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Preferences for physical activity: a conjoint analysis involving people with chronic knee pain

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SUMMARY

Objective: To investigate individual preferences for physical activity (PA) attributes in adults with chronic knee pain, to identify clusters of individuals with similar preferences, and to identify whether individuals in these clusters differ by their demographic and health characteristics.
Design: An adaptive conjoint analysis (ACA) was conducted using the Potentially All Pairwise RanKings of all possible Alternatives (PAPRIKA) method to determine preference weights representing the relative importance of six PA attributes. Cluster analysis was performed to identify clusters of participants with similar weights. Chi-square and ANOVA were used to assess differences in individual characteristics by cluster. Multinomial logistic regression was used to assess associations between individual characteristics and cluster assignment.
Results: The study sample included 146 participants; mean age 65, 72% female, 47% white, non-Hispanic. The six attributes (mean weights in parentheses) are: health benefit (0.26), enjoyment (0.24), convenience (0.16), financial cost (0.13), effort (0.11) and time cost (0.10). Three clusters were identified: Cluster 1 (n = 33): for whom enjoyment (0.35) is twice as important as health benefit; Cluster 2 (n = 63): for whom health benefit (0.38) is most important; and Cluster 3 (n = 50): for whom cost (0.18), effort (0.18), health benefit (0.17) and enjoyment (0.18) are equally important. Cluster 1 was healthiest, Cluster 2 most self-efficacious, and Cluster 3 was in poorest health.
Conclusions: Patients with chronic knee pain have preferences for PA that can be distinguished effectively using ACA methods. Adults with chronic knee pain, clustered by PA preferences, share distinguishing characteristics. Understanding preferences may help clinicians and researchers to better tailor PA interventions.

Introduction

Symptomatic knee osteoarthritis (KOA) affects 14 million people in the US[1] and presents clinically as knee pain, stiffness, functional loss, and reduced quality of life[2]. KOA is the leading cause of disability in older adults and the 11th highest contributor to global disability[3]. Physical activity (PA) – any movement produced by skeletal muscles requiring energy expenditure[4] – is a universally accepted recommendation for improving pain, function, and quality of life in people with KOA[5,6]. Insufficient PA is associated with disability onset and progression[7], representing 20% of KOA-related disability[8], and is a potential reason for the societal increase in KOA over time[9]. Unfortunately, the average adult with KOA spends two-thirds of daily awake time in sedentary activities.[10]

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Clinical guidelines recommend PA regardless of disease severity. All PA intensities (light and moderate-to-vigorous) and modes (e.g., aerobic, resistance training) provide the potential for improvement in pain or function in people with KOA[11,12]. Many factors across the socio-ecological spectrum affect PA adherence in adults with knee pain[12–16], however sustained behavior change depends on individual decision-making concerning self-management[17]. In order to accommodate the multi-factorial nature of PA engagement, there is a need to assess individual preferences when attempting to facilitate PA adherence.[12,18]

Adaptive conjoint analysis (ACA) is a method originating in mathematical psychology[19] and economics[20] that is used increasingly in health care to capture individual preferences related to health care services[21]. ACA is based on the premise that a health care service can be described by its attributes or characteristics, and the value of the service depends on the levels of the attributes[22]. Among other uses, ACA can serve as a means to estimate the relative importance of different attributes of a service[22]. A recent example from the rheumatoid arthritis literature combined preference elicitation and statistical population segmentation (clustering) methods to derive ‘preference phenotypes’ to guide medical treatment decisions in the management of rheumatoid arthritis.[23]

The purpose of this study was to conduct an ACA with individuals who experience chronic knee pain to (1) determine the relative importance of attributes associated with PA, and (2) investigate whether clusters of individuals with similar preferences (preference phenotypes) for PA exist and, if so, to investigate whether individuals in these clusters differ by their sociodemographic and health characteristics.

Methods

Participants and procedures

Participants were recruited at community senior centers and resource fairs and from general internal medicine clinics at Northwestern Medicine, the Shirley Ryan AbilityLab (formerly the Rehabilitation Institute of Chicago) and via flyers posted on the Northwestern University medical campus, Chicago, USA.

Participants self-reported knee pain, ache or stiffness on most days of at least 1 month during the last year, were at least 45 years old, expressed interest in increasing or maintaining PA, and had no prior history of knee replacement on the side of complaint. Participants underwent a standing, fixed-flexion knee X-ray to identify presence of KOA, completed the online ACA, and answered patient-reported outcome measures. Participants provided informed consent, and the Northwestern University Institutional Review Board approved all aspects of the study.

Descriptive characteristics and health outcomes

Sociodemographic factors. Participants reported ethnicity, age, gender, education, income, and the presence of comorbidities were captured on a demographic and health history form. The presence of comorbidities was defined as having more than one comorbidity from a list of comorbidities from the Modified Charlson Comorbidity Index[24]. Body mass index (BMI) was calculated from measured height and weight (kg/m^2).

Patient-Reported Outcomes. Pain Interference, Physical Function, Ability to Participate in Social Roles and Activities, and Satisfaction with Social Roles and Activities were measured using the Patient-Reported Outcomes Measurement Information System (PROMIS) in Assessment Center[SM] (https://www.assessmentcenter.net). PROMIS computer adaptive tests were used and the scoring of each factor assessed results in a T-score[25]. Self-efficacy for engaging in PA was captured using the Self-Efficacy for Exercise Scale.[26]

Knee Radiograph. Radiograph was acquired using a standing fixed flexion view[27]. Films were assessed for KOA presence by co-author LS using the Kellgren and Lawrence (KL) radiographic criteria[28]. Presence of KOA was defined using the established and widely used definition of radiographic KOA, KL grade ≥2.

Conjoint analysis

A qualitative process was used to determine the six attributes and their levels for the ACA (Table I)[29]. We used a community-based participatory research approach to recruit and conduct five focus groups at three locations in Chicago, USA to identify attributes of PA. In the last three focus groups, we conducted attribute prioritization exercises to begin the process of attribute selection for the ACA. We consolidated the total number of attributes from 27 attributes to six attributes by grouping those with overlapping domains, e.g., ‘intensity’ and ‘pace’ were combined to form ‘PA effort’ and removing those that were incapable of being traded (‘sharp’ knee pain) or not experimentally manipulable, e.g., previous PA experience. Finally, we conducted semi-structured interviews and pilot testing to develop instructions and to use language that was acceptable by participants with chronic knee pain. Full details of the qualitative process have been previously reported.[29]

An online ACA used 1000minds software[30] which implements the **P**otentially **A**ll **P**airwise **R**an**K**ings of all possible **A**lternatives (PAPRIKA) method[31]. PAPRIKA is based on pairwise ranking – i.e., choosing one alternative from two possibilities. Each participant reviewed pairs of hypothetical PAs defined on two attributes at a time (assuming all other attributes were identical) and involving a trade-off. Participants indicated which PA they preferred, including favoring them equally (indifference). All participants were instructed that the purpose of the study was to help people with knee pain to “start and maintain PA programs”. An example of a pairwise-ranking question is: Which of these two PAs do you prefer: Either PA#1 which requires ‘45–89 min’ of *time* and ‘low’ *effort*, or PA#2 which requires ‘10–44 min’ of *time* and ‘high’ *effort*? Participants read pairs of PA and were asked to choose which PA they preferred. An example question from 1000minds software is in Fig. 1 (additional examples are included in the Appendix).

The PAPRIKA method is computer-adaptive and minimizes the number of questions each participant needs to answer. ‘Part-worth utilities’ (weights) representing the relative importance of the attributes are derived by PAPRIKA for each participant. Hansen and Ombler provide methodological details[31]. The weights are averaged across all participants.

Cluster analysis

Clustering sorts objects according to their similarity on one or more dimensions and identifies groups that maximize within-group similarity and minimize between-group similarity[32]. The ACA yielded preference rankings of the six attributes for each participant. We used a hierarchical clustering approach to identify preference clusters[32,33], known as average-linkage clustering[33]. The first level of clustering aggregates the data into pairs of points forming the base level of clusters; the next level of clusters is obtained by considering each recently formed cluster as the new data points for clustering[32]. Hierarchical clustering often produces multiple solutions, and so it is necessary to decide on the number of clusters that fits the data. Various algorithms exist to assess the fit of clustering schemes; we used the NBClust package in R (R Core Team 2013, Vienna, Austria) to determine the optimal number of

Table I
Attributes and their levels

Attribute	Attribute Level	Description
Health benefits	Low	Small relief in discomfort, small increase in strength and ability to move
	Medium	Moderate relief in discomfort, moderate increase in strength and ability to move
	High	Large relief in discomfort, large increase in strength and ability to move
Enjoyment	Low	You are bored and would rather be doing something else
	Medium	You could 'take it or leave it'
	High	You are absorbed in the activity, you find it exhilarating and feel euphoric
Convenience*	Low	With ease and minimal need for modification
	Medium	With some need for modification
	High	With difficulty and large need for modification
Physical activity effort	Low	You can sing during the activity
	Medium	You can talk, but can't sing, during the activity
	High	You can't say more than a few words without pausing for breath
Monthly cost	Low	$20 per month
	Medium	$50 per month
	High	$80 per month
Time per physical activity occasion	Low	10–44 min
	Medium	45–89 min
	High	90 min or more

* How well the activity fits into your schedule.

clusters for our data[34]. NBClust assesses clustering schemes across 30 indices and identifies the best clustering scheme based on the greatest agreement across indices[34]. Using this method, a three-cluster scheme was identified as the best for this analysis. Chi-square and ANOVA were used to assess differences in patient characteristics and health outcomes by cluster.

Consistency test

1000minds software allows for three pairwise-ranking questions to be repeated at the end of the ACA, as a test of preference consistency. Based on the literature concerning inconsistent preferences our main analysis included all participants[35–37]. We conducted a sensitivity analysis by removing from the analysis those who inconsistently answered two or three (all) repeated questions.

Cluster assignment

We used multinomial logistic regression to identify whether participant sociodemographic and health characteristics were associated with preference cluster assignment[38]. Predictor variables included PROMIS Pain Interference score, Self-Efficacy for Exercise Scale score, presence of a co-morbidity, presence of radiographic KOA, age, gender, and BMI. A 5-point (1/2 SD) difference in T-score was used as a conservative level of important difference in PROMIS Pain Interference score[39]. All analyses were performed using STATA version 15 (Stata Corp, College Station, Texas, USA).

Results

Of the 150 participants who completed the ACA, four had incomplete responses and were excluded, resulting in 146 participants with usable data. Participants were 72% female, 48% white (39% black/African American), with a mean age of 65 years. Sociodemographic characteristics are reported in Table II. On average, each participant answered 35 questions to complete the ACA, taking an average of 13 min. Only 12% of participants inconsistently answered two or three (all) of the repeat questions.

Table II also shows the mean preference weights for PA attributes for the entire sample and by preference clusters. Three

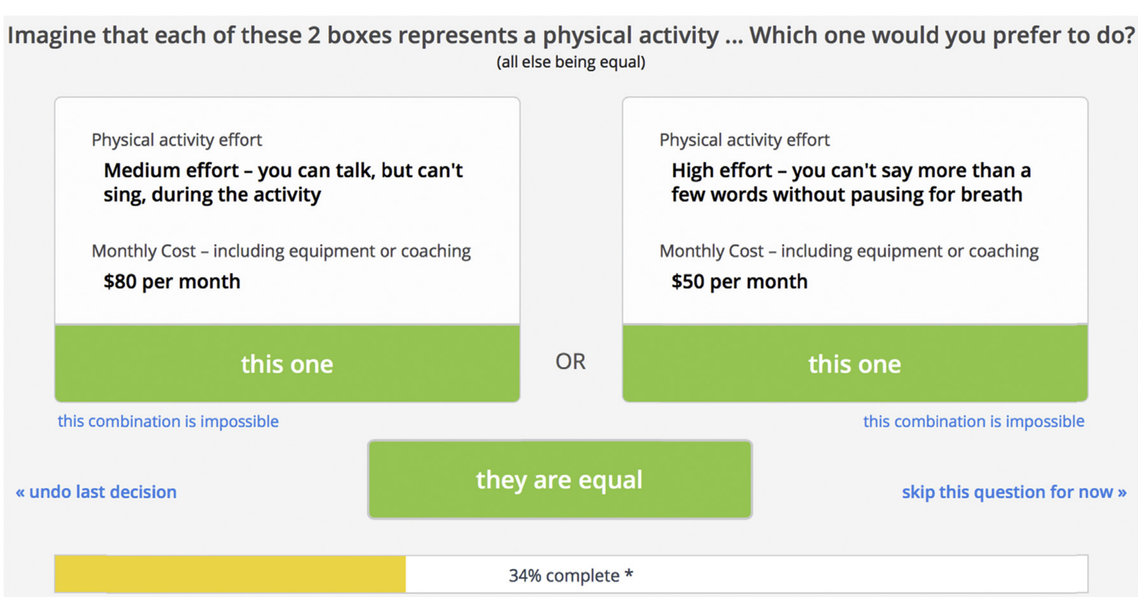

Fig. 1. Example of a pairwise-ranking question from 1000minds conjoint analysis software.

Table II
Physical activity preference weights, socio-demographics and health factors by Cluster

	Full sample n = 146	Cluster 1 n = 33	Cluster 2 n = 63	Cluster 3 n = 50
Physical activity preference weights[*]				
Health benefits	0.26 (0.13)	0.18 (0.07)	0.38 (0.07)[†]	0.17 (0.08)
Enjoyment	0.24 (0.09)	0.35 (0.07)[†]	0.23 (0.06)	0.18 (0.07)[‡]
Convenience	0.16 (0.07)	0.18 (0.08)	0.15 (0.04)	0.16 (0.07)
Effort	0.11 (0.09)	0.08 (0.06)	0.06 (0.05)	0.18 (0.09)[†]
Cost	0.11 (0.08)	0.12 (0.08)	0.10 (0.04)	0.18 (0.10)[†]
Time	0.10 (0.07)	0.09 (0.06)	0.08 (0.05)	0.13 (0.10)[‡]
Socio-demographic characteristics (%)				
Sex (female)	72	73	63	82
Age (65 years and older)	47	52	41	50
Race (White/Caucasian)	47	52	43	50
Education (bachelors or greater)	60	61	63	56
Family income (<$25,000 USD/year)	46	43	42	55[§]
Health factors (mean [SD] unless indicated)				
PROMIS pain interference T-score	57.7 (7.1)	55.2 (7.0)	56.9 (6.6)	60.2 (6.9)[†]
PROMIS physical function T-score	43.2 (7.3)	46.5 (6.6)	43.5 (7.5)	40.5 (6.5)[‖]
PROMIS ability to participate in social roles and activities T-score	48.7 (7.7)	51.7 (8.5)	49.4 (6.7)	46.0 (7.7)[‖]
PROMIS satisfaction with social roles and activities T-score	47.6 (9.3)	51.1 (10.3)	47.3 (7.8)	45.6 (9.8)[‖]
Self-efficacy for exercise scale score	5.5 (2.7)	5.5 (2.7)	6.2 (2.2)	4.5 (2.9)[¶]
Any comorbidity (%)	52	44	44	69[§]
BMI (% >30 kg/m^2)	47	39	46	50
Radiographic KOA (% KL grade II or higher)[¶]	62	52[§]	68	62

PROMIS = Patient-Reported Outcomes Measurement Information System. T-score range 0–100, general population mean = 50, SD = 10; Self-Efficacy for Exercise Score range 0–10, higher scores = greater self-efficacy.
[*] Preference weights– higher values represent greater importance related to physical activity choice, physical activity attributes were used for cluster analysis. Significant differences in preferences between clusters are expected due to the clustering technique and do not represent meaningful findings.
[†] Value significantly higher than other two clusters at $P < 0.05$ level.
[‡] Cluster 3 is significantly different than Cluster 2 at $P < 0.05$.
[§] Significantly different frequency than expected at $P < 0.05$ level.
[‖] Cluster 3 is significantly lower than Cluster 1 at $P < 0.05$.
[¶] Participants who declined having an X-ray due to recent or numerous knee radiographs in medical management were assumed to have KL grade II or higher.

clusters were identified by the cluster analysis, as depicted in Fig. 2. For the entire sample, *enjoyment* and *health benefit* were of greatest importance with little difference between them. Significant differences between clustering variables exist for all PA attributes except ‘convenience’. Among Cluster 1 participants, *enjoyment* was the most important attribute: approximately twice as important as *health benefit* and *convenience*. In contrast, *health benefit* was the most important attribute for Cluster 2 participants: 62% more important than *enjoyment*. Cluster 3 participants found *enjoyment*, *cost*, *effort*, and *health benefit* to be of nearly equal importance. For both the entire sample and the three clusters, *time* was the least important attribute.

Table II shows participant characteristics and outcomes by cluster. Cluster 1 participants had better scores on all PROMIS measures than Clusters 2 and 3, and Cluster 1 had the fewest participants with radiographic KOA. Differences between Cluster 1 and

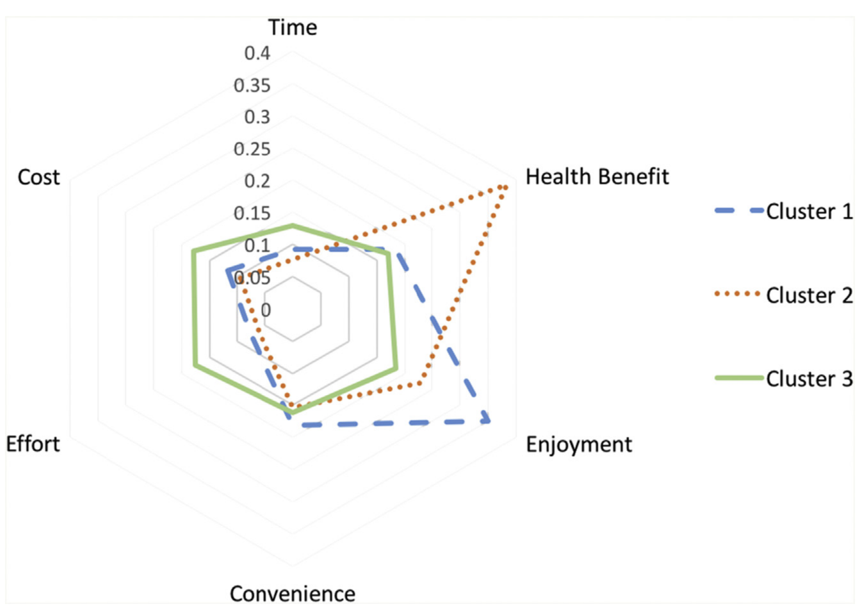

Fig. 2. Preference weights* for physical activity (PA) attributes by cluster. *Preference weights – higher values represent greater importance related to PA choice.

Cluster 3 were greatest for pain interference (5.1, 95% CI: 2.0 to 8.1, $P = 0.004$), physical function (6.0, 95% CI: 2.9 to 9.1, $P = 0.001$), Ability to Participate in Social Roles and Activities (5.8, 95% CI: 2.5 to 9.1, $P = 0.002$), and Satisfaction with Social Roles with Roles and Activities (5.5, 95% CI: 1.4 to 9.5, $P = 0.025$). Differences between Cluster 1 and 2 were only significant for physical function (3.0, 95% CI: 0.03 to 6.0, $P = 0.048$). Cluster 2 participants had significantly higher self-efficacy than Cluster 3 (15.4, 95% CI: 6.7 to 24.1, $P = 0.002$). Despite statistical significance, the lower bounds of the 95% confidence intervals for all comparisons are less than the minimal important difference indicating that we cannot have 95% confidence that the differences between clusters were clinically significant.

Cluster assignment

Table III shows the results of the multinomial logistic regression, assessing the association between clinical characteristics and cluster assignment by reporting relative risk ratio comparing each cluster to reference cluster 3. With a likelihood chi-square of 38.84 ($P = 0.0004$), the multinomial logistic regression fit significantly better than a model without predictors. Each 5-point increase in PROMIS Pain Interference score decreases the likelihood of assignment to Cluster 1 vs 3, (relative risk ratios (RRR) 0.53, 95% CI: 0.34–0.86), and each 3-point increase in Self Efficacy for Exercise Scale score doubles the likelihood of assignment to Cluster 2 vs 3, (RRR 2.10, 95% CI: 1.16–3.87).

Discussion

This study finds that *health benefit* and *enjoyment* are the most important attributes associated with the decision to engage in PA for adults with KOA. In the whole sample, *health benefit* and *enjoyment* are approximately twice as important as the cost of PA, the PA effort of PA, or the time needed to engage in PA. Cluster analysis identified three subgroups. Clusters 1 and 2 participants weighted *enjoyment* and *health benefit* as more important than Cluster 3 participants, whereas Cluster 3 participants weighted effort, cost and time higher. Cluster 1 participants valued *enjoyment* more than *health benefit* and Cluster 2 participants valued *health benefit* more than *enjoyment*.

Participant characteristics were related to cluster assignment. The risk of being assigned to Cluster 1 (relative to Cluster 3) decreased with each unit increase in the PROMIS Pain Interference score, suggesting that participants were less likely to be in the cluster that most valued *enjoyment* with increasing levels of pain interference. The risk of assignment to Cluster 2 (relative to Cluster 3) increased with each unit increase in the Self-Efficacy for Exercise Scale score, suggesting that participants with greater self-efficacy were more likely to be in the cluster that placed the greatest value on *health benefit*.

Few studies describe the trade-offs specific to PA in older adults. Franco *et al.*[40] used a best–worst scaling (case 2, profile case) survey in adults with a history of falls or disability and found non-health attributes to be of greater importance than health attributes. In our study, *health benefit* was either the most or second most important attribute depending on the preference cluster. There are several potential reasons for this difference in reported preference. Our study only considered one health attribute (compared to three in the Franco *et al.* study), and we described health differently. Our study used general terms to convey that *health benefits* can be improved to a small, moderate or large degree. The Franco *et al.* study included specific levels of improvement, reported as percentages and, for falls, changes were shown as improvement in falls risk. Risk attributes can be understood differently by how they are framed, and an examination of such framing has been suggested[41]. The authors conducted a pilot study where participants were “able to answer the scenarios presented without reporting excessive difficulty,” but an examination of risk attribute framing was not specifically reported.

Our findings highlight the variability of patient's values for PA and may have implications for how clinicians and researchers interact with people with chronic knee pain who express an interest in being more active. Cluster 1 participants were slightly younger and healthier and experienced less interference in their daily activities due to their knee complaints. These participants may have been more inclined to consider a PA framed as *enjoyable* vs a PA with known *health benefits* for managing KOA. Advances in exercise psychology that reframe PA within the context of a social experience[42] may be effective for individuals similar to those in Cluster 1. PA alternatives without social experiences can be structured to emphasize *enjoyment*. Partfitt, Alrumh, and Rowlands[43] used affect-regulated exercise prescription with high retention rates and increased cardiovascular fitness when participants were instructed to ‘feel good’. Zenko, Ekkekakis, and Ariely[44] affected post-exercise pleasure, remembered pleasure and forecasted pleasure in an treadmill training exercise by ordering exercise intensity. These strategies may be suited optimally for individuals like those with Cluster 1's characteristics.

Cluster 2 participants had a greater interest in the *health benefit* of PA and had higher levels of self-efficacy for exercise. Therefore, individuals like Cluster 2 participants may be more likely to adhere to PA regimens that are likely to improve, pain, function, and quality of life. Recent meta-analyses have shown structured exercise programs led by a trained instructor and delivered at a frequency of 3 times per week over 12 weeks deliver the greatest

Table III
Relative risk ratios (and 95% confidence intervals) from multinomial logistic regression analyses assessing associations between predictors and cluster assignment

Predictors	Cluster 1 *Enjoyment*		Cluster 2 *Health benefit*		Cluster 3 *Constrained*
	RRR*	95% CI	RRR*	95% CI	
Female gender	0.88	0.26–2.96	1.69	0.62–4.59	Reference
Any comorbidity	0.57	0.19–1.69	0.54	0.22–1.36	
Self-efficacy for exercise scale score†	1.00	0.91–1.06	2.10‡	1.16–3.87	
PROMIS pain interference T score†	0.53‡	0.34–0.86	0.70	0.47–1.05	
Radiographic KOA (KL grade II or higher)	0.30‡	0.10–0.96	1.00	0.35–2.83	
Age (65 or greater)	0.75	0.26–2.21	0.38‡	0.15–0.97	
BMI (≥30)	1.62	0.534.96	1.96	0.76–5.18	

KOA = knee osteoarthritis, OR = adjusted odds ratio, 95% CI = 95% confidence interval, multinomial logistic regression includes all predictors in Table III.
* Adjusted Relative Risk Ratio (RRR) from multinomial logistic regression including all predictors in Table III compares each cluster to referent cluster 3.
† The adjusted RRR was scaled to ½ SD (5 point) change in PROMIS score and a 3-point change in self efficacy for exercise scale.
‡ $P < 0.05$.

effect over the short term[12]. With higher levels of self-efficacy, individuals like Cluster 2 participants may also be better suited for self-management strategies.[45]

Cluster 3 participants were older, had the most co-morbidities, lowest levels of education, lowest self-efficacy, and fewest financial resources. They appear to be resource constrained or otherwise disadvantaged and may have little ability to conceive of incorporating PA into their lives. Strategies to build self-efficacy coupled with an incremental lifestyle PA approach may be most suitable for individuals similar to Cluster 3 participants.[46]

Limitations: ACA results are affected by the selection of PA attributes and how they are worded. Important PA attributes may have been omitted from the study and the wording of attributes may have created a scenario in which more than one construct was considered in a single attribute. For example, the importance assigned to health benefit may have differed if specific health benefits, such as physical function or pain, were separately addressed. With respect to attribute wording, our enjoyment attribute included the word ‘bored’ as part of the lowest attribute level description; it could be argued that ‘bored’ represents a different construct. When developing the attributes for this study we followed a robust qualitative research process, as suggested for stated choice experiments[47,48]. When writing attribute level descriptions we selected and tested words expressed by respondents of focus groups, semi-structured interviews, and pilot-studies. Our use of participant language may limit the generalizability of conclusions related to the enjoyment attribute.

Our study had a modest sample size. Minimum sample sizes in ACA depend on several considerations, including the question format, the complexity of the task, the desired precision of the results, and the need to conduct subgroup analyses[21]. Despite this, the identification of three distinct clusters − Cluster 1 (n = 33), Cluster 2 (n = 63), Cluster 3, (n = 50) − was robust, even after removal of participants with inconsistent preferences as a sensitivity analysis. Likewise, the sensitivity analysis did not alter our main findings (see Appendix, Tables S1 and S2).

The generalizability of these findings is affected by our inclusion criteria and our sample's characteristics. In particular, we recruited individuals interested in increasing or maintaining their PA, and so the findings may be most relevant to people like them. Our sample also had an average BMI of 31 kg/m^2, 46% earned less than USD$25,000 per year, and 50% had at least one comorbidity. In characterizing our sample, we did not assess current level of PA which may influence preferences. The dynamic nature of a person's preferences in the context of their PA experiences is a subject for future research.

Finally, there is need for caution when interpreting stated preferences as they may represent an ideal rather than a realistic decision-making setting. The behavioral science literature suggests that systematic biases make it difficult for individuals to fully understand and control their decisions[49,50]. These biases are also present when considering PA with some variance between PA intention and PA behavior explained by factors outside of our rational conscious[51,52]. For example, stairwell use increases with natural lighting, stairwell visibility, music, artwork, and point-of-decision messaging[53,54]. Consequently, behavioral economic interventions seek to change behavior through external interventions, i.e., ‘nudges’, vs engaging executive function. Nonetheless, ACA may inform how to create ideal PA conditions, to which behavioral strategies can be added to further optimize adherence[55]. Despite its limitations, this study lays the foundation for preference-aligned PA intervention studies in adults with chronic knee pain.

In conclusion, adults with chronic knee pain have preferences for PA that can be distinguished effectively using ACA methods. Adults with chronic knee pain, clustered by PA preferences, share distinguishing characteristics. This study provides new evidence for targeting and framing specific PA attributes as a novel strategy for developing PA interventions.

Author contributors

DP, RWC, JLH, PH, UB, AWH were responsible for study design; DP, DJF, LS were responsible for data acquisition; DP and JL analyzed the data, DP wrote the initial draft of the manuscript. All authors critically revised the manuscript and approved the final version.

Conflict of interest

PH is a co-inventor of 1000minds conjoint analysis software. All other authors have declared that no competing interests exist.

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Supplementary data

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