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The Effects of Gender and Aging on Pain Perception

The purpose of this study was to examine how the perception of pain, induced in the cold pressor test, is related to age and gender. Volunteers (40 men and 40 women), aged 18-23 and 65-81 years, immersed their dominant hand in a bucket of water kept at 2º C. Pain threshold was determined as the time taken to notice pain from the stimulus. Pain tolerance was determined as the time before the participant removed his or her hand from the water, presumably because the pain became too intense. Analyses revealed that pain thresholds remain constant across age and gender, but that women have lower pain tolerance than men. Also, pain tolerance is lower for older adults than for younger adults.

Aging is associated with a high prevalence of degenerative diseases that often result in acute and chronic pain. Because pain can cause a significant reduction in one's quality of life (Pickering, Jourdan, Eschalier, & Dubray, 2002), it is an important public health issue. In fact, those who experience pain are more depressed, less productive, and require more sick days than those who do not experience pain (McGuire, Wells, Bruce, Miranda, Scheffler, Durham, Ford, & Lewis, 2002). Pain perception is a highly complicated process that is related to numerous psychological, physiological, and behavioral factors. In addition, the experience of pain may vary with gender (Berkley, 1997; Dao, 2001).

Despite older adults' higher risk for illnesses involving pain, many dismiss pain experienced by older individuals as a normal part of the aging process. Because research on pain perception is typically done on young or middle-age adults, the literature on age differences in pain perception is quite limited, and often contradictory. Pain threshold is defined as "the first barely perceptible pain to appear in an instructed subject under given conditions of noxious stimulation" (Buchanan & Midgley, 1987, p. 510). And pain tolerance is defined as "the greatest level of stimulation at which the subjects request stimulus cessation" (Woodrow, Friedman, Sieglaub, & Collen, 1972, p. 552).

The effect of aging on pain tolerance can greatly depend on the type of pain. Some studies suggest that there is an approximately 20% increase in pain threshold for older adults for certain types of pain, such as mechanical and electrical (Jensen, Rasmussen, Pedersen, Lous, & Olesen, 1992; Tucker, Andrew, Ogle, & Davidson, 1989). However, Pickering et al. (2002) reported that thermal pain thresholds, specifically, remains relatively constant throughout the aging process, whereas pain threshold to pressure decrease with age, particularly in men. With regard to pain tolerance, Walsh, Schoenfeld, Rammamurthy, and Hoffman (1989) suggested there is a significant decrease in tolerance to cold stimuli with increased age. Gibson and Helme (1995) reported that, in comparison to younger adults, older adults have a lower pain threshold and tolerance level to very strong levels of noxious stimuli, particularly mechanical pressure and cold pain sensation.

Not much is known about gender differences in pain perception, but the data that have been collected

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suggest that men and women respond differently to painful stimuli. Most clinical trials of pain perception and of new pain management tools have been restricted to men, due in part, to concerns about exposing women of childbearing age to unknown and potentially harmful drugs (Miaskowski, 1999). Recent research examining gender differences, however, suggests that women tend to report more pain and show a lower tolerance than men to high levels of electric shock (Lautenbacker & Rollman, 1993), heat stimuli (Feine, Bushnell, Miron, and Duncan, 1991), and mechanical pressure (Ellermeier & Wetsphal, 1994; Kelli, 1999; Pickering et al., 2002). Several studies, in fact, have shown that while pain thresholds are relatively constant across gender, pain tolerance tends to be lower in women (Ellermeier & Westphal, 1994; Hellstrom & Lundberg, 2000). With regard to cold pain stimuli, there appears to be no reliable difference in pain thresholds between men and women, but cold pain tolerance is higher in men than in women (Hellstrom & Lundberg, 2000). Although experimentally induced pain is the topic of interest in this study, it is important to note that research on clinical pain is in agreement that women tend to report pain that is more severe, more frequent, and of longer duration than do men (Dao, 2001).

The periodic variation of some pain conditions, both clinical and experimentally induced, across the menstrual cycle suggests that reproductive hormones may influence pain perception. Romano, Harlan, Shivers, Howells, and Pfaff (1988) reported that, in rats, estrogen can regulate opioid receptors, which mediate analgesia. Hellstrom and Lundberg (2000) also reported that pain thresholds in women vary across different times of the menstrual cycle, such that women are less sensitive to pain when estrogen levels are higher. Riley, Robinson, Wise, and Price (1999) studied the perception of experimentally induced pain across the menstrual cycle and found pain threshold and tolerance to be higher during the follicular phase (days 6-11), when estrogen was the highest, than in later phases. Because estrogen levels appear to have an effect on pain perception in women, one might infer that pain perception in elderly women who have gone through menopause will be affected.

The purpose of this study was to examine how the perception of pain is related to gender and age. Specifically, the study is designed to probe the interaction between gender and pain across the lifespan by measuring pain threshold and pain tolerance to a cold stimulus in both young and old men and women. The cold pressor test is a widely used test, which brings forth an emotional/motivation pain experience from the immersion of a limb in cold water, and chosen for use in this study mainly for the reason of ease of testing. While it has been shown that gender differences exist in the perception of cold water pain (Walsh, et al., 1989), the purpose of this study was to expand on these findings by examining whether these differences are consistent across the lifespan. The hypotheses are that (a) pain threshold to cold pain will remain constant across gender and age, but that (b) pain tolerance will be higher in men than in women, and that (c) pain tolerance will be higher in younger adults than in elderly adults. In addition, (d) the data will show a significant interaction between age and gender on pain tolerance to the cold stimuli.

Method

Participants

Forty college students aged between 18-23 years (20 men and 20 women) and 40 older adults, aged 65-81 years from two senior living communities in upstate New York (20 men and 20 women) volunteered to participate in the study. Participants who had any physiological or psychological disorders likely to impair sensory function were excluded. Data from the younger participants were collected in a laboratory setting at a small liberal arts college in upstate New York; the older participants were tested in their homes. College students received extra credit points in their psychology courses, and older volunteers received a raffle ticket for a dinner for two.

Materials

The cold water bath was created by chilling water in a bucket of ice until it reached the temperature of 2º C. The water only (no ice cubes) was then poured into an insulated bucket. Participants were instructed to immerse their fisted hand in the water to just above the wrist. There were three different insulated buckets—one used for each trial with each participants. Immediately prior to testing, the temperature of the water was recorded by an instant-read thermometer to ensure that it was at the correct temperature.

Procedure

To recruit participants, notices requesting volunteers were posted at the college campus and the two senior living communities. Upon their arrival at the testing site, participants read and signed a consent form that explained the purpose of the study, and stated that they could terminate the stimulus at any time, or withdraw from the experiment with no penalty. Pain perception was measured using the cold pressor test. The participant was instructed to say the word "painful" when the cold water first became painful. This measured the participant's pain threshold. In order to measure pain tolerance, each participant was

TABLE 1

Pain Tolerance Measured in Seconds

	Mean Tolerance	
	Young	Old
Men	78.21 (32.87)	74.70 (40.11)
Women	59.45 (43.64)	32.23 (30.38)

Note. SD in parentheses; $n = 20$ for each group.

instructed to hold his or her hand in the water as long as possible and to remove it as soon as the pain became too intense. Submersion was limited to 2 min to avoid any damage to the hand. Once participants removed their hand, they were given 5 min to let their hand warm up and rest. Two more trials were conducted in the same way, using the same hand for each trial. The mean time it took participants to first notice pain and the mean time it took them to remove their hand from the water were measured with a stopwatch.

Results

Two measures were derived from each participant. Participants were measured on the mean time taken to notice pain from the stimulus (threshold) and the mean time taken to remove the painful stimulus (tolerance). The means and standard deviations of the pain tolerances for the participants in each group are shown in Table 1.

A 2 X 2 (gender and age) between groups analysis of variance was conducted on threshold and tolerance. There was no significant gender difference in pain threshold, as measured by the time until the pain was reported, $F(1,76) = 2.07$, $p = .15$. The main effect of age on pain threshold was also not significant, $F(1,76) = 1.03$, $p = .31$. There was not a significant interaction between gender and age on pain threshold, $F(1,76) = 1.21$, $p = .27$.

Men tolerated more pain than women, as indicated by the time they kept their hands in the icy water, $F(1,76) = 12.03$, $p < .01$. Younger adults also tolerated more pain than older adults, evidenced by increased length of time they kept their hands in the icy water, $F(1,76) = 8.41$, $p < .01$. There was not a significant interaction for pain tolerance, $F(1,76) = .08$, $p = .78$.

Discussion

The primary purpose of this study was to examine the influence of age on pain perception in both men and women. The results support the first hypothesis, that pain thresholds would be similar across age and gender: Each group required a similar amount of time to detect pain induced by a cold stimulus. This finding replicates previous findings regarding pain threshold, which shows no gender differences (e.g., Ellermeier & Westphal, 1994) and no age differences (Walsh et al., 1989). Note, however, that studies of pain threshold have yielded inconsistent findings and some studies have shown that women have lower thresholds than men (Berkley, 1997; Hall & Davies, 1991). These inconsistencies can be perhaps best explained by the fact that pain threshold level depends on the type of noxious stimuli, experimental protocol, and testing environment.

The second hypothesis, that pain tolerance will be greater in men than in women, was also supported. The mean time that men could withstand the cold pain stimulus was significantly longer than the mean time that women could tolerate the pain. The bulk of the literature is consistent with the prediction (Feine et al., 1991; Kelli, 1999; Lautenbacker & Rollman, 1993), but the exact cause of this difference is unknown. One factor that may contribute to the gender difference in pain tolerance is hand size or skin thickness (Hellstrom & Lundberg, 2000). Another explanation for gender differences in pain sensitivity is attitudes or role expectations. Men and women may express themselves differently, that is, they may have different ways of reporting symptoms. For example, a study by Levine and DeSimone (1991) found that young men reported significantly less pain in the presence of a female experimenter than a male experimenter, but the responses of women were not influenced by experimenter gender. In the current study, there was not a significant effect of the gender of experimenter on the responses of men or women.

The third hypothesis, that pain tolerance to a cold pain stimulus would be higher in younger adults than in older adults, was also supported. Although the vast majority of studies report a modest increase in pain tolerance with advanced age, this is not the case for high levels of mechanical, electrical, and cold pain, to which older adults appear to be more sensitive (Gibson & Helme, 1995). The commonly held belief that older adults can tolerate more pain might be explained by a psychological responses bias in older adults. Older adults may come to expect more pain and, therefore, may be more stoic in reporting pain sensations and less likely to label a sensation as painful (Gibson & Helme, 1995). However, the findings of this study are consistent with those of a study of 18-87 year-olds by Walsh et al. (1989), which revealed that older adults report lower pain tolerance when using the cold pressor test. This lower tolerance to specifically cold pressor pain in older adults may be explained

by physiological factors such as decreased skin thickness and body size, less subcutaneous fat, and reductions in skin elasticity (Gibson & Helme, 1995).

In light of these findings, one may speculate why there are gender and age differences in pain *tolerance*, but not in pain *threshold*. One plausible explanation is that pain threshold may be more closely related to biological processes, whereas pain tolerance may be more related to psychological factors. Psychological factors such as role expectations and attitudes appear to have little, if any, influence on the detection of pain, evidence by the similar amount of time required to detect pain in all four of the groups in this study. On the other hand, it has been proposed that these factors can play a direct role in the amount of pain one can tolerate in a given situation (Hellstrom & Lundberg, 2000).

The data presented here indicate that pain tolerance to the cold pain stimulus is higher in younger than in older adults. However, the difference between younger and older women is not greater than the difference between younger and older men, as hypothesized. One reason for this could be that the present study did not control for menstrual cycle phase, and so it is likely that at least some of the younger female participants were tested at a time in their cycle when estrogen was relatively low, and they were experiencing enhanced pain sensitivity (Riley, Robinson, Wise, & Price, 1999). If so, then the inclusion of these particular young women reduced the mean pain tolerance of the younger group and thereby narrowed the margin between the pain tolerance of the two female groups. Note that all of the participants in the group of older women had previously experienced menopause, and, therefore, likely experienced increased pain sensitivity due to drastic estrogen reduction (Hellstrom & Lundberg, 2000, Riley et al., 1999). That the female comparison was made between a postmenopausal older group and a younger group at varying stages of the menstrual cycle, then, might explain why the younger women did not differ more from the older women than the younger men did from the older men. Future research should expand on this study by controlling for menstrual cycle stage in young women, and questioning the older women about hormone replacements in order to determine if hormones play a role in how pain perception differs between individuals of different genders and ages.

The painful stimuli used in this study were restricted to experimentally induced cold pressor pain. Because the human body responds differently to different types of noxious stimuli, the findings cannot be generalized beyond the specific type of stimulus used. Older adults may be at a disadvantage in this particular pain measure due to changes in the skin with age; however, it was beyond the scope of this study to replicate with a new measure of pain. Future research should attempt to replicate these findings with different measures of pain to further explore the idea that the experience of pain through the lifespan differs for men and women. Another reason the data should be interpreted with caution is that there are vast differences between experimentally induced pain and real or chronic pain caused by an illness. Pain induced in this study poses no real threat or source of anxiety because it neither affects nor reflects the participant's health condition. Therefore, most experimentally induced pain, such as that in the present study, is administered to the skin, whereas chronic pain is typically felt internally, such as deep in muscles or joints (Dao, 2001).

Because pain is a multidimensional experience with both sensory and cognitive components, results will vary depending on the environment in which the experiment takes place and the dimension of the pain being assessed. In the present study, data were collected from the younger and older adults at three different locations. To avoid confounds due to location, data were collected in similar settings; all of the younger participants were tested in a small laboratory and all of the older participants were tested in their comparably sized living rooms.

The present study, along with all other studies to date that have examined age and pain perception, involves cross-sectional comparisons, which confound cohort differences and age differences. In addition, a cross-sectional study cannot identify individual differences on changes across time. Future research should employ a longitudinal study so that firm conclusions can be drawn about the effects of aging on pain perception.

Another limitation of this study is the difficulty ensuring that health status was not confounded with age. Advanced age is associated with a much higher prevalence of chronic disease than it is in younger populations, and given that pain is a primary symptom of many diseases, it is reasonable to expect a greater prevalence of pain in older adults (Gibson & Helme, 1995). In this study, an attempt was made to exclude all volunteers who suffered from chronic pain or illness, and those who felt regular pain or uncomfortable sensations. However, we were unable to exclude participants who had been diagnosed with arthritis because it was too common in the older population. Participants with arthritis were allowed to participate providing they did not have any arthritis in the hand they used in testing. This limitation is important because it could have contributed to the large within-group variability in the present study; some partici-

pants suffered no arthritis at all, whereas others had some form of arthritis in a body part other than the dominant hand. It is also possible that this could have affected the between group variability because arthritis might reduce one's tolerance to pain, as chronic pain in one area of the body can cause heightened levels of inflammation in other parts of the body (Machelska, Cabot, Mousa, Zhang, & Stein, 1998).

Many recent animal studies have shown substantial sex differences in opioid and nonopioid analgesia, as they both are influenced by estrogen and other reproductive hormones (For review see Berkley, 1997). Although it is clear that sex differences in analgesia are present in animals, the underlying mechanisms are not yet well understood. Future research should investigate sex-related and hormonal differences in pain which are clearly relevant to analgesia.

Although the finding of age-related differences leaves many unanswered questions, the results of this study do have important clinical implications. Even though clinical and experimental pain cannot be equated, this study suggests that one should not ignore nor underestimate the vulnerability of elder patients to pain and painful stimuli. The prevalence of articular joint pain, such as in the knees and hips, is more than twice as high in older adults than in the younger population (Gibson & Helme, 1995). Whereas it appears that older adults are particularly prone to pain in certain areas of the body—such as joints, legs, arms, and neck—these problems also differ between men and women, and research on this topic has been scarce and conflicting. It is important to expand on what is already known about the aging process and how it affects experimentally induced pain to clinical treatment of pain. A better understanding of age and gender-related differences and similarities in the perception of pain should lead to more effective management of pain conditions in the elderly.

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