User Needs in the Performance of Prescribed Home Exercise Therapy

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Abstract
Musculoskeletal disorders are a globally significant health problem affecting millions. Physiotherapy, including prescribed exercises performed independently by patients in their homes, is a key treatment for many sufferers. However, many fail to complete home exercises, prolonging recovery periods or accelerating decline. Pervasive health technologies, capable of monitoring users in their homes, are ideally suited to address this problem. This paper describes user research with a group of three physiotherapists and eleven current physiotherapy patients to understand the problems and user needs underlying non-compliance with home exercise regimes. The user research adopted a speed dating approach and culminated with recommendations relating to the design of feedback, scheduling systems and privacy.

Keywords
Health; physiotherapy; biofeedback; EMG; design

ACM Classification Keywords
H.5.m [Information Interfaces and Presentation]: Misc;

General Terms
Design, Human Factors

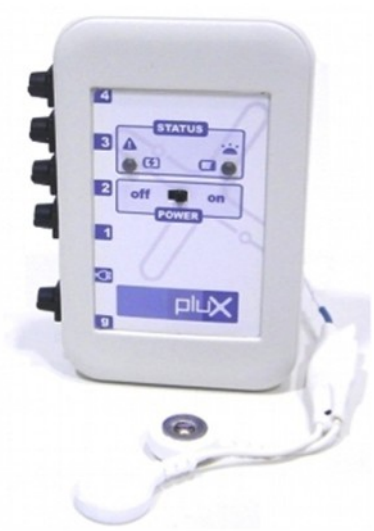

Figure 1. bioPLUX biosignal acquisition device. The bioPLUX system for clinical biofeedback applications features Bluetooth connectivity and four input channels, allowing real-time wireless monitoring of up to four muscles via EMG and display of interactive feedback relating to this activity on a base station, where both patients and practitioners can visualize the work being done and main outcomes.

Introduction

Musculoskeletal disorders (MSDs) are a highly significant global health problem. Many are work related; in Europe, 40 million workers, or one in seven, are affected by work-related MSDs, with an estimated total economic cost of €240 billion [13]. The prevalence of MSDs also increases with age, making them a pressing concern across the graying developed world.

Physiotherapy is a key part of treatment for many MSDs. It involves consultations with practitioners who diagnose conditions and recommend exercise regimes as therapies. Treatment programs last months and involve bi-weekly (or more) clinical sessions supported by daily exercises performed independently by the patient at home [e.g. 8]. Performance of exercises at home is key to achieving treatment goals. However, despite this health incentive, it has been long acknowledged that many patients fail to perform home therapies; one study reports non-compliance with prescribed exercises to be as high as 70% [12]. The result of non-compliance is non-effective (or unnecessarily prolonged) treatments, resulting in extra costs and increased levels of pain and impairment.

This paper addresses this problem space. It explores how pervasive health systems might support patients in the performance of prescribed exercises at home. In particular, it is inspired by recent developments in bio-monitoring for physiotherapy such as the bioPLUX Clinical system (Figure 1, www.plux.info/). This is a compact wireless biosignal acquisition unit with a wide range of sensor nodes. Sold as a clinical analysis service, it enables therapists to use Electromyography (EMG) to measure and display muscular activity during clinical sessions. Its compact and robust form factor also makes the underlying technology ideal for home health monitoring, such as continuous monitoring in ambient assisted living scenarios [11]. This paper describes user-research exploring how this kind of system, a muscle activity sensor, could be combined with existing connected consumer technologies, such as smart phones, to tackle the problem of non-compliance with prescribed exercises. To achieve this objective, it describes a series of interviews with physiotherapists and patients to understand non-compliance behaviors and explore how home bio-monitoring technologies might support performance of exercises at home. The paper concludes with design recommendations for this application space. The remainder of this paper is structured as follows: a review of related work in the field of physiotherapy and pervasive health; a description of the user research and concept development; conclusions and future work.

Related Work

Non-compliance with prescribed physical therapy regimes often results from patients' explicit, reasoned decisions. Factors contributing to these non-compliance choices include: low perceived severity of symptoms; perceived ineffectiveness of the intervention; and unwillingness and inability to incorporate the treatment into everyday life [4]. Individual factors such as attitudes towards exercise, past experiences, availability of facilities and social environment also play a role [12, 10]. However, interventions to overcome non-compliance can be highly effective. For example, concordance, a term referring to practitioners and patients collaboratively setting treatment goals and monitoring progress can lead to substantially higher levels of treatment compliance compared to physiotherapist-mandated goals [2].

Pervasive health technologies are ideally suited to address problems of non-compliance. There is an existing and diverse body of work demonstrating that digital technology can motivate and support users in performing exercises. For example, researchers have created systems that act as empathic consultants to aid and coach patients [3]. Others have explored motivating users by embedding exercise within entertainment, such that physical activities are part of game play [e.g. 7]. However, such exercise support systems are typically designed for individual users pursing personal exercise goals rather than as part of a program of prescribed physiotherapy. Regardless, their popularity suggests the techniques they employ may also be effective tools for therapy programs. Work in pervasive health has also popularized the notion of home monitoring systems. Such applications allow caregivers and clinical practitioners to follow patients more closely, improving diagnosis processes and enhancing and customizing assistance [1].

In sum, past work has shown that digital technology can effectively monitor users at home and also motivate them to perform exercise. This paper explores one intersection of these spaces by conducting user research on how sensing technology can best be integrated into clinically prescribed home exercise regimes in order to increase treatment effectiveness by reducing patient non-compliance.

Fieldwork

The user research took place in two distinct stages. In the first stage, interviews were conducted with three practicing physiotherapists. The insights captured from this process were used to generate materials (in the form of scenarios) for a speed dating [5] concept exploration and validation process that was conducted with eleven physiotherapy patients. These stages are described in more detail below.

Practitioner Interviews

60-90 minute interviews were conducted with three physiotherapists working in Funchal, Portugal. Their mean age was 30 and time in practice was 3-12 years. Two had direct experience (1-2 years) of using EMG biofeedback devices in clinical settings. The goal of these sessions was to explore issues and problems in physiotherapy treatment regimes, in particular focusing on exercise performance in home settings, on patient motivation and non-compliance, and on how biofeedback technology might add value. The results highlighted findings from the literature. Patient sessions were reported to commence with reviews of home exercise performance, typically involving patients reporting a range of reasons for non-compliance (e.g. too busy, forgetful, lack of immediate benefit). The individual nature of patients was also stressed: exercise completion varied substantially from patient to patient. The therapists also indicated that stressing the impact and value of exercises and conveying progress were the most effective tools to address non-compliance.

Concept Generation

Synthesizing the results of these interviews with the literature on motivation and pervasive health led to the generation of six user scenarios expressing different approaches to motivating physiotherapy patients to perform exercises at home. Each was based around the core idea of EMG based bio-monitoring hardware linked to a smart-phone and ultimately expressed as short storyboards, examples of which are shown in Figures 2 and 3. The six scenarios were as follows:

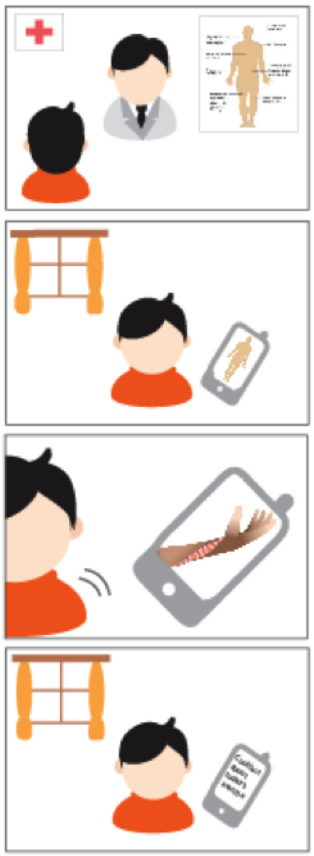

Figure2: Motivation by Understanding Storyboard. In (1) A physiotherapist explains the effects of exercises to a patient. In (2) the patient reviews the physiotherapist's explanation at home. In (3) a bio-monitoring application detects the patient's movements and visualizes his performance. In (4) the patients receives a message about his condition and how the exercise helped.

- **Motivation by Understanding**: Home regimes can appear counter-productive to patients, particularly due to perceived ineffectiveness of exercises or discomfort [4]. This scenario explored the presentation of real time feedback illustrating the problem and effect of exercises. This was shown as live visualizations (muscles activating on a stylized body) of EMG data.
- **Motivation by Enjoyment**: Games have been frequently explored as a mechanism to support and motivate rehabilitation activities [e.g. 7]. This scenario explored the use of simple "mini-games" driven by exercise performance and interactively displayed on a smart-phone.
- **Motivation by Results**: Physiotherapy treatments work incrementally and gradually; patients experience difficulty in observing improvements in such prolonged processes [10]. This scenario explored allowing users to visualize and explore bio-sensed data charting their performance and progress over time.
- **Motivation by Scheduling**: Willingness and ability to accommodate prescribed exercises regimes into everyday life is a key to the success of a treatment program [4]. This scenario explored the use of technology to prompt patients to complete exercise sessions (based on contextual cues such as arrival at home), to track completion (via biosignal monitoring) and to manage and mediate clinical appointments.
- **Motivation by Support**: Bio-monitoring technology has the potential to increase levels of clinical support. This scenario explored online connections that transferred data recorded from home exercise sessions immediately to therapists who could monitor, evaluate and give feedback on performance immediately and outside of regular clinical appointments.
- **Motivation by Peers**: Social factors such as peer pressure, public commitment and group membership are strong motivating influences [9]. This scenario explored the role of sharing of biofeedback based exercise performance data with peer-patients.

Concept Exploration and Insights

The six concepts were explored with the speed dating method [5], a rapid, low-cost technique intended to let designers and researchers quickly identify and understand the user needs and critical contextual aspects of a design space. A total of 11 physiotherapy patients participated in this stage of the work. The youngest was of age 16, the oldest 75 and all had been in physiotherapy for at least one year. All attended the same practice and all had previous experience of EMG based biofeedback during clinical sessions. They were under treatment for a wide range of conditions including muscle strain (due to sporting injuries), upper and lower back pain (due to overexertion), paraplegia (due to stroke or spine injury) and osteoarthritis (associated with age). Eight of the participants completed a speed boarding process while the remainder completed follow-up user enactments. Speed boarding took the form of semi-structured interviews in which participants were exposed to the six storyboards. An experimenter led a discussion of each scenario in turn, eliciting opinions, comments and comparisons with the goal of extracting user needs. The enactments were targeted to reveal patient attitudes towards involvement of a mobile device, or their doctor, family or peers in supporting their motivational needs.

The results from the speed dating process were analyzed to uncover insights and design guidelines relating to the introduction of sophisticated home

Figure 3. Motivation by Support Storyboard. In (1) a patient and physiotherapist collaboratively determine a set of home exercises. In (2) these exercises appear as 'goals' in a mobile application. In (3) exercise performance automatically checks off the goals and a report is sent to the physiotherapist. In (4) the physiotherapist reviews the report in his clinic and sends feedback to the patient about his performance.

monitoring technologies to physiotherapist practice. Particular foci were how such devices could support patient motivation and exercise regime compliance. Six findings emerged, as described below:

- **Effectiveness and Correctness**: In the understanding scenario, users stated the visualizations would increase comprehension of the impact of their exercises. Similarly, in the enjoyment scenario, users reported associating success or progress in the game with correctly performing the exercise. Feedback from a mobile device to confirm accuracy of exercise performance was very well received. Future designs should aid patients' understanding by tackling uncertainty related to effectiveness of exercises as well as correctness of performance.
- **Results are Rewards**: Participants also reported difficulty understanding their progress through therapy and responded positively to tracking features in the entertainment scenario through a record of game achievements (stars awarded). In the motivation by results scenario, participants reported that easy access to visualizations of their long-term performance and subjective state would help them gauge progress and appreciate the value and impact of home exercises. Applications should combine subjective and objective evaluations to fully track and visualize results.
- **Exercise is not Entertainment**: All participants saw the mini-games in the entertainment scenario as useful but not due to any inherent entertainment value. Instead, they were considered valuable because they were an accessible and understandable mechanism for conveying exercise correctness and for tracking performance (as mentioned above). Patients indicated they did not seek to enjoy their treatment; making and understanding progress was more important. Thus if games are used in physiotherapy, the focus of the game design should be less on entertainment and more on providing understanding and results.
- **Contextual Scheduling**: Participants reported non-compliance behaviors due to forgetfulness and difficulty in integrating exercises with other tasks (e.g. work). However, many also reported irritation with the idea of external parties (therapists, family members or a mobile device) mandating their routines. They responded positively to the idea that a mobile device could remind them to perform exercises at suitable locations or times of day. Future designs for reminder and scheduling systems for exercise regime compliance should be context aware [e.g. 6].
- **Lightweight Communications**: Practitioners and patients both expressed a desire for improved communication relating to home exercise performance. Patients felt this would aid recovery but doubted that practitioners would review or respond to it. Critical and low frequency messages were viewed as more likely to receive attention. This suggests that, if real-time monitoring applications are to effectively motivate users, they should emphasize the significance of the data they transmit. Communications to therapists should remain lightweight in order to be credible.
- **Health Information is Private Information**: Participants responded negatively to the idea of social feedback and sharing of their health information. Many reported appreciating how the idea would work, but that they would not use such a service. Overall, there was a strong reluctance to share or receive even abstracted information relating to medical condition, progress and prognosis. We suggest that information captured by biosignal monitoring sensors or paired

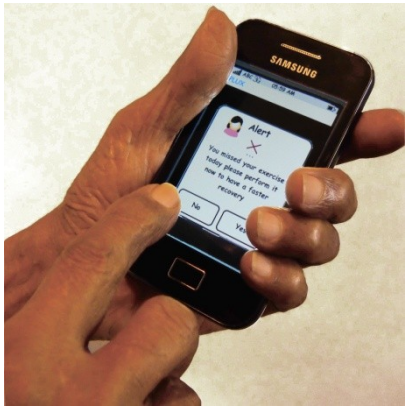

Figure 4. Physiotherapy patient enacts the scenario where their family member/friend 'Ana' keeps track of missed exercises and sends them a 'Nudge' (friendly reminder)

application is viewed as too personal for sharing with anyone except their therapist.

Conclusions

This paper highlights the problem of treatment non-compliance in physiotherapy and suggests that appropriately designed technology may be able to support patients and reduce the negative impact of this behavior. To understand how this might be achieved, interviews with 3 practitioners and 11 patients were conducted using a speed dating approach. The resultant data was analyzed into six insights for design. Future work will attempt to create, implement and field-test concrete solutions based on this work. In sum, pervasive health technologies have much to offer their users, but must be designed to match lifestyles and genuine needs. Comprehensively capturing and understanding such information will be a long and complex process; this paper highlights its importance and takes small steps to achieving this objective.

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