



The Development of a Technology-Based Hierarchy to Assess Chronic Low Back Pain and Pain-Related Anxiety From a Fear-Avoidance Model

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Abstract: Previous studies have not examined the assessment of chronic low back pain (CLBP) and pain-related anxiety from a fear avoidance model through the use of motion-capture software and virtual human technologies. The aim of this study was to develop and assess the psychometric properties of an interactive, technologically based hierarchy that can be used to assess patients with pain and pain-related anxiety. We enrolled 30 licensed physical therapists and 30 participants with CLBP. Participants rated 21 video clips of a 3-D animated character (avatar) engaging in activities that are typically feared by patients with CLBP. The results of the study indicate that physical therapists found the virtual hierarchy clips acceptable and depicted realistic patient experiences. Most participants with CLBP reported at least 1 video clip as being sufficiently anxiety-provoking for use clinically. Therefore, this study suggests a hierarchy of fears can be created out of 21 virtual patient video clips paving the way for future clinical use in patients with CLBP.

Perspective: This report describes the development of a computer-based virtual patient system for the assessment of back pain-related fear and anxiety. Results show that people with back pain as well as physical therapists found the avatar to be realistic, and the depictions of behavior anxiety- and fear-provoking.

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Key words: Chronic low back pain, kinesiophobia, anxiety, fear, avatar, hierarchy, exposure.

The fear-avoidance model describes why and how patients with acute pain may progress into a chronic pain condition.^{10,17} According to the fear-avoidance model, one's experience with pain is on a continuum ranging from confrontation of a feared stimulus to avoidance of a feared stimulus. Confronting a feared stimulus is often challenging for patients because of patterns of learned behaviors and maladaptive behavior and cognitions.

Consistent with fear-avoidance models, exposure-based treatments have been proposed and investigated for their effectiveness.¹⁶ Integral to the application of exposure treatments for low back pain is the assessment

of fear- and anxiety-inducing behaviors that can be targeted for graded exposure via the establishment of a graded hierarchy of behaviors. Throughout this article we use the terms "fear" and "anxiety" synonymously, although we recognize that there are some indicators that these constructs can be separated at the behavioral and physiological level.¹⁴ For the purposes of this investigation and the development of an assessment tool for evaluating specific behaviors avoided by patients with pain, the distinction between fear and anxiety is less relevant. There is also ample evidence that fear and anxiety are substantially correlated.^{6,11,12} Furthermore, proponents of the fear-avoidance model often use the terms synonymously, and cite anxiety theories as support for the model.⁸ The results of the hierarchy ratings act as a way for therapists to create a treatment plan for patients.⁹ The Fear of Daily Activities Questionnaire (FDAQ) is a measure that has been used for assessing fear of certain activities; it has 10 feared activities with 2 fill-in-the-blank options that are rated on a 0 to 10 scale.⁴ However, a video or computer-based format of the FDAQ or similar measure has not yet been established.

There have been recent advances in the use of computer-based virtual patients and motion capture

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technology for use in medical conditions. Commercial video games as a rehabilitation tool have gained popularity and are rated as acceptable by patients receiving physical therapy.⁷ Motion capture technology has also been used with young adults with motor difficulties who engaged in a Kinect-based rehabilitation program in the school setting, also called “Kinerehab.”² Virtual humans (avatars) have been developed to assess sex, race, and age biases in medical decisions and these avatars show high levels of realism and acceptability.⁵ This technology has not been used to assess pain-related fear and anxiety, although avatars and motion capture may provide realistic depictions of physical activities and movements for participants to rate.

Therefore, the purpose of the present project was to combine computer-based virtual patient, and motion capture technologies to create a hierarchy of low back pain-relevant fearful stimuli. This project reports on the development and psychometrics of a virtual patient scale. The development of an assessment scale based in a computer virtual environment sets the stage for use of these technologies for assessment or treatment of fear and avoidance behaviors in individuals with low back pain. Specific goals of the project were to show that the virtual patient stimuli could be appropriately scaled by patients with chronic low back pain (CLBP). Second, we wished to assess the acceptability and realism of Web-based presentation of the stimuli to patients and physical therapists. Finally, we assessed the reliability of these fear ratings, and initial validation was determined via correlations with other fear questionnaires.

Methods

Participants

Two sets of participants were recruited for the study: physical therapists, who reported treating CLBP, and individuals reporting CLBP. Participants with CLBP were included in the study if they reported current back pain for a minimum duration of 3 months. They were also required to have a high score (>40) on the Tampa Scale of Kinesiophobia (TSK). This cutoff score is consistent with other pain studies.¹⁶ Participants who were physical therapists met eligibility requirements if they were licensed and reported experience with CLBP.

All study participants were recruited through posted advertisements at the University of Florida campus and in a variety of clinical settings such as UF Health. We also used electronic mailings and advertisements at Brooks Rehabilitation Hospital to recruit physical therapists. To participate in the study, participants were required to be 18 years or older and be able to understand and communicate in English. It was also required that each participant have access to a computer with an Internet connection.

All participants first agreed to participate through an online informed consent, and participants received compensation. The study was approved by the University of Florida institutional review board.

Development of Stimuli

The Microsoft Kinect (Microsoft, Redmond, WA) is a motion-sensing input device that was used to record 3-D movements that could be used to build an avatar for the participants' viewing (Fig 1).

iPi Markerless Mocap Studio and iPi Recorder (iPi Soft, LLC, Moscow, Russia)¹⁸ software programs were used to integrate with the Microsoft Kinect to capture, play, and process videos recorded with the Kinect. Two Kinect systems were used to obtain better spatial resolution of the avatars performing the movements from the fear-avoidance hierarchy (Fig 1).

A list of 21 movements, derived primarily from the FDAQ were recorded using 2 Microsoft Kinect systems.

To create the simulated clips we first calibrated the system to ensure proper recording. Following, a series of actions were recorded. These video-recorded movements were then transformed into “skeletons” for processing (Fig 2). Each “skeleton” was processed for smooth motion in the video and later had an “avatar” placed onto the body to more closely resemble a human (Fig 3). The avatar that was created is a Caucasian man of average height and appears slightly overweight. The expression on the avatar's face is relatively neutral (ie, no specific pain expression on his face). Thirty-second segments of these processed videos were then uploaded onto the study Web site for the participants to view and rate on their personal computer. Using an avatar and not simply a video of a person performing the movement was important because it allows for future flexibility in varying characteristics of the avatar, such as gender, age, ethnicity, height, and weight.

Participant Measures

Physical therapists were asked to complete information about their employment status, their experience with treating low back pain, and other demographic characteristics. The following self-report psychological questionnaires, pain-questionnaires, and demographic information were completed by participants:

Assessment of Acceptability (Completed by Physical Therapists)

A numeric rating scale (NRS) was used on a 0 to 100 scale where 0 = “not at all acceptable” and 100 = “very

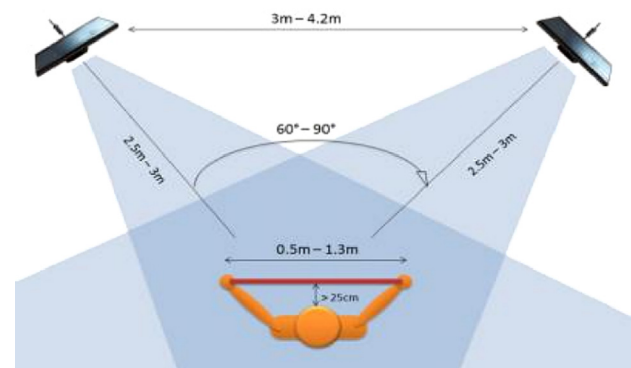


Figure 1. Configuration of dual sensors (<http://wiki.ipisoft.com>).

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