3–7] and nationally [8], cancer patients and survivors do not engage in sufficient PA [9–12]. Through strategies of encouragement and communication with their patients, HCPs can play a significant role in promoting PA [13, 14]. However, PA advice is limited by several barriers. There are HCPs-related barriers, patient-related barriers, and institutional barriers [15, 16].

Utilizing mobile apps to increase PA levels is now standard practice. A meta-analysis has demonstrated their short-term efficacy [17]. An increase in daily steps and a nonsignificant decrease in sedentary behavior have been demonstrated [18]. However, few PA apps adhere to WHO’s recommendations [19]. A survey of oncology nurse specialists regarding the role of apps in cancer care revealed the impact of apps on PA’s access and the autonomy it affords cancer patients [20]. The literature

on mobile apps for promoting PA in cancer care is growing. However, apps with a well-described design methodology are recent and mainly targeting women with breast cancer [21–25] or other specific cancers [26, 27].

This study describes the user-centered design process of a mobile app that facilitates the provision of PA advice and the initiation of physical exercise programs (PEP) based on international recommendations for cancer patients and survivors.

Materials and methods

Design procedural methods

The design process is user-centered, which is viewed as a prerequisite for successful technological intervention [28, 29]. The process involves three phases of problem-solving: Understanding the user and the context; conceptualization and early prototyping; testing the prototype (Fig. 1).

Multidisciplinary team

A multidisciplinary team covering the various skills required to design a PA and PEP advice app for cancer patients and survivors. The design process was directed by a six-person team with the following areas of expertise: Sports medicine and adapted physical activity; Medical oncology; Physiotherapy and cardiorespiratory rehabilitation; and Bioinformatics.

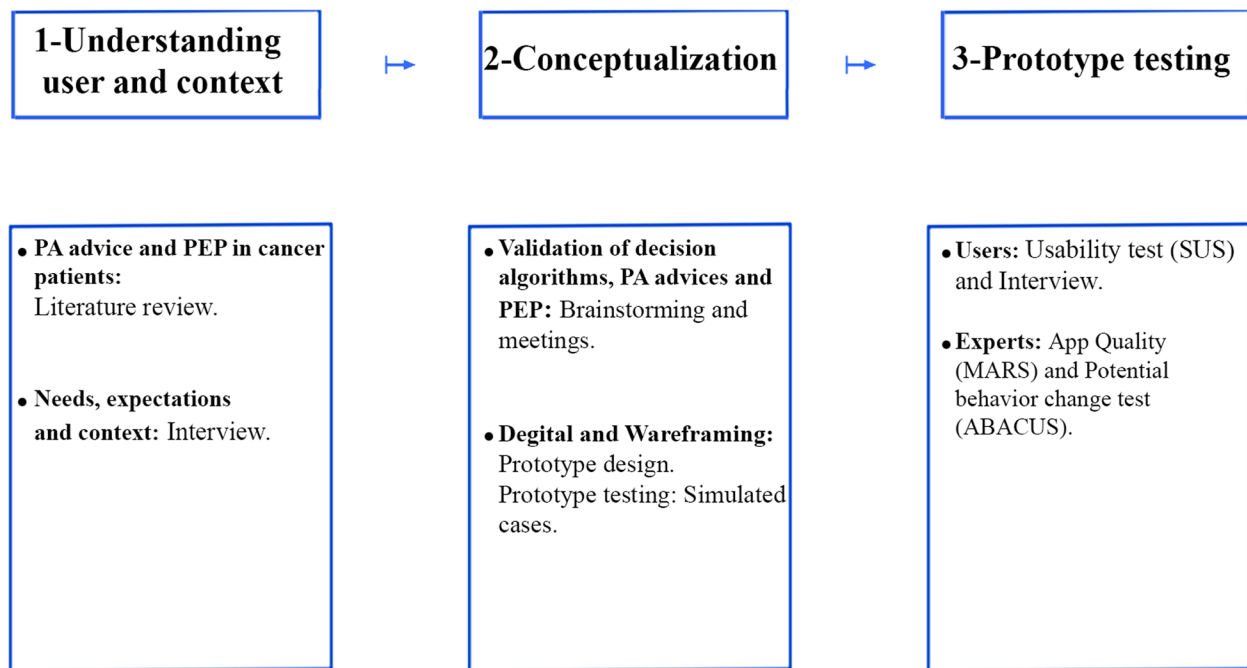


Fig. 1 The steps followed during the Mobile App User-Centered Design Process

Recruitment of participants and ethical considerations

The beneficiaries' recruitment was carried out by HE and BS, oncologist physicians. Participants met the following criteria:

- for beneficiaries: Be a cancer patient or cancer survivor; Be at least 18 years old; Own and use a smartphone; Be able to read at least Arabic; Be willing to participate in the process of maintaining or enhancing the PA level.
- for HCP: oncology-specializing HCP; smartphone ownership and use; regular contact with patients during and after oncology care; regular participation in therapeutic patient education.

HCPs were recruited from within institutions. Beneficiaries were solicited during doctor's visits. The Joint Ethics Committee of the Faculty of Medicine and Pharmacy at Mohammed V University in Rabat, Morocco, approved this investigation (November 2019; CRTN: 104/19). All participants gave informed consent before participation.

Conceptual models

We used self-determination theory [30] to facilitate long-term changes in PA-related behaviors. In order to accomplish this, we utilized the Coventry, Aberdeen, and London-Refined taxonomy, which has been characterized as an efficient, straightforward, and simple method for identifying the factors most likely to produce positive effects on PA behavior change [31]. In apps for PA promotion, several strategies for accompanying behavior change have been listed [32]. We have prioritized feedback, adaptation, goal-setting, and user targeting.

Step 1: understanding user and context

First, extensive research was conducted on the content of PA advice and suggested PEPs. Several international organizations in the United States, Australia, and Europe have developed general guidelines for combating sedentary lifestyles and physical inactivity, as well as guidelines for specific clinical contexts. PEP guidelines and modalities were developed based on available literature data, which determined the type of exercise, its frequency, intensity, duration, risks, and precautions [33–39]. Literature data was analyzed by HE and SB, oncologist physicians, and by HB, IBA, and YA, PA and sports physiotherapists. The data sheets were presented, discussed and validated by all work team.

In the second stage, participants underwent a semi-structured interview. For the beneficiaries, we determined their requirements and expectations regarding the app's features, as well as PA barriers. We searched for difficulties associated with therapeutic education in the field

of PA prescription for HCPs. This interview was conducted by FE, nursing care manager; and YA, specialized PA physiotherapist.

Step 2: conceptualization

After the team had discussed the literature review on PA advice and PEP, we established decision-making algorithms. The process of validation was predicated on a team meeting, followed by a discussion. Objectives of the app's participation procedure, decision-making matrices, and the nature of the deliverables were the primary topics of discussion. YA designed the user participation pathway and algorithms according to the beneficiary's clinical and functional conditions.

The team based the design process for the mobile app's features on a brainstorming session. Subsequently, it concluded by a validation of the mobile app's features according to needs and possibilities. The team then began designing the interfaces and deliverable document templates, while wireframes were created using the "Bootstrap 5.3 in Front-end, and Bootstrap smart admin in Back-end". JD, IT specialist, designed the wireframes and proposed several models for the mobile app; then the work team chose the graphic models.

Multiple trial tests (simulated cases) were conducted to ensure that the PA boards or PEPs adhered to the established decision algorithms. As a result of suggestions from team members, enhancements were implemented.

Step 3: evaluation of the prototype

User evaluation

The objective of this phase was for users, both beneficiaries and HCPs, to evaluate the app. Using the available audiovisual tutorials, participants were able to independently discover the app's functionalities following a concise explanation. In addition, participants were instructed to capture screenshots of any ambiguous information. Participants were instructed to utilize all of the app's features to obtain PA advice and/or PEPs. FE, nursing manager, was the administrator of interviews and instruments for recruited users. The user evaluation consisted of two instruments:

- i. The System usability Scale (SUS): As its name suggests, the SUS evaluates the usability of apps [40]. We utilized the Arabic version of the SUS scale, which demonstrates comparable levels of reliability, validity, and sensitivity to the original English SUS questionnaire [41]. The questionnaire contains ten questions used to assess the usability of a system swiftly and accurately. Each item is scored between one and five points (Strongly disagree: one point; Disagree: two points; Neutral: three points; Agree:

four points; Strongly agree: five points). Higher scores indicate increased user-friendliness. The rating is computed as follows: $X = \text{Sum of points for questions with an odd number} - 5$; and $Y = 25 - \text{Sum of points for questions with an even number}$; then $(X + Y) \times 2.5$. The SUS score was interpreted using the Significance scale adapted by de Bangor, Kortum, and Miller (2009) [42]. The interpretation proposed is as follows: Excellent (if score > 80.3); Good (if score varies between 68 and 80.3); Acceptable (if score = 68); Poor (if SUS score varies between 51 and 68); Bad (if score 51).

- ii. Semi-directive interview: After the session, a semi-structured interview was conducted to address the following topics: (a) opinions on the app and its functionalities; (b) users' opinions on PEP and PA advice; and (c) missing elements and development opportunities if the app lacked something.

Expert evaluation

After perusing a document and audiovisual aids describing the app, two mobile app experts in design and usability conducted an evaluation based on the following instruments:

- The Mobile App Rating Scale (MARS) evaluates mobile apps' overall quality [43]. The MARS scale consists of 23 items that are rated on a scale of 1 to 5 across four categories: engagement, functionality, aesthetics, and information. Each commodity is rated between "1" and "5" This score's metrological qualities are excellent [44]. We employed the validated Arabic version [45].
- The App Behavior Change Scale (ABACUS) evaluates the likelihood of behavior change. The ABACUS scale, which consists of 21 items, was used to evaluate the app's potential for behavior change in terms of goal setting, action planning, obstacle identification, self-monitoring, and feedback. The ABACUS scale fills a void by standardizing the evaluation of a large number of health-related mobile apps [46].

Results

Step 1: understanding user and context

The results of the semi-structured interview outlined the socio-demographic and clinical characteristics (Tables 1 & 2). The participants in the design process were 24 beneficiaries and 11 HCPs. The beneficiary's mean age was 49, SD (14.27). As indicated by both HCPs and beneficiaries, there were no PEP recommendations. Smartphones, messaging, and social networks are significantly associated with the participants' technology uses .

Table 1 Beneficiaries' sociodemographic and clinical information and use of technology (N1=24)

Characteristics	Statistics (n)	
Gender	Women	15
	Men	9
Marital status	Single	6
	Married	15
	Divorced	2
	Widowed	1
Educational Level	Less than high school	10
	High school degree	6
	University degree	8
Types of cancer	Breast	6
	Gynecological	2
	Prostate	3
	Gastro intestinal	4
	Pulmonary	2
	Others	9
Therapeutic education session about PA	PEP	0
	PA advice	15
	None	9
Type of technological support used	Laptop computer	3
	Desktop computer	1
	Mobile phone	24
	Tablet computer	4
	Others	2
Type of use of technological media	Instant messaging	24
	Mailing	8
	Social media	24
	Use apps	8
	Others	2

PEP Physical exercise program, PA Physical activity

In Table 3, participants' requirements and expectations for the app, as well as barriers and enablers to participation in PEP, are outlined. Overall, participant expectations highlighted the significance of an easy-to-use solution, accessible and secure PA advice and PEPs, and care partner communication.

Step 2: conceptualization

This work's app is titled "Nachate Badani," which is the Arabic word for "PA" written in Latin script. It is a dynamic, open-source, web-based solution that is accessible to multiple stakeholders, including the patient, the healthcare provider, and the app manager. The app is available in Arabic and French, as well as smartphone, tablet, and computer varieties. The contents and functionalities of the app are explained via audiovisual tutorials. In Fig. 2, some screenshots of

Table 2 HCPs' Sociodemographic and professional information and use of technology (N2=11)

Characteristics		Statistics (n)
Gender	Women	7
	Men	4
Profession	Physician	2
	Nurse	4
	Physical therapist	4
	Other	1
Therapeutic education session about PA	PEP alone	0
	PA advice alone	10
	Both	1
Type of technological support used	Laptop computer	10
	Desktop computer	7
	Mobile phone	11
	Tablet computer	7
	Others	4
Type of use of technological media	Instant messaging	11
	Mailing	11
	Social media	11
	Use apps	9
	Others	7

PEP Physical exercise program, PA Physical activity

the app. Here is the link to the app: <http://www.azemmouryouness.com/nachatbadani/>

The app attempts to:

- i. The beneficiaries to receive specific PA advice regarding the improvement of their PA levels, or even the initiation and follow-up of a specific and individualized PEP.
- ii. The HCP should provide both general and specific PA advice, as well as specific, structured, accessible, and adapted PEPs.
- iii. For surveillance and evaluation purposes, the app manager must have access to certain clinical and functional data on the beneficiaries.

The design principles are:

- i. Ensure the safety of beneficiaries by, on the one hand, adhering to the applicable guidelines and, on the other hand, involving the accompanying physician.
- ii. Respect the self-determination approach and supporting behavior change strategies.
- iii. Promote the autonomy and empowerment of beneficiaries by requiring their participation in all phases of the process, including form entry, com-

pletion, monitoring, and evaluation of recommendations.

- iv. Respect evidence-based design guidelines when constructing PA boards and PEPs.
- v. Respect the inter-individual and environmental diversity of beneficiaries by describing PEPs that are accessible (without special apparatus or infrastructure) and require minimal functional skills.
- vi. Respect the basic principles of progression, dosage, and tolerance.
- vii. Respect the beneficiary's requirements and preferences.

The process and algorithms: Participation in the app begins with the HCP or beneficiary completing a form. The form includes fields (input) that serve as parameters for HCP advice and/or PEP (output). The beneficiary, the HCP, and/or the virtual coach conduct follow-up. The form contains two complementary sections: PA level assessment with the International Physical Activity Questionnaire, and Quality of life assessment with the SF12 questionnaire. Screenshots of the static portion of the app (a), the form (b), and the social connectivity/virtual coach (c) are displayed in Fig. 2. The HCP can receive a PEP during both the survival and post-treatment segments, while the beneficiary can only do so during the survival phase. As this necessitates close medical supervision and control, it has been decided that PEP will not be sent to beneficiaries in other phases of the treatment pathway or who are experiencing side effects. Therefore, we prefer to give specific PA advice according to the participant's clinical and functional condition only.

The eligibility for a PEP is contingent upon the absence of exercise-related risk and the possession of the bare minimum of required physical abilities. Every PEP recipient is entitled to general guidance on combating sedentary lifestyles and sustaining an active lifestyle. PEP is always accompanied by advice, especially in cases of lymphedema or abdominal hernia or risk of hernia. If the PEP entails potential risks, receiving specific PA guidance may be the only content provided (Fig. 3).

The suggested PEP comprises the following information (Fig. 4):

- i. Essential programs include aerobic exercise training and muscle strengthening. Beneficiaries at risk of abdominal hernia (abdominal surgery, stoma) are excluded from the "muscle strengthening" program. For gynecological malignancies, "pelvic floor exercises" is an essential program; otherwise, it is a supplementary program. The programs for "bal-

Table 3 PA context and Overview of the application needs and expectations

		Beneficiaries	HCPs
Context	PA Barriers	<ul style="list-style-type: none"> • Fatigue, dyspnea and kinesiophobia. • Pain exacerbation. • Lack of equipment, gyms, and time. • Lack of knowledge related to PA. • Lack of precise and adapted advice by HCP. • Lack of encouragement from family and friends. 	<ul style="list-style-type: none"> • Lack of theoretical and practical knowledge in PA advice. • Safety and potential contraindications. • Lack of time and funds. • Unavailability of a PEP in the hospital. • Lack of clarification of roles in PA promotion by the administration.
	PA Facilitators	<ul style="list-style-type: none"> • Willingness to engage in PA. 	<ul style="list-style-type: none"> • Positive opinions about PA benefits for patients in oncology care. • Willingness to participate in PA promoting in patients.
Application needs and expectations	App features and characteristics	<ul style="list-style-type: none"> • Have all the necessary information. • Easy to use. • Ability to open the app in multiple devices. 	<ul style="list-style-type: none"> • Possibility of PA monitoring and control in the application. • The possibility of verifying the content of the recommendation given to the beneficiary • The ability to track achievements.
	Personalization	<ul style="list-style-type: none"> • Give specific PEP and adapted PA advice: Walking distance and duration, frequency... • PEP that is not difficult to perform. • PEP that does not require specific equipment or gyms. 	<ul style="list-style-type: none"> • Give PA advice adapted to the patient's clinical situation. • Respect patient safety in PEP. • PEP Adaptation according to age, gender, stage of cancer, stage of cancer care pathway, treatments given, disability status... • Slow but sure progression in PEP.
	Communication	<ul style="list-style-type: none"> • Feedback given by HCP about the performance achieved. • Clear explanation of information. • Give motivation and encouragement notifications 	<ul style="list-style-type: none"> • Provide information to convince beneficiaries of PA benefits. • Popularization of information. • Design of user guides and tutorials.
	Social connectedness	<ul style="list-style-type: none"> • Ability to communicate with HCP. 	<ul style="list-style-type: none"> • Ability to communicate with beneficiaries. • Ability to involve family.
	Trustworthiness, Data sharing and portability	<ul style="list-style-type: none"> • Ability to share PA advice and PEP with attending physician. 	<ul style="list-style-type: none"> • Confidentiality of personal and clinical information. • Ability to contact beneficiaries and verify information.

ance exercises" and "stretching exercises" are complementary.

- ii. Counsel in parallel: Read the section on receiving counsel.
- iii. Duration: six months for those in the survival phase and three months for those in the post-treatment phase.
- iv. Frequency per week: three times for adults and five times for the elderly.

Regarding the app's dependability, several case simulation tests were conducted to identify defects in the PA advice and the PEPs.

A chat space and a forum exist to facilitate communication between users with each other and with the virtual coach. The self-monitoring is daily, which consists in giving a feedback to the beneficiary according to the

objectives of the day. Self-monitoring is carried out daily . The graphs and curves visible in the personal space and which reflect the data provided daily by the beneficiary. Some videos explain the app's use, PA programs, and self-monitoring (Table 4).

The app's PA recommendations for beneficiaries varied according to their clinical and functional conditions. a dozen participants received a specific PA advice, seven received both specific and general PA advice, and five received only specific PA advice.

Step 3: evaluation of the prototype

Due to non-response or loss of sight, the number of users participating in the evaluation decreased from 24 to 18 for beneficiaries and from 11 to 10 for HCPs. The average SUS score for beneficiaries was 90,6 (SD: 7.33) and for HCPs, it was 92.75 (SD: 3.83). The obtained

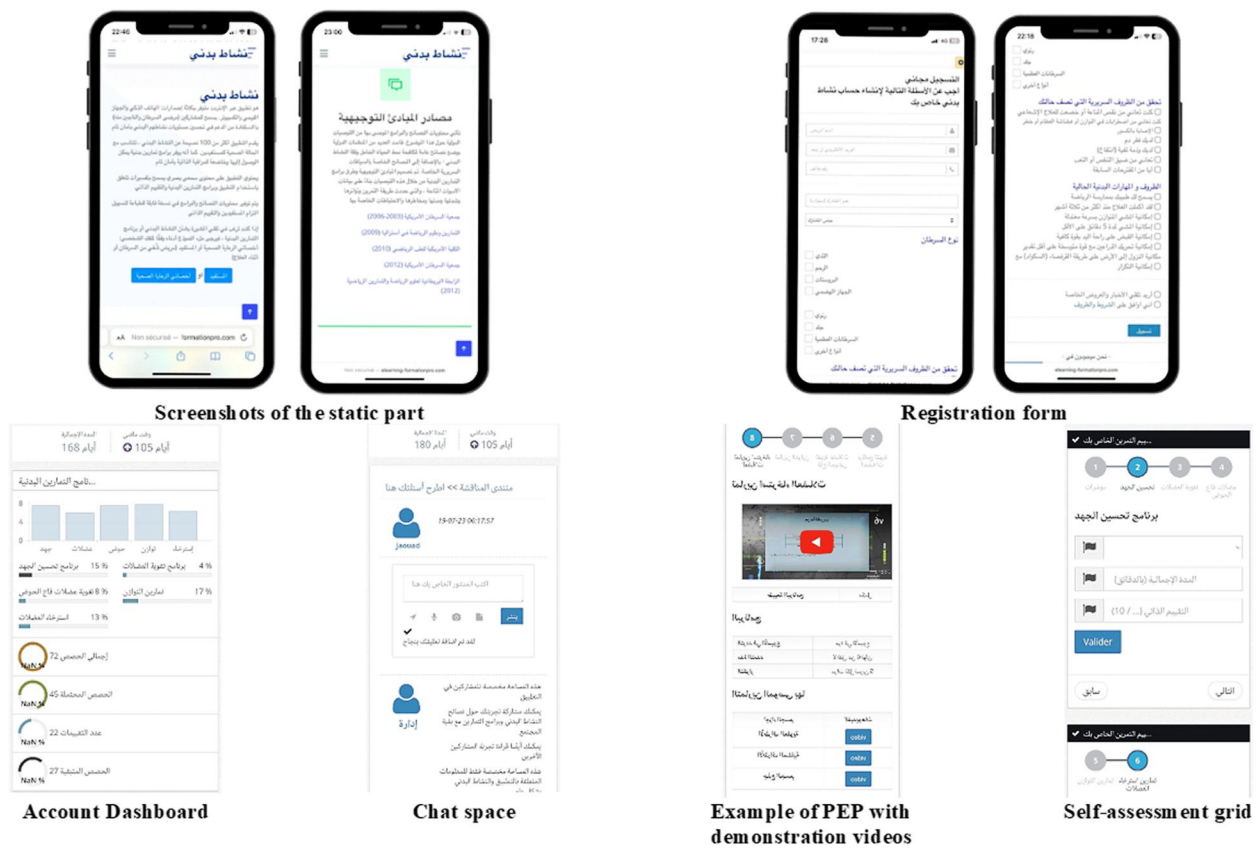
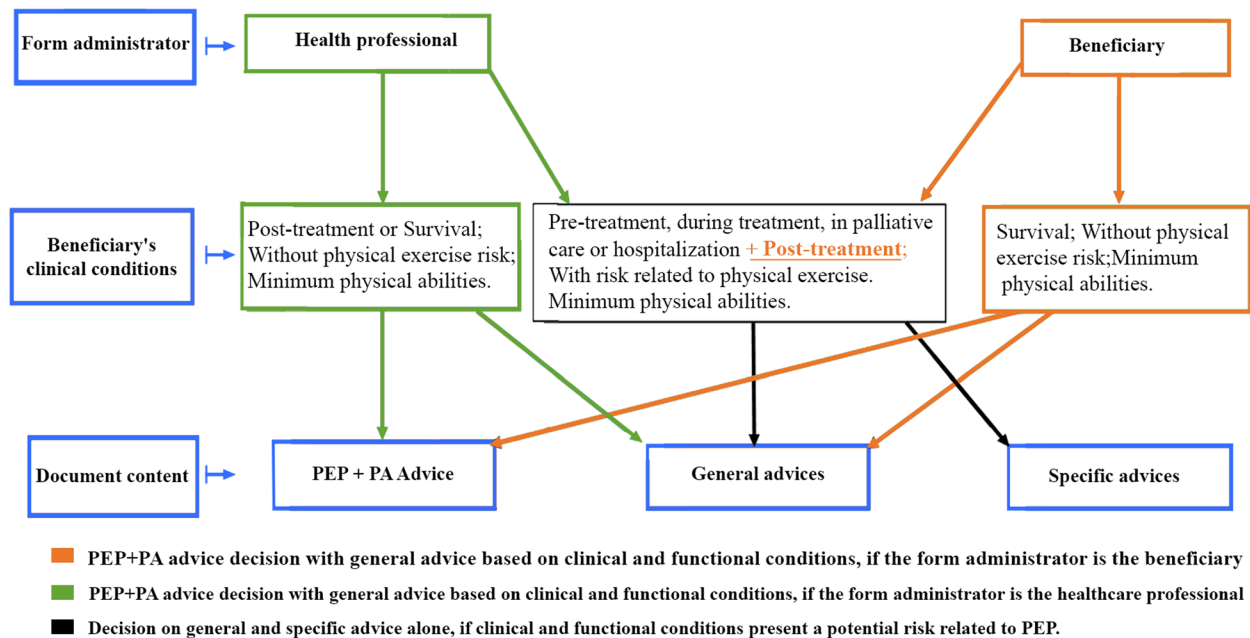
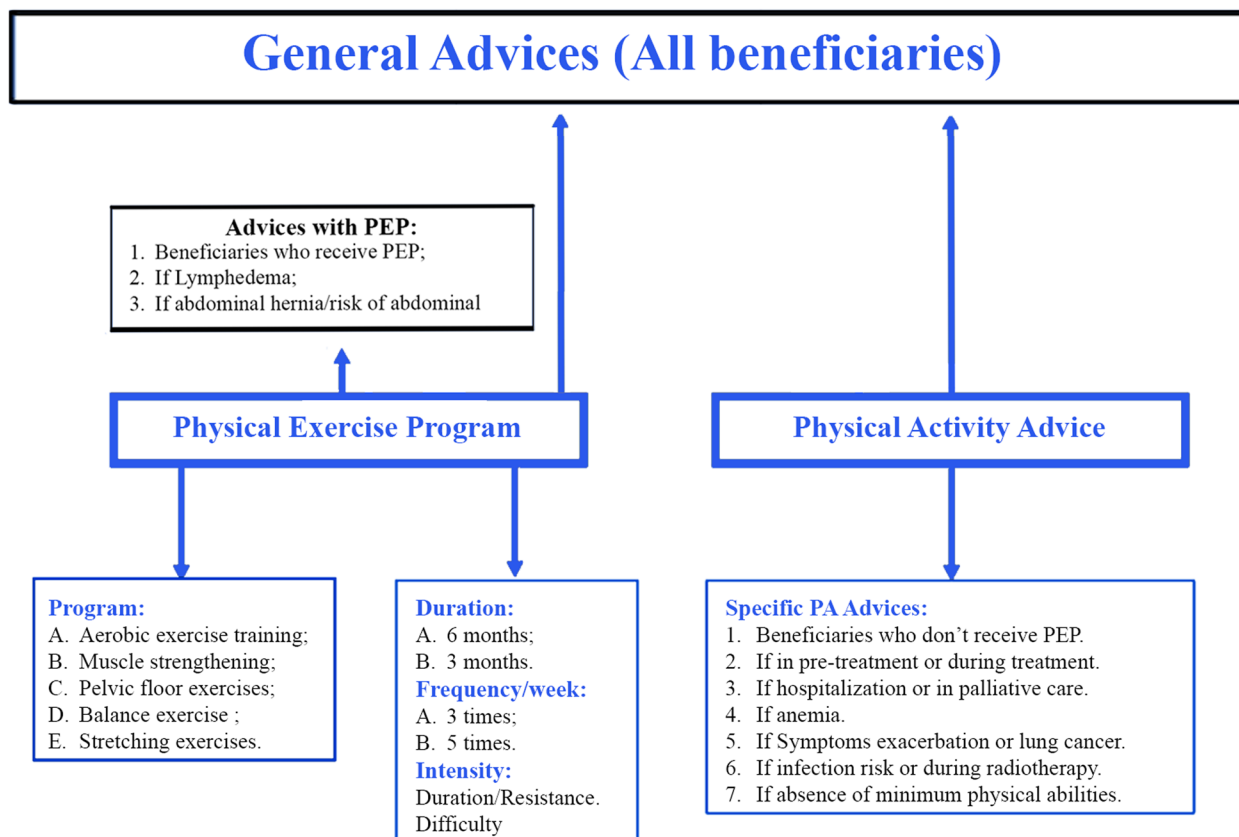


Fig. 2 Screenshots of the "NachateBadani" mobile app: static part, registration form, dashboard, chat area, example of PEP, and evaluation grid



PA: Physical activity; PEP: Physical Exercise Program

Fig. 3 PA recommendation algorithm based on form administrator and patient's clinical and functional conditions



PA: Physical activity; PEP: Physical Exercise Program

Fig. 4 PEP parameters with different PA advice (General advice, advice given with PEP, Specific advice without PEP)

ratings are above the threshold for acceptability (above 68). Moreover, according to Bangor, Kortum, and Miller’s (2009) verbal scale [47], the two scores obtained indicated that the usability of the app for both beneficiaries and HCPs would be categorized as outstanding (Table 5).

The results of the semi-structured interviews with app users revealed a generally favorable perception of the app. Users expressed satisfaction with both the app’s usability and the PA advice and PEPs it generated. They did, however, observe the lack of reminder notifications, the limited selection of exercises, and the inability to integrate pedometers (Table 6).

The first expert received a mean overall quality score of 4.51 on the MARS scale, while the second expert received a score of 4.27 (Table 7). The results of the ABACUS scale gave the first expert a score of 17/21 and the second expert a score of 15/21 (Table 8). Overall, the results suggest that the designed app is of high quality and has the potential to alter behavior. However, the experts identified areas for enhancement, such as appealing to the desire for change.

Discussion

To our knowledge, this is the first mobile app developed on a national scale and adapted to the sociocultural and linguistic context of Morocco to promote PA in cancer care, and possibly in the care of all chronic diseases. This solution is a response to the expanding demand for developing mobile apps in the field of cancer in order to improve patient adherence while respecting cultural and linguistic requirements [47].

Participants reported some impediments to the utilization and promotion of PA in the oncology care pathway. These results appear to corroborate the barriers identified in a previous study of the same setting, namely the difficulties and lack of training for HCPs [8]. Nonetheless, the "E-health" initiative is viewed as a chance to improve the results of the healthcare system, given the high rate of connectivity among Moroccans compared to other African nations [48].

Evidence-based design is one of the developed solution’s strengths. This characteristic is a requirement for mobile PA apps, but it is rarely respected [49]. In addition, adherence to the adaptation strategies retained in

Table 4 A detailed description of the main features of the application

Features	Description
Personal account	<ul style="list-style-type: none"> • There are 4 different spaces in the app: (a) Public space: it contains general information about the application and PA benefits in cancer care pathway; (b) Beneficiary account: it allows access to the content of AP advice and PEP, with statistics and self-monitoring; (c) HCP account: it allows the creation of beneficiaries accounts, the consultation of the data filled in by the same beneficiaries only and the communication with them; (d) Administrator account: it allows the consultation of all the beneficiaries and HCP data. • Opening the HCP account requires authorization following an interview with the HCP. • Opening the beneficiary account is a simple feature, which only requires the first name and the telephone number. The account allows the user to store data already recorded by the user and to monitor the various recommendations of the application. the account can be opened on different devices: laptop, phone, or tablet.
Form filling (In put)	<ul style="list-style-type: none"> • The form can be completed by the HCP or the beneficiary himself. it contains information such as age, sex, weight, height, stage of the cancer care pathway, therapies, risks related to PA, and current functional capacities. to inform some items, beneficiaries are asked to contact their physicians. • The beneficiary can optionally in personal space complete the international physical activity questionnaire (IPAQ) and the quality of life questionnaire (SF12).
PA advice (Output)	<ul style="list-style-type: none"> • The content of the PA advice is composed of three parts: (a) general advice: the beneficiary is asked to be more active and less sedentary; (b) specific advice: advice adapted according to the clinical situation of the beneficiary, such as anemia, dyspnea, the stages of pre-treatment during treatment or in palliative care, etc.; (c) some practical tips for becoming more physically active.
PEP (Output)	<ul style="list-style-type: none"> • The content is composed of several parts: (a) general presentation: information filled in the form, program components, duration, and frequency per week; (b) aerobic exercise training; (c) muscle strengthening; (d) pelvic floor exercises, (e) balance exercises; (f) stretching exercises; (g) self-assessment sheet. • In the document on the application, we have video links, which explain the exercises and how to follow the program. • The exercises are chosen to require the minimum physical capacities, to adapt to the maximum of people.
Social connectivity and virtual coach	<ul style="list-style-type: none"> • A chat space exists between the beneficiary on the one hand, the virtual coach, and/or the PS on the other hand. the beneficiary can ask questions if necessary. • A forum that brings users together is available allowing the exchange of the experience of using the application and its content;
Self-monitoring and self-evaluation	<ul style="list-style-type: none"> • The self-monitoring is daily, which consists in giving feedback to the beneficiary according to the objectives of the day. An agenda is systematically programmed from the date of registration for this reason. the agenda can be modified, if the beneficiary has missed his training, he can therefore postpone the session. • In the personal space there is the calendar/plan of activities which contains the programs and/or the day's advice. • Self-monitoring and self-assessment are carried out daily and at the end of the program. The information is entered every day for AP and every training session for PEP. • Self-monitoring is facilitated by the graphs and curves visible in the personal space and which reflect the data provided daily by the beneficiary: rate of compliance with AP advice and PEPs, performance over time in several exercises, etc. • some videos explain the methods of self-monitoring and self-assessment.

Table 5 Mean SUS of the application beneficiaries and HCPs

SUS Items	Beneficiary n1=18 Mean (SD)	HCPs n2=10 Mean (SD)
I think that I would like to use this system frequently.	4.28 (0.72)	4.50 (0.50)
I found the system unnecessarily complex.	1.33 (0.51)	1.30 (0.42)
I thought the system was easy to use.	4.55(0.55)	4.30 (0.56)
I think that I would need the support of a technical person to be able to use this system.	1.38 (0.56)	1.10 (0.18)
I found the various functions in this system were well integrated.	4.72 (0.70)	4.70 (0.42)
I thought there was too much inconsistency in this system.	1.05 (0.10)	1.20 (0.32)
I would imagine that most people would learn to use this system very quickly.	4.22 (0.77)	4.60 (0.48)
I found the system very cumbersome to use.	1.11 (0.19)	1.10 (0.18)
I felt very confident using the system.	4.61 (0.67)	4.80 (0.32)
I needed to learn a lot of things before I could get going with this system.	1.27 (0.40)	1.10 (0.18)
SUS score	90.60 (7.33)	92.75 (3.87)

SUS System Usability Scale

Table 6 User opinions about the application, PA advice, and PEPs

	Beneficiaries	HCPs
User opinions on the app and its features	<ul style="list-style-type: none"> • The app gives the impression of monitoring by HCP. • The app is easy to use. • Clear explanation in video tutorials on how to use the app. • The app provides daily monitoring by AP advice and PEP. • The app allows contact with HCP and app administrators. • The app allows the history recording and graphing by day and period. 	<ul style="list-style-type: none"> • The app makes the promotion of PA in oncology care accessible and easy. • The app is easy to use. • The app integrates the mental and physical health status of patients daily. • The app allows the follow-up of real achievements by the patients (PEP and PA advice) outside the moments of the medical consultations. • The app allows the exchange between peers. • The app allows the evaluation and self-evaluation of performance and compliance rates for PA advice and PEP.
User opinions on PEP and PA advice	<ul style="list-style-type: none"> • Accessible and adapted PEP advice. • Adapted, precise, and clear PEP. • Possibility of adapting PEPs if you have forgotten or an unfavorable state of health. • Detailed and clear explanation of PEP contents, via video tutorials. 	<ul style="list-style-type: none"> • Accessible and adapted PEP advice. • Adapted, precise, and clear PEP.
Missing elements and areas for improvement	<ul style="list-style-type: none"> • If some exercises are difficult or impossible, several choices of exercises should be provided. • Lack of reminder notifications to motivate us 	<ul style="list-style-type: none"> • It is preferable to integrate pedometers to have reliable data

Table 7 Evaluation results using MARS by the two experts

MARS Section	Items	Expert 1	Expert 2
Engagement	Entertainment	4	3
	Interest	5	4
	Customization	5	5
	Interactivity	5	5
	Target group	4	4
	Mean Section Score	4.60	4.20
Functionality	Performance	4	4
	Ease of Use	5	5
	Navigation	5	5
	Gestural design	4	5
	Mean Section Score	4.50	4.75
Aesthetics	Layout	5	4
	Graphics	5	5
	Visual Appeal	4	3
	Mean Section Score	4.66	4.00
Information	Accuracy of app description	4	4
	Goals	3	4
	Quality of information	4	4
	Quantity of information	4	3
	Visual information	5	5
	Credibility	5	4
	Evidence based	5	5
	Mean Section Score	4.28	4.14
Mean App quality Score		4.51	4.27

MARS Mobile Application Rating Scale

theoretical models appears to enhance the efficacy of PA-specific apps [50].

According to the obtained results, both experts and users approved and praised the functionality of the app. A higher level of persuasiveness in a mobile app promoting PA should be characterized by dependability, expertise, authority, third-party endorsement, and verifiability [21]. In addition, the app’s appearance, which inspires science and professionalism [51], and provides access to credible information sources [27], contributes to its credibility .

Both experts highlighted the dearth of appeal of behavioral change motivation. However, the feedback provided by the HCP or virtual coach would help beneficiaries maintain their motivation. In fact, it appears that users who receive social feedback are more engaged with HCP recommendations [52]. However, users noted that our solution lacked reminder notifications. This feature appears to be a factor ensuring user compliance with the desired behavior [53]. In our app, however, we have emphasized visual aids, especially graphics. This permits the visualization of behavior modification [44]. Participants in the study who were HCPs recommended the incorporation of pedometers for the objective surveillance of PA. In fact, a meta-analysis revealed that the incorporation of a PA tracker could serve as a useful instrument for HCPs to provide ongoing monitoring and support [18] However, a faint correlation has been established between user evaluation and clinical utility [54], so positive user evaluation does not necessarily imply clinical utility. The evaluation of healthcare apps faces some obstacles, including

Table 8 Evaluation results using the ABACUS by the two experts

ABACUS		Expert 1	Expert 2
Sections	Items		
Knowledge and information	Does the app have the ability to customize and personalize some features?	0	1
	Was the app created with expertise and/or Does the app provide information that is consistent with national guidelines?	1	1
	Does the app ask for baseline information?	1	1
	Does the app provide instruction on how to perform the behavior?	1	1
	Does the app provide information about the consequences of continuing and/or discontinuing behavior?	1	1
	Score section	4	5
Goals and planning	Does the app ask for willingness for behavior change?	0	0
	Does the app allow for the setting of goals?	1	1
	Does the app have the ability to review goals, update, and change when necessary?	1	1
	Score section	2	2
Feedback and monitoring	Does the app give the user the ability to quickly and easily understand the difference between current action and future goals?	0	1
	Does the app have the ability to allow the user to easily self-monitor behavior?	1	0
	Does the app have the ability to share behaviors with others (including social media or forums) and/or allow for social comparison?	1	1
	Does the app have the ability to give the user feedback—either from a person or automatically?	1	0
	Does the app have the ability to export data from app?	1	0
	Does the app provide a material or social reward or incentive?	1	1
	Does the app provide general encouragement?	1	1
	Score section	6	4
Actions	Does the app have reminders and/or prompts or cues for activity?	1	0
	Does the app encourage positive habit formation?	1	1
	Does the app allow or encourage for practice or rehearsal, in addition to daily activities?	1	1
	Does the app provide opportunity to plan for barriers?	1	0
	Does the app assist with or suggest restructuring the physical or social environment?	1	1
	Does the app assists with distraction or avoidance?	0	1
	Score section	5	4
Total score		17	15

ABACUS Application Behavior Change Scale

the time required to complete the evaluation, the paucity of evidence-based data regarding evaluation instruments, and the inflexibility of the latter [55]. We believe that the devised solution also addresses these obstacles.

The methodology for designing mobile apps to promote PA in people with cancer has been described by several previous studies [21–27]. Compared to previous solutions, ours appears to be more global and comprehensive, as it is designed to assist HCPs in recommending PA and to assist patients in maintaining an adequate level of PA throughout the entire therapeutic pathway. The realities of the clinical context, which have demonstrated HCPs’ lack of knowledge in this field [8], may justify these decisions. The absence of comparable experience in the context in which this app was developed was also a determining factor, as we sought to fill the void in this field to the best of

our ability. The app’s general nature is also reflected in its numerous and diverse recommendations, as it offers both PA advice and PEPs. The latter include all components, including exercise retraining, muscle strengthening, pelvic floor exercises, balance exercises, and flexibility exercises. In a study on the design of a mobile PA app, the authors acknowledged that the recommended PEP [22], lacked a resistance program (muscle conditioning).

Limitations

Due to the limited sample size, results obtained from users (beneficiaries and HCP) should be interpreted with caution. Although the results of the user evaluations are encouraging, they must be supported by a post-hoc evaluation of the program’s long-term impact. The selection of beneficiaries based on the criteria of smartphone

ownership and use brings into question the applicability of such a solution to all individuals who are dismayed by the oncology recommendation for PA. Despite the potential for mobile apps to improve access to e-health, there are some related issues: unequal access to mobile technology, lack of familiarity with or knowledge of how to use apps, and privacy and security concerns [47].

Conclusion

The design of the "NachateBadani" app based on a user-centered process was able to identify the specific PA recommendation requirements of cancer patients and survivors. We adhered to the pertinent guidelines, the self-determination approach of the beneficiaries, and the accompanying behavior change strategies. The objective was to improve the user-friendliness and acceptability of the tool, as well as the recipients' long-term commitment to the behavior change process. The outcomes of the evaluation of usability, quality, and behavior-change potential appear favorable. Also, the short-term impact on the volume and quality of beneficiaries' PA appears promising.

This is a preliminary evaluation, which will be followed by additional, in-depth evaluations with larger sample sizes. In the future, we intend to evaluate the solution's long-term impact, develop other, more specialized tools (such as those for breast cancer), and possibly expand the experiment to other chronic diseases.

Abbreviations

ABACUS	The Application Behavior Change Scale
MARS	The Mobile Application Rating Scale
HCP	Healthcare Professional
PA	Physical Activity
PEP	Physical Exercise Program
SUS	The System Usability Scale

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Authors' contributions

YA, SB, and HE participated in the design of the study. JD was responsible for the IT aspect of the design. The original manuscript was drafted by YA and reviewed by all authors YA, SB, HB, IBA, HC, FE, and HE. All authors read and approved the final manuscript.

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Availability of data and materials

The anonymized data used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

The Joint Ethics Committee of the Faculty of Medicine and Pharmacy at Mohammed V University in Rabat, Morocco, approved this investigation (November 2019; CRTN: 104/19). All participants gave informed consent before participation.

Consent for publication

Not Applicable. Participants signed a consent form that informed them about the intention to publish the data from the study. In addition, no identifying or personal details are presented in this study.

Competing interests

The authors declare no competing interests.

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