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The effects of manipulating the inter-stimulus-interval on heat-evoked temporal summation of second pain across the age span

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Abstract

This study examined the effects of inter-stimulus-interval (ISI) on heat-evoked temporal summation of second pain (TSSP) and tested whether greatest maintenance of TSSP would occur at longer ISIs in older adults. Several lines of evidence support that TSSP is associated with central sensitization and is centrally mediated. The participants were 198 community-dwelling adults divided into three age cohorts (18–39, 40–59; and 60–78 years of age). Six TSSP trials used a train of 10 contacts with a preheated probe that made repetitive contact with the volar forearm. Participants completed two trials at each ISI of 2.5-sec, 3.5-sec and 4.5-sec. The intraclass correlations for each pair of trials support the reliability of the current methodology. TSSP scores declined in a time dependent manner across ISI. In addition, greater maintenance of TSSP at longer ISIs was observed in middle-aged and older age groups compared to the younger cohort. Significant associations were found between TSSP and measures of recent pain. Greater summation at longer ISIs in older adults would suggest slower decay of excitability in spinal neurons and infer increased risk for central sensitization with advancing age.

1. Introduction

In part because of gains in life expectancy, the study of pain in older adults is gaining interest. Community-based and clinical findings indicate that older adults are at greater risk for more frequent and prolonged pain and suffer from pain at multiple sites compared to younger cohorts (21,31,48). In addition, pain is the number one reason for disability in older persons (23,31).

Although multiple mechanisms likely contribute, findings from laboratory research suggest dysfunction in pain modulatory mechanisms may place older adults at increased risk for an increased transition from acute to chronic pain associated with aging (8,9,18,38.) Pain modulatory mechanisms include increased pain facilitation likely caused by a sensitized

central pain system (53). Central pain sensitization represents changes in the functional properties of spinal nociceptive neurons in the dorsal horn and is evidenced by diverse experimental noxious conditioning stimuli including enhanced temporal summation (54).

Temporal summation of second pain (TSSP) results from repetitive stimulation of peripheral C-fibers. Typically, short discrete painful thermal stimuli of a constant intensity are administered and the delayed sensation of second pain is rated. The time delay is a function of the slower transmission speed of unmyelinated C-fibers (34) and pain summation is produced using inter-stimulus intervals of up to 3-sec and in humans it degrades with longer intervals and becomes minimal by 6-sec (29,49). A number of studies have compared temporal summation across different age cohorts using various stimulus modalities, with heat-evoked pain the most common. These studies have examined differences across the age span using a series of stimuli at a standardized stimulus interval (SI) and inter-stimulus interval (ISI) with mixed findings (22). Two studies have tested for differences in heat-evoked TSSP across a range of ISIs, both using only three and nine healthy participants respectively (29,49). We are unable to find studies that have tested for age differences at different ISIs.

The aim of this study was to examine the effects of manipulating the ISI on heat-evoked TSSP and on age differences therein. The first aim was to successfully demonstrate summation of second pain using our novel TSSP testing protocol as a recent review has reported a substantial number of individuals fail to show positive heat pain summation profiles. (1) Next, Hypothesis 1 proposed that reduced TSSP scores would be observed under conditions of increased ISI. We then tested Hypothesis 2, that enhanced TSSP would be observed in older adults compared to younger cohorts and Hypothesis 3, that greatest maintenance of TSSP at longer ISIs would occur in older adults. In addition, this study adds to the aging literature with the inclusion of a middle-aged group which has not been tested in previous studies of TSSP. Earlier studies of temporal summation have compared younger cohorts (mean age in the early to mid-20s) with older groups 55 years of age and older. Finally, associations between TSSP and measures of psychological functioning and recent pain are reported.

2. Methods

2.1. Participants

Participants were 198 community dwelling adults that included 88 younger adults (Age: $M=25.4$, $SD=5.5$, age range: 18–39 years; 47 females and 41 males), 48 middle-aged adults (Age: $M=49.9$, $SD=5.3$, age range: 40–59 years; 25 females and 23 males) and 62 older adults (Age: $M=67.9$, $SD=5.2$, age range: 60–80 years; 31 females and 31 males). The sample was recruited as part of a larger study examining age-related changes in pain inhibitory and facilitatory function. Recruitment and study procedures were approved by the University of Florida Institutional Review Board. Written informed consent was obtained from all participants.

Study exclusion criteria included a Mini Mental Status score below 23, current use of narcotics or chronic use of analgesics, uncontrolled hypertension, systemic disease that

restricts normal daily activities, neurological problems with significant changes in somatosensory and pain perception at the intended stimulation sites, and serious psychiatric conditions (e.g., schizophrenia and bipolar disorder). We excluded participants who received a Grade 4 (i.e., severely limiting pain) on the Graded Chronic Pain Scale (51). Participants refrained from the use of any pain medication or coffee on the day of testing.

2.2. Apparatus

Testing was performed on a Thermo-Electric Stimulation System (Neuroanalytics, Gainesville FL). Thermal stimuli were administered by a 40×40mm thermode (Peltier thermoelectric device) housed in a freestanding stimulation module that was adjustable from 20–28 inches in height. At rest, the thermode is recessed behind a cutout in a thermally neutral plastic surface and out of contact with the skin. The thermode is brought into reproducible light skin contact and retracted following each contact by a solenoid-powered mechanism with temperature and thermode positions controlled by a computer.

Experimental pain was measured with an electronic visual analog scale (eVAS). The eVAS consisted of a low-friction sliding potentiometer of 100 mm travel. The left endpoint of the scale was identified as “no pain”, while the right endpoint was defined as “intolerable pain”. The position of the slider was electronically converted into a pain rating between 0 and 100. The slider automatically returned to the left (“no pain”) position when so required by the protocol. The eVAS was mounted into the surface of a small inclined desk positioned to facilitate precise operation with minimal fatigue. The experimental set-up allows the participant to be separated from the investigator and facing away to minimize non-verbal communication and transmission of bias.

2.3. Study procedures

2.3.1. Orientation and training session—Individuals who were interested in the study were provided information about the procedures, informed about privacy regulations, and reviewed and signed an Informed Consent Form. Eligibility for the study was determined after participants completed a health history questionnaire, supplemented by interview and blood pressure measurement. As part of this orientation participants watched a PowerPoint presentation with imbedded video and audio overlay that described using a 0–100 pain scale, the nature of second pain, and the TSSP testing sequence. This included instructions to rate the late sensation experienced between thermode contacts similar to Vierck (49) and Staud (45).

In addition to experiencing other sensory testing procedures, participants received multiple practice trials with the TSSP testing procedures using several temperatures. During the training session, an individualized temperature was determined such that participants would experience at least moderate pain during the temporal summation series, similarly to the process used by Staud (43,44). When pain was not experienced by the second trial or surpassed 70 during a trial the testing temperature was adjusted up or down, respectively, as needed. Using an individualized temperature has been shown to increase the success rate in demonstration of temporal summation and minimizes both floor and ceiling effects (11,15).

2.3.2. Testing sessions—Participants were seated on a comfortable chair and relaxed for several minutes. Then, two blood pressure readings were taken separated by 5 minutes. A third blood pressure measurement was taken if there was a change of greater than 5% in the first two readings. During the session, subjects completed an ascending/descending series, offset analgesia, and temporal summation trials in a counterbalanced order.

This paper presents data from trials of TSSP using thermal heat stimuli at the volar forearm. The temperature of the thermode used in the temporal summation trials was verified for each participant based on their data from the orientation and training session (see above). Prior to the administration of the TSSP trials, participants watched an additional short video describing the procedure and providing instructions on distinguishing between first pain second pain. Then, participants were administered up to two practice trials to ensure comfort with the procedure. All temporal summation trials used a train of 10 contacts at a constant, individualized temperature with stimulus contact interval of 0.8-sec and an inter-stimulus-intervals (ISI) of 2.5-sec, 3.5-sec and 4.5-sec during which the thermode was retracted. Participants completed two trials using painful heat stimuli at each ISI for a total of six TSSP trials. All trials were separated by a minimum of 3 minutes and administered in counterbalanced order.

2.4. Measures of biopsychosocial functioning

Center for Epidemiological Studies – Depression Scale (CES-D).—The CES-D is a 20-item measure of symptoms of depression that has been shown to be reliable and valid in both general and clinical populations (3).

Pain Catastrophizing Scale.—The PCS asks the respondents to reflect upon past painful experiences and to rate the degree to which they experienced negative thoughts or feelings about pain (47). Catastrophizing is a multidimensional construct composed of rumination, helplessness, and magnification.

State Trait Anxiety Inventory-Trait.—The STAI-T has extensive normative data and is a frequently used measure of anxiety in pain studies (42). The Trait-Anxiety subscale consists of 20 items that evaluate how respondents generally feel.

Short-Form Health Survey-36 Bodily pain subscale (SF-36 BP).—The SF-36 is a health survey that of health status designed for use in the general population (52). The SF-36 BP assesses bodily pain intensity and interference of pain with normal activities. For the Bodily Pain Scale score a higher score indicates less bodily pain.

Graded Chronic Pain Scale (GCPS).—The GCPS is a 7-item scale that asks about pain severity and disability that results from pain and was designed to assess pain in the general population (51). The original version asked about pain over the past 6 months, however this measure is commonly used to assess pain in the past 3-months (50), as was done in this study. The frequency of endorsed pain sites was also recorded.

2.5. Data reduction and analysis

2.5.1 Demonstrate summation of second pain—Descriptive statistics for TSSP ratings at each of the ten stimuli (S1-S10) for each of the two trials at the three ISIs (2.5-sec, 3.5-sec and 4.5-sec) were calculated and their distributions examined. Pain ratings at each of the ten stimuli (S1, S2...S10) for the two trials at each of the three ISIs (2.5-sec, 3.5-sec and 4.5-sec) were averaged. To test whether pain ratings increased across each contact (S1 through S10), repeated measures ANOVAs (stimulus number as the within-subjects factor) were performed for each ISI (2.5-, 3.5- and 4.5-sec). Thermode temperature was used as a covariate.

2.5.2 Magnitude of overall TSSP across ISI.—The magnitude of TSSP for each of the two trials at the three ISIs (2.5-sec, 3.5-sec and 4.5-sec) was calculated by subtracting the pain intensity rating of the first stimuli (S1) from the pain intensity of 10th stimuli (S10 minus S1). Interclass correlation coefficients (ICC) were calculated between pairs of S10 minus S1 scores for each of the three ISI to confirm the reliability of TSSP trials. The study primary dependent variables, TSSP2.5, TSSP3.5, and TSSP4.5 were then calculated by averaging the difference between the first stimuli (S1) from the pain intensity of 10th stimuli (S10 minus S1) for each of the ISIs (2.5-sec, 3.5-sec and 4.5-sec.). To test Hypothesis 1, that TSSP was reduced at longer ISI, a repeated measures ANOVA (ISI as the within-subjects factor) was conducted using the three TSSP scores (TSSP2.5, TSSP3.5, and TSSP4.5).

2.5.3 Magnitude of TSSP across Age x ISI—To test Hypothesis 2, that enhanced TSSP would occur in older adults compared to younger cohorts, an Age x ISI mixed model ANOVAs with repeated measures on ISI were conducted on the TSSP scores (i.e., 10th stimuli rating – 1st stimuli rating). Thermode temperature and sex were used as covariates. Post-hoc tests were conducted using Tukey's honestly significant difference procedures.

To test for age differences within each individual in the maintenance of TSSP (Hypothesis 3), two variables, TSSP2.5 – 3.5 and TSSP2.5 – 4.5 were created and tested using an Age x ISI mixed model ANOVAs with repeated measures on ISI scores.

2.5.3 Associations of TSSP with recent pain—Pearson correlation coefficients were calculated to test for associations between TSSP and measures of psychological functioning and recent pain. The TSSP-Ave score was used because of the high correlations between the TSSP variables (TSSP2.5, TSSP3.5, TSSP4.5; *r*'s of 0.59 to .65). In addition, TSSP2.5 – 4.5 was also tested for associations with psychological functioning and recent pain

3.0 Results

There were no age cohort differences on measures of trait anxiety (STAI-T = 30.1, SD = 7.6), depression (CES-D = 8.0, SD = 7.3), and pain catastrophizing (PCS = 10.1, SD = 9.2) by age group. Group differences were found for the SF-36 BP and GCPS intensity but not GCPS disability (Table 1). Thermode temperature differed across age cohorts at $p < .001$ (18–39, mean = 48.5°C, SD = 1.4; 40–59, mean = 48.8°C, SD = 2.0; 60–80, mean = 49.7°C, SD = 1.7).

3.1 Summation of second pain

Figure 1 presents mean and standard error for the pain ratings at each of the ten stimuli (S1-S10) in a TSSP series for the 2.5-sec, 3.5-sec and 4.5-sec ISI. Repeated measures ANOVAs testing for differences in pain scores indicated a significant multivariate effect of contact number for 2.5-sec ISI [$F(2.094,397.843) = 15.231, p < .001$], 3.5-sec ISI [$F(1.842,350.004) = 17.512, p < .001$], and 4.5-sec ISI [$F(1.590,302.195) = 13.492, p < .001$] indicating overall positive profiles. As Mauchly's Test of Sphericity was significant, the Greenhouse-Geisser correction was applied.

3.2 Magnitude of overall TSSP across ISI

The ICC for each pair of trials were 0.83 for 2.5-sec, 0.81 for 3.5-sec and 0.82 for 4.5-sec for S10-S1 and support the combining of pairs of ISI trials. ICCs when calculated within age group ranged from 0.83–0.75. Table 2 presents the overall mean and standard deviation for TSSP at each ISI (2.5-sec, 3.5-sec and 4.5-sec). Repeated measures ANOVA testing for differences in TSSP between ISIs indicated a significant multivariate test of ISI [$F(2,382)=178.179, p < .001$]. Pairwise comparisons revealed differences at $p < .001$ between each mean (2.5 ISI: mean = 34.3, 95% confidence interval (CI) = 32.7–35.8; 3.5 ISI: 27.0, 95% CI = 25.2–28.8; 4.5 ISI: 20.9, 95% CI = 19.0–22.8) and supports Hypothesis 1.

3.3 Magnitude of TSSP across Age x ISI

Table 2 also presents the mean and standard deviation for TSSP at each ISI (2.5-sec, 3.5-sec and 4.5-sec) by age group (also see Figure 2). Repeated measures ANOVA testing the hypothesis that older adults would demonstrate enhanced temporal summation compared to the younger groups using the TSSP variable indicated a main effect of age [$F(2,189)=13.754, p < .001$] supporting Hypothesis 2. However, this effect was superseded by a significant age x ISI interaction [$F(4,374) = 5.414, p = .001$].

Pairwise comparisons indicated that for the 2.5-sec ISI series, the younger group (mean = 31.6, 95% CI, 29.4–33.9) demonstrated less temporal summation than the middle age group (mean = 35.9, 95% CI, 32.7–39.1) and the older group (mean = 36.9, 95% CI, 34.1–39.6), but the middle age and older groups were not different. For the 3.5-sec ISI series, all three groups were significantly different [younger group (mean = 23.2, 95% CI, 20.7–25.6); middle age group (mean = 28.3, 95% CI, 24.8–31.8); older group (mean = 31.6, 95% CI, 28.6–34.5)]. For the 4.5-sec ISI series, all three groups were significantly different [younger group (mean = 15.5, 95% CI, 13.0–17.9); middle age group (mean = 21.6, 95% CI, 18.1–25.1); older group (mean = 28.1, 95% CI, 25.2–31.1)].

Repeated measures ANOVA further tested the hypothesis that older adults would show greater maintenance of TSSP and indicated a significant Age x ISI ($F(2,187) = 3.565, p = .030$). For the TSSP2.5–3.5 variable, the younger group demonstrated a greater reduction in TSSP (mean = 8.4, 95% CI, 6.5–10.3) compared to the older group (mean = 5.3, 95% CI, 3.0–7.6), whereas the middle-age group (mean = 7.6, 95% CI, 4.9–10.3) did not differ from either of the other groups. For the TSSP2.5–4.5 variable, the younger group (mean = 16.2, 95% CI, 14.1–18.2) and the middle-aged group (mean = 14.3, 95% CI, 11.3–17.3),

demonstrated a greater reduction in TSSP compared to the older group (mean = 8.7, 95% CI, 6.3–11.3), whereas the younger and middle-age groups were not different. These findings support Hypothesis 3 that greatest maintenance of TSSP would occur at longer ISIs in older adults.

3.4 Associations of TSSP with psychological and recent pain variables

Correlations between TSSP-Ave or TSSP2.5–4.5 and STAI-T, CES-D, and PCS scores were not significant (all $p < .15$). Both TSSP-Ave or TSSP2.5–4.5 were correlated with the four recent pain variables (ranging from $p < .001$ to $p = .03$). To further examine these associations, linear regression was used entering sex and age in step one and examining the $R^2 =$ in a second step for TSSP-Ave or TSSP2.5–4.5 for each recent pain variable in separate models (Table 3).

4. Discussion

The objectives of this study were to examine the effects of the manipulation of ISI on heat-induced TSSP and to test whether these effects differ across three age cohorts. Using a TSSP testing protocol that used repetitive contact of the skin with a preheated probe, TSSP scores declined in an ISI dependent manner across ISIs of 2.5-sec, 3.5-sec, and 4.5-sec. As hypothesized, greater maintenance of TSSP at longer ISIs was observed in middle-aged and older age groups compared to the younger cohort. To the best of our knowledge, no study has successfully used an ISI manipulation to demonstrate age differences in TSSP.

4.1 TSSP shares characteristics with wind-up

TSSP is relevant to the study of pain because of the association with dorsal horn neuron wind-up and therefore, central sensitization. Wind-up was first described by Mendell as facilitation of dorsal horn neuron activity in the cat spinal cord induced by repetitive electrical stimulation of peripheral C-fibers at train frequencies of up to 3-sec (24). Central sensitization results in an enhanced excitability of spinal cord neurons, and therefore, pain is less connected to the presence, strength, or duration of pain from peripheral stimuli (17). Central sensitization has provided a mechanistic explanation for many of the temporal, spatial, and threshold changes in pain sensitivity seen in persistent pain (53).

Since in vivo recordings of wind-up from human dorsal horn neurons are not feasible, heat-evoked TSSP protocols represent proxies for the phenomenon of wind-up. Several lines of evidence support that TSSP is associated with wind-up and that TSSP is centrally mediated. First, studies have found similar intervals were required for TSSP to be observed in healthy volunteers (29,49). Another parallel is that N-methyl-D-aspartate receptor antagonists attenuate both wind-up in experimental animals (5,6) and the temporal summation of electrical and thermal evoked pain in human subjects (2,35,49).

4.2 Inconsistent findings for age differences

Marouf (22) provided a review of studies testing for age differences in temporal summation and placed them into 3 categories based on the pain stimulus. No age differences have been reported for mechanical stimulation that included pressure algometer (18), punctate using

large von Frey filaments (37), and rapid inflation of pressure cuff (32). These methods activate cutaneous and deeper tissues and stimulate a combination of A-delta and C-fibers. Several studies have used the nociceptive or flexor withdrawal reflex which is elicited following activation of nociceptive A-delta afferents (39) and showed small to no age effects (10,22,26). The most commonly tested stimulus has been noxious heat which activates Ad and C-fibers, but more predominantly C-fibers. Edwards (9) reported enhanced summation for elders only at lower temperatures, whereas Lautenbacher (28) reported summation for older but not younger participants. A larger study found the oldest individuals experienced greater heat temporal summation at the forearm compared to a middle-aged group with no differences at the knee (37). Naugle (25) reported differences for increases in spatial characteristics of second pain but not pain intensity ratings, although the findings for intensity were in the direction of greater TSSP for the older group. Marouf proposed that specific nociceptive fibers activated by each stimulus modality are responsible for the above reviewed mixed pattern of findings (22).

Pain evoked by a range of stimuli (electrical, mechanical, thermal) can summate. However, by definition, TSSP depends on spinal processes driven by the activation of C-fibers (49). Thermal heat is suitable for rating of second pain, particularly when participants are trained to rate the late sensation (25). Other methodologies may summate because of peripheral sensitization, brain level processing following multiple stimulations, loss of descending inhibition, or other aspects of central sensitization but not the C-fiber mechanism as described in wind-up (22)

4.3 Lack of robust findings for heat TSSP

Recently, the robustness and validity of heat-evoked temporal summation has been questioned because studies have reported a substantial number of trials failing to display positive summation profiles (1,11,36). To address this, studies have adjusted stimulus parameters such as temperature or method of calculation in an attempt to improve the percentage of participants who demonstrate reliable temporal summation (1,11,15,43). The advantage of individualized temperatures when participants have very different thresholds for noxious stimuli is that floor and ceiling effects are avoided. Enhanced validity may also result from instructions and practice in rating second pain. Robust TSSP using a procedure involving intermittent, repetitive contact of the skin with a preheated probe has recently been demonstrated (7). Vierck (49) has already shown superior TSSP with this technique compared to a thermode which ramps to the targeted temperature and returns to baseline temperature while in constant contact with the skin. The current study used this intermittent-contact methodology with carefully trained participants and individualized testing temperatures. This method produced substantial temporal summation with good to excellent reliability in this large sample.

4.4 ISI manipulation

This study is novel in that we tested for differences using an ISI manipulation. TSSP magnitude declined across ISI of 2.5-sec, 3.5-sec, and 4.5-sec, which is consistent with animal studies where frequencies of up to 3-sec were needed to facilitate wind-up of dorsal horn neurons. Greater summation at longer intervals in older adults would suggest slower

decay of spinal excitability and imply differences in the maintenance of central sensitization. In healthy controls, several studies have shown a lack of significant summation at intervals between 4-sec and 6-sec, similar to physiological demonstrations of wind-up summation (29,49). Staud demonstrated a pattern of reduced TSSP as ISI increased from 2-sec through 5-sec, but no test of significance across ISI was reported (45). Staud also established that following a train of stimuli at 3-sec ISI, lower stimulus frequencies (6-sec to 12-sec) maintain enhanced second pain (44). In an animal model, Li showed that once wind-up of wide dynamic range neurons occurs, wind-up is maintained by lower frequency C-fiber stimulation (19). It appears that for both wind-up and TSSP, once a sensitized state is reached, it can be maintained by lower frequency stimulation.

4.5 Clinical relevance of TSSP

Clinical relevance of TSSP testing is supported by studies which have shown that compared to healthy comparison groups, samples of patients with widespread pain (27), knee osteoarthritis (32), headache (4), low back pain (30), painful gastrointestinal disorders (41), temporomandibular pain (14), and fibromyalgia (28,45,46) demonstrate enhanced summation. However, other studies have not found differences (20,36). The implications is that chronic pain is maintained by this altered excitability of the central nervous system. There is also limited evidence for a prospective effect of TSSP on treatment outcome from hip replacement surgery (13,33) and onset of temporomandibular pain (12).

To the best of our knowledge, this is the first study to demonstrate an association between TSSP and recent pain using measures designed for population use across the adult lifespan including middle-age. These measures are an aggregate of many acute and chronic pain experiences, thus suggesting that persons who suffer from pain in general that is not formally classified as “chronic pain” may experience changes in central pain processing. The substantial TSSP at longer ISI in middle-aged and older participants supports the hypotheses that aging is associated with enhanced central nociceptive excitability that result in greater risk for more frequent and prolonged pain (21,31). Future research is warranted to verify the causal direction of the relationship and demonstrate the extent to which it varies with age.

4.6 Summary and Conclusion

Limitations of this study include that participants were recruited from the community at large and sampling bias is likely and that measures of current and past health were self-report. Also, many genetic and non-genetic factors that contribute to aging were not measured (40). This study has several strengths which include a large sample that included middle-aged adults, stimulus intensity that was adjusted to avoid floor or ceiling effects, and participants who were well-trained in rating the delayed sensation of C-fiber mediated second pain.

In conclusion, TSSP scores declined in an ISI dependent manner across ISIs of 2.5-sec, 3.5-sec, and 4.5-sec and greater maintenance of TSSP at longer ISIs was observed in middle-aged and older age groups compared to the younger cohort. These results also support findings by Larivière that that changes in central pain processing begin to occur in middle-

age (16). To the best of our knowledge, no study has successfully used an ISI manipulation to test for differences between groups thought to differ on TSSP. Greater summation at longer intervals in older adults would suggest slower decay of excitability in spinal neurons and potentially infer increased risk for central sensitization with advancing age.

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Figure 1.
Second pain ratings for each contact by ISI

Figure 2.
Temporal summation of second pain by age and ISI

Table 1.

Mean and standard deviation for recent pain measures by age group.

	SF-36 BP*	GCPS disability**		GCPS intensity**		GCPS # pain sites		GCPS Pain Grades		
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Grade 0 % (n)	Grade 1 % (n)	Grade 2 % (n)	Grade 3 % (n)	
Younger group (18–39, n=88)	85.4 (19.3)	11.8 (20.5)	22.6 (23.5)	1.4 (1.3)	37% (n=34)	50% (n=46)	8% (n=7)	7% (n=6)		
Middle-aged (40–59, n=45)	74.4 (22.6)	11.2 (18.9)	29.6 (23.5)	1.5 (1.4)	27% (n=12)	50% (n=22)	14% (n=6)	9% (n=4)		
Older (60–80, n=62)	76.3 (22.6)	11.8 (15.9)	30.9 (22.9)	1.8 (1.3)	20% (n=12)	53% (n=33)	18% (n=11)	10% (n=6)		
p. value for age difference	.004	>.010	.022	>.010		.201	***			

Short-Form Health Survey-36, bodily pain (SF-36 BP), Graded Chronic Pain Scale (GCPS).

* Higher scores on the SF-36 reflect less pain and pain-related interference.

** Higher scores on the GCPS reflects greater pain and disability.

*** Although overall differences were not significant, post-hoc pair-wise comparisons indicated differences in GCPS Pain Grade between the younger and older groups ($p = .015$).

Table 2.

Mean and standard deviation for TSSP for the total sample and by age group.

	TSSP-Ave *			
	TSSP2.5	TSSP3.5	TSSP3.5	TSSP4.5
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Younger (18–39, n=88)	31.2 (10.5)	22.0 (12.1)	15.0 (11.7)	23.1 (10.2)
Top-aged (40–59, n=45)	35.7 (10.3)	27.4 (12.7)	21.4 (11.9)	28.3 (10.9)
Older (60–80, n=62)	36.8 (11.0)	32.6 (12.9)	29.6 (14.6)	33.2 (11.5)
Total sample	34.3 (10.8)	26.5 (13.0)	20.9 (13.5)	27.5 (11.3)

* TSSP-Ave was calculated as (TSSP2.5 + TSSP3.5 + TSSP4.5) / 3

Table 3.

Associations between TSSP and measures of recent pain

	SF-36 BP*	GCPS disability**	GCPS intensity**	GCPS # pain sites
TSSP-Ave	R ² = .075 p < .001	R ² = .061 p = .001	R ² = .08 p < .001	R ² = .049 p = .002
TSSP2.5-4.5 ISI	R ² = .014 p = .089	R ² = .019 p = .059	R ² = .038 p = .006	R ² = .033 p = .011***

Short-Form Health Survey-36, bodily pain (SF-36 BP), Graded Chronic Pain Scale (GCPS).

* Higher scores on the SF-36 reflect less pain and pain-related interference.

** Higher scores on the GCPS reflects greater pain and disability.

*** To adjust for multiple comparisons the critical value was adjusted to p = .01