Pain Tolerance: Differences According to Age, Sex and Race

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The nature and extent of group differences in pain tolerance according to age, sex and race were examined. The method of pain tolerance determination was mechanical pressure on the Achilles tendon, performed on 41, 119 subjects as part of the Kaiser-Permanente Automated Multiphasic Screening examination. The results showed that, on the average, a) pain tolerance decreases with age; b) men tolerate more pain than women; and c) Whites tolerate more pain than Orientals, while Blacks occupy an intermediate position. When the results of this study are compared with earlier work, it appears that, with increasing age, tolerance to cutaneous pain increases and tolerance to deep pain decreases.

Differences in patients' pain tolerance have been a continuing source of interest and concern to their physicians. Some individuals appear to bear severe pain with surprising equanimity, while others react to more moderate pain with apprehension and emotional turmoil.

A test of pain tolerance was included in the routine multiphasic health examination of more than 40,000 subjects in the hope that the findings would be clinically useful. While the clinical value has yet to be demonstrated, rather clear-cut differences in pain tolerance according to age, sex and race were noted. These differences may reflect important cultural and biologic variability in pain reaction.

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SUBJECTS

The subjects were the 41,119 persons who presented themselves for the Automated Multiphasic Screening (AMS) examination at the San Francisco or Oakland multiphasic testing laboratories between January 1 and December 31, 1966. More than 99% were members of the Kaiser Foundation Health Plan. The majority of patients who apply for the AMS examination do so of their own accord; only 13.1% are referred by doctors.

The demographic characteristics of the study population are shown in Table 1. Race was determined by observation of the subject's skin color. The educational categories in the table indicate the highest level of attainment but do not imply graduation.

METHODS

The pain tolerance test was given as a routine part of the AMS examination (1). The seated subject placed his heel on the floor with the Achilles tendon positioned between two motor-driven rods whose tips measure ¼″ × ⅜″ The subject was then instructed as follows, without use of the word "pain": "This is a pressure tolerance test. This test is to determine the amount of pressure which you can take on your ankle tendon. I will increase the pressure and stop it as soon as you tell me to. This test cannot injure you in any way. Try to stand it as long as you can."

The instrument, custom-built for about $200, produces deep pain (with some cutaneous contamination), is easily standardized, functions rapidly (average test time is 30 seconds) and requires minimal staff training.

Pain tolerance was studied for possible relation to age, sex and race.

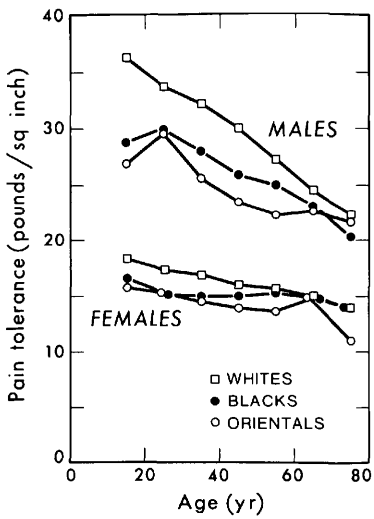

Fig 1. Differences in pain tolerance according to age, sex, and race

Table 1. Demographic Characteristics of Population Examined for Pain Tolerance

41,119 Subjects	%
Age	
<20	2.3
20–29	12.9
30–39	18.7
40–49	27.0
50–59	22.4
60–69	12.7
70+	4.0
Sex	
Male	42.3
Female	57.7
Race	
White	82.9
Black	13.1
Oriental	4.0
Education	
Elementary	10.9
High school	29.1
Trade or business	12.3
College, 1–2 years	16.3
3–4 years	13.3
Postgraduate	15.2
Unknown	2.9

Each pain tolerance test experience may affect the reaction to subsequent tests by alleviating or increasing apprehension and anxiety. Thus, any test of reliability or reproducibility of the instrument itself may be confounded by changes in the mental state of the patient. Nevertheless, some estimate of reliability was obtained by examining differences in response by the same subjects from one examination to the next. Changes in pain tolerance over time in individuals were studied by comparing the first three examinations of 14,046 subjects who had been examined at least three times during a 4-year period. The mean interval between the first and second examinations was 14.3 months, with a standard deviation of 4.0 months. Between the second and third the mean was 14.5 months, with a standard deviation of 4.0 months. Only 21 subjects (0.15%) had undergone their first and second examinations at intervals of less than 6 months, and 17 (0.12%) had taken the second and third examinations at intervals of less than 6 months. Of the 41,119 subjects tested in 1966, 44% had had previous AMS examinations.

RESULTS

There were consistent and statistically significant differences in pain tolerance according to age, sex and race (Figure 1 and Table 2).

Age

The age trend observed in a cross-section of the study population as a whole was based on the first test for 56% of the subjects. Pain tolerance decreased with increasing age for both sexes. In males the age trend was fairly smooth, with those age 60 and over showing about two-thirds to three-fourths the pain tolerance of those under 30. In females the decrease with age was also steady but less marked.

Sex

Men tolerated more pain than did women (Figure 2). Six percent of men could endure pain above the upper limit of the test—50 pounds/sq inch. Even the oldest men had a higher average pain tolerance than the youngest women. The mean pain tolerance of all men was 28.7 pounds/sq inch; the mean for all women was 15.9 pounds/sq inch. The differ-

Table 2. Mean Pain Tolerance in Pounds per Square Inch According to Age, Sex and Race

	Age							
	< 20	20–29	30–39	40–49	50–59	60–69	70+	Total
Male								
White								
Number	319	1565	2801	3844	3394	1948	735	14,606
Mean	36.29	33.77	32.14	30.03	27.26	24.58	22.33	29.21
SD	10.59	11.23	10.90	10.19	9.53	8.93	8.18	10.60
Black								
Number	50	249	452	728	422	139	17	2057
Mean	28.82	29.95	28.04	25.97	25.01	23.17	20.35	26.54
SD	11.19	10.54	9.42	8.57	9.46	8.86	6.74	9.46
Oriental								
Number	11	73	227	244	144	44	6	749
Mean	26.91	28.62	25.26	23.53	22.31	22.59	21.67	24.30
SD	9.63	10.99	9.82	8.40	7.77	9.25	10.09	9.24
Female								
White								
Number	440	2697	3164	4873	4566	2863	868	19,471
Mean	18.42	17.35	16.90	16.01	15.67	14.96	13.93	16.07
SD	7.32	6.41	6.17	5.50	5.21	4.88	4.43	5.68
Black								
Number	108	576	742	1103	617	172	18	3336
Mean	16.62	15.20	15.13	15.11	15.35	14.73	14.06	15.20
SD	5.97	5.01	4.84	4.81	4.92	4.34	3.96	4.89
Oriental								
Number	13	159	311	290	87	37	3	900
Mean	15.85	15.31	14.52	13.97	13.64	14.81	11.00	14.42
SD	5.49	4.90	4.94	4.67	3.74	6.83	0.00	4.86

ence was highly significant ($P < .001$). In addition, pain tolerance varied less among women than among men.

Race

Racial differences were consistent in both sexes but were less marked than were differences by age and sex. Whites showed the highest average pain tolerance (males 29.2, females 16.1 pounds/sq inch); Blacks were second (male 26.5, females 15.2 pounds/sq inch); and Orientals were lowest, (males 24.3, females 14.4 pounds/sq inch). All differences between racial groups were significant ($P <$ .001). Both race and age differences in pain tolerance were more marked in men than in women.

Changes with Time in the Same Individuals

Table 3 shows the means and standard deviations of pain tolerance values on three consecutive examinations for men and women. The total group shows very little change over the years. The overall mean dropped from 23.4 to 22.1 pounds/sq inch between the first and second examinations but then rose to 23.1 pounds/sq inch on the third. However, the changes in men differed from those in women. Pain tolerance in men rose slightly, on the average, with each successive examination. This is opposite in direction to the decrease noted with age in a cross-section of the population. In women the situation was more complex. The mean fell by 2.6 pounds/sq inch between the

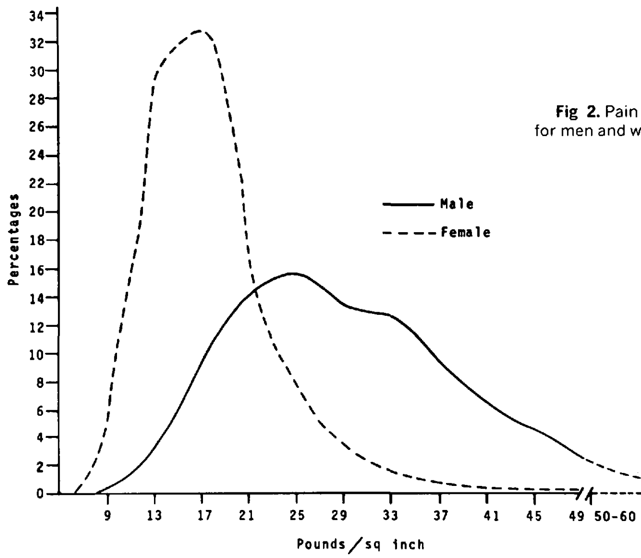

Fig 2. Pain tolerance distributions for men and women

first and second examinations but then rose 0.9 pounds/sq inch between the second and third.

The correlation coefficients between the results of the first and second examinations were .51 and .48 for men and women, respectively. Between the second and third examination they were .69 and .56 for men and women, respectively.

DISCUSSION

Pain is a topic of widespread scientific interest. Its ramifications have been examined by psychiatrists, psychologists, anesthesiologists, pharmacologists and others who have contributed to a vast, unwieldly literature. Some order and perspective has been brought to the subject by such workers as Merskey and Spear (2) and Sternbach (3) in their thorough and lucid reviews.

Since Libman's work in 1934 (4), investigators have experimented with many instruments capable of producing deep and superficial pain. Of the various mechanical, electrical, chemical and thermal techniques used for investigation,

Table 3. Pain Tolerance in Pounds per Square Inch in the Same Subjects Examined Three Times

		First Examination		Second Examination		Third Examination	
	No.	Mean	SD	Mean	SD	Mean	SD
Men	5963	28.7	7.8	29.2	10.2	30.1	9.8
Women	8083	19.5	6.4	16.9	6.1	17.8	6.1
Total	14046	23.4	8.3	22.1	10.2	23.1	10.0

only thermal and mechanical methods seemed to yield reproducible results; the others have been largely discarded. The most popular device, the Hardy, Wolff and Goodell dolorimeter, used a focused light source directed at a black spot on the forehead (5). It gave good reliability and quantification but had two major shortcomings from a clinical standpoint. The instrument was hard to standardize, and more important, the "heat-spot" technique was a measure of *superficial* pain rather than *deep* pain. The difficulty with using a superficial pain stimulus, such as thermal radiation, is that this type of pain is not relieved by morphine any better than by a placebo (6). Thus, it differs from most clinical pain.

To circumvent these problems, experimenters (7–11) employed a wide variety of pressure devices, which improved reliability and standardization. (The submaximal effort tourniquet technique, inducing ischemic pain, had not been reported at the time this project was started.) The instrument employed in our studies similarly applies calibrated pressure, but the pressure is applied to the Achilles tendon instead of to the skin of the forehead or arm. Measurement of deep pain was selected primarily because we assumed that deep pain was more significant clinically than superficial pain. So far, however, our pain tolerance test results have not been shown to be correlated with clinical pain.

Pain Tolerance versus Pain Threshold

Once a particular method of pain induction is selected, one must decide whether to measure pain threshold, pain tolerance or both. Pain threshold is that level of stimulus at which the subject first recognizes pain or discomfort. Pain tolerance is that greater level of stimulus at which the subject requests stimulus cessation.

Some workers (12) have found pain threshold and pain tolerance highly correlated (correlation coefficient = 0.72) and have suggested that the factors contributing to individual differences for threshold and tolerance are largely the same. The more convincing data of Benjamin (13) and Gelfand (14) indicate that pain threshold and pain tolerance are probably not highly related.

In an excellent summary of the differences between pain threshold and pain tolerance, Merskey and Spear (15) concluded that "pain threshold is more dependent on physiological factors, and pain tolerance on psychological factors." Petrie (16) reported that the pain threshold remains unchanged after prefrontal lobotomy and may also remain constant after pain-relieving drugs, although pain tolerance increases in both situations.

We selected pain tolerance rather than pain threshold, because we felt the former had greater clinical utility. Medical attention is sought more on the basis of intolerance of pain and discomfort than on pain recognition.

Induced versus Endogenous Pain

The issue of whether induced pain felt by "well" subjects in an experimental situation can accurately reflect endogenous clinical pain is a troubling one. Beecher is one of the most articulate proponents of the view that experimental pain cannot be compared with clinical pain, and he supports his argument by showing that most experimental pain is useless in assaying the potency of analgesic medication (6). He notes that the symbolic quality of pathologic pain is crucially important in the assessment of analgesic efficacy. We agree with this point but believe that such differences as we have found in reaction to induced pain may be of value in other areas of concern to the medical practitioner. However, confirmation of such clinical utility remains absent at the present time.

In studying our results we looked carefully for components in the testing situation which might be responsible for the differences in pain tolerance we found. Beecher has compiled an extensive list of factors which may influence experimental pain perception (17). Included in this list are such variables as nausea, skin temperature, anxiety, room temperature, fatigue, and diurnal variation, most of which do not seem immediately relevant to our study, principally because of the randomization resulting from our very large sample size.

The physical setting was constant and nonthreatening. As perceived by the authors the pain tolerance phase did not seem to arouse any more apprehension or negative reactions than the other aspects of the multiphasic testing. Previous work (18) has shown how the personality of the interviewer can influence anxiety and hostility, and secondarily, pain tolerance (17). Therefore, technician personality might influence pain tolerance in a relatively small sample. But given the size of our sample and the nonsystematic interscheduling of patients and technicians, personality appears to be an unlikely determinant of observed differences in pain tolerance. We have concluded, therefore, that differences in pain tolerance in our study are due to underlying differences in our subject groups. The extent to which these differences in pain tolerance are culturally determined or biologically determined is still unknown.

Group Differences in Pain Tolerance

Age. Probably the most important finding in our study is that pain tolerance decreases with increasing age. This is true for both sexes, and for White, Black and Oriental people. This finding is contradictory to all previous studies (19–23) except one (24).

There appears to be a discrepancy between the general decrease in pain tolerance with age and the increase in pain tolerance noted on repeated examinations of men. It seems likely that this increase is due to adaptation to the test situation.

We believe that the explanation for the difference between our observation of decreasing tolerance with age, and the observations of others, lies in the means of measuring pain tolerance employed in the different studies. When pain tolerance is measured by radiant heat, it increases with age. When measured by pressure on the Achilles tendon, it decreases with age.

It appears, therefore, that with increasing age, tolerance to cutaneous pain increases and tolerance to deep pain decreases. If correct, this concept may prove helpful in understanding and relieving pain clinically. Much has been written about differential systems of pain perception. Pain has been divided into epicritic and protopathic, fast and slow, superficial and deep, somatic and visceral, A-gamma (smallest myelinated) and C (unmyelinated) conducted. If there are opposite changes with aging in two different pain perception systems, it is quite possible that more effective analgesia could be developed on the basis of these differences.

Sex. In a recent review Notermans and Tophoff (25) noted wide disagreement in the relationship of pain sensitivity to sex. They cited five publications which stated that sensitivity to pain is greater in women than in men, and five publications which reported no differences between the sexes in pain sensitivity. Interestingly, there is virtually no experimental evidence to back the widely held notion that women are more tolerant of pain than men.

One explanation for the sex differences in pain tolerance might be a desire on the part of male patients to impress a young appealing female technician. With this in mind, we reviewed our records and found that during the test year eight female technicians were employed —five Black, two White and one Philippine. Their age range was from 28 to 60, with a mean age of 41 When the personnel supervisor was asked if any of the technicians were likely to elicit a "show-off" response, the answer in seven instances was "no" and in one "possibly." It thus appears that the sex-appeal factor was not a significant determinant in the higher pain tolerance of men.

In published studies it is often difficult to separate sex differences in pain threshold, labeled as "pain perception," "sensitivity," and "verbal report of pain," from sex differences in

Table 4. Pain Tolerance According to Education, Sex and Race in Subjects Age 40 to 49

	Education						
	Elementary	High school	Trade school	College 1–2 yr	College 3–4 yr	Post-graduate	Total
Male							
White							
Number	229	910	420	578	605	1006	3748
Mean	29.2	30.1	29.7	30.0	30.9	29.9	30.1
SD	9.8	10.2	10.1	10.2	10.4	10.2	10.2
Black							
Number	136	228	118	96	53	37	668
Mean	25.3	26.4	26.0	26.5	27.1	25.9	26.1
SD	8.2	8.3	8.3	9.7	8.4	10.0	8.6
Oriental							
Number	17	40	32	42	67	36	234
Mean	20.2	24.1	24.5	22.6	24.1	22.6	23.4
SD	5.1	9.5	9.3	7.9	9.1	6.4	8.4
Female							
White							
Number	315	1581	740	787	539	766	4728
Mean	15.4	15.9	15.7	15.8	16.9	16.6	16.0
SD	4.9	5.2	5.2	5.4	6.4	5.9	5.5
Black							
Number	186	381	147	155	73	77	1019
Mean	15.7	15.1	14.6	14.3	15.7	14.9	15.1
SD	5.3	4.5	4.2	5.0	4.9	5.0	4.8
Oriental							
Number	22	107	40	50	27	28	274
Mean	13.3	13.8	13.5	14.3	13.5	14.8	13.9
SD	4.5	4.7	3.8	5.2	4.2	3.9	4.5

pain tolerance, "pain reaction point." While a majority of authors have concluded that men have somewhat higher pain thresholds than women, there is much disagreement concerning this point (25). However, when pain tolerance is measured, the evidence is more consistent: men tolerate more pain than women (25, 26). This agrees with our own findings.

Race. In contrast to the numerous studies detailing the association of pain tolerance to sex and age, there are very few studies of racial and ethnic differences in pain tolerance. Chapman and Jones (27) found that "Jewish and other Mediterranean races" had lower pain tolerance than Caucasions of "Northern European stock" and that their pain tolerance levels closely corresponded to those of the Negro. Micmac Indians were reported by Sherman (28) to have higher pain tolerance than patients who came to his office with a variety of organic and functional illnesses. Sherman and Robillard (20) found that pain tolerance in a combined population of Jewish and French subjects was lower than in a comparable Canadian Anglo-Saxon group.

Merskey and Spear (11), using a pressure device over the tibia and forehead, found no difference in pain tolerance between male White students and male Afro-Asian students. Chapman and Jones (27) found the pain tolerance of Negro subjects to be below that of

Caucasians as measured with the Hardy-Wolff-Goodell heat apparatus; but this study is marred by failure to specify the sex of the subjects. No differences were found in the ability of Negro and White women to tolerate obstetric pain (29).

It would appear that, with the exception of the findings of Chapman and Jones (27), there has been no experimental evidence to show that Blacks have a lower pain tolerance than Whites. The uniformity of our findings within every age group and for both sexes (the single exception being women over 70) considerably reduced the chance that our observation was an artifact.

The possibility that the racial differences were due to socioeconomic factors was explored. Pain tolerance was studied in all racial groups, subdivided by educational attainment, in a mid-age sample (40 to 49 years) of 10,671 subjects. The racial differences in pain tolerance were observed at all levels of educational attainment (Table 4), and educational level was not related to pain tolerance in any consistent manner. Although we found no consistent relationship between educational level and pain tolerance, it should be noted that Schludermann and Zubek (21) reported higher socioeconomic status associated with higher pain threshold.

The discovery that Orientals have lower pain tolerance than Whites and Blacks is a new finding so far as we could determine from the English language literature. (In our study no distinction was made between Japanese and Chinese.) It is intriguing to speculate whether this deviation from the popular stereotype of the "stoic Oriental" can be ascribed primarily to biologic differences or to cultural factors such as minority status (29, 30).

SUMMARY

This analysis of the pain tolerance scores of 41,119 subjects who took the Automated Multiphasic Screening examination during 1 year showed that, on the average: a) Pain tolerance decreases with age; b) Men tolerate more pain than women; and c) Whites tolerate more pain than Orientals, while Blacks occupy an intermediate position. When the results of this study are compared with earlier work, it appears that with increasing age, tolerance to cutaneous pain increases and tolerance to deep pain decreases.

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