Research Paper

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People with painful knee osteoarthritis hold negative implicit attitudes towards activity

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Abstract

Negative attitudes/beliefs surrounding osteoarthritis, pain, and activity contribute to reduced physical activity in people with knee osteoarthritis (KOA). These attitudes/beliefs are assessed using self-report questionnaires, relying on information one is consciously aware of and willing to disclose. Automatic (ie, implicit) assessment of attitudes does not rely on conscious reflection and may identify features unique from self-report. We developed an implicit association test that explored associations between images of a person moving/twisting their knee (activity) or sitting/standing (rest), and perceived threat (safe vs dangerous). We hypothesised that people with KOA would have greater implicit threat–activity associations (vs pain-free and non-knee pain controls), with implicit attitudes only weakly correlating with self-reported measures (pain knowledge, osteoarthritis/pain/activity beliefs, fear of movement). Participants ($n = 558$) completed an online survey: 223 had painful KOA ($n = 157$ female, 64.5 ± 8.9 years); 207 were pain free ($n = 157$ female, 49.3 ± 15.3 years); and 99 had non-KOA lower limb pain ($n = 74$ female, 47.5 ± 15.04 years). An implicit association between "danger" and "activity" was present in those with and without limb pain (KOA: 0.36, 95% CI 0.28-0.44; pain free: 0.13, 95% CI 0.04-0.22; non-KOA lower limb pain 0.11, 95% CI −0.03 to 0.24) but was significantly greater in the KOA group than in the pain free ($P < 0.001$) and non-KOA lower limb pain ($P = 0.004$) groups. Correlations between implicit and self-reported measures were nonsignificant or weak ($rho = -0.29$ to 0.19, $P < 0.001$ to $P = 0.767$). People with painful KOA hold heightened implicit threat–activity associations, capturing information unique to that from self-report questionnaires. Evaluating links between implicit threat–activity associations and real-world behaviour, including physical activity levels, is warranted.

Keywords: Implicit association test, Attitudes, Osteoarthritis, Threat, Activity

1. Introduction

Osteoarthritis (OA) is a common cause of pain and disability in older adults.[1,16,39,55,61] Despite high-quality evidence that physical activity and exercise are beneficial for OA,[42,52] 9 of 10 people with knee OA (KOA) do not engage with physical activity.[1,16,39] People with KOA often hold attitudes that activity is dangerous (eg, may worsen OA progression). These attitudes may influence their choices surrounding management,[46,60] including negatively influencing activity engagement,[9,10,51,64] and may worsen pain and disability.[17] Comprehensive understanding of activity-related attitudes may identify unique barriers to exercise engagement.[2,9,48]

Attitudes are commonly assessed through explicit self-report measures. These measures rely on reflection, which only accesses information one is consciously aware of and willing to disclose.[19,27,37,62] Self-report measures are also prone to bias, whereby the respondent may intentionally or unintentionally misrepresent their attitude (eg, response bias).[32] In addition, self-report questionnaires can be impacted by conceptual inconsistencies, such as cognitive dissonance,[63] whereby a person reports conflicting attitudes (eg, "exercise is safe"; yet "osteoarthritis is caused by wear [activity] and tear [damage]").[5]

To overcome some of these limitations of explicit measures, implicit measures explore automatic associations to indirectly evaluate the construct of interest.[19] Implicit associations tests (IATs) measure response times during rapid categorisation tasks, with the strength and direction of an implicit association calculated.[27] Implicit associations tests may mitigate limitations of self-report questionnaires by minimising conscious deliberation of conceptual associations.[26] Implicit associations tests predict behaviour with more stable effect sizes than explicit self-report assessments, particularly when a high chance of social desirability bias exists.[22,28]

New work has shown that physical activity is influenced by nonconscious (implicit) processes[54]; implicit attitudes towards physical activity are positively associated with physical activity levels in healthy populations.[14] Only recently have implicit attitudes been explored in pain. People with persistent back pain show an implicit association against movement, namely,

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increased perceived threat of lifting with a rounded (versus straight) back.[8] In addition, lack of correlation between implicit and explicit threat attitudes in people with back pain suggests that implicit tests capture a potentially important construct not captured by self-report measures.

We sought to develop an IAT assessing the perceived threat of activity involving the lower extremity to assess implicit attitudes in people with painful KOA.[9] First, we evaluated whether implicit threat–activity associations differed between people with painful KOA and people without lower extremity pain (Aim 1). We hypothesised heightened threat–activity associations in people with KOA. Second, we evaluated whether the IAT provided information additional to that captured by explicit self-reported attitudes about osteoarthritis, pain, or activity (Aim 2). If implicit–explicit measures capture similar constructs, a moderate-sized correlation would be expected; if they capture different constructs, a small/nonsignificant correlation would be expected. Finally, we explored threat–activity associations in a lower limb pain control group without KOA (Aim 2). Given heightened activity–danger beliefs in OA and use of IAT illustrations depicting knee movement, we hypothesised lower threat–activity associations in people with general lower limb pain (no-KOA) than in those with KOA.

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2. Methods and materials

2.1. Study design

This study consists of a guideline informed IAT development,[24] followed by cross-sectional administration of the IAT online. The protocol for this study was preregistered on the Open Science Framework (https://osf.io/r46kv/), and deviations from this protocol are transparently reported. All participants provided written, informed consent before participation. This project was approved by the Human Research Ethics Committee of the University of South Australia (Ethics Protocol 204069).

2.2. Participants

Members of an Arthritis South Australia (Adelaide, Australia) educational support group were recruited for initial IAT development and pilot testing, with attendance on the day being the sole inclusion criterion. Piloting of the IAT was conducted in a convenience sample of adults aged 18 years or older with normal or corrected-to-normal vision, recruited through word of mouth from the University of South Australia.

Full-scale online testing of the IAT was conducted in a convenience sample, recruited through social media (Facebook, Twitter, Instagram), the University of South Australia research volunteer Web site, and shared through email newsletters and mailing lists of people who had previously expressed interest in participating in future research studies. Volunteers with or without knee pain who were aged 18 years or older were eligible to participate. Eligible participants also had normal or corrected-to-normal vision and access to a computer with a physical QWERTY keyboard (as opposed to a virtual touchscreen keyboard) because these factors are required for participants to reliably complete the visual IAT task. Volunteers were not eligible if they reported having a cognitive impairment (eg, Alzheimer, dementia; due to concerns about providing adequate informed consent through an online survey and ability to accurately perform the IAT), a neurological disorder (as it may affect lower limb movement/perceived safety unrelated to pain; eg, stroke, multiple sclerosis), if they were unable to read English fluently, or if they had an uncorrected visual impairment (as these would inhibit completion of the surveys). This sample was split into 3 groups. Group 1 included people with painful KOA. This was defined as participants with self-reported knee pain that was present for at least the past 6 months, who did not have a diagnosis of rheumatoid arthritis (self-report), and who met the National Institute for Health and Care Excellence (NICE) KOA clinical diagnostic criteria (per self-report): aged 45 years or older; knee pain with activity (assessed through Western Ontario McMaster University [WOMAC] pain subscale); morning knee stiffness lasting ≤30 minutes or no morning stiffness.[42] Group 2 included healthy pain-free controls; this was defined as volunteers who did not report any lower extremity pain. Group 3 included people with general lower extremity pain, defined as self-report of pain in the foot, ankle, knee, and/or hip, who did not meet the NICE criteria for KOA (Aim 2). For ease of interpretation, we will refer to this group as non-KOA lower extremity pain.

2.3. Sample size

A priori sample size calculations were conducted using G*Power[18] and an online sample size calculator.[35] Past work in pain populations found moderate effects for implicit threat–movement associations[8]; however, small samples have a greater risk of chance findings, with calls in IAT research to recruit larger samples.[43] Thus, we powered for a small–moderate effect size (Cohen's d = 0.3, Pearson's $r = 0.3$). Given power of 80% and alpha of 0.05, a minimum of 176 participants (per group) was necessary to detect IAT Dscores that differed between the two groups (two-tailed independent *t* test), and this ensured that we were sufficiently powered for our other analyses. We held our recruitment window open from October 20, 2021, to October 20, 2022, aiming to recruit a minimum of 176 participants per group to allow evaluation of between-group differences. We did not cap recruitment, acknowledging that a larger sample allowed us to detect a smaller effect, which holds potential relevance for secondary comparisons between those with painful KOA and non-KOA lower limb pain.

2.4. Implicit association test development

2.4.1. Development of test stimuli

We aimed to develop test stimuli that reflected neutral categories of "active" and "rest" (illustrations), and the weighted attribute targets of "safe" and "danger" (illustrations and words). The congruent pairs (rest–safe, active–danger) were selected to identify people with an implicit association that may indicate attitudes against physical activity. The incongruent pairs (rest–danger, active–safe) were selected to identify those with an association that may indicate attitudes or biases against rest. The "safe" and "danger" pairing was previously used in a similar study.[8] Congruence and incongruence refer to the direction of our hypotheses, whereby we proposed that most people with painful KOA would implicitly associate rest with safety and activity with danger, thus making these conceptually "congruent."

Relevant lower limb illustrations that depicted activity involving knee movement and that depicted rest, and that elicit varying perceptions of threat (danger and safety) were also developed. Here, lower limb postures that involved knee movement were chosen through consultation with people who have lived experience of arthritis. Eight adults from an arthritis education and support group (*Arthritis South Australia*, Adelaide, Australia) provided anonymous written feedback, where they described

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their perceptions about the danger and safety of a variety of lower limb activities (such as standing, sitting, squatting, twisting, kneeling, walking on flat ground, going up or down stairs, getting out of a car, walking on uneven ground, quickly changing directions while walking). Standing and sitting were consistently reported as "safe," "good," and "easy," whereas squatting and twisting were consistently reported as "dangerous," "bad," and "difficult," and these postures were selected for inclusion in the IAT.

Line-drawn illustrations used in the IAT were created by an illustrator (J.M.), based on photographs of volunteers in stationary sitting/standing positions and in active squatting/twisting positions. Following several rounds of discussion between the authorship team, a final set of 10 illustrations was developed. An even number of illustrations was chosen to ensure that all test blocks (each with 20 or 40 stimuli) included all illustrations. Consistent with recommendations,[24] a mirror copy of each posture was created, so the illustration would be presented facing both left and right to avoid left/right visual bias, and depiction of both men and women was used to avoid gender bias. Five of the illustrations aligned with the "rest" category (subject seated or standing), and 5 aligned with the "active" category (subject squatting or standing while twisting); see Appendix 1, http://links.lww.com/PAIN/C22 for all illustrations.

Finally, relevant word stimuli that would depict categories of "danger" and "safety" for use during in the task were chosen. We used words relating to threat from similar work in people with low back pain.[6–8] Ten stimuli (words) were selected; 5 aligned with the "danger" category (damaging, vulnerable, threatening, alarming, risky) and 5 aligned with the "safe" category (confident, secure, protecting, certainty, and reliable). Words were selected for each category such that each category had words of similar length (syllable count) and complexity.

2.4.2. Creation of the implicit association test

The IAT was designed in R (R Core Team, Vienna, Austria) using the *iatgen* package[12] and administered through Qualtrics (Qualtrics, Provo, UT).

The administration procedure for the IAT was based on established guidelines,[24,43] using 7 blocks with either 20 or 40 trials (stimuli) per block. The first 2 blocks were unscored practice blocks, used to familiarise participants with the test. In these practice blocks, participants categorise test stimuli (words and illustrations) to a category (active, rest) or an attribute (safe, danger) but not both (**Fig. 1A**). Blocks 3 and 4 were test blocks and thus were scored (ie, contribute to Dscore); in these blocks, participants categorise stimuli (words, illustrations) to a combined category–attribute pairing (active–safe vs rest–danger) and to the opposite pairing (active–danger vs rest–safe; **Fig. 1B**). In block 5, one of the categories switched sides in the transition from congruent to incongruent or vice versa. The block is used to train the new stimulus response mapping; thus, this block is not included in the analysis. Blocks 6 and 7 were scored and as above, involved dual categorisation tasks. Blocks 4 and 7 each had 40 trials, while all other blocks had 20 trials.

Participants viewed test stimuli (illustrations and words) on a screen and categorised them as quickly as possible.[12] The stimuli words were presented in bold, 20-point Arial font in black lowercase on a white background and sized to 200 by 200 pixels. Target categories were displayed in 20-point Arial black font, whereas attributes were displayed in green font. Using a computer with a physical keyboard, participants were instructed to use the *E*, *I*, and *Spacebar* keys to navigate through the test. To assign an illustration to a category on the left of the screen, participants clicked the "E" key, and to assign an illustration to a category on the right of the screen, participants clicked the "I" key (*Spacebar* was used to navigate to the next block of the test). If a participant responded incorrectly to any stimulus, a red "X" appeared and remained on screen until they responded correctly (ie, forced error correction method).[11] The sequence of congruent and incongruent stimulus pairings during blocks 3 and 4 and blocks 6 and 7 was randomised and counterbalanced across participants.

2.4.3. Implicit association test piloting

Consistent with best practice, the IAT was piloted to ensure that task performance was within recommended thresholds (eg, error rates less than 10%).[24] Five adults completed the IAT online (4 females and 1 male, aged between 30 and 42 years), with acceptable latency and error rates demonstrated (no trials were dropped due to excessively fast or slow response speeds; error rate = 8.3%), supporting the use of the test in this study.

2.5. Online survey procedures and implicit association test evaluation

The IAT was administered as part of an online survey. Participants were first presented with the participant information sheet and consent form, followed by an eligibility screening survey, whereby they were excluded from participation if they were younger than 18 years or reported a diagnosis of cognitive impairment. Those passing this initial eligibility screen were then asked questions about the presence of pain. If knee pain was present, they were provided with additional questions to evaluate the NICE diagnostic criteria of OA. Participants reporting pain (of any location) answered questions about the location of pain.

Participant demographics were collected, including their date of birth, gender, highest level of completed schooling, financial situation, and country of residence. Participants then completed numerous self-report questionnaires, including (in order): their conceptualisations about OA and activity (Osteoarthritis Conceptualisation Questionnaire: OACQ)[50]; pain intensity (0-10 numerical rating scale; NRS)[21]; OA-related pain and stiffness (WOMAC pain and stiffness subscales);[3] function (lower extremity functional scale; LEFS)[49]; pain knowledge (revised neurophysiology of pain questionnaire: rNPQ)[13]; fear of movement (Osteoarthritis Brief Fear of Movement scale: BFOM)[58]; beliefs about exercise (exercise benefits/barriers scale: EBBS)[57]; pain catastrophising scale (PCS)[4]; comorbid health conditions (functional comorbidity index with a body diagram: FCI)[29]; and any history of hip and knee replacement. Following completion of the questionnaires, participants undertook the IAT. When this task was finished, participants were asked to explicitly rate the perceived danger associated with each of the illustrations used during the IAT on a 0 to 10 NRS (0 = not at all dangerous; 10 = most danger imaginable); this allowed us to explore performance of our novel illustrations. For explicit ratings, a bespoke questionnaire was used as a process outcome given the lack of a validated questionnaire with sufficient specificity for this situation.

2.6. Data handling

For the IAT, consistent with suggested practices, (1) participants were excluded if more than 10% of their responses were faster than 300 milliseconds and (2) individual trial responses slower

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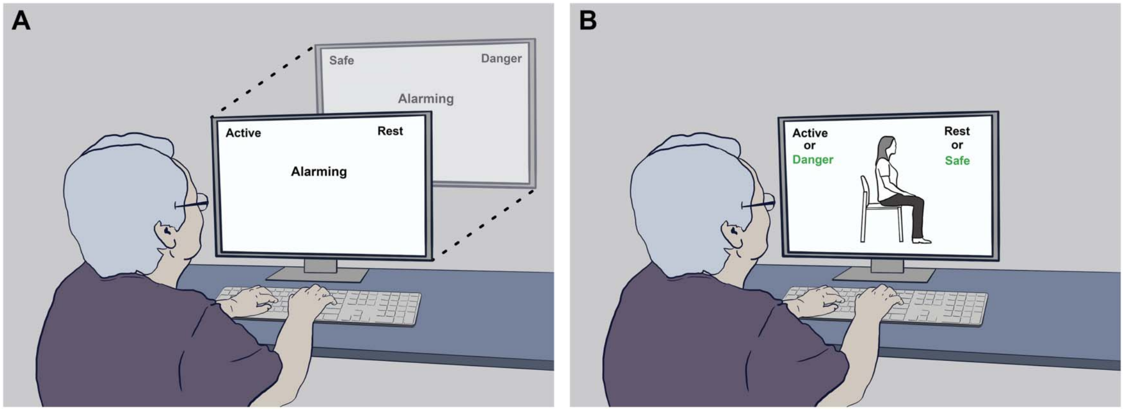

Figure 1. Visual depiction of the IAT task. (A) Practice block where participants sort stimuli (words and illustrations) into single categories. The "ghost" screen (offset) demonstrates that the categories change during different practice blocks. (B) Test block where participants sort stimuli into one of the 2 dual (paired) categorisations. The combination and side of targets (black text) and of attributes (green text) is randomised for each block of the IAT. IAT, Implicit Association Test.

than 10 seconds were excluded from the analysis.[11,27] Given that the forced error correction method was used, no time penalty was applied for incorrect responses.[24] Per guidelines, the Greenwald improved scoring algorithm for implicit association tests was used,[24,27] resulting in a Dscore calculated for each participant. A positive Dscore represents an implicit association against activity (activity is dangerous, rest is safe), and a negative Dscore represents an implicit association against rest (rest is dangerous, activity is safe).

2.7. Data analysis

Data were analysed using R (R Core Team, Vienna, Austria). Deidentified data and code are freely available (https://osf.io/r46kv/). Data were evaluated for normality by visual inspection of plotted residuals and Kolmogorov–Smirnov statistics.[38]

Means and standard deviations for participant demographic variables, pain-related variables, questionnaire responses, and IAT Dscores were calculated for each group. Independent *t*-tests and χ^2 tests (as appropriate) were used to compare demographic variables between the groups, and exploratory correlational analyses between IAT Dscores and demographic variables were undertaken; these analyses guided consideration of possible covariates/confounders. To assess performance of the IAT itself, trials were sorted by target/category and then scored separately by odd and even numbered trials, before correlating the two using the Spearman–Brown correction for split-half reliability estimation.[33] Cronbach's alpha was calculated to evaluate the internal consistency of the IAT. In addition, we assessed error rate defined as a percentage (number of incorrect trials divided by total trials).

Aim 1: One sample *t*-tests were used to determine whether threat–activity associations were present in each group (evaluating the degree and direction of difference from zero). Independent sample t-tests were used to compare IAT Dscores between groups (primary: painful KOA vs healthy pain-free controls; secondary: non-KOA lower limb pain vs healthy pain-free controls; painful KOA vs non-KOA lower limb pain). Effect sizes (Cohen's d) were calculated, where $d = 0.2$ was considered small, $d = 0.5$ moderate, and $d = 0.8$ a large effect.[20] Given age differences between the KOA group and healthy pain-free control group, a sensitivity analysis was undertaken to evaluate whether the between-group difference in Dscore was due to an overrepresentation of younger adults. It has been shown that IAT reaction time may increase as a function of age[43]; while the Dscore algorithm controls for this variance,[27] it is plausible that substantial variation in age between the groups could confound these findings. Thus, we conducted two sensitivity analyses: (1) analysis of covariance (ANCOVA) to compare Dscore between groups (pain vs no pain) with age as a covariate and (2) independent *t*-tests, restricting the pain-free group to those older than 45 years to match the age criterion of NICE diagnostic criteria used in the KOA group. Both analyses were undertaken to ensure comprehensive evaluation: the first analysis maintained sample size, and the second analysis was completed due to limitations and assumptions of ANCOVAs, whereby controlling for age as a covariate may not address residual confounding. However, it is acknowledged that this latter analysis may also increase the risk of introducing bias due to nonrandom participant exclusion. These sensitivity analyses were a deviation from our original protocol and were added as a protocol amendment.

Aim 2: Pearson's *r* correlations were used to evaluate associations between IAT Dscore and explicit attitude/belief questionnaires (rNPQ, BFOM, EBBS, PCS, OACQ), where ± 0.2 = small, ± 0.5 = medium, ± 0.8 = large correlation.[20]

Exploratory analyses comparing explicit measures between painful KOA and pain-free healthy control groups were undertaken using independent t-tests. This was a deviation from the original protocol but was completed to better contextualise between-group comparisons for implicit vs explicit measures. We did not explore between-group differences for the OACQ because it has not been psychometrically evaluated in people without pain.

3. Results

Table 1 summarises participant demographic and questionnaire data. Between October 20, 2021, and October 20, 2022, 1323 people were recruited to the online survey: 1177 provided demographic data, and 561 completed the IAT. Data for 3 participants were excluded due to >10% of their responses being faster than 300 milliseconds (n = 2 KOA, n = 1 non-KOA lower limb pain), resulting in full data for 558 participants. Of these, 223 participants met the criteria for painful KOA (157 females and 66 males, average age 64.52 ± 8.94 years); 207 participants were pain free (157 females and 49 males, 1 prefer not to say, average age 49.28 ± 15.32 years); and 99 had non-KOA lower extremity pain (74 females and 23 males, 2 nonbinary, average age of 47.53 ± 15.04 years). Internal consistency of the IAT (as measured by split-half reliability with Spearman-Brown correction and Cronbach's alpha) was >0.90 in all groups: painful KOA (0.93, 0.93;

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respectively); pain-free controls (0.94, 0.94); non-KOA lower limb pain (0.95, 0.95); and age-matched pain-free controls (0.95, 0.95). Error rates for the IAT were below 10% in all groups: KOA (7.8%); pain-free controls (7.0%); non-KOA lower limb pain (7.5%); and pain-free controls aged >45 years (7.0%).

3.1. AIM 1: Implicit association test threat–activity associations

In those with KOA, the mean IAT Dscore was 0.36 (95% CI: 0.28-0.44) and differed significantly from zero (t_{222} = 8.6596, P < 0.001, Cohen's d = 0.58), indicating an implicit association against activity (safety–rest, active–danger) and a moderate effect size (**Fig. 2**). Similarly, in those without pain, the mean IAT Dscore was 0.13 (95% CI: 0.04-0.22) and differed significantly from zero (t_{206} = 2.9308, P = 0.004, Cohen's d = 0.20), indicating a small implicit association against activity (safety–rest, active–danger).

Those with KOA had a significantly greater Dscore than those without pain ($t_{420.46}$= 3.6504, P < 0.001, mean difference = 0.22, 95% CI: 0.10-0.34, Cohen's d = 0.35), indicating a stronger association between danger and activity for people with painful KOA than for those without lower extremity pain.

3.1.1. Sensitivity analysis

Given a significant difference in mean age between those with KOA and those with no lower extremity pain ($t_{322.65}$ = 12.427, P < 0.001, mean difference = 15.24 years, 95% CI: 12.83-17.65), and a significant Spearman's rho correlation between age and IAT Dscore for the KOA group (rho = 0.21, P < 0.002) and the no pain group (rho = 0.17, P = 0.014), we conducted sensitivity analyses.

The first sensitivity analysis showed that when controlling for age, the main effect of group remained ($F_{1,425}$ = 17.24, P < 0.001): people with KOA had a significantly heightened threat–activity association (Dscore) relative to people without pain. Age-adjusted estimated marginal mean (EMM) and standard error (SE) for those with KOA was 0.283 (0.0453); for those without pain, EMM (SE) was 0.208 (0.0476).

In the second sensitivity analysis, we compared those with KOA with a sample who had no lower extremity pain and who were also older than 45 years (ie, matched to the age criterion of the NICE guidelines), which resulted in 114 pain-free participants (87 female and 27 male, average age of 60.78 ± 9.61 years). There was a smaller but statistically significant difference in age between these groups ($t_{213.79}$ = 3.4577, P < 0.001, mean difference = 3.74 years, 95% CI: 1.61-5.87). The mean IAT Dscore of the pain-free group older than 45 years was 0.22 (95% CI: 0.09-0.35), which differed significantly from zero (t_{113} = 3.38, P < 0.001; Cohen's d = 0.32), indicating a small-to-moderate implicit association against activity (safety–rest; active–danger). There was no significant difference in Dscore between those with KOA and the pain-free group aged over 45 years ($t_{205.63}$ = 1.79, P = 0.074, mean difference = 0.14, 95% CI: −0.014 to 0.289; Cohen's d = 0.21), although the direction of effect remained consistent.

3.2. AIM 2: Associations between implicit (implicit association test) and explicit self-report measures

For people with painful KOA, IAT Dscore weakly correlated with explicit assessments (**Table 2**) about pain knowledge, exercise beliefs, kinesiophobia (attitudes towards movement), and conceptualisation of osteoarthritis. Correlations of similar magnitude and direction were present for people without pain but only for explicit assessments about pain knowledge and kinesiophobia. All correlations were consistent in direction such that stronger associations of rest with safety corresponded to poor pain knowledge, negative exercise beliefs, and high kinesiophobia (fearful attitudes towards movement). Explicit ratings of danger for rest illustrations correlated with IAT Dscores, such that lower ratings of danger for rest illustrations corresponded to associating rest with safety (IAT).

3.3. Secondary analysis of implicit association test results

In those with non-KOA lower extremity pain (n = 99), the mean IAT Dscore was 0.11 (95% CI: −0.03 to 0.24) and did not differ significantly from zero (t_{98} = 1.6109, P = 0.1104, Cohen's d = 0.16). People with non-KOA lower extremity pain did not differ in

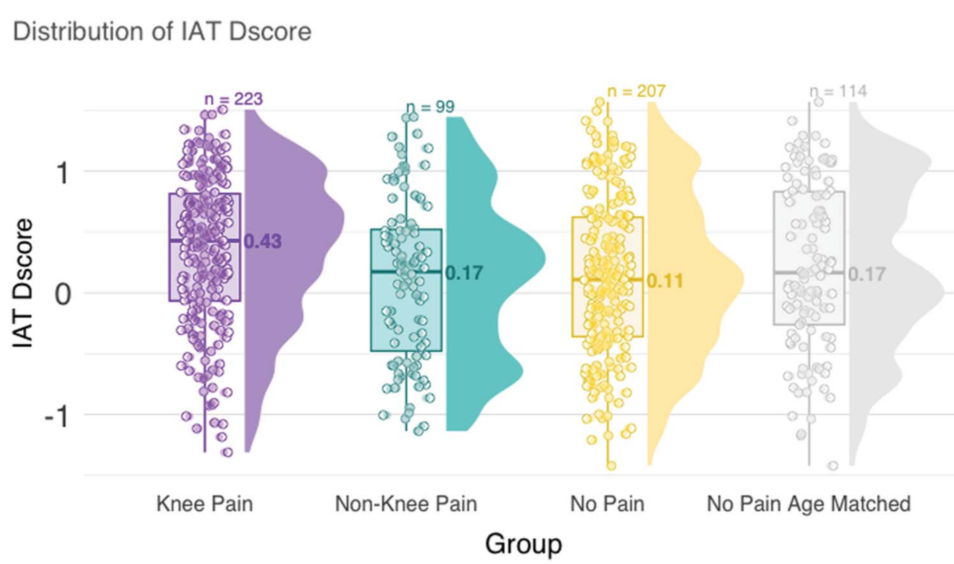

Figure 2. Dscore distribution raincloud plot. For each of 4 groups, raw data jitter plot, overlaying a boxplot summarising median and quartiles, adjacent to a density plot.

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Table 1

Participant characteristics.

Characteristic	Painful KOA N = 223*	No lower extremity pain N = 207*	Non-KOA lower extremity pain N = 99*	No pain aged >45 y N = 114*
Sex*				
Female	157 (70%)	157 (76%)	74 (75%)	87 (76%)
Male	66 (30%)	49 (24%)	23 (23%)	27 (24%)
Nonbinary	0 (0%)	0 (0%)	2 (2%)	0 (0%)
Prefer not to say	0 (0%)	1 (0.5%)	0 (0%)	0 (0%)
Age (y)	64.52 (8.94)	49.28 (15.32)	47.53 (15.04)	60.78 (9.61)
Residence*				
Oceania	159 (71%)	101 (49%)	43 (43%)	60 (53%)
North America	23 (10%)	37 (18%)	18 (18%)	20 (18%)
Europe	18 (8%)	44 (21%)	22 (22%)	23 (20%)
Africa	4 (2%)	5 (2%)	2 (2%)	2 (2%)
Asia	14 (6%)	18 (9%)	10 (10%)	7 (6%)
Middle East	0	1 (0.5%)	1 (1%)	1 (0.8%)
Not listed	2 (1%)	0	1 (1%)	0
Not reported	3 (1%)	1 (0.5%)	2 (2%)	1 (0.8%)
Education*				
Less than high school degree	3 (1.3%)	1 (0.5%)	1 (1.0%)	1 (0.9%)
Postgraduate	86 (39%)	97 (47%)	50 (51%)	50 (44%)
Secondary	50 (22%)	16 (7.7%)	11 (11%)	12 (11%)
Tertiary	84 (38%)	93 (45%)	37 (37%)	51 (45%)
Finance*				
Not reported	3 (1.3%)	1 (0.5%)	3 (3.0%)	1 (0.9%)
Finding it difficult	13 (5.8%)	8 (3.9%)	5 (5.1%)	2 (1.8%)
Getting by	62 (28%)	53 (26%)	31 (31%)	22 (19%)
Living comfortably	145 (65%)	145 (70%)	60 (61%)	89 (78%)
Duration of pain*				
Less than 6 mo	0 (0%)	13 (4.5%)	16 (16.1%)	4 (36%)
6 to 12 mo	25 (11%)	0	11 (11%)	0
2 to 4 y	60 (30%)	1 (0.5%)	26 (26%)	1 (8%)
5 y or more	138 (62%)	8 (36%)	44 (45%)	6 (55%)
Joint pain*				
Knee	223	0	71	0
Hip	89	0	40	0
Foot/ankle	87	0	41	0
Joint symptoms*†				
Knee	214	33	70	21
Hip	113	43	52	29
Foot/ankle	107	28	43	16
Upper extremity	149	76	53	54
Back/neck	136	0	56	60
None	0	60	3	23
Average knee pain intensity over the last week (0-10 NRS)	4.74 (2.06)	N/A	3.83 (1.93)	N/A
Average knee pain intensity while walking over the last week (0-10 NRS)	4.73 (2.31)	N/A	3.38 (2.24)	N/A
Average leg pain intensity over the last week (0-10 NRS)	4.65 (2.35)	N/A	3.81 (2.02)	N/A
Average leg pain intensity while walking over the last week (0-10 NRS)	4.78 (2.71)	N/A	3.70 (2.40)	N/A
WOMAC	65 (21)	N/A	47 (19)	N/A

One thousand three hundred twenty-three people were recruited to the online survey. Of these, 1177 provided demographic data (note, 13 completed the IAT and were included in the study but provided partial or no demographic data). Of these, 629 did not complete the IAT (480 female and 140 male, 6 nonbinary, 2 prefer not to say, 1 self-described; average age 56.3 ± 15.8 years). Of these, 254 had a mean (SD) knee pain over the past week of 5.4 (2.1).

* n (%).

† Reports the presence of pain, aching, discomfort, or stiffness; mean (SD).

KOA, knee osteoarthritis; N/A, not applicable (data were not collected or relevant in this group); NRS, numerical rating scale; WOMAC, Western Ontario McMaster University Osteoarthritis Index.

IAT Dscore from people with no lower extremity pain ($t_{190.71}$ = −0.32017, P = 0.75, mean difference = −0.11, 95% CI: −0.18 to 0.13; Cohen's d = 0.039) but did significantly differ from those with KOA ($t_{176.08}$ = 3.188, P = 0.002, mean difference = 0.25, 95% CI: 0.1-0.4; Cohen's d = 0.39), with heightened implicit association against activity in those with KOA.

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Table 2

Associations between explicit (self-report) and implicit (Dscore) outcomes.

Variable	Group	M	SD	N	r	P	Implication
Explicit ratings of danger for rest images	KOA No pain	9.12 8.23	7.89 7.67	219 206	−0.20* [−0.32, −0.07] −0.02 [−0.16, 0.12]	0.003 0.767	KOA: Lower perceived danger of images of rest is associated with higher implicit threat-activity associations (Dscore) No pain: Perceived danger of images of rest is not associated with implicit threat-activity associations (Dscore)
Explicit ratings of danger for activity images	KOA No pain	13.46 7.95	10.72 6.11	220 205	0.10 [−0.03, 0.23] 0.15† [0.01, 0.28]	0.14 0.038	KOA: Perceived danger of images of activity is not associated with implicit threat-activity associations (Dscore) No pain: Greater perceived danger of images of activity is associated with greater implicit threat-activity associations (Dscore)
rNPQ	KOA No pain	6.61 9.20	3.24 3.12	217 205	−0.25* [−0.37, −0.12] −0.29* [−0.41, −0.16]	0.0002 0.000024	For both groups, lower pain knowledge is associated with greater implicit threat-activity associations (Dscore)
BFOM	KOA No pain	11.49 9.30	4.11 3.28	222 203	0.11 [−0.02, 0.24] 0.19* [0.06, 0.32]	0.097 0.0054	KOA: Fear of movement is not associated with implicit threat-activity associations (Dscore) No pain: Greater fear of movement is associated with greater implicit threat-activity associations (Dscore)
EBBS	KOA No pain	136.33 144.79	16.99 15.21	199 194	−0.17† [−0.31, −0.04] −0.12 [−0.26, 0.02]	0.014 0.087	KOA: Negative exercise beliefs are associated with greater implicit threat-activity associations (Dscore) No pain: No association between exercise beliefs and implicit threat-activity associations (Dscore)
PCS	KOA No pain	8.83 8.35	3.47 3.23	221 207	0.11 [−0.02, 0.24] 0.08 [−0.06, 0.22]	0.11 0.24	Pain catastrophising was not associated with implicit threat-activity associations (Dscores) in either group
OACQ	KOA	135.77	19.56	210	−0.26* [−0.38, −0.13]	0.0001	KOA: A more expert conceptualisation (understanding) of OA is associated with lower implicit threat-activity associations (Dscore)

M, SD, N, *r*, and *P* are used to represent mean, standard deviation, sample size, Pearson's r coefficient, and *P* value, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. Explicit ratings of danger (0-10 numeric rating scale averaged for 5 images where higher scores indicate more perceived danger); rNPQ (revised Neurophysiology of Pain Questionnaire; scored 0 to 13 where higher scores indicate more contemporary knowledge about pain); BFOM (Brief Fear of Movement Scale; scored 6 to 36 where higher scores indicate greater kinesiophobia); EBBS (Exercise Barriers/Benefits Scale; scored 43 to 172 where higher scores indicate more positive attitudes towards exercise); PCS (Pain Catastrophising Scale; scored 1 to 20 where higher scores indicate greater catastrophising); OACQ (Osteoarthritis Conceptualisation Questionnaire; scored 36 to 180 where higher scores indicate a more expert conceptualisation).

* $P < 0.01$.

† $P < 0.05$.

KOA, knee osteoarthritis.

3.4. Exploratory analyses

Analyses evaluating explicit measures showed significant between-group differences for rNPQ, BFOM, and EBBS (see Supplementary File 2, http://links.lww.com/PAIN/C22), such that people with painful KOA had worse pain knowledge, greater fear of movement, and greater barriers to exercise when compared with people without pain. There was no difference between groups for the PCS.

4. Discussion

We developed a novel IAT to assess implicit associations between threat and activity, consistent with best practice guidelines,[24] that shows acceptable test performance (low error rate; high internal consistency). Our hypotheses were supported: people with painful KOA implicitly associated activity involving the lower limb with danger (and rest with safety), and this negative association between threat and activity was greater in those with KOA relative to both those without lower limb pain and those with non-KOA lower limb pain. We also found small or null correlations between implicit and explicit assessments of attitudes about physical activity, pain, and OA.

Previous work in persistent back pain[8] demonstrates heightened implicit threat–activity attitudes about the danger/safety of back movement (area affected by pain). Our findings support these results and extend them by showing that these implicit attitudes against movement are significantly greater in magnitude in people with painful KOA than in those without lower limb pain. These differences were robust to sensitivity analyses controlling for age, and the direction of effect remained consistent in comparisons limited to pain-free participants aged >45 years, increasing confidence in these findings. Although there is little literature to contextualise what magnitude of change in implicit attitudes may hold behavioural importance, our results support further evaluation of this measure.

Our findings provide important knowledge regarding the specificity of pain condition on implicit attitudes towards lower limb activity. Past work has shown specificity of implicit–shame associations in relation to type of disorder (eg, body dysmorphic, obsessive compulsive, vs social anxiety)[15]; relatedly, our results suggest that implicit threat–activity attitudes may be specific to the type of painful disorder. When using illustrations depicting rest/activity of the lower limb (focussing on the knee), people with painful KOA held the largest implicit association between threat and activity, differing significantly from both people with non-KOA lower limb pain and those without lower limb pain. However, that

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differences were still seen between the painful KOA and non-KOA lower limb pain groups (despite low numbers in the latter) may suggest that having KOA itself may be an important factor for the development of implicit attitudes about the safety of activity for the affected joint. Whether these effects also hold somatotopic specificity (specific to the body part in pain) is unknown—comparison to a control group without knee pain, but with pain elsewhere, is required.

Our finding that people without pain hold implicit attitudes against activity may speak to overarching societal narratives surrounding physical activity (eg, too much activity, such as high-level sport[30] or hard labour[66] can be detrimental to your knee). Such a narrative is not without support: past injury can increase the risk of developing future conditions such as OA.[47] This idea of activity being potentially detrimental can also be supported by societal narratives surrounding commonly known conditions such as KOA (eg, you need to reduce your activity because KOA is a degenerative joint disease,[31] for which only surgical intervention will help[5]). This pervasive message that activity ("wear") might be dangerous ("tear") may support such implicit associations between threat and activity, even in those without painful OA. Whether experiencing pain heightens existing associations, or results in the development of new negative associations, is unknown given the cross-sectional nature of our data. That those with non-KOA lower limb pain showed threat–activity associations of similar direction and size as those without pain (albeit statistically nonsignificant) further supports that it is not merely pain alone that contributes to these effects and that a societal threat–activity narrative may also play a role.

Previous work has shown the degree to which a concept is integrated into a person's identity (ie, "attitude importance") moderates implicit–explicit correlation.[34] Although we did not evaluate identity, attitude importance, or attitude extremity (ie, strength of an attitude), our sample had low-to-moderate pain and disability ratings. It is plausible that our relatively unimpaired population may not find their attitudes about OA to be important to their identity relative to other attitudes. In other words, when people explicitly report that the construct is important to them, we might expect stronger implicit–explicit correlations because of the integration of the construct into their identity. Future research is needed to evaluate whether our findings generalise to more severely impacted populations, as well as to evaluate how people with different levels of burden or disability from OA may explicitly weight the importance of their attitudes towards physical activity.

Future research investigating the relationship of physiological threat responses (eg, skin conductance, eye blink reflex) with explicit and implicit threat–activity attitudes may hold relevance to understand individual differences in threat weighting. Although specific fears and phobias may activate parasympathetic arousal,[56,65] our previous work showed that threat–activity attitudes in low back pain were not associated with physiologic measures.[8] Our findings may have been moderated by attitude importance, whereby an individual may not find an image or illustration of someone else doing a potentially threatening activity to be *personally* threatening.[23,40] Future work may experimentally elicit a personal and context-specific (ie, related to activity) threat response, whereby physiological arousal can be monitored.

The behavioural significance of our findings is unknown. There is conflicting evidence over the predictive value of IAT compared with explicit assessment.[28] Of note, explicit assessments have been shown to be better predictors of *deliberative* behaviours.[34] Future research is warranted to evaluate whether our threat–activity IAT differently predicts *automatic* behaviours like general physical activity as compared with deliberative/planned activities such as exercise. Discordant implicit–explicit assessments have poorer predictive validity than correlated implicit–explicit assessments.[28] Thus, the use of IAT and explicit assessments may provide incremental predictive validity, particularly given that we found between-group differences on several explicit measures. Our finding of weak and null implicit–explicit correlations is largely consistent with previous work[32,45] and offers further evidence that IATs and explicit self-report evaluate related but distinct constructs.[44,53] Future work should evaluate whether the combined use of this IAT and explicit assessments exceeds the predicted criterion variance of either method alone. If the IAT contributes to the predictive validity of automatic and/or deliberative physical activity, this assessment will offer a new opportunity to identify and target unhelpful attitudes about physical activity through clinical intervention.

Recent work has called for improved understanding of the multiple, complex factors surrounding KOA (eg, knowledge, attitudes/beliefs, and experience) and to address the common misconception that physical activity is inherently dangerous.[9] Our IAT holds potential for improved understanding of implicit threat–activity attitudes in people with KOA, which may hold clinical value. For example, discussion of implicit/explicit attitudes (particularly when they differ) offers a potentially important therapeutic opportunity. Reflection about one's attitudes and how they may impact behaviour is a strategy recommended by educational interventions rooted in conceptual change[41] and schema[62] theory. Therapeutic benefit would be predicted by self-regulated learning theory,[59] which posits that reflection about one's attitudes as they relate to experiences/behaviours may facilitate conceptual change.[59] Implicit measures may aid clinicians in the identification of unhelpful implicit attitudes, which pose barriers to activity, or when used as an outcome for interventions aiming to induce conceptual change, such as pain science education or holistic confrontation, to evaluate the possible mediating role of implicit attitudes on pain and disability outcomes. Although IAT measures have shown limited responsiveness (ie, potentially reducing utility as an outcome measure for attitudinal change),[24] they may hold utility as a clinical tool to facilitate therapeutic discussion (eg, when what people explicitly say differs to what they implicitly think).

4.1. Limitations

Given use of convenience sampling, our study holds a risk of homogeneity among the sampled population. Further that we did not capture the recruitment source of participants, nor participant race or ethnicity, limits our ability to assess sample representativeness. All groups were highly educated and reported low financial burden. Although participants were mostly Australian residents, 44% of participants with pain and 52% without pain reported residence outside Australia. Future work to develop a larger representative sample will facilitate a detailed interpretation of individual participant Dscores with greater nuance.[46] All illustrations used for this IAT are digitally drawn black line illustrations filled with white and shades of grey on a white background. Given the potential impact of identity factors on attitude importance, future IAT evaluation using images that capture varying identity factors (eg, skin colour) and assessing respondent ethnicity/race is warranted.

Strengths of this study include the preregistration of a study protocol per guidelines,[36] the implementation of best practice guidelines for the development/analysis of IATs,[24] and the use of

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open-source software for IAT development/analysis.[12] The IAT materials are available under creative commons license (CC BY-NC-SA) on the project Web site for independent validation. Adherence to IAT guidelines reduces possible concerns about measurement order and/or expectation effects; past work shows no influence of the order of explicit and implicit assessment[43] or previous experience with IATs[25] on the IAT score.

5. Conclusion

Our newly developed threat–activity IAT was found to have adequate test performance and revealed a heightened implicit threat–activity association in those with painful KOA relative to those without lower limb pain. Implicit threat–activity associations were weakly associated with explicit self-report questionnaires, suggesting that IAT findings may capture a unique construct not fully captured by explicit ratings. These results offer support for the potential clinical and research utility of the IAT to evaluate implicit threat–activity attitudes. Future research to determine whether the IAT predicts activity-related behaviour is needed, as is establishing a larger representative database to facilitate more nuanced interpretation of individual's scores.

Conflict of interest statement

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Deidentified data and code are freely available on the project Web site (https://osf.io/r46kv/).

Data availability: Deidentified data and code are freely available on the project Web site (https://osf.io/r46v/).

Previous presentation of findings: Preliminary findings were presented through poster at the World Congress of Pain in Toronto (2022).

Supplemental digital content

Supplemental digital content associated with this article can be found online at http://links.lww.com/PAIN/C22.

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