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Motive8! Feasibility of a Text Messaging Intervention to Promote Physical Activity in Knee Osteoarthritis

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Abstract

Aim: To develop and test the feasibility of using a SMS text messaging intervention to promote physical activity in patients with knee OA.

Methods: 27 people (6 male, 21 female; aged 25-81 years) with knee osteoarthritis received 4 text messages per week, for 6 weeks. Telephone surveys were conducted at baseline and 6 weeks to measure physical activity levels and beliefs, including self-efficacy for exercise, barriers and benefits of exercise, social support and pain. Participants completed physical activity diaries. Process evaluation included participant perceptions of the intervention and 'real-time' data on intervention fidelity (automated collection of delivery and response data) and participant engagement (text response).

Results: 648 messages were sent, 100% were accurately delivered. From baseline to 6 weeks, physical activity, self-efficacy for exercise, perceived benefits of exercise and social support significantly increased; reductions were observed in barriers to exercise and pain. Participants engaged with the intervention; 100% read the messages, 89% responded to texts requesting replies, 64% completed physical activity diaries with low attenuation (1.8% drop) by six weeks. Participants perceived messaging to be enjoyable (96%), personally relevant (85%), of appropriate frequency (100%) and duration (88%). Mobile phones, email and web were perceived to be most acceptable for health promotion compared with other forms of technology.

Conclusions: People with knee osteoarthritis can engage meaningfully with an interactive mobile phone messaging intervention over a six-week period. Health communications promoting physical activity demonstrate potential for behaviour change and positive implications for perceptions of exercise and pain; this needs to be tested in a randomised trial. Data collected in 'real-time' can be used for process evaluation to demonstrate participant engagement and intervention fidelity.

Keywords

Cellular phone, Mobile phone, Health communication, Text messaging, Exercise, Physical activity, Knee osteoarthritis

Introduction

Regular physical activity is essential for lifelong health and reducing the risk of chronic disease and all-cause mortality [1]. Many people in the general population do not achieve government recommended levels for daily physical activity [2] and rates tend to be significantly lower with advancing age[2,3]. Sixty per cent of adults with arthritis do not adhere to physical activity guidelines although sedentary lifestyles are predictors of poor function in the osteoarthritis population [4,5]. Individuals with knee osteoarthritis (OA) are even less likely to follow physical activity recommendations and have poorer overall physical activity profiles than those without knee OA [6]. Despite low participation rates, aerobic physical activity and strengthening exercises (combined with weight loss, if overweight) are first-line concerns in the management of OA [7]. Obesity and overweight are common in knee OA [8], but excess weight is associated with increased OA pain and lowered effectiveness of OA pain management [9,10]. Physical activity can facilitate weight control, and has been associated with reductions in OA pain and improved quality of life [11,12].

Mobile technologies are a growing platform for the delivery of health information and self-management interventions and research demonstrates their utility in promoting lifestyle behaviour change, such as increasing physical activity and in weight management initiatives [13].

Short-messaging service (SMS) interventions have shown to be effective at increasing physical activity and reducing obesity in a range of populations [14,15], and offer broad reach for relatively low cost. SMS interventions that are informed by behaviour change theory have shown increases in lifestyle physical activity in healthy adults of diverse age [16,17]. Previous studies have shown that interventions using mobile phones are acceptable to healthy mid-life and older adults but, there is limited evidence of their acceptability in mid-life and older adults with chronic illness [18,19]. Here, it is proposed that health communications delivered by mobile phone text messaging might be an appropriate

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mechanism for reaching osteoarthritis patients and encouraging active lifestyles in this population. The aim of the study was to develop and test the feasibility of a theory-based SMS messaging intervention to promote physical activity in people with knee OA, and conduct process evaluation using data collected in 'real-time'. Knee OA was selected since it is the joint most frequently affected by osteoarthritis and contributes significantly to disability [20]. The objectives of the study were to (i) establish whether the components of an SMS intervention are delivered consistently and accurately to the target group (intervention fidelity); (ii) monitor engagement with the intervention and comprehension of the messaging content; (iii) ascertain whether the method is feasible and acceptable to knee OA patients and whether it is perceived as obtrusive or unobtrusive; (iv) determine the likelihood of change in health behaviour, physical activity and pain perceptions which could be tested in a future trial.

Methods

Study Design

This was a cohort feasibility study in which physical activity-promoting messages were developed in collaboration with service users, and delivered to a group of people living with knee OA over a six-week period. Participants received a total of 24 messages each; four SMS communications each week for six weeks. All participants received generic publicly available information booklets on how to be more active with knee OA and were encouraged to complete a physical activity diary.

Message Development

Message content was developed by a health psychologist and a medic. Content was informed by research on motivators and barriers to physical activity in knee OA patients [21,22], communication theory [23] and public consultation; messages included information about the importance of physical activity for general health and knee OA, and practical suggestions for ways of increasing physical activity alongside knee OA. The public consultation took the form of a discussion group lasting approximately one hour and guided by two facilitators, with four individuals with knee OA (aged 45-68) recruited from a patient and public involvement (PPI) group. Participants were asked about their experiences of osteoarthritis, their perceptions of exercise, their perceived barriers to active lifestyles, their opinions on the use of mobile phones to promote health, their preferences for message content, and their preferences for both how and when the messages should be delivered. Physical activity guidance was informed by National Institute for Health and Care Excellence (NICE) guidelines for the treatment of osteoarthritis [7]. The health communications were intended to encourage participants to increase their physical activity beyond their current level, ideally meeting the government recommendation for daily physical activity (e.g. achieving 150 minutes per week of moderate-intensity physical activity) [1]. An intervention mapping approach was adopted; messages were presented in accordance with Transtheoretical models [24], with content including behaviour change techniques informed by Social Cognitive Theory [25] and motivational interviewing [25,26]. Messages were aimed at building self-efficacy (confidence) for exercise, and encouraging individuals to make small incremental changes, set their own achievable goals, and pace themselves in order that their physical activity could be manageable alongside knee pain and stiffness. Messages aimed to manage pain expectations (e.g. to instill recognition that short-lived increases in pain may be expected with increases in physical activity, although long-term benefits of being active may outweigh short-term costs). Content was designed to positively influence attitudes, subjective norms, perceived behavioural control, and intention regarding physical activity behaviour, which are known to predict physical activity behaviour [27]. Messages were personalised using recipients' names (e.g. 'Hi John…'), and were designed to be socially contextualised whilst culturally sensitive.

Draft messages were reviewed and amended by a panel of 10 'experts' who worked in the area of rheumatology, orthopaedics or pain management (5 male, 5 female), including two health psychologists, a clinical psychologist, a medical consultant, four nurses, and two 'service users' who were community-living individuals with knee osteoarthritis. Example messages are provided in table 1.

Table 1: Example message content

Message	Example Theoretical construct+
Hi! Set a realistic goal for today. Begin with small steps (using stairs/brief walk). Increase physical activity gradually. Congratulate yourself for starting!	*Suggestion* Preparation for physical activity Psychological capability Perceived behavioral control Cue to action Building self-efficacy
We all like (and can manage) different things. Is there are a type of physical activity you enjoy? Text us about it! What is it and how does it make you feel?	*Reflection* Contemplating physical activity Social norms Motivation/Reflection Benefits of physical activity Building self-efficacy
Interesting fact: as well as helping to manage your arthritis, being physically active helps reduce the risk of osteoporosis, diabetes and some types of cancer!	*Information* Contemplating physical activity Motivation/Reflection Attitudes to physical activity Susceptibility/Severity Benefits/Barriers Cue to action
If you feel demotivated, write a list of all the good reasons for you to be active when you can - and remind yourself how well you've done so far. Keep it up!	*Motivation* Maintenance of physical activity Susceptibility/Severity Benefits/Barriers Perceived behavioural control Cue to action Building self-efficacy
What do you do when you get pain when being active? A) Stop completely; B) Have a rest then continue; C) Keep going; D) Other. Text back and let us know!	*Reflection* Preparing for physical activity Physical activity behavior Susceptibility/Severity Benefits/Barriers Cue to action Building self-efficacy

+based on Transtheoretical Models of behaviour change; Social Cognitive Theory; and informed by National Institute for Health and Care Excellence (NICE) guidelines for the treatment of knee osteoarthritis (NICE, 2014).

Study Procedures

People with knee OA were recruited over a four-week period through PPI groups, online osteoarthritis support groups, and notices in public buildings and community areas (e.g. waiting rooms, local shops, places of worship and cafes). Interested participants contacted the research team and were provided an overview of the research. Those who provided verbal consent were sent information sheets and consent forms in the mail. Eligible participants were: adults ≥18 years of age with knee OA, who provided informed consent, and a valid mobile phone number. There were no restrictions based on physical activity level or severity of condition. Individuals were only excluded if they reported health issues that they perceived would prohibit them from increasing their activity level above their current status. The researcher telephoned consenting participants to confirm their eligibility using the Physical Activity Readiness Questionnaire [28]. This is a brief, validated seven-item questionnaire used to assess current physical health and physical activity 'readiness'. The PAR-Q sensitivity and specificity is reported to be high (100% and 80%, respectively) [29]. If the consenting participant was eligible, the researcher conducted a structured interview to complete the baseline questionnaire. This took approximately 30-40 minutes to complete, and included demographic and health information, together with standardised measures of physical activity stages of change, self-efficacy for exercise, barriers and benefits of exercise, and self-reported pain. Participants were then sent a pack by mail, which contained a welcome letter, a generic Arthritis Research UK information booklet about knee OA and exercise, and a physical activity diary consisting of six weekly record sheets. All participants then received text messages for a six week period, delivered via an automated system at the same specified times and dates. Five (20.8%) of the messages requested a brief reply from the participant. Participants were required to pay for any reply messages sent, although all participants received a £20 high street shopping voucher as reimbursement at the end of the study.

At the end of the six-week period, participants were telephoned again by the researcher and completed a structured interview to complete the follow-up questionnaire. This took approximately 45 minutes to complete and included the same standardised measures collected at baseline, as well as process evaluation question items.

Messaging intervention: format and delivery

All participants received four physical activity-promoting messages per week over a period of six weeks. The primary aim was to test the feasibility of delivering physical activity health communication via mobile phones rather than assess health outcomes, and so the intervention was designed to be brief, yet informative with regards demonstrating likelihood of changes in health outcomes in a controlled trial. The frequency of messaging was determined on the basis of a minimum of one message per week being required to promote behaviour change [30], and preferences expressed by the PPI group. The duration was determined on the basis of prior studies that have determined the feasibility of, and/or found positive health benefits of text messaging interventions over a six-week period [31,19]. Furthermore, six weeks is generally accepted to be the minimum length of time required to develop a physical activity habit. Message length was limited to 160 text characters - no emoticons or visuals were included; all participants received the messages at the same time of day, on the same days of the week (delivery included weekdays, weekends, morning, afternoon and early evening, since no consensus on timing was reached in the PPI discussion group). The messages were delivered in a pre-determined sequence using an automated computer system using the Application Programming Interface (API) provided by textlocal (www.textlocal.com). The intervention took place during the winter season (November 2014 - January 2015) within two weeks of baseline data collection.

Process Evaluation

Process evaluation included techniques not involving face-to-face contact as described by [32] (2012) to assess: intervention fidelity (the extent to which the text messages were delivered as intended); meaningful engagement with the messages (whether the messages were opened, read and responded to by participants); attenuation (whether engagement was sustained); engagement with the key components of the behaviour change strategy; and ways in which the intervention could be improved [32]. Participants' perceptions of the message content and delivery, their familiarity with other forms of technology, their perceptions of the use of technology for health promotion, and their willingness to engage in future research studies were collected in the follow-up interview.

Intervention fidelity: SMS messages were tracked to determine whether they were delivered as intended. When SMS messages were not immediately delivered to the telephone, the automated programme continued to attempt to send the message for 24 hours. Any message not delivered during this period was recorded as a delivery failure and the program would then send the next message in the sequence. Data captured on the delivery status of the SMS messages was recorded as: delivered (the phone had reception and was switched on); undelivered (the phone was switched off or it had no signal for 24 hours); or no status returned.

Engagement with the intervention and attenuation: Meaningful engagement with the messages was determined by whether the messages were opened, read and responded to by participants. Attenuation was determined by study retention rates, adherence to physical activity monitoring for six weeks and whether responses to messages were sustained during the study period.

Engagement with behaviour change strategies: This was assessed through pre-post analysis of health and behaviour measures, content analysis of response messages received from participants, and information recorded in physical activity diaries.

Measures: health behaviour, attitudes and beliefs

Data was collected between November 2014 and February 2015. Demographics collected at baseline included age, gender, occupation, and time since diagnosis. The following variables were measured at baseline (T1) and at 6-week follow-up (T2) to test the willingness of participants to complete health and behaviour measures, and determine likelihood of health and behavioural change:

Physical Activity Stages of Change: Participants were asked to rate whether they get 30 minutes of activity per day on most days of the week from the following response options: "Yes, and I have been for more than 6 months", "Yes, and I have been for less than 6 months", "No, but I intend to in the next month", "No, but I used to (over 6 months ago)", "No, but I intend to in the next 6 months", "No, and I do not intend to in the next 6 months". Participants who answered with either of the 'Yes' options were categorised as active (meeting recommendations for daily physical activity) whilst those who responded with any of the other 'No' options were categorised as inactive (not meeting recommendations for daily physical activity).

Self-Efficacy for Exercise Scale (SEE): The SEE is a brief, validated measure of self-efficacy for exercise, showing good evidence of reliability and validity [33]. Using a scale from 0 (not confident) to 10 (very confident), respondents were asked to assess their current confidence for whether they could exercise three times per week for 20 minutes each time, within nine situations that might affect participation in exercise (e.g. having to exercise alone, feeling tired or stressed). Total scores on the scale range between 0 and 90, with higher scores representing greater self-efficacy for exercise.

Exercise Benefits and Barriers Scale (EBSS): The EBSS comprises 43 statements relating to various beliefs towards participation in exercise [34]. Respondents were asked to indicate the degree to which they agree/disagree with the statements on a scale of Strongly Agree, Agree, Disagree and Strongly Disagree. Barrier items are reverse coded and total scores on the scale range between 43 and 172. Higher scores on the scale indicate higher perceived benefits and lower perceived barriers, and thus more positive attitudes towards exercise.

Social Support for Exercise Survey (SSES): The SSES is a reliable scale measuring social support for increasing physical activity amongst adults [35]. Respondents were asked to indicate how often their family and friends have shown support for increasing physical activity within the last three months, (where 1 = None, 2 = Rarely, 3 = A few times, 4 = Often and 5 = Very often) for a series of 13 statements. Respondents were asked to give two separate answers to the 13 statements, one answer for family and one for friends. Total scores on each of the family and friends sub-scales can range between 13 and 65, with higher scores indicating greater perceived support.

Self-reported pain: Respondents were asked to estimate their current pain on a rating scale of 1-10.

Statistical analysis

Analysis was conducted using SPSS for Windows Version 22.0. Analysis included descriptive statistics and Wilcoxon signed-rank test.

Results

Sample Characteristics

Thirty participants provided consent to participate, of which three were ineligible (two did not have knee osteoarthritis and one was unavailable during the study period due to knee surgery). Sample characteristics are shown in table 2. Of the 27 participants receiving the intervention, age ranged from 25-81 years; age at diagnosis ranged from 22-81 years. Time since diagnosis ranged from three months to 41 years. Participants were from a range of socioeconomic backgrounds, spanning both more and less disadvantaged Census Super Output Areas; 13 (48.1%) were employed in diverse occupations (e.g. nursing, education, domestic services, factory work, administration).

Participants reported having knee osteoarthritis in the right (19%, n = 5) or left (19%, n = 5) or both knees (62%, n = 17). Almost three-quarters (74.1%, n = 20) could walk unaided, six relied on a walking stick or frame (22.2%), and one required a wheelchair or scooter to move around (3.7%). All participants owned and regularly used a mobile phone, and 96% expressed a familiarity with text messaging at the time of recruitment. Nineteen participants (70.4%) met current recommendations for physical activity at baseline; although 21 (77.8%) felt there was scope to increase their physical activity from their baseline level. Two participants were lost to follow-up at T2 (25/27 completed T2 measures). There were no significant differences in baseline characteristics between responders and non-responders at follow-up.

Table 2: Sample Characteristics

Characteristic	Mean; SD
Age	25-81 (M = 58.11; SD 12.38)
Time since diagnosis	3 months-41 years (M = 8.11; SD = 9.01)
Characteristic	**N (%)**
Gender	
Male	6 (22.2)
Female	21 (77.8)
Ethnicity	
White British	25 (92.6)
White Irish	2 (7.4)
Occupational status	
Employed	13 (48.1)
Unemployed	2 (7.4)
Retired	12 (44.4)
Marital Status	
Single	5 (18.5)
Married/co-habiting	21 (77.8)
Divorced/separated	1 (3.7)
Highest Educational Level	
Higher Education*	5 (18.5)
Further Education+	5 (18.5)
Professional qualification**	8 (29.6)
Secondary Education++	9 (33.3)

M = Mean; SD = Standard Deviation; *degree level or equivalent; +commonly age 16-18 (A-Levels or equivalent); ++ commonly up to age 16 (O-Level/GCSE or equivalent); **professional training post-16years

Intervention fidelity

Of the 648 messages sent during the delivery period, 100% were recorded as successfully delivered. Subsequently, no participants missed messages containing a question.

Engagement with intervention and attenuation

Engagement with the text messaging intervention and attenuation was determined by whether the messages were opened, read and responded to by participants, compliance with physical activity monitoring and study retention rates. 100% of participants reported opening and reading the messages. Of the 27 participants recruited, the majority provided a text message response to at least one of the text messages that asked questions (n = 24, 89%). Of responders, 23 (96%) replied to the initial question, 19 (79%) replied to three or more of the questions, and 15 (63%) replied to all of the questions. Three participants did not respond to any questions, of which two were unobtainable at follow-up and so did not complete Time 2 questionnaire. Of those who responded to questions there was minimal attenuation in the proportion responding across the six weeks (drop of 1.8%). Five participants sent at least one spontaneous text or email response (following messages that did not request a reply), containing acknowledgement of receipt, expressions of gratitude, or additional comments related to the message content. Sixty-eight per cent (n = 17) of participants completed and returned the physical activity diaries, of which 88.2% (n = 15) found them helpful (these participants had completed diaries for all six weeks). Compliance with physical activity monitoring was based on completion rates for physical activity diaries across the intervention period. Of the diary completers: Week 1 (n = 17, 100%); Week 2 (n = 17, 100%); Week 3 (n = 16, 94.1%); Week 4 (n = 15, 88.2%); Week 5 (n = 15, 88.2%); Week 6 (n = 15, 88.2%). Therefore, diary completion rate dropped by 1.8% from week one to week six. Study retention rates were based on the number of participants who completed baseline and follow-up questionnaires: Time 1 (n = 27, 100%); Time 2 (n = 25, 93%).

Engagement with behaviour change strategies

In physical activity diary completers, total minutes of recorded physical activity across the six weeks ranged from 495 to 4295 minutes (8.25-71.58 hours; n = 17). Mean minutes of physical activity recorded were: Week 1 (n = 17, 403 mins); Week 2 (n = 17, 338 mins); Week 3 (n = 16, 381 mins); Week 4 (n = 15, 342 mins); Week 5 (n = 15, 350 mins); Week 6 (n = 15, 384 mins).

Text replies demonstrated that participants were engaging with the message content. Participants were asked about their progress with physical activity in the previous week and what types of activities they had undertaken. They described engagement in diverse activities such as swimming, cycling, structured exercise classes, walking and household activities.

"I like swimming as it makes me feel light as a feather" (female, age 49)

"Aquaareobics as I can enjoy being with a group of people and it's good fun…I enjoy the feel good factor afterwards" (female, age 66)

"I like classes such as Pilates when I can find a class to attend it makes me feel like my joints are well-oiled and I feel supple" (female, age 55)

"my favourite physical activity is swimming because it is the only time I am not in pain when moving…it gives me energy and a sense of achievement" (female, age 60)

"I realise I cannot walk the way I did, however, even just doing daily tasks involves some form of walking" (female, age 61)

Many participants indicated that they had increased their physical activity and several noted that they had been pacing themselves to achieve their goals.

"Walked a bit more than usual, and my wife has noticed that I'm more active generally" (male, age 67)

"I've been very active all of this week and most of last, my knees have ached but not been too bad….taking breaks and not pushing myself to do everything in one go…I'll be doing some more walking later today" (female, age 25).

When asked to describe the way physical activities made them feel, the majority of responders felt positively.

"it is very satisfying to have walked daily albeit for 30-40 minutes only…I need to keep daily walk as a top priority…I certainly feel pleased with myself when I do it" (female, age 77)

"the thought of going for that walk now is daunting, but once I have made that initial effort I feel good that I have done it" (female, age 66).

Only three participants raised any adverse effects of increased physical activity:

"very sore and tired, night cramps have increased, sleep suffering at the min….but keep going" (female, age 56).

Another participant recognised the contribution of her approach to physical activity and lack of pacing to an increase in her OA symptoms:

"I've been over-doing it since Monday, so had a bad flare up since" (female, age 25)

When asked to describe how they would advise other people about being active with OA, participants emphasised the importance of '*keeping to a regular programme*' of physical activity, and illustrated not only the benefits of exercise for reducing pain and stiffness in OA, but also the overall health benefits of active lifestyles.

"it's hard to do but keep trying because it's important to move for all of your body, not just your knees" (female, age 67)

"To keep moving is beneficial on so many levels…a body in motion tends to stay in motion" (female, age 47)

"Working round pain with good pain relief to allow activity is essential…better to use pacing to allow consistent activity…" (female, age 60).

They suggested mechanisms for using physical activity as a way of '*meeting new like-minded people*', and proposed ways of overcoming barriers to exercise and managing pain expectations:

"exercise doesn't have to cost, just try walking a bit more and using the stairs" (female, age 51)

"to keep going and try not to let the pain take control of you…you have to accept there will be inevitable discomfort and pain but not to give into it and do nothing at all" (female, age 55)

"keep going, but at a slower pace then your joints don't get too stiff and swollen" (female, age 66)

"Having a short rest does make a difference" (female, age 61)

Participants were asked to describe what they had gained by being more active. Specified response options included (a) happiness, (b) less pain, (c) independence, (d) control over OA, (e) feel stronger and healthier. All of the provided options were selected by at least one participant, and several participants gave additional, unprompted free responses:

"definitely happier, less pain….feeling stronger, more positive and determined to carry on" (female, age 66)

"I could hardly walk at the end [after 2 hour walk] and was worried my knees would be really bad today. But the opposite happened, they have been really good …so there is light at the end of the tunnel" (female, age 66).

Participants expressed the motivation to maintain the positive changes they had made in the future:

"I feel healthier and encouraged to put more effort into looking after myself" (female, age 61)

"It has given me an opportunity to focus on my lifestyle and build more exercise into every day" (female, age 60).

Psychosocial and behavioural measures

All participants completed all items on the study questionnaire. 100% of participants found telephone data collection acceptable, and all indicated that their involvement in the study generated minimal burden. At baseline, 70% (n = 19) of participants were meeting current physical activity guidelines of 30 minutes per day on most days of the week. At post-intervention, all 25 (100%) respondents who were contacted at follow-up were meeting current physical activity guidelines. Ninety-two per cent (n = 23) of participants felt that the messages motivated them to increase their physical activity levels; and 88% (n = 22) reported actual increases in their physical activity during the intervention period regardless of how active they were at baseline. Scores on the psychosocial measures were compared from baseline to follow-up using Wilcoxon signed-rank test. There was a significant reduction in self-reported pain level, and a significant increase in participants' self-efficacy for exercise, perceived benefits of exercise, and social support for exercise from both family and friends. Non-significant reductions were observed in the proportion 'currently in pain', and the proportion using pain medication (Table 3).

Participant perceptions of the intervention

All of the participants reported that they felt comfortable receiving health communications via their mobile phone, and were happy to have taken part in the study (100%). The vast majority of participants enjoyed receiving the messages (n = 24, 96%), understood the content (n = 24, 96%), and found the information both useful (n = 22, 88%) and personally relevant (n = 21, 84%). Only two participants reported technical problems with receipt of the messages, related to signal strength when sending replies. More than three-quarters of participants (n = 19, 76%) shared the message content with other people (including partner, family, friends and work colleagues).

Regarding message delivery timings, none of the participants expressed a preferred day of the week to receive communications, although one third of participants expressed a preferred time of

Table 3: Pain, physical activity and psychosocial characteristics

Characteristic	Baseline N=27	6 Weeks N=25	Comparison
Variable n (%)			
Currently in pain No Yes	 8 (29.6) 19 (70.4)	 13 (52.0) 12 (48.0)	$P = 0.227^{+}$; 95% CI [-9.66-38.70]
Currently taking painkillers No Yes	 5 (18.5) 22 (81.5)	 9 (36.0) 16 (64.0)	$P = 0.125^{+}$; 95% CI [-3.28-16.00]
Physical activity Active Inactive	 19 (70) 8 (30)	 25 (100) 0 (0)	$P = 0.016^{+*}$; 95% CI [5.06-28.00]
Variable Median (IQR)			
Perceived pain	4.0 (4.0)	2.0 (4.0)	$Z = -2.93^{++}$ $p = 0.003^{**}$
Self-Efficacy for Exercise	41.0 (25.0)	50.0 (28.5)	$Z = -3.15^{++}$ $p = 0.002^{**}$
Exercise Benefits and Barriers	125.0 (21.0)	139.0 (41.0)	$Z = -3.22^{++}$ $p = 0.001^{***}$
Social support for exercise - family	30.0 (13.0)	42.0 (24.5)	$Z = -3.10^{++}$ $p = 0.002^{**}$
Social support for exercise - friends	22.0 (16.0)	25.0 (25.5)	$Z = -2.42^{++}$ $p = 0.016^{*}$

[+]McNemar test; [++]Wilcoxon signed ranks test; [*]p ≤ 0.05; [**]p ≤ 0.01; [***]p ≤ 0.001

the day for messages to be delivered (24% preferred morning, 8% preferred evening). All of the participants were satisfied with message frequency (messages per week) and 88% (n = 22) were satisfied with the duration of messaging (number of weeks); three participants expressed a preference for a longer intervention. Ninety-six per cent (n = 24) of participants found it helpful to receive the supporting guidance booklet on physical activity and osteoarthritis, with 22 (88%) participants reporting having read the information thoroughly during the 6-week period, the remainder indicating intention to read it later.

Perceived willingness to receive future health communication via technology varied according to type of media. Most participants would be happy to receive it via mobile phone (n = 23, 92%), more than half would receive it by email (n = 13, 52%), and 44% (n = 11) would be happy to use health-related websites. More than one third would be happy to use Facebook (n = 9, 36%), and more than one quarter (n = 7, 28%) would be willing to use mobile apps. A minority reported a willingness to use Skype, Twitter, WhatsApp, SnapChat, Podcasts, video or DVD. Although 100% of participants reported that they liked receiving the messages, one fifth of participants (n = 5, 20%) reported concerns about using forms of technology other than mobile phones for health promotion. Of these, one had concerns about their ability to use the technology, and four had concerns relating to privacy and fear of information being shared without their consent. However, almost all the participants (n = 24, 96%) indicated that they would be willing to engage in future research using technology for physical activity promotion.

Discussion

This study shows that an interactive health communications intervention delivered by mobile phone is feasible to deliver with community-dwelling individuals with knee osteoarthritis. Text messaging can be successfully delivered over a six-week period, without technical difficulty. There were no demographic or health differences between those who responded at six weeks and non-responders, although there was minimal loss to follow-up (2/27). This is important since loss to follow-up is not only common in research but it is a particular challenge in non-contact technology-based intervention studies [36,16].

This study demonstrates that a diverse group of individuals with knee OA are willing to engage and interact with mobile phone text-messaging intervention. The messages were opened and read by all participants, with the majority responding with replies on request and some offering additional, spontaneous and unprompted replies by text and by other communication channels (e.g. email). The text messaging intervention was received positively, since all of the participants reported that they enjoyed the intervention, all participants liked receiving health communications via their mobile phone and several indicated they would have preferred the intervention to continue for longer than six weeks. If the duration of messaging was extended in future interventions, it may be that adopting an individualised or decreasing frequency of messages over the course of the intervention may be more successful than fixed message frequency [37]. Furthermore, there was high satisfaction with the message timing, volume, and frequency of the intervention, with a minority of individuals expressing mixed preferences for messaging to be delivered at a certain time of day (morning or evening). There was high reported familiarity with mobile phones and text messaging, although we did not collect information on the volume of text messages that participants typically received, which may alter the dynamic of engagement with the intervention (e.g. messages being novel, or alternatively getting lost amongst volume of messages sent by others). Nevertheless, our participants were all receptive to the use of technology for health promotion intervention. There was high familiarity with other forms of technology, including email, DVD, web and apps (in all age groups), and low-to-moderate use of Skype (less frequent in older users), with a general agreement that intervention delivered through these routes would be acceptable. Fewer participants engaged with alternative forms of technology beyond those listed here, and there was some scepticism amongst the majority of participants about the use of other approaches in general (albeit not specifically to promote health).

Most participants reported that they read the supplementary information booklets about exercise and OA, which provided evidence-based suggestions on mechanisms for being active alongside OA. The messaging was delivered in conjunction with physical activity and OA guidance with the intention of providing participants with both the motivation and knowledge required to safely and appropriately engage in at least the recommended levels of daily physical activity. The messaging aimed to increase awareness about physical activity, instill knowledge, build confidence for exercise and encourage people to set personally tailored goals and monitor their own progress. Participants had been encouraged to use a paper-based diary to self-monitor their physical activity levels and achievement of goals. Our interest was therefore in acceptability and compliance with use of the diary for self-monitoring purposes, rather than assessing the accuracy of recorded information as an assessment of behaviour change. Compliance with the diaries was generally good, since almost two-thirds of the participants returned completed diaries for each week, and for the completers, this was well-sustained by most (although not all) participants, with minimal attenuation through the six-week study period (drop of 1.8%). Indeed, the compliance rate was higher (over a longer time period) than that found in previous studies with chronic pain patients [38], although our participants were self-selected. Whilst the majority of those who completed the diaries found them useful for self-monitoring, non-completers had indicated that they presented a burden to complete, and some completers admitted that they had 'backfilled' on occasion, which limits their value as a self-monitoring tool. There remains a risk with paper-diaries of recall bias, response bias, forward or backward filling, and compliance commonly declines over time [39,38]. Given the willingness of many respondents to send text message replies (even unprompted), there may be scope for future studies to collect 'real-time' self-report monitoring data from participants (e.g. for them to text details of the type, frequency and duration of their physical activity at the time of engagement). Electronic diaries may be considered in future studies since they have demonstrated higher rates of compliance (83-94%) [38,40,41].

The primary aim of this study was to determine the feasibility of delivering health communications to people with knee osteoarthritis via mobile phone text messaging, rather than to assess the effects of messaging on health and behaviour outcomes. However, collecting measures before and after the intervention allowed for an appraisal of the willingness of participants to complete the measures, and provided an indication of the likelihood of change in outcomes over time, to be assessed in a controlled trial.

Willingness and ability to complete the measures was confirmed, since all those who were contactable at follow-up (25/27) fully completed all of the survey items, with no missing data, and no reports of dissatisfaction with outcome assessments. The intervention delivered in this study was valued by individual participants, since the vast majority of participants found the messaging both useful in supporting behaviour change, and personally relevant. This is consistent with previous studies indicating that participants value messaging that is personally tailored [42], and personalised message content has been associated with increased intervention efficacy [37]. Following the intervention, there was evidence of improvement in behavioural and psychosocial outcomes. Although changes in outcome need to be assessed in a controlled trial, participants reported that as a direct result of the messaging, they felt more motivated to engage in physical activity. This was supported by the majority of participants reporting some level of increase in their physical activity as a result of the intervention, and a 30% increase in the proportion of individuals meeting recommendations for daily physical activity by the end of the study (with 100% achieving by six weeks at least 150 minutes of moderate intensity physical activity on most days of the week). Increases in physical activity have been demonstrated in other studies delivering health messaging by mobile phone text

messaging [17,31]. This finding is particularly promising over a brief, six-week intervention period, given the known individual variation in the length of time required to generate automaticity in dietary and physical activity behaviours, which is estimated to range from 18-254 days [43]. Additionally, the intervention was delivered over the winter season in inclement weather, when physical activity (and interest in physical activity) may be naturally reduced due to known seasonal variations in activity [44], and when many people with knee OA experience increased levels of discomfort, pain and stiffness affected by cold weather and may therefore be inclined to be more sedentary than usual [45].

Although we are unable to determine whether the physical activity increases reported by participants were maintained in the medium and long term, we observed an improvement in self-efficacy for exercise which was evident both in the health outcome measure, and in participants' descriptions of improved confidence for physical activity resulting from their participation. This is important since self-efficacy plays an important role in forming intentions to exercise, and maintaining behaviour change over time [46,47]. Indeed, individuals with higher self-efficacy may be more likely to adopt and use strategies to increase their physical activity [48], and self-efficacy predicts adherence to exercise regimes in both healthy and clinical populations [49,50].

Our participants reported an increase in perceived social support from family and friends after the intervention. The positive relationship between perceived social support for exercise and exercise behaviour has been shown elsewhere, in older adults and adults with long-term conditions [47,51]. Social support plays a critical role in health behaviours, since perceived support can indirectly influence exercise behaviour through self-efficacy and outcome expectations [52]. It may be that increasing perceived social support may have benefits for individual health behaviour change and maintenance of individual physical activity behaviour; additionally, this form of intervention may have wider benefit beyond the target individuals since a high proportion of our participants reported that they had shared messages with others, and actively engaged family and friends in physical activity alongside them.

After the intervention, there was a significant reduction in perceived pain. Given that most participants reported increases in physical activity, this reduction in perceived pain is consistent with previous research showing reductions in OA pain with increased physical activity [11]. In our study, participants were more active and this was associated with increases in self-efficacy for exercise, and reductions in perceived pain. Together with feedback provided by participants, this suggests that the messaging may have altered participants' perceptions of the impact of physical activity on their physical condition although this requires further research. Indeed, our message content focused on managing pain expectations relating to physical activity and osteoarthritis, and at the end of the intervention, participants perceived more benefits of exercise and there was a notable reduction in their perceived barriers to active lifestyles.

This text messaging intervention was used in conjunction with supportive printed materials and a physical activity diary, with minimal researcher contact through telephone data collection to measure attitudes and behaviours. As such, is not possible to ascertain whether any positive changes observed resulted directly from the text message content or from the supplementary printed materials provided, or contact with the researcher. Firstly, it is important to note that assessing behavioural change was not the primary aim of the study, rather, we were interested in whether individuals with knee osteoarthritis would engage with a health intervention delivered by mobile phone. Secondly, the message content aimed to provide encouragement for people with knee OA to engage in active lifestyles, although many of these individuals experience long-term pain and as such find physical activity challenging, or anxiety-provoking due to concerns about joint damage. As such, the printed materials directly supported the messages by providing practical information on the *mechanisms* by which exercise could be safely undertaken in this patient population. These printed materials were not developed for this intervention and are freely accessible to members of the public; indeed many of our participants had already been provided with the booklet by a healthcare provider as part of routine care, but indicated that the messaging had provided them with the motivation to read and engage with the content. Similarly, the text messages aimed to build self-efficacy for physical activity, and participants were given explicit instructions within our messaging to 'self-monitor' their physical activity, pace themselves, and set themselves goals - recording their daily physical activity was therefore part of this process and participants were simply provided with printed record sheets on which to do this. Thirdly, although data for this interactive yet non-contact intervention was collected pre and post-intervention by telephone (therefore introducing an element of contact with the researcher), the data collection was undertaken using a brief structured questionnaire, and the telephone follow-up method aimed to minimise research burden on participants.

Here, we report early indications of the potential for change in important behavioural and psychosocial outcomes, which now needs to be tested in a well-designed randomised controlled trial. This study was based on a small sample of participants who self-reported having a diagnosis of OA, and were volunteers. As such, their views may not be representative of the OA population as a whole since they may have been highly motivated with regards using mobile phones, and/or particularly motivated about physical activity. However, mobile phone use is highly prevalent population-wide, with 93% of adults in the UK personally owning or using a mobile phone [53,54]. Furthermore, the intervention attracted a diverse group of participants in terms of demographics (age, gender, socioeconomic status), health characteristics (severity of condition, use of mobility aids, length of time since OA diagnosis, comorbidities) and behavioural characteristics at the outset (active or inactive, low to high self-efficacy, perceived pain level, low to high benefits and barriers to exercise, low to high perceived social support). Whilst the recruited sample may have been more physically active than the general population (UK: 67% of men, 55% of women), almost one third of our participants at baseline were not meeting the minimum daily physical activity recommendation for the benefit of their health although all had achieved this by the end of the intervention.

Conclusion

Mobile phone text messaging is a viable approach for promoting health behaviour change in people with knee osteoarthritis in the community. Messages promoting physical activity have potential to positively influence behavioural and psychosocial outcomes.

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Ethical Statement

Ethical approval for the study was granted by the local institutional review board (ref: 008052014 SoHS).

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