Running title: Sensitivity to physical activity among elderly

Sensitivity to physical activity predicts daily activity among pain-free older adults

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ABSTRACT

Objective: Prior research indicates older adults with knee osteoarthritis have increased sensitivity to physical activity (SPA) and respond to physical activities of stable intensity with increases in pain. Whether SPA is present in healthy older adults without chronic pain and predicts functional outcomes remains relatively unexplored. The purpose of this study was to determine the degree of SPA in healthy older adults in response to a standardized walking task, and whether SPA was associated with temporal summation of pain, pain-related fear of movement, and functional outcomes. **Methods:** Fifty-two older adults without chronic pain completed self-reported measures of activity-related pain and physical function, the Six-Minute Walk Test (6MWT), underwent quantitative sensory testing to measure temporal summation of heat pain, and wore an accelerometer for one week to measure physical activity behavior. Subjects rated overall bodily discomfort (0-100 scale) prior to and during each minute of the 6MWT. An SPA index was created by subtracting the initial bodily discomfort ratings from the peak ratings. **Results:** Repeated-measure analysis of variance indicated bodily discomfort significantly increased across the walking task, with approximately 60% of the sample experiencing SPA. Hierarchical regressions indicated that greater SPA was associated with less average steps per day and greater activity-related pain. Additionally, analyses revealed that temporal summation of pain and pain-related fear of movement significantly predicted the degree of SPA on the walking task. **Conclusions:** These findings shed light on potential mechanisms underlying SPA in older adults, and suggest that SPA might be a risk factor reduced physical activity.

Key Words: Physical activity, temporal summation of pain, activity-related pain, fear of pain, older adults, quantitative sensory testing

Recent studies suggest that individuals with musculoskeletal pain conditions, such as osteoarthritis, fibromyalgia and whiplash, experience a prolonged sensitized response to physical activity (1-3). For example, Wideman and colleagues revealed that individuals with knee osteoarthritis respond to activities of stable intensity, such as walking, with increasing discomfort (1). Notably, this greater sensitivity to physical activity (SPA) was associated with self-reported worse physical function, greater osteoarthritis-related pain, and poorer performance on the walking task. Evidence suggests that this increased sensitivity to physical activity may be linked to sensitization of the central nervous system and psychological processes. Indeed, greater temporal summation of pain, a marker of central sensitization, was predictive of SPA in knee osteoarthritis patients (1). Furthermore, prior studies show that fear of movement due to pain (4) and pain catastrophizing (1,2) predict a greater sensitized response to physical activity in chronic low back pain and knee osteoarthritis patients, respectively.

Accumulating research indicates that older adults, even without chronic pain, are characterized by a sensitized central nervous system compared to younger adults. For example, several studies show that older adults exhibit greater temporal summation of pain compared to younger adults (5-7). Temporal summation of pain refers to the increased perception of pain in response to repetitive noxious stimuli and is thought to represent an indirect marker of central sensitization (8,9). It is hypothesized that enhanced central sensitization may place older adults at greater risk for developing chronic pain. Given the potential link between temporal summation and SPA, enhanced temporal summation of pain could also place older adults at greater risk for a sensitized response to physical activity. However, the existence of SPA in older adult populations without chronic pain has remained relatively unexplored. Older adults who

experience a sensitized response to physical activity may be at risk for increased sedentary behavior and functional decline.

The purpose of this study was threefold. First, we aimed to determine whether healthy older adults experience increasing levels of discomfort during a standardized walking task. Similar to Wideman and colleagues, participants completed the 6-Minute Walk Test (6MWT) and bodily discomfort was assessed each minute of the task. Sensitivity to physical activity was determined by comparing pre-task discomfort levels to discomfort levels while walking. Secondly, we explored whether individual variance in sensitivity to physical activity predicted physical activity levels, self-reported physical function and activity-related pain in older adults. Third, we examined whether psychological factors and temporal summation of pain predicted SPA. We hypothesized that older adults who exhibited greater temporal summation of pain would also experience greater SPA (i.e., increasing levels of bodily discomfort during the 6MWT). Moreover, we hypothesized that a greater sensitivity to physical activity during the walking task would be associated with reduced physical activity and physical function, and increased activity-related pain.

METHODS

Participants

Participants were 52 healthy adults ranging in age from 60 to 77 (males=20, females=32). Table 1 presents the descriptive characteristics of the sample. The racial composition of the sample included 47 Caucasians, 1 Hispanic, and 4 African Americans. Participants were recruited through posted advertisements in the local community. Individuals meeting any of the following criteria were excluded from the study: 1) current use of narcotics or any tobacco products, chronic use of analgesics, 2) serious systemic disease or condition that restricted

normal daily activities (e.g., cancer, severe osteoarthritis), 3) cognitive impairment that would interfere with understanding of the study procedures as defined by a score of greater than 7 on the Six Item Cognitive Impairment Test, 4) uncontrolled hypertension, 5) cardiovascular, metabolic, or pulmonary disease, 6) neurological disease, 7) serious psychiatric conditions (e.g., schizophrenia and bipolar disorder), and 8) chronic pain or any ongoing pain problem (headaches, injury-related pain, etc.).

Procedures

This study was approved by the Indiana University Human Subject Review Board. Participants completed a screening/orientation session and three experimental sessions. All sessions were scheduled on separate days and separated by at least 48 hours. Additionally, participants were instructed to refrain from consuming caffeinated beverages or any pain medications prior to the experimental sessions. During the experimental sessions, participants completed several questionnaires, the six-Minute Walk Test, and underwent quantitative sensory testing. Additionally, physical activity behavior for one week was assessed with an accelerometer. These assessments are described below.

Screening and Orientation Session

The screening and orientation session lasted approximately 2 hours and occurred on a separate day than the experimental sessions. All participants were provided information about the experimental procedures, and reviewed and signed an informed consent form prior to participation in the study. To determine eligibility, participants completed a health history questionnaire, supplemented by interview, blood pressure, and height and weight measurements. Participants were also administered the Six-item Cognitive Impairment Test to ensure that participants were free of cognitive impairment that would compromise study participation (10).

No participants were excluded following the orientation and training session. Once eligibility was determined, participants completed a quantitative sensory test training session which allowed them to become accustomed to the pain tests and laboratory setting. At the end of the training session, participants were given an accelerometer, instructions on how to wear the device, and a physical activity diary (described further below).

Assessment of Physical Activity

All participants were instructed to wear an accelerometer (Actigraph GT3X+) on the hip to measure physical activity levels. The Actigraph is a small lightweight tri-axial accelerometer that is designed to detect tri-axial accelerations in the range of 0.05-2 G. Output from the ActiGraph is in the form of step counts, body positions and activity counts for a specific time period. Data were captured in 1-minute epochs, and non-wear time was defined as 60 minutes of consecutive zero counts. Participants were given the accelerometer and instructions on how to wear it during the screening session. They were instructed to wear the accelerometer for 7 consecutive days following the screening session except during sleep, showering/bathing, and swimming. A valid day was defined as having worn the device for more than 10 hours. Participants were also provided a Physical Activity Diary in which they recorded the start and finish times each day, as well as the duration and reason for any periods where they took the accelerometer off. Participants received reminder calls or emails from research staff about wearing the accelerometers. Data obtained from the accelerometer was expressed in steps per day, as calculated by the ActiLife Data Analysis Software (Actigraph, LLC). The Actigraph accelerometer has shown good accuracy for monitoring step counts in community-dwelling older adults (11).

Temporal Summation of Heat Pain.

During each experimental session, participants underwent quantitative sensory testing. At the beginning of each session, temporal summation of heat pain was measured first followed by other QST procedures. Only the temporal summation results are reported in this study. Temporal summation refers to the increased perception of pain in response to repetitive noxious stimuli delivered at frequencies above 0.3 Hz (8,9). Brief repetitive suprathreshold heat pulses were delivered to the right and left ventral forearms by a Pelteir-based thermode (32mm x 32mm; TSA-II, Medoc Advanced Medical Systems, Durham, NC, USA). Each trial consisted of a series of 5 heat pulses, with each pulse delivered at a rate of 10ºC/s. The peak to peak inter-pulse interval was approximately 2.5 seconds. The baseline temperature was 34-38 ºC and the target temperature was either 44ºC, 46 ºC, or 48ºC. Participants were instructed to rate the intensity of the late pain sensations experienced after each pulse (i.e., pain felt between the pulses not during each pulse, termed second pain) with a 0-100 numeric rating scale, with "0" indicating no pain and "100" indicating "intolerable pain". Two trials (one on each forearm) at each temperature (44ºC, 46ºC, and 48ºC) were administered to each participant during each session, with at least 1 minute between trials. The order of trials for each temperature was randomized for each participant but kept constant across sessions. A TS score was calculated by subtracting the pain rating following the first pulse from the highest inter-pulse pain rating. This score captures the maximum amount of TS across the 5 pulses. These temporal summation procedures were conducted during each experimental session. An average TS score was calculated for each temperature across the three sessions and used for data analysis.

Self-Report Questionnaires

Fear of Pain. Tampa Scale of Kinesiophobia (TSK) consists of 17 items used to measure fear of movement or re-injury associated with pain (12). The TSK is a reliable and valid method for determining fear of movement in both clinical and non clinical populations (13,14).

Physical Function. The Short-Form Health Survey-36 (SF-36) was used to measure physical function. This form provides 8 scaled scores in the areas of physical functioning, role limitation due to physical problems, bodily pain, vitality, general health perceptions, social function, role limitations due to emotional health and mental health (15). This survey is commonly used in studies of pain (16,17).

Activity-related Pain. Participants completed the Quality of Well-being Scale- Self-administered (QWB-SA: 18,19). The QWB-SA is a generic measure of health-related quality of life (HRQOL) that combines preference-weighted values for symptoms and functioning. The measure has been used in multisite NIH clinical trials and with various medical conditions (20-22). The QWBA-SA includes a 12-item pain scale. The first six questions asked participants to indicate "*how often he/she experienced pain in the past week while doing the following activities*": 1) getting in and out of bed, 2) walking a short (1 block) distance, 3) getting in and out of a chair, 4) walking up a flight of stairs, 5) getting in and out of a car, and 6) walking down a flight of stairs. Participants rated the frequency of pain on a 5-point likert scale ranging from *always* to *never*. The remaining 6 questions asked participants to indicate the severity of pain experienced while doing the same activities. Pain severity was rated on a 6-point likert scale ranging from *no pain* to *excruciating pain*. The mean pain frequency and severity scores were calculated for each subject. Frequency scores ranged from 0 – 4, with higher scores indicating more frequent pain. Severity scores ranged from 0 to 5, with higher scores indicating greater pain severity.

Sensitivity to Physical Activity

Six Minute Walk Test. The six minute walk test (6MWT) is a test of functional aerobic capacity commonly used in older adults (23). Participants were instructed to walk as far as possible for 6 minutes around a 60-meter indoor course (30 meters down and 30 meters back). Distance covered indicates walking performance, with greater distance indicating greater aerobic capacity. At the end of the walk, participants gave a rating of perceived exertion using Borg's Rating of Perceived Exertion (RPE) scale, ranging from 6 to 20- where 6 is no exertion at all and 20 is maximal exertion for the subject (24).

Measurement of Whole Body Discomfort. Participants were asked to rate their level of whole body discomfort before, during and after the six minute walk with a 0-100 numeric rating scale, with 0 being no bodily discomfort and 100 being extreme bodily discomfort. Participants were asked to rate their bodily discomfort immediately before starting the walk and once after each minute of walking for a total of 7 ratings.

Calculation of Sensitivity to Physical Activity Index. Similar to the calculation of temporal summation of pain, an index of SPA was calculated by subtracting participants' first ratings of bodily discomfort from their peak ratings during the walk.

Data Analysis

A power analysis using G Power 3.0.10 was used to estimate the sample size needed for predicting the change in R^2 in a multiple linear regression model, when the independent variable of interest was added to the model. With an estimated moderate effect size (f^2=0.16) and including two covariates, a sample size of fifty-two participants would provide power of 0.80 at 0.05.

Descriptive statistics were calculated for age, BMI, SPA index, 6MWT – meters walked and RPE, TSK score, SF-36 Physical Function scale score, QWB – Pain Frequency and Severity scale scores, average steps per day, and temporal summation at 44ºC, 46ºC, and 48ºC. The descriptive statistics are presented in Table 1. The means are presented separately for those who experienced SPA (SPA ≥ 1) and those participants who did not experience SPA (SPA=0). Mann-Whitney U tests were conducted to determine if the non-normally distributed variables differed by SPA group. Independent t-tests were used to examine the normally distributed variables by SPA group.

Repeated measures analysis of variance (ANOVA) was conducted to determine whether reports of whole body discomfort increased during each minute of the 6MWT. Second, bivariate correlation analyses were conducted to determine whether the SPA index was associated with psychological factors, performance on the 6MWT, self-reported activity-related pain (QWB-pain scale) and physical function (SF-36), physical activity level (step count), and temporal summation of heat pain. Third, hierarchical regressions were conducted to determine whether the SPA index predicted performance and effort on the 6MWT, self-reported pain and function, and physical activity level, after controlling for significant covariates. Finally, a hierarchical regression was also conducted to determine whether fear of movement due to pain and temporal summation of pain predicted the SPA index. For all regressions, covariates that were significantly associated with the dependent variable were entered into the model before entering the predictor of interest.

RESULTS

Table 1 presents the characteristics of the study sample as well as the means for all the primary measures of the study. The means are presented separately for those who experienced

SPA (SPA ≥ 1) and those participants who did not experience SPA (SPA=0). SPA index, 6MWT-RPE, SF-36 Physical Function score, QWB-pain severity scale score, and QWB-pain frequency scale score significantly differed between SPA groups.

Changes in bodily discomfort during the 6MWT

The repeated measures ANOVA indicated bodily discomfort ratings significantly ($p<.001$) increased 1) from baseline to minute 1 ratings, 2) from minute 1 to minute 2 ratings, 3) from minute 2 to minute 3 ratings, and 4) from minute 3 to minute 6 ratings. Thirty-one participants (59.6%: 11 males, 20 females) experienced SPA, with an average SPA score of 7.61±1.7 across all participants. Figure 1 shows the bodily discomfort ratings during the 6MWT for all participants and the average ratings for the 31 participants who experienced SPA.

Correlations between SPA index and primary study variables

Table 2 presents the correlations between SPA and performance on the 6MWT, TSK scores, self-reported physical function (SF-36) and activity-related pain (QWB-pain scale), average steps per day, and temporal summation of pain at 44ºC, 46ºC, and 48ºC. SPA was positively and significantly related to RPE on the 6MWT and the frequency and severity of self-reported activity-related pain. Higher levels of SPA were associated with greater perceived effort on the 6MWT and greater severity and frequency of activity related pain on the QWB scale. Additionally, steps per day was negatively correlated with SPA, with those exhibiting higher SPA walking fewer steps per day.

SPA index as a predictor of 6MWT performance

Results of the regressions with 6MWT performance, pain, physical function, and physical activity as the dependent variables are presented in Table 3. The model for prediction of 6MWT performance (meters walked) was significant with sex, BMI, and fear of movement as the

significant predictors. Females compared to males, participants with a higher BMI, and those with greater fear of movement due to pain walked less meters on the 6MWT. The regression model predicting RPE on the 6MWT was also significant, with SPA (β=.565, p<.001) being a significant predictor of RPE, even after controlling for meters walked. Greater SPA was associated with greater perceived effort on the 6MWT.

SPA index as a predictor of physical function and physical activity

The model for prediction of self-reported physical function on the SF-36 was significant (Table 3), with fear of movement (β=-.473, p=.001), but not SPA, significantly predicting self-reported physical function. Those who reported greater fear of movement also self-reported worse physical function. The regression model with SPA as a predictor of steps per day was also significant. Fear of movment (β=-.316, p=.025) and SPA (β=-.284, p=.032) predicted average steps per day, such that those who experienced greater fear of movement and SPA walked fewer steps per day.

SPA index as a predictor of activity-related pain

SPA (β=.434, p=.001) predicted frequency of activity related pain reported on the QWB-pain scale, such that greater SPA was associated with more frequent pain. Similarly, fear of movement (β=.298, p=.024) and SPA (β=.332, p=.012) positively predicted the severity of activity related pain.

Predictors of SPA index

Fear of movement and temporal summation at 44ºC significantly predicted SPA on the 6MWT (Table 4). Participants who reported greater fear of movement (β=.415, p=.003) and had greater temporal summation of pain (β=.359, p=.010) experienced greater SPA on the 6MWT.

Temporal summation at 46ºC (β=.232, p=.103) and 48ºC (β=.239, p=.084) were not significant predictors of SPA.

DISCUSSION

This study explored whether healthy older adults experience a sensitized response to standardized physical activity, as well as the predictors and clinical outcomes of this response. Several significant findings emerged from the data. First, we demonstrated that a significant portion of apparently healthy older adults do not respond normally to continuous physical activity that is essential to everyday life and function (i.e., continuous walking). Furthermore, we discovered that this sensitized response to physical activity may place older adults at greater risk for activity-related pain and reduced physical activity – two factors that contribute to declining health and physical function. Third, we provided additional evidence for the role of central sensitization and psychological processes in SPA.

In the current study's older adult sample, approximately 60% experienced SPA during the walking task. For these individuals, whole body discomfort increased steadily across the 6 minutes with an average SPA of 18.5. Comparatively, Wideman and colleagues found a considerably higher prevalence of SPA (~85%) but a similar magnitude of SPA (~15) in a sample of middle-aged to older adults with knee osteoarthritis using the same walking task (1). Notably, Wideman et al. calculated SPA based on discomfort ratings at the knee, whereas the current study measured whole-body discomfort. Interestingly, most participants in the current study experienced no bodily discomfort (~2/100) prior to the walk. These results suggest that bodily discomfort or pain at rest is neither a necessary precursor nor predictor of which older adults may experience increasing discomfort with physical activity. This notion is supported by

related research suggesting that discomfort/pain at rest is modulated by different underlying processes compared to activity-related discomfort and pain (25,26).

In accordance with previous research, the current study's results were able to shed some light on factors placing older adults at risk for experiencing SPA. Greater fear of movement due to pain predicted SPA in older adults, with greater fear of pain associated with greater SPA on the walking task. Similarly, prior studies have shown that fear of movement due to pain is associated with increased pain during repeated and standardized physical activity in chronic low back pain patients (4) and fibromyalgia patients (3). Several different mechanisms exist by which psychological factors such as fear of pain could influence activity related pain and discomfort. One explanation involves a possible link between psychological processes and temporal summation of pain. Prior work indicates that psychological processes, such as pain catastrophizing, enhance temporal summation of pain (27), and temporal summation of pain may be a central process underlying the summation of activity-related pain (1). However, in contrast to this hypothesis, the present findings did not show a relationship between fear of pain and temporal summation of pain. Other possibilities involve greater co-contraction of antagonist muscle groups during movement associated with pain-related fear (28,29) and the potential subsequent muscle fatigue due to muscle co-contraction (30). Nonetheless, the precise mechanisms linking psychological processes to SPA remain unclear.

The present findings also suggest that endogenous facilitatory processes may influence SPA. Consistent with previous work (1), temporal summation of heat pain predicted SPA on the walking task. Facilitated responses on the temporal summation test are related to hyperexcitability of the central nervous system (i.e., dorsal horn neurons of the spinal cord) and an indication of central sensitization (31). Interestingly, temporal summation at 44ºC but not

46ºC and 48ºC was associated with SPA. Generally, older adults exhibit greater endogenous facilitation of pain compared to younger adults (5,7,32), which may place them at greater risk for development of chronic pain (33). Our results further suggest that older adults who exhibit greater temporal summation of pain at low stimulation intensities are at a greater risk for a sensitized response to physical activity.

The present study also revealed important clinical correlates of SPA in healthy older adults. Specifically, the data indicated that increasing levels of body discomfort during the walking task were uniquely predictive of average steps taken per day, even after controlling for BMI, aerobic capacity (i.e., meters walked during 6MWT), and fear of movement due to pain. In other words, older adults experiencing a sensitized response to the walking task were less physically active. Additionally, older adults with greater SPA reported greater severity and frequency of pain during common activities of daily living. These findings are in line with other research demonstrating that individual variance in SPA predicts self-reported pain and physical function in knee osteoarthritis patients (1,34). It is well established that adults become more sedentary with advancing age (35,36). Importantly, our evidence suggests that activity-related increases in discomfort or pain in older adults may be a key factor facilitating sedentary behavior and could present as a hidden barrier to activity promotion efforts. Clinical measures of sensitivity to physical activity could identify those at risk for declining physical activity and those who are in need of extra strategies to encourage adherence to activity-based interventions.

Wideman and colleagues revealed that SPA predicted self-reported physical function and performance on the 6MWT in knee osteoarthritis patients, with greater SPA associated with poorer physical function and less meters walked, respectively (1). Furthermore, another study showed that increases in pain during a repetitive lifting task were associated with decreases in

work output on the task in fibromyalgia patients (3). Surprisingly, SPA did not predict physical function or performance on the 6MWT in the current study. On average discomfort levels reported during the 6MWT were considerably lower in the current study compared to the Wideman study (1) and the overall discomfort levels may have been too low to significantly affect performance. Additionally, we measured overall bodily discomfort vs. discomfort of a specific body part (i.e., knee) as assessed in prior research. In the assessment of overall bodily discomfort, participants could have experienced discomfort in body sites not significantly influencing the ability to walk. Another potential explanation is that a longer task may have been needed to increase the magnitude of SPA to a more clinically meaningful range and to have this increased discomfort disrupt physical performance. In line with this notion, Wideman and colleagues showed that evaluating SPA using a shorter functional task compared to a longer task was associated with less predictive power in knee OA patients (34). While SPA did not predict 6MWT performance, it had a significant impact on perceived effort during the walk even after controlling for meters walked. Hence, older adults experiencing SPA might be vulnerable to perceiving activities of the same relative intensity (work rate/ physiological effort) at a higher exertion compared to those who do not experience SPA. This perceived higher level of exertion during physical activity could contribute to the reduced physical activity evidenced in older adults experiencing SPA.

Several limitations of this study merit some discussion. First, this study was cross-sectional in nature and therefore, causality cannot be determined. Second, the study sample was fairly active and fit based on the 6MWT and accelerometer data. Less active older adults may have demonstrated even greater levels of SPA. Additionally, we only measured SPA on a single continuous task. Therefore, it cannot be determined whether we would have observed

comparable results using other physical tasks, such as intermittent tasks. Notably, we did find a relationship between SPA on the walking task and self-reported pain on common daily tasks, such as walking up and down stairs, getting out of bed, and getting in and out of a chair and car. Fourth, while approximately 40% of our sample did not experience SPA during the walking task, a more intense form of physical activity may have evoked a sensitized response in a greater proportion of individuals. Future research should explore whether more intense or prolonged physical tasks would enhanced the predictive value of the SPA index, particularly for healthy older adults. Finally, it should be noted that the current study was powered to conduct hierarchical regression analyses with two-covariates. Given that the regression model predicting performance on the 6MWT contained 3 covariates, it is possible that with a larger sample size SPA would have been a significant predictor of performance.

Despite these limitations, several important implications emerged from this study. Overall, this study demonstrated that older adults who have fear of pain and/or a sensitized central nervous system are more vulnerable to experiencing a sensitized response to standardized physical activity. This sensitivity to physical activity may place older adults at a greater risk for sedentary behavior. Future research needs to examine the prognostic value of SPA for trajectories of physical activity behavior. For example, longitudinal studies need to determine if those who experience SPA are more likely to exhibit a significant decline in physical activity behavior over time. As such, activity-related measures of discomfort and pain may provide insight into individuals at risk for functional decline.

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FIGURE LEGENDS

Figure 1. Bodily discomfort ratings during the Six Minute Walk Test for all subjects (solid line) and for only the subjects who experienced SPA (dashed line).

Table 1.

Means and standard deviations for primary study measures in participants who exhibited SPA and those who did not exhibit SPA.

Variable	SPA (n=31)	No SPA (n=21)
Sex, % female	64.5%	62%
Age, year	67.8 ±5.1	66.9±5.1
BMI	26.6±4.5	26.1±4.7
SPA index	18.5±18.9	0±0*
6MWT - meters walked	549.5±115.1	541.2±90.0
6MWT RPE	12.1±2.1	9.2±1.4*
Tampa Scale of Kinesiophobia	19.1±4.8	18.6±4.0
SF-36, physical function scale	83.6±19.5	94.5±5.0*
QWB – pain frequency scale	1.7±0.8	1.2±0.4*
QWB – pain severity scale	1.5±0.5	1.2±0.3*
Average Steps per day	6494.9±2789	7109±2348
Temporal summation, 44ºC	1.3±1.8	0.7±1.1
Temporal summation, 46ºC	2.2±2.8	1.4±1.81
Temporal summation, 48ºC	5.7±7.5	3.6±2.9

Note: *Indicates significant difference between SPA groups, $p<.05$; SPA=sensitivity to physical activity; BI=Body mass index; 6MWT=Six minute walk test; QWB=Quality of Well Being

Table 2

Bivariate correlation matrix between SPA and study measures

	1	2	3	4	5	6	7	8	9	10	11
1. SPA	1.00										
2. TSK	.24	1.00									
3. SF-36 PF	-.20	-.49**	1.00								
4. 6MWT Meters	.13	-.44**	.39**	1.00							
5. 6MWT RPE	.65**	.20	-.28*	.22	1.00						
6. QWB-pain freq	.50**	.35*	-.61**	-.22	.37**	1.00					
7. QWB-pain sev	.41**	.38*	-.65**	-.26	.35*	.94**	1.00				
8. TS 44ºC	.20	-.17	.01	-.19	.07	.01	-.03	1.00			
9. TS 46ºC	.10	-.16	.10	.02	.06	-.23	-.10	.65**	1.00		
10. TS 48ºC	-.20	-.11	.12	-.08	.14	-.08	-.05	.53**	.63**	1.00	
11. Steps per day	-.32*	-.54**	.54**	.41**	-.17	-.38**	-.36**	-.02	-.04	.11	1.00

Note: *=p<.05; **=p<.001; SPA=Sensitivity to physical activity; TSK= Tampa Scale of Kinesiophobia score; PF=Physical function; 6MWT=6 meter walk test; QWB= Quality of well-being; freq=frequency; sev=severity;TS=temporal summation.

Table 3.

Hierarchical regression analysis with (A) 6MWT performance, (B) 6MWT RPE, (C) Physical function, (D) Frequency of activity-related pain, (E) Severity of activity-related pain, and (F) Steps per day as dependent variables.

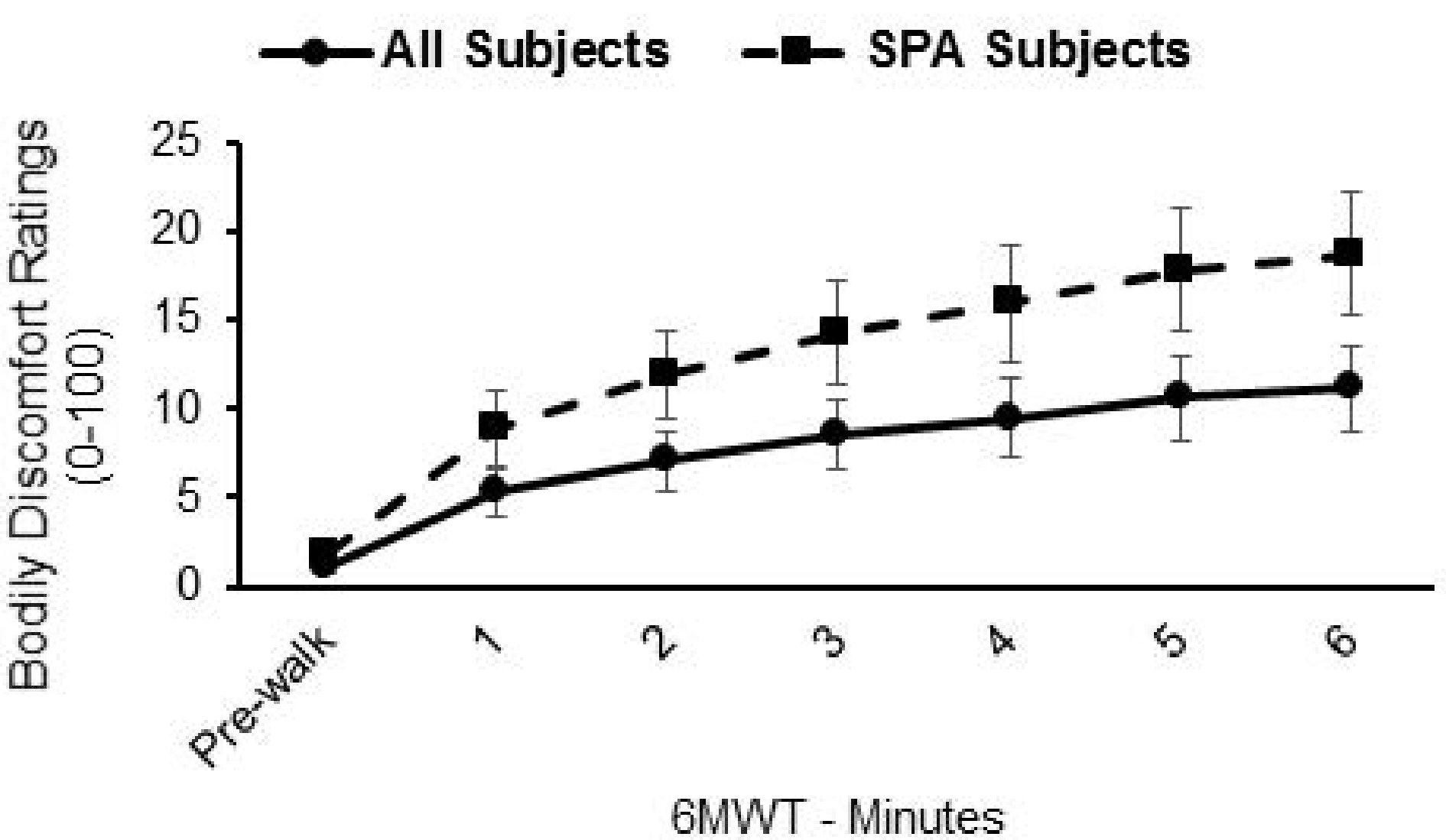
Dependent Variables and Step number	R	ΔR^2	Standardized β	P value for β	Model P-value	Multi-Collinearity Statistics	
						Tolerance	VIF
A. Predicting 6MWT performance							
1. Sex	.498	.248	-.40	.001*	<.000	.969	1.032
BMI			-.256	.029*		.913	1.096
2. TSK	.646	.168	-.475	<.001*		.865	1.155
3. SPA	.669	.031	.184	.111		.913	1.095
B. Predicting RPE on 6MWT							
1. Age	.358	.128	.250	.025*	<.000	.920	1.087
2. 6MWT-meters	.447	.072	.175	.107		.953	1.049
3. SPA	.702	.293	.565	<.001*		.918	1.089
C. Predicting Physical function on the SF-36							
1. TSK	.494	.244	-.473	.001*	.001*	.941	1.062
2. SPA	.500	.250	-.084	.514		.941	1.062

D. Predicting frequency of activity-related pain on the QWB-pain scale							
1. TSK	.352	.124	.247	.050	<.001*	.941	1.062
2. SPA	.549	.177	.434	.001*		.941	1.062
E. Predicting severity of activity-related pain on the QWB-pain scale							
1. TSK	.378	.143	.298	.024*	.001*	.941	1.062
2. SPA	.496	.104	.332	.012*		.941	1.062
F. Predicting average steps per day							
1. BMI	.367	.135	-.180	.148	<.001*	.939	1.066
6MWT-meters			.179	.179		.822	1.217
2. TSK	.299	.253	-.316	.025*		.755	1.325
3. SPA	.368	.070	-.284	.032*		.853	1.172

Table 4.

Predicting SPA with Hierarchical Regression Analysis

Dependent Variables and Step number	R	ΔR^2	Standardized β	P value for β	Model P-value	Multi-Collinearity Statistics	
						Tolerance	VIF
1. TSK	.479	.229	.415	.003*	.002*	.942	1.062
TS 44ºC			.359	.010*		.942	1.062


All Subjects
SPA Subjects
Bodily Discomfort Ratings
(0-100)
25
20
15
10
5
0
Pre-Walk
1
2
3
4
5
6
6MWT - Minutes