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Original article

Mindset is associated with future physical activity and management strategies in individuals with knee osteoarthritis

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ABSTRACT

Background. Despite the benefits of physical activity for individuals with knee osteoarthritis (KOA), physical activity levels are low in this population.
Objectives. We conducted a repeated cross-sectional study to compare mindset about physical activity among individuals with and without KOA and to investigate whether mindset relates to physical activity.
Methods. Participants with (n = 150) and without (n = 152) KOA completed an online survey at enrollment (T1). Participants with KOA repeated the survey 3 weeks later (T2; n = 62). The mindset questionnaire, scored from 1 to 4, assessed the extent to which individuals associate the process of exercising with less appeal-focused qualities (e.g., boring, painful, isolating, and depriving) versus appeal-focused (e.g., fun, pleasurable, social, and indulgent). Using linear regression, we examined the relationship between mindset and having KOA, and, in the subgroup of KOA participants, the relationship between mindset at T1 and self-reported physical activity at T2. We also compared mindset between people who use medication for management and those who use exercise.
Results. Within the KOA group, a more appeal-focused mindset was associated with higher future physical activity (β=38.72, p = 0.006) when controlling for demographics, health, and KOA symptoms. Individuals who used exercise with or without pain medication or injections had a more appeal-focused mindset than those who used medication or injections without exercise (p<0.001). A less appeal-focused mindset regarding physical activity was not significantly associated with KOA (β = -0.14, p = 0.067). Further, the mindset score demonstrated strong internal consistency (α = 0.92; T1; n = 150 and α = 0.92; T2; n = 62) and test-retest reliability (intraclass correlation coefficient (ICC) > 0.84, p < 0.001) within the KOA sample.
Conclusions. In individuals with KOA, mindset is associated with future physical activity levels and relates to the individual's management strategy. Mindset is a reliable and malleable construct and may be a valuable target for increasing physical activity and improving adherence to rehabilitation strategies involving exercise among individuals with KOA.

Introduction

An estimated 14 million individuals in the United States have knee osteoarthritis (KOA) [1], a disease characterized by degradation of the cartilage and meniscus in the knee joint. This incidence has grown as the population has aged and obesity has become more prevalent [1]. Because of this growth, combined with the pain and dysfunction associated with osteoarthritis and a lack of disease-modifying therapies, KOA is a leading cause of disability [2]. One beneficial but often under-used strategy to counteract the effects of KOA is physical activity.

Long-term engagement in physical activity can improve pain and function [3] and is related to better cartilage health [4] in individuals with KOA. As an additional benefit, physical activity helps prevent loss of muscle strength, a contributor to disability [5]. Despite these benefits, physical activity is underused as a strategy to manage KOA [6], and long-term adherence to physical activity programs among people with KOA is low [7]. Because of limited engagement in physical activity, individuals with KOA are more susceptible to functional decline [8]. One major contributor to the underuse of physical activity may be that individuals with KOA are balancing the understanding that physical activity, like walking, is beneficial to their osteoarthritis

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with the fear that they may further damage their cartilage or increase their knee pain [9]. Thus, a critical need is to increase physical activity despite, or by reducing, these fears and physical pain.

Emerging research has highlighted the powerful influence of mindsets about physical activity on engagement in physical activity. Mindsets are core assumptions about a domain or category that orient individuals to a particular set of attributions, expectations, and goals (a "meaning system") [10]. Mindsets have been studied in a variety of domains, with one of the most well-studied being education [11] (e.g., mindsets about intelligence as "fixed" or "malleable"). Recent studies have investigated mindsets about health-related constructs, including stress [10], illness [12], and physical activity [13]. For example, in a study of hotel room attendants, an improvement in an individual's mindset about the adequacy of their physical activity (i.e., my activity level is adequate and thus beneficial to my health), without an increase in activity, significantly decreased weight, blood pressure, and body fat as compared with a control group [14]. The ability of mindset to influence one's health and well-being, in addition to behavior, differentiates it from other well-studied constructs related to physical activity levels. For example, an adaptive adequacy mindset predicts greater self-efficacy and physical activity levels and, separately, predicts better perceived health [15].

Another mindset about physical activity regards the *process* of being physically active, which can be measured using the Mindset about the Process of Health − Physical Activity (MPH-Physical Activity) scale. This mindset is defined as the extent to which individuals associate the process of engaging in exercise behaviours with fewer appeal-focused qualities (e.g., difficult, unpleasant, stressful, inconvenient, boring, isolating, and depriving) [16] versus (vs.) more appeal-focused qualities (e.g., easy, pleasurable, relaxing, convenient, fun, social, and indulgent). Study of graduate and undergraduate students has shown that the MPH-Physical Activity score can be improved, is associated with health status and predicts physical activity involvement. For example, a brief intervention that emphasized the social, fun, and self-indulgent aspects of exercise shifted individuals' mindsets about the process of physical activity to be more appeal-focused (called an "appeal-focused mindset" for brevity) and increased adherence to a 10-week fitness class and motivation for future exercise [16]. Further, this mindset predicted self-reported physical activity when controlling for perceived importance of health and self-efficacy [16]. An appeal-focused mindset is theorized to be adaptive because it fosters more intrinsically motivating [17] and enjoyable [18] experiences with physical activity.

Individuals with KOA may view physical activity as less appeal-focused than the general population because of the unique challenges of joint pain, swelling, and stiffness [3], functional limitations [3], and misconceptions about physical activity as it relates to their osteoarthritis status [7,9]. For example, individuals with osteoarthritis commonly believe that osteoarthritis is caused by "wear and tear" and that further activity may quicken this wear [9]. These beliefs and misconceptions, along with one's experiences and social interactions, inform an individual's mindset. The mindset that individuals with KOA hold about physical activity may be particularly influential because of their associated attributions (e.g., "physical activity is unpleasant because it's bad for my knees" vs. "physical activity is pleasant because it strengthens my body and improves my joint function"), expectations (e.g., "physical activity is boring and will make me tired and achy" vs. "physical activity is fun and will make me energized and refreshed"), and goals (e.g., "I want to avoid physical activity" vs. "I want to seek out ways to adapt physical activity and use it as a means for rehabilitation"). In this way, mindset about physical activity may affect physical activity participation and management strategy preference in the KOA population beyond other known determinants of physical activity, such as age [19], sex [19], body mass index (BMI) [20], overall health [21], and pain due to KOA [20]. Mindsets have not been evaluated in the KOA population. Yet, understanding and intervening to improve mindset about the appeal of physical activity in the KOA population may increase their physical activity participation.

This study examined the mindset that individuals with KOA hold about physical activity using the MPH-Physical Activity scale. We hypothesized that individuals with KOA would have a less appeal-focused mindset about physical activity than those without KOA. Additionally, we hypothesized that a more appeal-focused mindset would be associated with higher future physical activity levels and relate to increased use of exercise as an individual's KOA management strategy. As a secondary analysis, we assessed the reliability and internal consistency of the MPH-Physical Activity scale among individuals with KOA.

Patients and methods

We reported this study according to the Strengthening the Reporting of Observational studies in Epidemiology guidelines for observational studies (Table S1).

Participants

Individuals with a self-reported clinical diagnosis of KOA and individuals without KOA within the United States participated in this repeated, cross-sectional, and self-administered online survey study. We recruited individuals using Centiment Research, an online survey platform. We included participants in the study if they were 45 −85 years old. We excluded participants who had previous total knee arthroplasty surgery or other knee surgery, could not speak English, or did not complete the survey. The survey was completed by 150 individuals with KOA and 152 individuals without KOA at time point 1 (T1), which immediately followed the screening questions for study inclusion. All participants who passed the screening were allowed to join the study. Participant recruitment ended once 150 people with KOA completed the study. This sample size was chosen from previous studies that used the MPH-Physical Activity scale in populations without osteoarthritis [16]. All survey measure items required a response to move on to the next measure. We used the same survey platform to ask all participants in the KOA group to repeat the survey 3 weeks later at time point 2 (T2). A subset of these participants (62 of the 150 participants; 41%) repeated the survey. Those who completed the survey at T2 and those who did not differed in age (mean [SD] 63.7 [7.6] vs. 62.4 [8.0] years), BMI (33.6 [9.3] vs. 62.4 [8.0] kg/m^2) and knee pain and function (WOMAC = 39.4 [16.1] vs. 37.6 [18.4]) (Table S2). We obtained approval for the study from the Stanford University Institutional Review Board and digital informed consent from all participants.

Measures

Physical activity

We assessed physical activity levels using the Physical Activity Scale for the Elderly (PASE). The PASE asks respondents about the frequency of light, moderate, and strenuous work and leisure activities and is a validated measure of self-reported physical activity for individuals with osteoarthritis [22].

Process of physical activity mindset

To assess mindset about physical activity, we used the MPH-Physical Activity scale (Table S3). This is a one-factor scale developed and validated by Boles and colleagues [16] to assess mindset about the process of engaging in physical activity (e.g., physical activity is difficult/easy, unpleasant/pleasurable, boring/fun). The scale consists of 7 items measured on a 4-point scale and scored from 1 to 4, with a higher score reflecting a more appeal-focused mindset about physical activity.

The MPH-Physical Activity scale was initially developed to investigate mindset about the process of health based on previous qualitative research that asked participants, "What keeps you from becoming your healthiest self?" [23]. Boles and colleagues, experts in mindset and health behavior, identified a list of 10 themes and their opponent terms, which formed the general Process of Health Mindset Inventory (difficult/easy, painless/painful, unpleasant/pleasurable, stressful/relaxing, time-saving/time-consuming, inconvenient/convenient, boring/fun, cheap/expensive, lonely/social, and depriving/indulgent). They then conducted an online survey to assess the process mindset measure with all 10 items in 415 participants. Factor analysis for the general measure suggested extracting no more than 2 factors and revealed 3 items with low loadings (≤ 0.4; painful/painless, time-consuming/time-saving, and expensive/cheap); removing these 3 items allowed the creation of a single-factor solution. Factor analysis of the 7 remaining items adapted for physical activity (as used in this study) further supported the use of a single-factor solution (Cronbach's α = 0.86; mean [SD] 2.54 [0.54]), which created a concise measure along a single dimension (e.g., appeal). The top 3 items (and their factor loading) that loaded on the single-factor MPH-Physical Activity were stressful/relaxing (0.76), unpleasant/pleasurable (0.67), and boring/fun (0.57). Together, these top loading factors indicate the extent to which physical activity is associated with more or less appealing qualities [16].

Health

We assessed overall physical and mental health status using the PROMIS v.1.1 Global Health Short Form [24]. The Global Health Short Form is a 10-item survey that measures overall physical function, fatigue, pain, emotional distress, and social health in healthy and clinical adult populations.

Knee pain and function

We captured osteoarthritis-related knee pain and functioning using the Likert version of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) [25]. The WOMAC is a disease-specific 24-item measure of knee pain, stiffness, and function that has been validated and shown to be reliable in patients with KOA [25].

Management strategy

We determined individuals' KOA management strategies with the open-ended response question, "In your own words, describe how you manage and/or improve the symptoms of osteoarthritis." Three researchers (MB, KE, and a member of the lab of AC) reviewed the open-ended management question responses to determine a set of strategy categories (e.g., pain medication or injections, independent physical activity, and diet or weight management). Once a set of categories was agreed upon, 2 researchers (MB and a member of the lab of SD) separately coded all 150 responses for whether the strategy category was apparent. We calculated inter-rater reliability for the 2 most common themes. Cohen's kappa was 0.987 ($p < 0.001$) and 0.948 ($p < 0.001$) for medication or injections and exercise, respectively, indicating "almost perfect" agreement [26]. A third researcher (another member of the lab of SD) determined the final coding decision for all disagreements between the 2 coders.

Other information collected included sex, age, and BMI calculated from height and weight. The survey for participants with KOA included all described assessments; the survey for participants without KOA included all described assessments except the WOMAC.

Statistical analyses

We used R (v3.5.0) [27] for analyses and the R package ggplot2 [28] to produce the figures. In all regressions, we standardized the continuous independent variables and examined the coefficients (β) with 95% confidence intervals (CI) and the adjusted coefficient of determination (R^2). $p<0.05$ was considered statistically significant.

We assessed the internal consistency and test-retest reliability of the MPH-Physical Activity scale within the KOA group to measure its reliability in the KOA population. We calculated Cronbach's alpha [29] to assess the internal consistency of the process mindset at baseline and follow-up (with R package psych [30]). We calculated the intraclass correlation coefficient (ICC) (using a two—way mixed-effects model with absolute agreement with R package irr [31]) and Pearson's product-moment correlation (r) to assess test-retest reliability between the mean MPH-Physical Activity score at baseline and follow-up. We performed an exploratory factor analysis at baseline to confirm the factor structure of the MPH-Physical Activity scale within the KOA population.

To test for differences in physical activity levels, demographic variables, and health between the KOA and control groups, we calculated the standardized mean difference (SMD) [32] (with R package stddiff [33]). We chose an SMD of < 0.1 to indicate a negligible difference, a threshold recommended to determine imbalance [34].

We used multivariate linear regression modeling (with R package lmSupport [35]) to determine whether having KOA was associated with the process mindset when controlling for other factors that may influence mindset. The dependent variable was the process mindset at T1. The independent variables were KOA (binary (0/1) with 1 indicating KOA), sex (binary with 1 indicating female), age, BMI, global health at T1, and physical activity level at T1.

To test whether the process mindset is associated with future physical activity levels in individuals with KOA, we used a multivariate linear regression with the PASE score at T2 as the dependent variable and the MPH-Physical Activity score at T1 as the independent variable. We controlled for demographics, health, and knee pain and functioning at T1 by adding all of these as independent variables in the model. In exploratory analyses, we used Pearson correlations to evaluate the correlation between the score for each item of the MPH-Physical Activity scale at T1 and physical activity level at T2 and the MPH-Physical Activity score and demographics, health, and knee pain and functioning at T1.

We used independent t-tests to assess differences in mindset between those who reported managing their osteoarthritis (1) with medication or injections but without exercise, (2) with exercise but without medication or injections, and (3) with both exercise and medication or injections.

Results

Internal consistency and test-retest reliability

The MPH-Physical Activity scale demonstrated strong internal consistency (α = 0.92, 95% CI 0.90; 0.94, with mean [SD] 2.2 [0.7] at T1 for n = 150; α = 0.92, 95% CI 0.87; 0.95, with mean 2.2 [0.7] at T2 for n = 62) and test-retest reliability (ICC > 0.84, 95% CI 0.75; 0.90, $p <$ 0.001; r = 0.84, 95% CI 0.75; 0.90, $p < 0.001$) within the KOA group. Exploratory factor analysis at T1 supported a single-factor solution for the MPH-Physical Activity scale within the KOA group (eigenvalue = 4.79, explained variance = 63%). Individual items showed sufficient loading scores (≥ 0.70; Table S4).

Between group differences

The group with KOA did not differ from the group without KOA in any of the measures (Table 1).

Association between having KOA and mindset

The association between knee osteoarthritis and a less appeal-focused mindset did not reach statistical significance (β = −0.14, 95%

Table 1
Characteristics of participants and standardized mean difference (SMD) between participants with and without knee osteoarthritis (KOA) at time point 1 (T1).

Variable	With KOA (n = 150)	Without KOA (n = 152)	SMD (95% CI)
Age (years)	62.9 (7.8)	60.3 (8.8)	0.32 (0.09; 0.55)
Sex (female)	81 (54%)	78 (51%)	0.05 (−0.17; 0.28)
BMI (kg/m^2)	32.5 (9.2)	27.9 (6.8)	0.57 (0.34; 0.80)
Global-10	3.1 (0.70)	3.5 (0.8)	0.63 (0.40; 0.86)
WOMAC	38.3 (17.5)	–	–
PASE	125.6 (87.7)	181.7 (128.2)	0.51 (0.28; 0.74)
MPH-Physical Activity	2.2 (0.7)	2.6 (0.7)	0.58 (0.35; 0.81)

Values are mean (SD) unless indicated otherwise. BMI, body mass index; Global-10, Global Health Short Form; PASE, Physical Activity Scale for the Elderly; MPH-Physical Activity, Mindset about the Process of Health – Physical Activity; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

CI = (−0.28; 0.01), p = 0.067) when controlling for sex, age, BMI, global health, and physical activity level (Table 2). A lower score corresponds to a mindset that physical activity is less appeal-focused (e.g., more boring, isolating, and depriving). Factors that related to a less appeal-focused mindset were lower global health (β = 0.15, 95% CI 0.07; 0.22, $p < 0.001$), and lower physical activity levels (β = 0.25, 95% CI 0.17; 0.32, $p < 0.001$).

Association between mindset and future physical activity

The MPH-Physical Activity score at T1 was associated with future physical activity levels (β = 38.72, 95% CI 11.71; 65.73, p = 0.006) when controlling for demographics, health, and knee pain and functioning at T1 (Table 3). This result means that a 1-SD increase in the MPH-Physical Activity score was associated with an increase of almost 39 points in the PASE. A 39-point increase in the PASE corresponds to, for example, going from "seldom" performing physical activity for 2–4 h per day to "often" (quoted words are from the PASE scale). Further, the process mindset was the only variable that was associated with physical activity level at T2. An additional sensitivity analysis with the same model but removing an outlier with a PASE score at T2 >3 SDs above the mean reduced this estimated effect to 23 points (β = 23.25, 95% CI 2.39; 44.10, p = 0.030) .[1] A 23-point increase in the PASE still corresponds to an increase in physical activity but of a smaller magnitude (e.g., going from performing a physical activity "seldom" for 2–4 h per day to "sometimes" for 2–4 h per day).

Individual MPH-physical activity item correlations

Additional exploratory analyses revealed correlations between the individual MPH-Physical Activity items at T1 and physical activity levels at T2 (Table S5). Of these items, rating the process of physical activity as easier (on a scale of difficult to easy) had the strongest correlation (r = 0.45, $p < 0.001$), whereas rating the process of physical activity as more fun (on the scale of boring to fun) had the weakest, and only non-significant, correlation (r = 0.24, p = 0.065).

Additional mindset correlations

A higher process mindset at T1 was correlated with higher global health (r = 0.30, $p < 0.001$), less severe knee pain and better functioning (r = −0.25, p = 0.002), lower BMI (r = −0.26, p = 0.001), and being male (r = −0.21, p = 0.011) but not age (Table S6).

Relation between management strategy and mindset

We determined 11 distinct management strategies from responses to the open-ended question about KOA symptom management (Table 4). Almost 50% of responses mentioned pain medications or injections (n = 74), whereas close to 27% of responses mentioned physical activity (n = 41). Additional strategies included self-soothing (n = 25), nothing (n = 22), imposing physical limitations (n = 21), home remedies (n = 7), rest (n = 9), talking to a doctor (n = 6), diet or weight management (n = 6), supervised physical therapy (n = 5), and self-motivation (n = 4). Individuals who used exercise with or without pain medication or injections had a more appeal-focused mindset than those who used medication or injections without exercise (t = −2.94, df = 13.22, p = 0.011, 95% CI −1.08; −0.17, mean mindset values 2.65 and 2.02, respectively, and t = −5.63, df = 64.80, $p < 0.001$, 95% CI −0.95; −0.45, mean mindset values 2.72 and 2.02, respectively; Fig.1). MPH-Physical activity score did not differ between individuals who used physical activity with and without medication or injections (t = 0.34, df = 15.13, p = 0.74, 95% CI −0.39; 0.54, mean mindset values 2.65 and 2.72, respectively).

Discussion

After controlling for demographic (e.g., sex, age) and health (e.g., BMI, global health) variables and physical activity level, individuals with KOA did not necessarily have a less appeal-focused mindset about physical activity than individuals without KOA. However, within the KOA group, mindset about physical activity was associated with future physical activity level, above and beyond other known determinants of physical activity, including demographic and health variables and knee pain and functioning. Finally, individuals who chose exercise as a strategy for osteoarthritis management had a more appeal-focused mindset about physical activity than those who chose pain medications or injections without exercise.

Whereas joint pain, functional limitations, and maladaptive misconceptions about KOA may negatively impact the mindset of an individual with KOA, mindset does not depend on osteoarthritis status or severity. For example, a person with KOA and a less appeal-focused mindset may focus on the unpleasant experiences during activity, such as pain, and feel held back from high intensity activities. However, a person with the same osteoarthritis diagnosis, but an appeal-focused mindset, may focus on pleasant experiences of activity, such as enjoying being in nature, and feel proud in their ability to adapt to find enjoyable lower impact activities. The mindset scores in this study display a range in mindset about physical activity. Some individuals hold a more appeal-focused mindset, demonstrating that a less appeal-focused mindset is not inevitable in individuals with KOA and supporting the potential for improving this mindset. This finding agrees with the broader class of research on schemas suggesting that beliefs or mindsets are not a direct reflection of physical state; instead they are an interpretation of reality, which can then influence an individual's behaviors and outcomes [36,37].

The 7-question MPH-Physical Activity scale can be efficiently and reliably administered in the KOA population, which suggests

[1] Although this outlying PASE score was > 3 SDs above the mean, a thorough inspection of the data suggested that there were no other reasons to remove this outlier from the dataset. This participant reported an increase in work or volunteer hours from 20 hours per week at T1 to 40 hours at T2 and reported having done yard work at T2, which they did not at T1. The increase in the PASE score was due to increases in activity frequency and duration across multiple questions, rather than a single outlying score. For example, the participant went from "seldom" to "sometimes" and "2-4 hours" to "greater than 4 hours" for light activities, "never" to "sometimes" for strenuous activities, and "seldom" to "often" for exercises that specifically increase muscle strength and endurance. Coinciding with this increase in physical activity, the participant's process mindset and global health scores increased, while other measures, such as the WOMAC, remained the same. Further, the participant passed the attention check question which immediately followed the PASE survey. These findings support our conclusion that the participant increased their physical activity over the course of 3 weeks, rather than an error in data reporting.

Table 2
Linear regression on the MPH-Physical Activity scores for participants with and without knee osteoarthritis (n = 302).

Dependent Variable	Independent Variables	β (95% CI)	p	Adj. R^2	F
Process Mindset	Age	−0.03 (−0.10; 0.05)	0.483	0.30	22.72
	Sex	−0.13 (−0.27; 0.01)	0.059		($p < 0.001$)
	BMI	−0.07 (−0.14; 0.01)	0.079		
	Global-10	0.15 (0.07; 0.22)	<0.001		
	PASE	0.25 (0.17; 0.32)	<0.001		
	Knee osteoarthritis (binary)	**−0.14 (−0.28; 0.01)**	**0.067**		

Coefficients (β) are presented with a 95% confidence interval (CI). BMI, body mass index. Global-10, Global Health Short Form; PASE, Physical Activity Scale for the Elderly; MPH-Physical Activity, Mindset about the Process of Health – Physical Activity.

Table 3
Linear regression analysis of physical activity level (PASE) at time point 2 (T2) for participants with knee osteoarthritis (n = 62).

Dependent Variable	Independent Variables	β (95% CI)	p	Adj. R^2	F
PASE (T2)	Age	−6.54 (−33.54; 20.46)	0.629	0.20	3.55
	Sex	−48.56 (−98.99; 1.87)	0.059		(p = 0.005)
	BMI	−10.02 (−36.93; 16.89)	0.459		
	Global-10 (T1)	19.81 (−12.77; 52.39	0.228		
	WOMAC (T1)	8.97 (−21.97; 39.90)	0.564		
	MPH-Physical Activity (T1)	**38.72 (11.71; 65.73)**	**0.006**		

BMI, body mass index. Global-10, Global Health Short Form; PASE, Physical Activity Scale for the Elderly; MPH, Mindset about the Process of Health – Physical Activity; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

Table 4
The themes that emerged from responses to the open-ended question: "In your own words, describe how you manage and/or improve the symptoms of osteoarthritis." Almost 50% of responses mentioned pain medications or injections, whereas close to 27% of responses mentioned physical activity (n = 150).

Theme	#/150	Example
Pain Medications or Injections	74	Pain medication every day; Cortisone shots
Independent Physical Activity	41	Exercise daily in all kinds of weather
Self-Soothing	25	Hot compress; Muscle rub; Creams and gels
Nothing	22	Just put up with it; Just continue on with normal activities
Impose Physical Limitations	21	Go very slowly and think before I make any sudden or stretching movements
Home Remedies	7	I drink apple cider vinegar; Soaking my knees with Epsom salts
Rest	9	Rest when my body tells me to
Doctor	6	Have switched doctors hoping to get relief from all the pain.
Diet or Weight Management	6	Clean eating; Giving up diet soda
Supervised Physical Therapy	5	Physical therapy every day getting stronger
Self-Motivation	4	I am motivated to move beyond the pain; Mind over matter

feasibility for use in more extensive studies. Capturing personal beliefs and expectations about physical activity is often done via qualitative surveys [21,38]. In contrast, the MPH-Physical Activity scale captures beliefs and expectations about physical activity quantitatively and facilitates analysis of the efficacy of potential interventions. Additionally, whereas many studies and interventions target a particular belief or expectation about specific health goals (e.g., "Running 3 days per week for the next 3 months is: *Not enjoyable*. . . *Enjoyable*") [18], this study sought to evaluate a more general mindset about the experience of being physically active (e.g., "The process of physical activity is: *Stressful*. . . *Relaxing*"). This general approach is valuable for intervening more broadly on the wide range of physical activities one might perform, which may facilitate long-term physical activity engagement.

These findings can help guide clinicians' strategies for increasing physical activity participation and adherence to rehabilitative programs involving exercise in patients with KOA by improving mindset about the process of physical activity. For example, a clinician might help patients with KOA adapt their current type or duration of physical activity to feel "easier" or more achievable, rather than simply suggesting the KOA activity guidelines of 30 min of moderate-intensity physical activity for 3 days per week [39]. Another strategy to improve the process mindset may include helping individuals think creatively about different types of physical activity they may enjoy (e.g., yoga, swimming, gardening, dancing, or walking the dog) while highlighting how it can also be social (e.g., walking with a friend, playing with grandchildren, or joining group exercise classes). The time of diagnosis may be a particularly important opportunity to shift mindset about physical activity. For example, one could suggest a newly diagnosed patient try various low- to moderate-intensity activities while focusing on what they enjoy about the activity.

Our study had several limitations. First, although all participants with KOA indicated a previous clinical diagnosis, we did not obtain radiographic confirmation of KOA. However, because individuals did not know that they would only be able to participate if they had KOA at the time of screening and are typically aware of a diagnosis of KOA, the error rate for this criterion should be low. A second limitation is that the sample size was relatively small at the time of follow-up. The significance of the small sample is made clear by the fact that the p-value varied from 0.006 to 0.030 on removal of one outlier. Despite

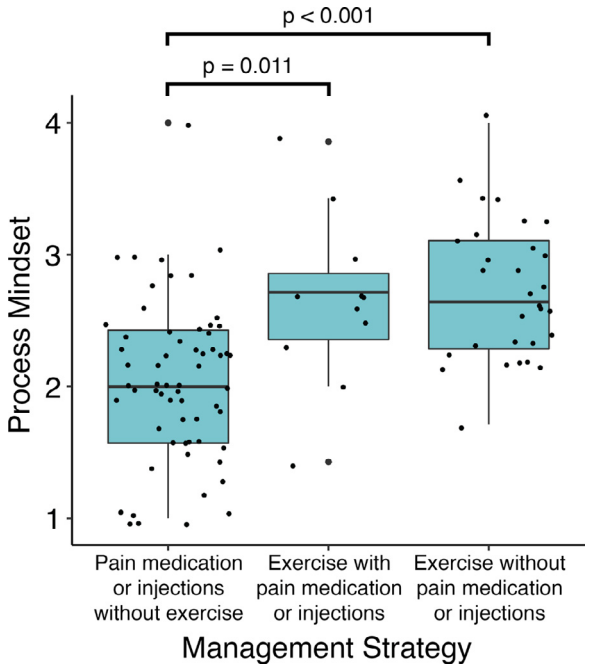

Fig. 1. Differences in MPH-Physical Activity score based on knee osteoarthritis management strategy. In each plot, the top and bottom lines of the boxes (hinges) are the first and third quartiles, repectively; the horizontal line is the median; and the whiskers extend from each hinge to the largest value no further than 1.5 times the inter-quartile range to the respective hinge.

the variability in significance values, the effect sizes with and without the outlier were still substantial and thus larger sample sizes would likely lead to even more reliable results. Recruitment through a third-party survey platform prevented knowing why many participants were lost to follow-up. Potential reasons were the 3-week gap without participant contact or an insufficient incentive relative to the duration of the survey. This loss to follow-up may have introduced bias through unmeasured factors. Additional limitations are a potential response bias towards those with internet access and self-selection bias. Although we did not evaluate these biases; the survey was available nationally and had characteristics such as sex, race, income, and education levels similar to the general US population. Still, we did not weight the data to obtain a nationally representative sample, which may have led to differences with the general population. Another limitation is that we did not collect objective measures of physical activity. The PASE is validated and widely used for this population; however, self-reported physical activity may be influenced by one's mindset beyond objective physical activity and remains a question for future investigation. Future studies may benefit from the inclusion of objective physical activity and health outcomes. Future studies should also include a large enough sample to detect small effect sizes.

In summary, we surveyed mindset about the process of physical activity in individuals with and without KOA and assessed the extent to which this mindset is related to physical activity participation. Within the KOA population, mindset was associated with future physical activity when controlling for other factors that commonly influence physical activity levels, and was related to an individual's preferred symptom management strategy. Our findings suggest that improving mindset about physical activity in the KOA population may increase physical activity participation, and as a result, improve health and osteoarthritis outcomes. Future research should identify effective strategies to deliver mindset interventions to individuals with KOA and measure if they indeed change mindset, physical activity, and health.

Data and code availability

The code and dataset associated with this manuscript are available on SimTK (https://simtk.org/projects/exercisemindset).

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.rehab.2022.101634.

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