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There's an App for That: Mobile Technology Is a New Advantage in Managing Chronic Pain

A global health challenge is to deliver affordable health care to a growing and aging society, especially to individuals with comorbid long-term medical conditions. Modern innovations including the Internet and mobile technologies offer significant opportunities to improve access to health care, contain costs, and improve clinical outcomes. This trend is reflected in the rapidly increasing numbers of publications evaluating technologies for health care delivery (e.g., telehealth, eHealth), which compare their user-friendliness, reliability, validity, and efficacy to conventional methods of direct human interaction.

Owing to the increasing spread of mobile technologies throughout the world, the World Health Organization (WHO) has coined a new term: mobile Health (mHealth), a component of eHealth. The Global Observatory for eHealth (GOe) of the WHO defines mHealth as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices"[1]

PDAs, popular in the early 1990s, have been largely replaced by smartphone and tablet devices. According to Global Mobile statistics in 2011, there were more than 6.8 billion registered users of mobile phones. In low-income countries, mobile communication technology is the fastest growing sector of the communications industry.[2] Estimates for smartphones have been well over 1 billion worldwide.[3]

This high density of modern mobile platforms worldwide allows people to access health care even where mobility, transportation requirements, or cost constraints present significant barriers to traditional face-to-face interaction with a health professional. Additional costs are minimal because no separate device is needed, and applications can use existing services for Internet access and text messaging. These services will allow for easy and time-effective coverage of a large patient population at a low cost by using downloadable material and automated emailing and messaging systems. Cell phones facilitate temporal synchronization for symptom monitoring, medication and appointment reminders, and possible interventions.

Mobile technology to monitor chronic health conditions has been used for several years with some reported efficacy,[4,5] yet the interest in mobile technology for management of chronic pain has only recently started to develop, and there is still a paucity of large, high-quality trials to evaluate its efficacy. This issue of *Pain: Clinical Updates* focuses on the scientific evidence of mobile technology for chronic pain management, with special atttention to mobile phone capabilities.

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Electronic Diaries

With the advent of handheld computer technology and increased availability of the Internet, electronic diaries have become popular for the purpose of pain monitoring. Acknowledging

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the shift from conventional to electronic data collection, the U.S Food and Drug Administration released guidelines for collecting and evaluating such data.[6] Several randomized controlled trials (RCTs) and multiple prospective longitudinal studies comparing paper with electronic diaries have convincingly shown that electronic recordings are superior with respect to compliance, user-friendliness, patient satisfaction, test reliability, and validity measures.[7]

In addition, pain can fluctuate widely over the course of time, depending on psychological and environmental influences, and is therefore prone to recall bias. Retrospective assessment usually leads to an overestimation of pain,[8] which can be prevented by frequent ratings of "now" pain (known as "momentary ecological assessment").[9] Psychological variables (e.g., anxiety, anger) and physiological factors (e.g., physical activity, sleep) preceding and following pain exacerbations can be captured and correlated.[9] Some studies have used additional electronic devices incorporated into the electronic diaries to evaluate objective environmental variables, (e.g., accelerometers to evaluate physical activity and sleep).[10]

As technology merges and advances, evidence-based electronic monitoring of chronic pain has become transferable to applications run on smartphones, which can offer additional features for telemonitoring, including universal wireless access and text messaging (Table I).

Internet-Based Interventions

Internet-based interventions are widely available on smartphones (Table II). A recent review of articles published between 1990 and 2010 on more than 2,500 patients with chronic pain evaluated the evidence for Internet-based interventions.[11] Interventions consisted mainly of (1) cognitive and behavioral therapy (CBT), (2) moderated peer-support programs, or (3) clinical visit preparation and follow-up. Internet-based CBT interventions consist of structured, self-administered therapy programs offered in weekly modules ranging in length from six to 20 weeks, with only minimal support from clinical staff. Most CBT studies showed significantly decreased pain levels, improved function, and decreased costs compared to standard care.

Evidence of beneficial effects of these interventions on mood was less consistent. Studies of peer-support forums designed to help patients exchange experiences with people with similar symptoms have demonstrated significant reductions in pain levels, disability, and distress but no change in the number of physician visits.[12] Online networks can consist of interactive components designed to promote communication, distraction, information, self-expression, and social support. Meta-analysis of several RCTs showed significant reduction in pain and anxiety. In addition, significant reduction in loneliness, withdrawn behavior, and a greater willingness to return for treatment was achieved in some studies.[13]

Lastly, clinical support interventions, including educational websites to help prepare for doctor visits and support self-management after outpatient

Table I
Types of Mobile Technology

Technology Types	How They Work	How They Can Be Used
Personal digital assistants (PDAs)	These handheld devices have programs (electronic diaries) that can monitor pain, mood, medication, side effects, and quality of life.	Programs can collect data and track changes in pain, mood, and medication use over time. These data can be summarized and saved for providers to assess progress.
Mobile applications (apps)	Users download these software programs to a mobile device with Internet capability for education and monitoring purposes.	These programs can be used for self-assessment and symptom management among those with pain. Daily reminders and tracking of medication, exercise, diet, and appointments are designed to help manage pain.
Text messages	Brief typed messages enable two-way communication with a care provider or friend.	This form of communication can transmit pain scores and level of functioning. Response to text messaging can be assessed as a measure of compliance.
Twitter	One-way brief (140-character) messages (called tweets) are posted for anyone who might be interested (known as microblogging).	Users can communicate issues associated with pain, mood, and function.
Accelerometers	These clip-on devices track movement and body posture.	Data from accelerometers can be transmitted to a provider to gain some understanding of an individual's level of activity and sleep.

surgical procedures, can significantly reduce postoperative pain after surgery and improve patient satisfaction and knowledge.[14,15]

Text Messaging

Text messaging is a simple, time-efficient, and inexpensive way for two-way communication between patients and providers, and its function is integrated into any mobile or smartphone device for chronic disease management. Several RCTs found significantly higher patient satisfaction rates compared to traditional communication means, higher medication compliance, and a higher probability of healthy lifestyle changes (e.g., smoking cessation).[16] For instance, a recent review of randomized studies found significant improvement in body weight, diet, or exercise with at least daily text messaging to encourage healthy lifestyle changes. Of the two studies evaluating weight loss beyond six months, only one found that a significant weight reduction was preserved.[17]

In contrast, a recent meta-analysis evaluating text messaging for management of diabetes, hypertension, and asthma found only limited evidence of improved clinical outcomes.[18] On the other hand, a newer RCT with more than 500 patients with impaired glucose tolerance showed that diabetes incidence can be markedly reduced by frequent mobile phone messaging of healthy lifestyle advice (e.g., "Use stairs instead of a lift").[5]

Collectively, there is some evidence to suggest improved self-management of long-term illnesses in patients receiving text messages, and it is likely that the number of such text-based self-management studies will increase rapidly. Another form of brief text messaging known as "tweeting" can be used to share information about pain, but little has been reported about use of this form of one-way communication in clinical settings. At present, while there are some trials evaluating compliance, feasibility, user-friendliness, reliability, and validity of text messaging in pain patients,[19–22] we are unaware of any studies evaluating the efficacy of such programs for pain relief.

In the available studies, several questions were texted to participants on a daily or weekly basis to explore pain and functional impairment. Typical questions were: "How many days this previous week has your low back pain been bothersome?" and "How many days have you been off work because of your low back pain this week?" Patients were asked to respond on a numeric scale, which for pain ratings typically ranges from 0 to 10. In some cases, a subsequent question would be sent out automatically after the first answer was received. If the patient did not respond, some studies sent reminder messages within a short period of time, and a few followed up with a telephone call if no response was received after the third message.

Table II
Summary of Smartphone Applications for Pain

Smartphone applications appear to be easy to use and are well accepted by patients with chronic pain conditions.
Compliance rates for use of mobile technology for all ages are around 80%.
Text messaging can be used to gather high volumes of patient data economically.
Alternative measures such as phone interviews or mailed surveys improve compliance.
There are no clear predictors for noncompliance.
There is insufficient evidence to judge the efficacy of app-based interventions for pain and limited evidence that text messaging is reliable and valid.
Text messaging used for intervention purposes is an unexplored field.
Technology could be used to support goal setting and feedback to help people with chronic pain in their own homes.
Technology that replicates aspects of human interaction could improve engagement with self-management interventions.

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Compliance

In general, average patient response rates to text messages are good (70–80%).[19,20] One multicenter study involving 262 patients with low back pain (LBP) who received weekly text messages reported 90% response rates the first week, with a decline to 79% after six weeks. Age, gender, intensity or duration of pain, type of occupation, or self-rated health did not distinguish between the high and low-frequency responders.[19] High responders showed continued recovery from their pain, while those who did not comply tended to show an increase in pain compared to baseline. There was also a tendency to fail to respond if the previous week's responses indicated a high number of bothersome pain days. Seasonal changes including holidays had no effect on compliance.[19]

Another randomized study followed 94 pain patients over the course of a year with monthly text messages and found a continuous decrease of response rates from 75% during the first months to 55% in the last months. An additional telephone interview after three unanswered text messages increased response rate significantly to well above 90%. Regression analysis revealed no significant influence of age, sex, education level, baseline pain, or pain improvement after two months. The overall results of this study suggested that text messaging can be used to adequately perform data collection during a one-year period.[21]

Another study following 101 patients with LBP recruited from chiropractic offices reported declining response rates to weekly text messages (three questions) over 18 weeks. Among 101 patients responding to the first message, response rates declined to 86%, 78%, and 70% at week 6, 12, and 18 respectively. Patient characteristics associated with noncompliance were male gender, acute flare-ups of pain, and radiculopathy.[20]

Reliability and Validity

Evidence for the validity of text messaging is limited compared with more traditional surveys such as paper questionnaires and telephone interviews. In an RCT examining 67 construction workers for efficacy of an exercise program to alleviate musculoskeletal pain, investigators found no differences between paper questionnaires and text messages before and after a 12-week course.[23] Telephone interviews for evaluation of LBP in 31 patients yielded similar results.[24] In another small study of 60 palliative patients admitted for pain medication titration, 10 randomly selected patients were asked to send text messages in set intervals over a 14-day course with ratings of pain and side effects. Telephone follow-up at the end of the study confirmed the accuracy of responses.[25]

Another study with 15 children ages 9–15 showed that description of pain intensity, duration, and functional limitation using a numeric scale with text messages was perceived as easy. Validity of the text response was confirmed by comparing the numeric response of "pain disability" to a visual analogue scale, with good calculated concordance. Similarly, retest reliability was acceptable at a three-day interval.[22]

Cost

Given reasonable compliance and at least some evidence for validity and reliability, text messaging has been used to obtain extensive data in an efficient and economical way to follow a patient's clinical course.[20,26] Automated text-messaging questionnaires (e.g., SMS-T-Q, *www.sms-track.dk*) are reliable measurement tools with high compliance rates unaffected by patient characteristics.[21,22,24] The costs of such a system were explored in a Danish study of 220 patients with LBP followed with weekly text messages over one year. Costs of using a commercially available automated text-messaging questionnaire were compared to the calculated costs of using regular mailed paper questionnaires, which were estimated to be 11 times higher than for text messaging.[24]

Pain Management Applications (Apps)

With the advent of smartphones, which combine features of mobile phones with computer handheld technologies, small, downloadable programs ("apps") have become increasingly popular. A recent review

of many prevalent chronic conditions (diabetes, migraines, asthma, vision and hearing loss, osteoarthritis, anemia, and depression) found more than 6,000 apps.[27] The general purpose of these apps is for monitoring and acquiring information about a specific condition. Typically, an Internet connection is not required, and most of the apps are designed for the general public and for nonclinical use. The prevalent type of data presentation is text followed by charts and pictures. Assistive and monitoring apps are frequently used, whereas informative and educational apps are only occasionally used.[27] One of the major shortcomings of existing apps is that they rarely adhere to established guidelines or link to scientifically proven concepts,[28,29] and there is only modest evidence for improvement in general health care based on smartphone app use (e.g., frequency of clinic visits, emergency room visits, and hospitalizations).[4,30]

In a recent review of commercially available pain applications,[31] 111 applications were found across the major mobile phone platforms, with 86% reporting no health-care professional involvement. Functions of pain applications could be divided into three major categories: (1) general information about pain, its symptoms, and treatment options; (2) diary-based tracking of symptoms, medication use, and appointment reminders; and (3) interventions for pain management, mostly relaxation strategies. Most (54%) of the applications provided general information, while only 24% had a tracking program, and only 17% included an intervention.[31]

Despite the abundance of commercially available applications offered for pain management, scientific evaluation of these programs is scarce. In a prospective, uncontrolled trial of 20 patients with fibromyalgia, symptoms were monitored three times a day for one week with an iOS-based application. Daily reports were generated and transmitted wirelessly to a nurse, who responded with emails or phone calls to encourage the patient to use previously learned self-management strategies. The vast majority (75–85%) of patients indicated that the method was easy to use and useful for tracking symptoms and that they would be willing to use this method in the future.

More than half of the patients said that this method gave them greater control of their disease, helped them manage their disease more efficiently, and was a critical component of their medical care. All participants agreed that it was an easier way to communicate with the care team. Compliance was 75%.[32]

Interviews revealed that the most helpful aspect of the program was to assess symptoms and potential triggers over time. In general, this type of telephone-based follow-up improves the outcomes of various nonpharmacological interventions for chronic pain, and technologies such as interactive voice response systems show tremendous potential for synergy with app-based mobile platforms.[33]

Similarly, a survey of 20 patients using a mobile phone app to rate postsurgical pain for six days found that the patients perceived the application as easy to use and convenient, and most were willing to use the same technology in the future. They reported significantly higher pain levels than controls who completed paper surveys at the same frequency, which may reflect greater accuracy/honesty when responding electronically.[34]

Some mHealth studies have examined pediatric samples, with generally promising results. One study of adolescents with sickle cell disease evaluated the use of a mobile-phone-based program to manage their chronic pain. The intervention included a daily assessment of pain intensity, location, and functional impairments, as well as a program to deliver audio files to encourage coping. Participation rates were high (76% compliance) over an eight-week period. The method was well received, with high satisfaction scores and reported ease of use by parents and children alike.[35] Another study of youth ages 10–17 compared smartphone-based diaries with traditional paper diaries, noting that smartphone-based reporting of pain, coping, and medication use was rated as easier, more time-efficient, and more accurate compared with assessment using paper diaries.[36]

To heighten interest in using electronic diaries among children, a game-based smartphone pain-assessment tool with cancer pain was developed. This program, known as "Pain Police Squad," encouraged users to complete a pain diary twice a day for 14 days. Incentives to complete the diary included promotions within the squad as well as short video sequences of a popular TV series. Compliance was higher than 80%, with no decline over the two-week period. No differences were found in compliance by gender or time and day of diary use. The vast majority of participants indicated that it was easy and enjoyable to use the program and that it did not interfere with activities of daily living.[37]

Therapeutic Interventions

Minimal data are available to judge the efficacy of smartphone interventions for pain. One RCT included 140 women with chronic widespread pain and evaluated a four-week smartphone-based intervention consisting of three daily

symptom surveys with immediate daily written therapist feedback encouraging coping skills.[38] The intervention group reported significantly less catastrophizing, better acceptance of pain, and overall better functioning than the control group, and this difference was maintained for five months after the intervention. There was a 30% dropout rate in the intervention group (versus 3% in the non-intervention group), which was correlated with older age, more pain, worse sleep, and overall worse functioning compared with compliers. The high dropout rate of patients with worse symptoms might have biased the measured improvement in the intervention group.[38]

Benefits and Barriers of Mobile Technology for Pain

Smartphone pain apps offer several benefits for monitoring and managing pain. Similar to PDAs, they allow for momentary measurement throughout the day. With increased accessibility of cell phones with Internet access, more individuals are able to download apps worldwide. In general, smartphones are predicted to decrease in cost, and their capability to store data, maintain a charge, and support programs with different platforms will most likely increase. Studies are underway to document outcomes of smartphone apps for pain, and despite limited evidence of controlled trials, reports of the validity and reliability of these programs are forthcoming. Most of the programs are easy to use, enjoyable, and have at least equal compliance rates compared with paper-based diaries.

Various concerns affect the widespread use of smartphone pain apps. Security issues and concerns over privacy and confidentiality remain, and greater efforts are needed to secure personal data. Data transmitted to a health-care provider may be vulnerable to hacking. Programs that request frequent monitoring with sound and text reminders throughout the day can represent a burden to the user. The volume of data transmitted to a health-care provider can also be overwhelming. There is further risk among certain individuals that smartphone pain apps may encourage too much focus on pain and pain-related symptoms and decrease opportunities for distraction from pain. This type of symptom monitoring could be problematic for individuals who are prone to somatization or increased anxiety.

Another concern with use of smartphone apps is the occasional need for technical support. Corrupted or erased data could be a problem for health-care providers who need to document treatment. Few programs have been compatible with hospital-based electronic medical records. Certain individuals may not be compliant in using smartphone pain apps, and older individuals may not feel comfortable using certain software. Some are limited by mobility issues and physical disabilities and others by poor reading skills or language restrictions.

Certain individuals who have problems with concentration owing to severe pain and loss of sleep may easily become frustrated in using computer and electronic technologies. Also, the cost (although it is decreasing) may limit the use of this new technology. Finally, there is limited evidence that information technology reduces health-care use. However, several recent studies do suggest that telephone-based educational interventions can significantly reduce medical costs.[39] Additional studies are needed to help determine how careful monitoring and informational support may affect frequency of hospital and clinic visits.

Summary and Future Outlook for Smartphone Pain Apps

Treatment of chronic pain is expensive (with annual estimates of up to $635 billion in the United States alone), and mean health-care expenses for adults with a medical condition with severe pain are three times higher than for those with a condition with no pain.[40] While mobile technology will not completely replace the traditional face-to-face interaction with a health-care professional, there is modest evidence of the cost-effectiveness in gathering clinical information and in the potential for reduced health-care use among pain patients using smartphones and pain management apps. Innovative systems currently in development designed to help manage pain without therapy involvement can deliver messages in real time close to any precipitating event. These programs can begin to simulate some of the processes of interacting with a therapist or health-care provider.[41]

There is a discrepancy, however, between the number of available apps and scientific studies designed to measure their efficacy, feasibility, usability, and compliance, and more research is needed. Although one might be able to extrapolate from PDA data using electronic diaries, this would neglect crucial aspects of mobile phone use, including Internet access and messaging, which are necessary for live, two-way communication. While no regulatory body is currently available to monitor, rate, and recommend available applications for chronic pain patients, rigorous interventional studies and reviews by the scientific community are needed. Investigators should assess the benefits of mobile technology in diagnosing and treating chronic pain, including pain assessment apps and electronic hospital records.

Although the future of mobile technology is promising in the management of acute and chronic pain, challenges remain in tracking more complex pain patients with severe symptoms to reduce their higher probability of dropout from app-based studies. Efforts must focus on these most challenging of pain patients, who use the highest percentage of resources.

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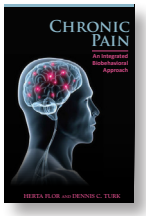
The Essential Pain Bookshelf

Cancer Pain: From Molecules to Suffering

edited by Judith A. Paice, Rae F. Bell, Eija A. Kalso, and Olaitan A. Soyannwo

An in-depth analysis by noted international experts of basic and clinical research on cancer pain, *Cancer Pain: From Molecules to Suffering* describes underlying mechanisms of cancer pain and reviews opioid treatment issues. It covers current drug trials and research, clinical trial designs, common reactions including inflammation and hyperalgesia, the psychology of cancer pain, and disparities in the availability of cancer care worldwide.

Price: **US$75** (IASP Members: US$60)

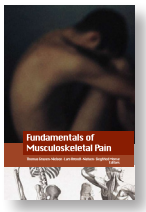


Chronic Pain: An Integrated Biobehavioral Approach

edited by Herta Flor and Dennis C. Turk

Flor and Turk successfully integrate current psychological understanding with biomedical knowledge about chronic pain. With an emphasis on psychological factors associated with chronic pain states, this volume includes recommendations for a structured assessment plan. Using detailed treatment protocols and case examples, the authors aim to guide clinicians in developing effective individualized treatments for their chronic pain patients.

Price: **US$95** (IASP Members: US$75)



Fundamentals of Musculoskeletal Pain

edited by Thomas Graven-Nielsen, Lars Arendt-Nielsen, and Siegfried Mense

Musculoskeletal pain is a major medical and economic problem that encompasses a broad range of conditions, including fibromyalgia, work-related myalgia, low back pain, and arthritis. The editors integrate research findings from the field of musculoskeletal pain into a comprehensive publication that explores translational aspects relevant to clinical pain.

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Mechanisms and Management of Pain for the Physical Therapist

edited by Kathleen A. Sluka

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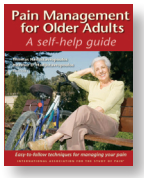

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