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PRINCIPAL INVESTIGATOR: Richard A. Sherman, LTC, MS

CONTRACTING ORGANIZATION: Fitzsimons Army Medical Center
Department of Clinical Investigation
Madigan Army Medical Center
Tacoma, Washington 98432-5000

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Richard A. Sherman, LTC, MS

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Fitzsimons Army Medical Center
Department of Clinical Investigation
Madigan Army Medical Center
Tacoma, Washington 98432-5000

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This project is determining relationships between back muscle tension, amount and type of activity, and onset and intensity of back pain among people in their normal environments in order to develop and test preventive and ameliorative measures. Ambulatory recorders are used to record muscle tension, activity, and back pain for 20 hours at a time among civilians in their normal work environments and among soldiers either in garrison or participating in combat training exercises. The portion of this study funded by MRDC has been completed but the program is continuing with local support using the ambulatory recorders developed through this funding. Results of the MRDC funded portion of the study demonstrate that, for people with muscle tension related low back pain, changes in low back muscle tension are correlated (0.88) with changes in pain intensity. There is a relationship between participation in field exercises and onset of low back pain among both soldiers who normally do and do not experience back pain. Both pain and muscle tension are higher in garrison than in the field. Subjects with headaches and back pain who wore the recorder both before and after muscle tension recognition and relaxation training showed changes in muscle tension - pain relationships which paralleled changes in their overall condition. Soldiers with musculoskeletal low back pain who wore the recorder both in the field and garrison before and after brief training to recognize changes in low back muscle tension showed reduced pain during post training activities. The standard way of scoring the Minnesota Multiphasic Personality Inventory (MMPI) was shown to exaggerate the psychological components of soldiers' reports of pain.

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FOREWORD

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Principal Investigator's Signature ___ 31 Oct 94 ___ Date

Etiology and progression of Acute muscle tension related back pain occurring during sustained activity including combat training exercises (HSC #MRP00489, MRDC #89065002).

TABLE OF CONTENTS

INTRODUCTION:	5
Program Summary:	5
Aims:	5
Hypotheses:	5
Objectives:	6
Status:	7
BODY:	9
Project 1	9
Overview	9
Methods	10
Results	11
Project 2	13
Methods	13
Results	13
Reevaluation of the MMPI for use with troops	13
Publications	14
References	15
Appendix	17

Etiology and progression of Acute muscle tension related back pain occurring during sustained activity including combat training exercises (HSC #MRP00489, MRDC #89065002).

1. INTRODUCTION:

a. Program summary:

(1) The field portion of phase two was prevented from starting for over a year by hiring freezes. However, we finally got permission to contract out the work and were able to complete enough of the training portion of the study to demonstrate that the hypotheses are likely to be supported by continuing, locally funded work.

(2) The project has already paid off for both the Army and for science in general as it has shown (a) that there is a relationship between both upper and lower back pain and back muscle tension (a relationship never clearly established before), (b) that people can learn to control their pain by altering muscle tension patterns (this mechanism was never established before), and (c) that there is a large group of solders who hurt more while in the field than while in garrison who have muscle tension related problems which can be altered with brief training. The study has had the unexpected spin off discoveries (a) that upper back pain problems and headache are frequently related), (b) that upper back pain related to headache is frequently caused by abnormal patterns of tension in the upper back, (c) that people with this problem can significantly reduce their pain by learning to control their muscle tension, (d) that the diagnoses of "migraine" and "tension" headaches are frequently not correct (rather, some of both are caused by upper back muscle tension while others are not), and (e) that the most common psychological test used to evaluate psychological components of low back pain among soldiers (the Minnesota Multiphasic Personality Inventory <MMPI>) is scored incorrectly because it does not take the effects of presence of pain into account when the test is scored. This will have an enormous effect on treatment decisions for soldiers reporting back pain. The MMPI is considered to be the best available test for determining psychological components of patients' complaints of back pain. It is used in this project to screen potential subjects. Any volunteers who show substantially abnormal amounts of psychological components of their pain are not permitted to participate in the study because their reports of pain intensity might be unduly influenced by factors other than muscle tension. We have been suspicious of the test's accuracy for some time. Initial results from potential subjects in this study led us to have a graduate student test the test in ways described in the body of this report. This portion of the study was done at minimal cost to the Army.

b. Aim for entire project: Determine relationships between muscle tension, amount and type of activity, and onset and intensity of low back pain among people in their normal environments in order to develop and test preventive and ameliorative measures. The program emphasizes soldiers who are usually pain free in their normal work environments but who experience debilitating low back pain or headaches during combat training exercises.

c. Hypotheses for current work - phase two (See the January 1992 annual report for phase one):

(1) That, for soldiers with no histories of back problems, keeping the paraspinal muscles too tense for too long results in low back pain and keeping the trapezius muscles too tense for too long results in headaches.

(2) That soldiers with no back problems keep their low back muscles and/or

their trapezius muscles tenser then necessary for longer than necessary during portions of combat training exercises, and, thus, develop more back pain, headaches, and fatigue then they would if muscles were tensed appropriately.

(3) That teaching groups of solders to habitually (rather than consciously) (a) recognize when their low back muscles are tenser then necessary at any given time and (b) to relax them to levels appropriate to the activity being engaged in will result in reduced occurrence of back pain and fatigue along with increased efficiency during combat training exercises.

(4) That the ability to make ambulatory recordings of low back muscle tension which correlate highly with low back pain and of trapezius muscle tension which correlate highly with headache activity among people whose pain is related to muscle tension can be utilized to determine how well treatments for these people are working and whether or not they are working by altering muscle tension patterns.

(5) That muscle tension awareness and control exercises can be used to alter muscle tension patterns sufficiently to test the above hypothesis in the above population.

(6) That resolution of back problems related to muscle tension can be predicted by return of muscle tension patterns to normal.

(7) That the information about patterns can be used to predict which soldiers are most likely to be debilitated during combat exercises and that the value of both preventive and post-debilitative treatments can be determined by using the recommended recording techniques.

d. Objectives:

(1) To determine whether among people with no history of chronic back pain, there are consistent relationships between (a) the intensity and duration of activity being performed, (b) the pattern of paraspinal muscle contraction, and (c) onset of low back pain.

(2) To determine whether patterns of muscle tension recorded throughout the normal day in the normal environment will be different for people with (a) low back pain only after physical effort and (b) no recent or significant history of back pain after similar physical effort.

(3) To determine whether paraspinal muscle tension becomes elevated prior to the onset of pain for the above types of people.

(4) To determine whether resolution of back problems related to muscle tension can be predicted by return of muscle tension patterns to normal.

(5) To determine whether information about patterns can be used to predict which soldiers are most likely to be debilitated during combat exercises and whether the value of both preventive and post-debilitative treatments can be determined by using the recommended recording techniques.

(6) To determine whether muscle tension recognition and training can alter relationships between low back pain or headache and muscle tension.

e. Status: For the past eight years we have been working with soldiers who experience debilitating pain during combat training exercises which they do not experience while in garrison. Their orthopedic diagnoses indicate that the pain is probably of muscle tension origin.

There is a paucity of objective data available about the relationship between low back pain and low back muscle tension. The literature is contradictory and prolonged treatment success frequently appears to be minimal and random. We performed the first large scale study which demonstrated consistent relationships between paraspinal muscle tension (as reflected by amplitude of bilateral surface EMG) and intensity of low back pain. We are in the process of performing a VA and Army funded study relating patterns of muscle tension to the results of standard diagnostic tests including X-Rays, orthopedic and neurological examinations, surface paraspinal EMGs and the Minnesota Multiphasic Personality Inventory (MMPI). Neither of these studies, nor any data from the literature, can provide information about the etiology of muscle tension problems in the low back which are related to low back pain. Other than the trial data presented below, no one knows what normal and abnormal patterns of muscle tension relative to activity look like in the normal environment. We propose to determine the temporal and intensity relationships between low back pain of muscle tension origin, patterns of paraspinal muscle contraction, and activity by performing continuous recordings of these factors among groups of low back pain subjects in their normal environments.

(1) <u>Relationships between pain and muscle tension as recorded using surface electromyography (EMG)</u>: Sustained muscle contraction has been shown to produce pain whereas relaxation of the muscles reduces the intensity of the pain (e.g. review by Dorpat and Holmes 1952). Relationships between sustained level of muscle contraction and occurrence of pain in the back are not well understood and the literature is confusing. For example, Basmajian (1981), Wolf and Basmajian (1979), and Kravitz et al. (1981) found that the paralumbar muscles of relaxed low back pain patients were less contracted than those of "normal" controls. Collins et al. (1982) found that in the standing position, the tension in the paraspinal muscles of low back pain subjects were similar to controls. Many other groups have reported similar findings while at least as many have reported just the opposite under apparently similar recording conditions. Hoyt et al. (1981) showed that surface EMGs of low back pain patients differ most from those of normals for the standing positions with low back pain patients being tenser by one third to one half. These types of results have been reported by many others including Grabel (1974) who also found that there were no differences in tension in response to simulated psychological stresses between groups with and without low back pain. Dorpat and Holmes (1952) did find such a relationship among several patients identified as having both high levels of anxiety and back pain. With the important exception of Dorpat and Holmes' few subjects, none of the research groups divided their subjects by diagnosed etiology of their subjects' pain. Many groups (e.g. Cram and Steger, 1983) have found trends toward asymmetry in left vs. right sides of the low back among subjects with low back pain.

Many psychological factors complicate the relationship between reported intensity of low back pain and paraspinal EMG. Psychological influences on perception of pain intensity are especially difficult to evaluate. For this reason, we eliminate all subjects with significantly abnormal psychological patterns from our studies and have all subjects keep logs of their perceived stress intensities. For example, Ahles (personal communication, 1989) reviewed findings from such workers as Flor et al 1985 and Dickson-Parnell and Zeichner 1988 and concluded that personally relevant stressors produce elevations in paraspinal EMG levels which distinguish low back pain patients from non-pain controls.

We have shown that much of the confusion and high variability in results is caused by (1) recording all of the subjects in only one or two positions regardless of the most painful position and (2) recording the subjects only once without regard to current level of pain. Our laboratory published the first evidence that there is an actual relationship between low back pain intensity and muscle contraction levels (Sherman 1985). We were able to show that a consistent relationship exists because we recorded each subject in many different positions and at many different pain intensities. One hundred and twenty-six subjects participated in the study. Each was recorded while standing, sitting supported and unsupported, prone, bending, and rising. Recordings were performed on days when subjects were at various pain intensities. Each subject reporting pain at the time of recording showed one or more position in which their muscle tension was different from the controls'. When the "low back pain" subjects were recorded without pain, their recordings were similar to those of the controls. For those positions where a subject showed abnormal muscle tension, there was a high correlation between reported pain intensity and number of microvolts showing in the recording over the series of recordings (Spearman's Rho = 0.92). Since that time, we have run an additional 256 subjects. Each subject had diagnoses based on through orthopedic tests. Our original findings have been confirmed and we have determined that there is a difference in muscle tension between pain free controls, subjects with muscle related back pain, and subjects with diagnoses not related to muscle tension (Arena, et al., 1989). We were also able to show that our electromyographic recording techniques are consistent between recordings so our results are not significantly confused by unrecognized factors (Arena, et al, 1988). Normative data for muscle tension have been developed and reviewed by Wolf et al (1979). However, at this time, the only evidence that muscles' tensing during normal work as related to diagnosed muscle tension pain is from our small trial. No studies other than our trial have been done to determine the duration, pattern, or intensity of muscle tension during normal activities in relation to subsequent onset of pain symptoms.

The critical point here is that we have demonstrated that the level of low back paraspinal muscle contraction increases as low back pain increases not just for people with back pain apparently due only to muscle related problems but for those with very clearly delineated diagnoses not associated with muscle contraction.

(2) Ambulatory monitoring of muscle tension and activity: Studies in which a physiological parameter is continuously recorded among freely moving people away from a laboratory have been done for many years. The simplest systems and those in most common use are the ones for recording blood pressure and electrocardiograms (e.g. Littler et al 1972). Equipment capable of accurately recording muscle tension among freely moving subjects has also been available for many years and is frequently used as part of a biofeedback system to alert people who tense their jaws when they come under stress or who neglect to raise the toe end of the foot sufficiently while walking due to a stroke (e.g. Rugh and Solberg 1974). Monitoring muscle tension among free moving subjects has a variety of problems. The most important one is that background levels of tension can not readily be differentiated from changes in tension due to movement. This becomes especially critical when muscles such as the paraspinals of the low back are being recorded. We avoid this problem by recording both gross - large body movements and acceleration types of movement measures. These measures are then related to the muscle tension signal. The other major problem is how to make a reliable record of muscle tension over a period of several days while the subject is away from a major recording facility. The commercially available physiological tape recorders which are genuinely wearable in a field environment are good for only 24 hours of continuous recording due to both battery life and tape length problems. They were designed for blood pressure, cardiac or brain wave monitoring and are not able to record an adequate bandwidth for large muscle EMG. The alternative solution is to sum the muscle tension activity level over a set period and have a device such as a printing counter record the amount of activity at the end of each period. This alternative was used in our initial trials and was able to produce the general outlines of the relationship between movement, pain, and muscle tension. However, it was not able to provide

sufficiently detailed data on relationships between movement and changes in muscle tension on a movement by movement basis to permit elimination of many artefacts. It was also not possible to determine sufficient detail about changes in activities related to changes in tension patterns because of the difficulty in making frequent notations in a written log necessitated by the lack of moment by moment recordings. Objective recording of intensity, duration, and amount of activity is very important because subjects have been shown to be very inaccurate about how much activity they have engaged in over various periods of time such as would be recorded in hourly logs of activity (e.g. Sanders 1983). When activity is recorded, information such as distance walked is not more important than the size and frequency of movements affecting the muscles being recorded. These types of measures can not be accurately recorded by estimate so we use a mercury cell based movement sensor which records amount as well as frequency of movement. The output goes to the same counter which records muscle tension.

Our own results from using an ambulatory surface muscle tension and movement recorder are detailed in the "work accomplished" section below. We were able to show reliable differences between paraspinal patterns produced while subjects experienced pain and while they were pain free. Patterns produced while subjects were pain free were very similar to those produced by subjects with no current or recent history of low back pain. Feuerstein has gathered some preliminary, unpublished data from brief ambulatory recordings of 16 subjects with mechanical low back pain (Paper presentations: Feuerstein 1986, Feuerstein and Cook 1987). He used equipment which worked similarly to ours but without the capability to accept constant input of log data. Feuerstein's data did not show significant differences in paraspinal activity patterns between control and low back pain subjects. Unfortunately, time commitments prevent him from being active in the field at this time. However, we are in close contact with him and he has read and commented on an earlier draft of this proposal. Thus, we can benefit from his experience and physiological expertise in the area even though he can not be a Co-Investigator.

(b) Supporting evidence that the recording methodology is correct and will provide accurate, useful information: A considerable amount of data has been gathered to show that the readings will (1) be reliable and replicatable, (2) be largely unaffected by normal changes in impedance occurring through the day, (3) not be significantly altered by slight changes in position of sensors required to avoid irritation during week long recordings, and (4) remain proportionate to the amount of exertion done by the back muscles across hours of recordings. Evidence has also been gathered to confirm the choice of bandwidth as being the best possible given the limitations of recording technology.

Our trial results indicate that (a) there are reactive relationships between muscle tension, movement, activity, stress, fatigue, and pain; (b) changes in muscle tension precede changes in pain and fatigue so are causative rather than reactive; and (c) the device is capable of performing the required recording without causing medical problems for the subject or interfering significantly with performance of normal duties.

See the January 1992 annual report for the results of phase one.

BODY:

a. Project 1 - Temporal relationships between muscle tension and pain before and after muscle tension recognition and control training (centered at FAMC):

(1) Overview: The progress reports for the first phase of this project contained evidence that people with muscle tension related back pain show clear patterns in which muscle tension recorded in the normal environment increases prior to increases in pain

and decreases prior to decreases in pain. This phase tested the ability of muscle tension recognition and control training to alter temporal relationships between pain and muscle tension.

(2) Methods: The ambulatory recording methodology was detailed in phase I's reports. Ambulatory recordings were performed for subjects with musculoskeletal low back pain, upper back pain / tension headaches, and migraine headaches (non muscle tension pain controls) for four consecutive days while they were not taking any medications (and after any washout period required). Each was given approximately six weeks of muscle tension recognition and control training (tape recorded exercises used twice per day at home as well as weekly EMG biofeedback sessions in the clinic). After training, each performed a final four consecutive days of ambulatory recording.

(3) Results of project one:

(a) Sixty-six subjects participated in the pain - muscle tension relationship study. Temporal relationships between changes in low back pain and paraspinal muscle tension are very complex and idiosyncratic. However, it is clear that a minority of people with mechanical low back pain have a consistent, predictive relationship between change in muscle tension and change in low back pain. Our data show that the temporal relationship between trapezius EMG and upper back and headache pain are exceptionally complex and include subgroups exhibiting a variety of relationships between EMG and headache pain intensity. One group includes individuals who experience an increase in trapezius EMG prior to and during upper back / tension headache pain. These results were detailed in earlier progress reports.

(b) Thirty-one subjects participated in the muscle tension recognition training study. Subjects were evaluated and diagnosed by either a neurologist or an orthopedic surgeon. Nine of the participants' demographics are shown in the table along with their results to illustrate typical relationships identified to date. Although each subject demonstrated unique pain - tension relationships during the initial baseline period, there was a general relationship between EMG levels and pain intensity at least on a day to day basis. There also appeared to be a minimum level of EMG which had to be exceeded for some minimum period of time before any pain would be reported. When EMG and pain were related during a day, changes in pain lagged changes in EMG by between 3/4 and 1 1/2 hours. Successful biofeedback treatment resulted in a general decrease in muscle tension levels as well as more and longer periods during which EMG activity was at the minimum level the recorder was capable of showing. The temporal relationships between pain and muscle tension are obviously quite complex and possibly idiosyncratic. For some people, it may only be possible to relate overall amounts of EMG activity to overall amounts of pain over a day. For many subjects, the pain may be related to muscles not recorded or may not be related to muscle tension at all. For people with muscle tension - pain relationships, it is likely that a minimum amount of muscle tension occurring for a minimum duration is required before pain is reported. The delay in time between change of EMG and change in pain appears to be highly variable. As most of our subjects who successfully learned muscle tension control skills produced numerous periods during which their muscle tension was at minimal levels only after training, it is possible that their pain was reduced because they produced much less overall muscle tension and long periods of minimal tension. A full study in which most of the muscles that are likely to be related to headache activity (e.g. the masseters) is likely to demonstrate more relationships.

Typical results for the most recent eight participants showed that the six who learned to control their muscle tension showed decreases in pain and changes in their pain - muscle tension relationships. The two who did not learn did not show decreases in pain and did not show and changes in temporal relationships between pain and muscle tension.

Table 1 PATTERNS OF MUSCLE TENSION - PAIN RELATIONSHIPS BEFORE AND AFTER BIOFEEDBACK AND RELAXATION TRAINING

SUBJ CODE	AGE	SEX	TREATMENT SUCCESS	PATTERNS BEFORE TRAINING	PATTERNS AFTER TRAINING	CHANGE IN RELATIONSHIPS
TENSION HEADACHES - BILATERAL TRAPEZIUS TENSION						
PG	58	F	yes	general trend with pain tracking EMG level	clear, time related patterns with pain tracking EMG levels but low pain with rare episodes	pain - EMG relationships tighter
SM	41	F	no	no obvious pain - EMG relationship but on a day to day basis, higher & more variable EMG related to more pain that day	same as before training	no change
CC	29	F	yes	on a day to day basis, EMG was higher on days with moderate pain than on days with very low or no pain	lower overall EMG after training corresponding to lower pain reports	no change but overall relationship between EMG & pain levels held
DM	58	F	yes	no obvious pain - EMG relationship	low and no pain periods corresponded to quiet EMG periods	more minimal EMG periods after than before bfb
JD	35	M	yes	on a day to day basis, EMG was higher on days with severe pain than on days with moderate pain	lower overall EMG after training corresponding to lower pain; daily lower EMG corresponded to lower pain	no change
MIGRAINE HEADACHES - BILATERAL TRAPEZIUS MUSCLE TENSION						
PS	63	M	yes	for 3 of 4 days, need minimal EMG for any pain, with enough tension, chng in pain lags chng in EMG by 3/4 to 1 hr. No relat on day 4	low pain, episodes rare. relationship same as before.	no change
LD	59	M	yes	on a day by day basis, overall EMG level predicts overall pain level	low pain, episodes rare. relationship same as before.	no change

COMBINED MIGRAINE & TENSION - BILATERAL TRAPEZIUS MUSCLE TENSION

DR	31	F	no	no obvious relationships	no obvious relationships	no change

MECHANICAL LOW BACK PAIN - BILATERAL PARASPINAL MUSCLE TENSION

KD	33	F	yes	2 days - no discernable relat. 2 days - on a day by day basis, overall EMG level predicts overall pain intensity. During one day, chng in pain lags chng in EMG by about one hour.	lower pain, episodes rare. 2 days, low EMG predicts low pain 1 day, unilat mod EMG = moderate pain. 1 day, only with moderate EMG. chng in pain lags chng in EMG.	tighter relationship between pain and EMG levels
KJ	37	M	yes	on a day by day basis, low EMG predicts low pain & a combination of increased EMG intensity & variability yields higher pain. 1 day on a half day basis, moderate EMG = moderate pain, low EMG = low/no pain	numerous periods of minimal EMG level with no / minimal pain. low EMG = low pain, one event of sharply increased EMG = increased pain in 1 1/2 hours.	tighter relationship between pain and EMG levels
LM	66	M	moderate	on a day to day basis, higher EMG predicts higher pain; same pattern within a day	EMG much lower each day, pain generally lower with low EMG but several episodes of pain at 3 & 4 with low EMG	no change in relationships

b. Project 2 - Ambulatory recordings of combat soldiers in garrison and during field training exercises before and after brief muscle tension recognition training (centered at Ft. Carson):

(1) Methods: Soldiers between the ages of 18 and 40 with no significant medical problems were recruited from units participating in combat training exercises who either (a) had no history of back pain during combat exercises or (b) had back pain diagnosed as musculoskeletal in origin during combat exercises but not in garrison. Each had three to four consecutive days of ambulatory recordings of low back muscle tension, movement, and pain intensity (as detailed in the original protocol) for approximately twenty hours per day while they participated in combat training exercises and an additional four days of recordings while they were in garrison. Each soldier was then given two weeks of muscle tension recognition training in which they used a tape recorded exercise twice per day for two weeks and had two biofeedback sessions in which they learned to recognize amount of muscle tension. They were told that keeping their muscles tenser than they had to be for longer than they had to be might cause some of their back pain. They were also told to use their knowledge of how tense their back muscles were to be aware of when they were keeping their muscles tense when they did not have to be. Standard training of this type normally takes at least six weeks.

(3) Results of study two: As detailed in the Annual Report, we were unable to hire a technician at Fort Carson because of an incredible series of delays caused by a series of hiring freezes and then by both Evans and Fitzsimons' decisions not to bring on more research technicians supported by Army grants because they might be construed as raising their levels of civilians at their respective facilities. We finally got permission from the command at Fitzsimons AMC to use the grant funds to contract for the work. By the time the contractor was brought on and trained, only six months of the study remained. Thirty-eight soldiers participated in the study. The results for the first twelve have been analyzed. Ten has back pain and two were pain free controls. The controls showed no changes in muscle tension - activity relationships during the study. Eight of the ten soldiers with histories of low back pain showed post training decreases in overall pain and altered relationships between muscle tension, activity, and pain. Two did not show any changes in pain or in relationships between the above variables.

c. Reevaluation of scoring methods used on the MMPI:

(1) Requirement: The most common psychological test used to evaluate psychological components of low back pain among soldiers is the Minnesota Multiphasic Personality Inventory <MMPI>. As stated in the original protocol, it is used to screen potential subjects for the project. Any volunteers who show substantially abnormal amounts of psychological components of their pain are not permitted to participate in the study because their reports of pain intensity might be unduly influenced by factors other than muscle tension. This would make it impossible to relate changes in pain to changes in muscle tension and thus obviate the premise of the project. We have been suspicious of the test's accuracy for some time. Initial results from potential subjects in this study led us to have a graduate student test the test.

(2) Abstract of the study: The scales frequently used in the evaluation contain numerous pain related questions whose answers might be expected to change when people go from pain free to painful states. We asked 53 male and 18 female consecutive inpatients on orthopedic surgery wards, who had organic findings accounting for their low back pain, to take the standard MMPI and a modified version which contained the questions contributing to the Hypochondriasis, Depression, K (correction), and Hysteria scales. The modified version required the subjects to answer each question twice - once as they felt before their pain began and once with their current pain. The results showed that the Hysteria and Hypochondriasis scales were significantly elevated when subjects changed from the way they would have answered

when pain free to their current "in pain" states. The Depression scale also rose but not to the same extent. Subscale analysis of items which were changed significantly between the "with pain" version and the "without pain" version revealed that elevations on Hs, D, and Hy were due to changes in endorsement of pain specific items. Once these pain specific items were accounted for, elevations on Hs, D, and Hy dropped below clinical significance. Thus, when the MMPI is given to low back pain patients, the presence of a low or mid-range conversion "V" is probably not clinically significant.

(3) Much of the data gathering and reduction was performed at no cost to the Army by Michael R. Camfield, Psy.D. as part of the requirements for his doctoral degree. An addendum describing the work and a relevant consent form was developed and approved locally (FAMC 87-206).

(4) Details of the study: The full study, including a full literature review and detailed methods, results and discussion sections, is presented in attachment 1.

e. Publications based on this work:

Sherman R, Sherman C: Physiological parameters that change when pain changes: Approaches to unraveling the "cause-or-reaction" quandary. Bulletin of the American Pain Society, 1(4): 11 - 15, 1991.

Sherman R, Varnado S, Caminar S, Arena J: Changes in paraspinal muscle tension as predictors of changes in low back pain. Proceedings of the 1991 annual meeting of the American Pain Society p. 64, 1991.

Sherman R, Evans C, Henderson C, Griffin V, Sherman C, Arena J: Continuous environmental recordings of relationships between Trapezius EMG, movement, activity, and headache pain intensity. Biofeedback and Self-Regulation, 1992.

Sherman R, Arena J: Biofeedback in the assessment and treatment of low back pain. Chapter 8 in: (J. V. Basmajian and R. Nyberg, eds) Rational Manual Therapies. Williams & Wilkins, 1992, pages 177 - 197.

Sherman R, Sherman C, and Evans C: Environmental - temporal relationships between changes in physiological parameters and pain. Proceedings of the 12th Annual Scientific Meeting of the American Pain Society, page A-56, Orlando, November, 1993.

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ATTACHMENT 1

REEVALUATION OF THE MMPI AS AN APPROPRIATE TOOL FOR ASSESSMENT OF:
(A) SOLDIERS' BACK PAIN AND
(B) APPROPRIATENESS FOR PARTICIPATION IN THE STUDY

Introduction
The Minnesota Multiphasic Personality Inventory (MMPI) is frequently the instrument of choice for assessing the contribution psychological factors make to reported intensity of low back pain (Long, 1981). The scales most frequently used in the assessment of low back pain (LBP) are the Hypochondriasis (Hs), Depression (D), and Hysteria (Hy) scales. Elevations on this triad are very common in chronic pain patients in general and LBP patients in particular (Calsyn, Louks and Freeman, 1976; Cox, Chapman and Black, 1978; Watson, 1982). Hs and Hy are frequently elevated with their normalized "T" scores greater than or equal to 70 (two standard deviations above normal). When the composite configuration of these scales is viewed graphically, the averaged results from groups of low back pain subjects typically produce a specific "V" shaped configuration of elevations in which Hs and Hy are elevated above D (Love and Peck, 1987). This configuration has become known as the "conversion V" and is used by numerous clinicians to predict that treatment (especially surgical) is not likely to be successful due to the presence of major functional factors (Adams et al. 1981, Elkins et al. 1984, Fordyce 1979, Josefowitz 1982, Southwick, 1983). Literally hundreds of references support the formation of this pattern by chronic pain patients (e.g. Fordyce 1979, Hanvik 1950, and Josefowitz 1982). However, Maruta (1984) and others have found that the MMPI is not capable of differentiating between patients with organic and functional bases for their pain.

The content of many of the questions which contribute to the Hs and Hy scales, as well as to the French Dorsales (DOR) and American Low Back (LB) scales relate to awareness of and concentration on bodily processes. The two later scales are designed to be especially sensitive to functional factors involved in low back pain. They have the same problems that the conversion "V" does as they are largely based on reports of physiological problems which normally appear among chronic pain patients but not among pain free research subjects. The above scales also contain items on restlessness, sleep problems, and other problems which have been shown typically to be increased by presence of chronic pain. Smythe (1984) suggested that there was virtually no way for a patient with chronic pain to answer the MMPI honestly without elevating these scales.

Our review of the literature on the use of the MMPI for assessing chronic pain did not locate any studies which analyzed the content of questions contributing to the conversion "V" with respect to usual physical sensations experienced by people with low back pain. Keller and Butcher (1991) recently reviewed the same literature with the same lack of findings. Watson (1982) found that chronic pain patients endorsed more "vague complaints" on Hs than normal subjects but produced specific complaints related to back pain on Hy. Ornduff et al (1988) did an item analysis of answers to items on the Hy scale made by low back pain and pain-free subjects. They found that low back pain patients endorsed more items related to "bodily concern" than non-pain controls. Many workers, including Bradley et al. (1978) and Mcgill et al. (1983) have done sophisticated statistical analyses of the direction in which different types of pain patients answer questions on all of the scales.

This study was designed to determine whether patients with clear organic diagnoses accounting for their low back pain would endorse more items related to sensations normally experienced by people in pain when they were in pain than when they were pain free.

Methods

The subjects were fifty-three males and eighteen females who were hospitalized on orthopedic wards at two Army Medical Centers for treatment of chronic low back pain. Chronic was defined as a minimum of six months prior treatment for low back pain. The mean number of years of treatment for low back pain was 6.66 (SD = 7.51; maximum = 30; minimum = 6 months). The subjects ranged in age from nineteen to seventy with a mean age of 40.46 years (SD = 12.61). They were consecutive admissions to the wards who volunteered to participate in the study. In order to be included in the study, a subject had to have been admitted to the orthopedic wards by a physician, based upon a specific diagnosis of low back pain. This diagnosis had to meet the criteria, as judged by the orthopedic surgeon, of being based upon objective organic findings or causes. These findings varied throughout the sample. All but two of the subjects had a variety of disk related problems. Details of the subjects' pain and characteristics are delineated in Table I.

TABLE I ABOUT HERE

Data for this study were obtained by using: (1) a questionnaire on demographic variables, pain duration and pain intensity (both at the time the questionnaire was completed and on the average over time), (2) the standard version of the MMPI (Form R) and (3) a modified version in which the items from Form R's scales Hs, D, Hy and K were presented in a format requiring the subject to answer each item twice consecutively. The first time, subjects were to answer the items as they felt before their pain began. The second time, they were to answer the items as they felt now that they were in pain. Permission was obtained from the copyright holder (The University of Minnesota) to alter the inventory's format.

Results

Table II presents the group means and standard deviations of the K corrected scores of male and female groups on the Hs, D and Hy scales across the three conditions (the standard - full MMPI (Form R) and the modified version with questions from these scales answered twice - once "with pain" and once "without pain"). When subjects answered the standard MMPI, the male and female groups have a composite conversion "V" profile with Hs and Hy at or near T=70 and D elevated but less than Hs and Hy (male: HS= 71, D=67 and Hy=70; female: Hs=70, D=58 and Hy=70). The profiles for male and female subjects are significantly different when answering with pain and pain free. A MANOVA for a within subjects, repeated measures design yielded a significant main effect for condition of administration, gender, and the format of the tests.

TABLE II ABOUT HERE

The F and p values for main effects and interactions are given in Table III. Multiple contrasts (SPSS 4.0 for VAX/VMS) of means yielded the following p values within the Hs, D and Hy scales. This generalization holds true particularly well in comparisons of various conditions of administration.

TABLE III ABOUT HERE

The items on Hs, D and Hy which were changed in different directions for a significant number of patients ($p < .05$, T Test for comparison of percents drawn from one sample) from the with pain version to the "without pain" version of the scales are presented in Table IV. The analysis was performed using items with a significant difference for all patients.

Answers of both male and female groups from the modified with pain version of Hs and Hy were scored with either Harris and Lingoes (Cited in Graham, 1987) content subscales for Hy or the Back Pain and Non-Back Pain content subscales for Hs developed by Schmidt and Wallace (1982). For Hy, T score conversions are possible using the Harris and Lingoes subscales (Graham, 1987). From the T scores of the subscales, (Table V) it can be seen that on Hy somatic complaints and lassitude-malaise account for most the change in profile configuration from the with pain condition to the pain free condition.

TABLES IV AND V ABOUT HERE

The Back Pain and Non-Back Pain content subscales (Schmidt and Wallace, 1982) for Hs are made up of Hs items that have to do LBP or its natural consequences (Back Pain subscale) and Hs items that are not connected with LBP (Non-Back Pain Subscale). The Back Pain Scale in Schmidt and Wallace's (1982) factor analytic study of Hs, D, and Hy loaded on a severity of physical pain symptom factor. The Non-Back Pain Scale is composed of psychogenic components, which "...reflect a pattern where physical symptoms become ways of defending against or coping with ineffectively resolved issues..." (Schmidt and Wallace, 1982, p 368). On the modified "with pain" version of the Hs scale, both male and female groups significantly over-endorsed 10 of 10 items on the Back Pain Scale in the direction of pathology. Both groups significantly over-endorsed only three of seventeen items on Non-Back Pain Scale in the direction of pathology. On the revised "without pain" version of Hs, all ten of the pathological items on the Back Pain Scale were reversed in endorsement direction. This pattern was also obtained for the three pathological items on the Non-Back Pain Scale. This reversal of endorsements in Hs suggests that elevations on Hs in the with pain condition were due primarily to LBP related items and not to a psychogenic factor. Elevations on Hs dropped below clinical significance in the without pain condition due to the reversal of endorsement on LBP related items.

Pearson's correlations between scales were calculated for both within and between the three versions. K corrected scores on Hs, D and Hy were correlated with number of years in pain for all three versions.

On the standard version, scores of all patients on Hs were highly correlated with scores on D (r=.5625, p=.000) and Hy (r=.8398, p=.0001). D and Hy were also significantly correlated with each other (r=.5491, p=.0001). K was not significantly correlated with either Hs, D, or Hy.

On the "with pain" version, scores of all patients on Hs were moderately correlated with D (r=.4351, p=.0001) and highly correlated with Hy (r=.8578, p=.0001). D and Hy were moderately correlated (r=.3594, p=.002). K was not significantly correlated with Hs or Hy but a small negative correlation was noted with D (r= -.2861, p=.016).

On the "without pain" version, scores of all patients on Hs were highly correlated with Hy (r=.8186, p=.0001) and moderately correlated with D (r=.4557, p=.0001). D and Hy were slightly but significantly correlated (r=.2741, p=.021).

Between the "with pain" and "without pain" versions, Hs, D, and Hy were modestly but significantly correlated (Hs: r=4988, p=.0001; D: r=2845, p=.016; Hy: r=5459, p=.0001) for all patients. For females, the "with pain" and "without pain" conditions were highly correlated on Hs and Hy to the standard version (Pain: HS: r=.7757, p=.0001; Hy: r=.7499, p=.000; Without pain: Hs: r=.8076, p=.0001; Hy: r=.7792, p=.0001). D on the two modified conditions was moderately correlated with the standard condition (Pain: r=.6361, p=.005; Without pain r= .3510, p=.153). For males, generally lower correlations between the two revised conditions and the standard condition obtained for Hs, D and Hy (Pain: Hs: r=.7413, p=.0001; D: r=.6867, p=.0001; Hy: r=.6927, p=.0001) (No pain: HS: r=.2419, p=.081; D: r=.4862, p=.0001; Hy: r=.3838, p=.005).

For all patients there were modest positive correlations between the number of years in pain and K corrected scores on Hs and Hy but not D in the modified "with pain" and modified "without pain" versions (Pain: HS: r=.3215, p=.007; Hy: r=.2941, p=.013; D: r= .0522, p=.668) (No Pain: HS: r=.3347, p=.005; Hy: r=.3235, p=.006; D: r=.0363, p=.766). For females, the only significant correlation between Hs, D, and Hy under standard conditions of administration and number of years in pain was a negative correlation with D (r= -.4606, p=.054). Hs and Hy were not significantly correlated (HS: r=.2535, p=.310; Hy: r=.0330, p=.896). For males, there were no significant correlations between Hs, D and Hy under standard conditions of administration on number of years in pain (HS: r=2528, p=.071; D: r=1647, p=.243; Hy: r=.1887, p=.180).

Discussion:

The data presented show that subjects answered the standard version of the MMPI differently than the modified "with - without pain" version because elevations on the Hs, D, and Hy scales were different. The only differences in administration were the test format and the instructions that either: (1) drew no attention to the patients' pain (the standard version), (2) focused their attention on their present pain (the "with pain" version), or (3) drew their attention to their condition before their pain (the "no pain" version). The differences in elevations with these versions are due to different patterns of endorsement. The different patterns of endorsement are probably due to the subjects significantly over-endorsing pain specific content in the "with pain" version and under-endorsing pain specific content in the pain free condition. Almost all of the items which reached a .05 level of significant difference between the "with pain" and "without pain" administration conditions are pain specific. The subscale content analysis demonstrates that Hy is elevated under the "with pain" condition due to somatic complaints or lassitude. This can be seen as a consequence or chronic disability. Use of Schmidt and Wallace's (1982) Back Pain and Non-Back pain subscales shows that Hs is elevated under the "with pain" condition due to LBP specific content and not to items unrelated to the pain syndrome.

D in the revised with pain condition is elevated due to disproportionate endorsements of subjective depression (T=91), physical malfunction (T=70) and mental dullness (T=90). On Hs and Hy, when pain specific content is accounted for in the "without pain" condition the elevations drop below T=70 and clinical significance (female - Hs: T=57; D: T=51; Hy: T=62; male - Hs: T=53; D: T=55; Hy: T=57). D drops out of the range of clinical significance, but the contribution of somatic complaints to elevations is less than that of subjective depression and mental dullness items.

A confounding factor to the interpretation of the data being offered is the significant main effect of test format and its significant interaction with standard versus modified version. The unambiguous presentation of the experimenters' intention to draw attention to the differences in with pain and pain free endorsement of items in the modified version may have caused a social desirability factor to come into play in the pattern of endorsements. Perhaps, because the experimenters made it so plain in the modified format what they were looking for, the patients gave it to them out of a desire to please or a hope for some benefit. If this were the case, it would be difficult to argue that the modified test was measuring actual differences in endorsement patterns due to a LBP condition alone.

Several facts argue against a large social desirability factor accounting for differences in endorsement patterns. First, the instructions to each patient stressed that the results were entirely anonymous. This emphasis was intended to convey to the patient that the experimenters, as well as the treating physician, would be unaware of which test results go with which patient. It was also emphasized that the test would not affect their treatment. The second fact is that K for both male and female groups was not inordinately elevated in either of the modified conditions of administration (all patients: K with pain =15.85; T=56 for males and T= 57 for females; K "without pain" = 16.44; T=56 for males and T= 57 for females). These moderate scale elevations on K indicate that these patients, as a group, were not in a response set which leaned toward endorsing socially desirable content nor were they looking to please.

When subjects took the standard MMPI, their attention was not focused on the relationship between their back pain and the inventory or its items. They just took the test because everyone on the ward took it. Thus, it is far more likely that the interaction effect came from the lack of bringing the subjects' attention to a possible relationship between items and their pain during the standard administration relative to the focus engendered by the format of the "with" and "with out" pain versions.

As with Leavitt's (1985) study of the intercorrelation of Hs, D and Hy, this sample's scale elevations Hs, D and Hy are highly to moderately correlated with each other, depending upon the condition of administration. The correlation between Hs and Hy ranged between .85 and .81 across conditions of administration. Hy and Hs were moderately but significantly correlated with D, ranging between .56 and .27, depending upon the condition of administration. D was not inversely proportional to Hs or Hy in any of the conditions of administration. This fact argues against the conversion hypothesis.

Watson's (1982) finding that is sample of chronic pain patients appeared hypochondriacal when compared to normal controls on Hs was not replicated in this study. When endorsements on Hs items were compared on the modified with pain condition to the pain free condition, the items that changed were focused disproportionately on items that are related to pain.

The correlations between years in pain and elevations on Hs, D and Hy support the conclusion that the "V" configuration becomes more pronounced and elevations increase as years in pain increase. This indicates that as the years in pain increase, so do the number of pain symptoms and, thus, the number of pain specific items endorsed on the MMPI.

It is critical to note that the findings of this study are limited to mid-range "V" configurations. A high range "V" would be produced by including psychologically relevant items as well as the pain related ones. Thus, A high "V" is still indicative of psychological factors.

The version of the MMPI which formed the basis for this study (Form R) is currently being replaced by a revised version called the MMPI-2. Most of the items relevant to this study are retained in the new version. The only potentially relevant items dropped from the validity and clinical scales were numbers 14, 63, and 462. They have to do with urine and bowel problems. Only item 63 was endorsed in a significantly different direction on the "pain-free" versus the "pain" versions. Thus, the results of this study hold for the MMPI-2 as well as for the MMPI.

We conclude that:

(1) A low or mid-range "conversion V" produced by apparently psychologically normal patients who have objective findings substantiating their low back pain is due mainly to people endorsing pain related items because they hurt and is of no clinical significance.

(2) The "conversion V" is likely to be higher the longer people are in pain because they will endorse more pain related items as the back pain results in more and more symptoms.

(3) Among patients with chronic low back pain who have substantiated organic findings, the relationship between the presence of a low or mid-range "conversion V" and failure of surgery is a self fulfilling prophecy because these people (a) endorse a

great many pain related items on the MMPI and (b) are frequently treated unsuccessfully with surgery.

(4) A high range "conversion V" is achieved only by endorsing both physically and psychologically related items so is still of clinical importance.

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Table I

Characteristics of the subjects and their pain
(means are shown with standard deviations in parentheses)

Age: 40.46 (12.61)

Gender: Males - 53 Females - 18

Number of years treated: 6.66 (7.51)

Subjects with Continuous vs. episodic pain
Number with Continuous Pain: 51
Number with Episodic Pain: 20
Number of pain episodes per year: 176.47 (171.07)
Number of painful days per month: 23.00 (8.93)
Number of painful hours per day: 10.71 (8.62)

Intensity of pain on a scale of 1-10
Usual amount of pain: 5.0 (2.25)
Most pain: 8.96 (1.13)
Least pain: 2.89 (1.85)
Present pain: 4.19 (2.52)

TABLE II
K corrected score means and standard deviations of the HS, Hy, and D scales for each version

Sex	**Scale**	**Standard Version**	**With Pain**	**Without Pain**
	HS	X=19.519 SD=5.594	X=22.283 SD=5.647	X=13.368 SD=4.793
Male (53)	D	X=23.962 SD=6.777	X=29.000 SD=7.460	X=19.057 SD=5.940
	Hy	X=26.604 SD=5.638	X=30.283 SD=5.789	X=21.189 SD=5.805
	Hs	X=22.667 SD=6.097	X=24.861 SD=5.938	X=17.278 SD=5.882
Female (18)	D	X=24.389 SD=5.158	X=32.167 SD=8.382	X=19.889 SD=4.199
	Hs	X=30.167 SD=5.983	X=34.278 SD=6.433	X=25.500 SD=6.600

TABLE III

F, DF and p values for main effects and interactions

Main Effects	F	DF	P
Standard Vs. Modified:	70.84	2	.0001
Pain Vs. No-pain:	94.98	2	.0001
Gender:	6.33	1	.014

Interactions	F	DF	P
Standard X Pain - No Pain	12.32	4	.0001
Gender X Standard X Pain - No Pain	1.77	2	.174
Gender X Pain - No Pain	.22	2	.807
Standard X Pain - No Pain X Gender			.119

Table IV

Items from the Hs, D, and Hy scales of the MMPI (Form R) which were endorsed in significantly different directions (p = 0.5) in the "with pain" vs. "no pain" versions

Item #	Item	Change in endorsement when changing from with to without pain
2	I have a good appetite.	F - T
3	I wake up fresh and rested most mornings.	F - T
7	My hands and feet are usually warm enough.	F - T
8	My daily life is full of things that keep me interested.	F - T
9	I am about as able to work as I ever was.	F - T
32	I find it hard to keep my mind on a task or job.	T - F
36	I seldom worry about my health.	F - T
41	I have had periods of days, weeks, or months when I couldn't take care of things because I couldn't "get going".	T - F
43	My sleep is fitful and disturbed.	T - F
44	Much of the time my head seems to hurt all over.	T - F
46	My judgement is better than it ever was.	F - T
51	I am in just as good physical health as most my friends.	F - T
55	I am almost never bothered by pains over my heart or in my chest.	F - T
62	Parts of my body often feel like burning, tingling, crawling or "like going to sleep".	T - F
63	I have had no difficulty in starting or	

	holding my bowel movement.	F - T
68	I hardly ever feel pain in the back of the neck.	F - T
71	I think a great many people exaggerate their misfortunes in order to gain the sympathy and help of others.	F - T
76	Most of the time I feel blue.	T - F
86	I am certainly lacking in self-confidence.	T - F
103	I have little or no trouble with my muscles twitching or jumping	F - T
107	I am happy most of the time.	F - T
137	I believe that my home life is as pleasant as that of most people I know.	F - T
142	I certainly feel useless at times.	T - F
152	Most nights I go to sleep without thoughts or ideas bothering me.	F - T
153	During the past few years I have been well most of the time.	F - T
155	I am neither gaining nor losing weight.	F - T
159	I cannot understand what I read as well as I used to.	T - F
160	I have never felt better in my life than I do now.	F - T
163	I do not tire quickly.	F - T
175	I seldom or never have dizzy spells.	F - T
186	I frequently notice my hand shakes when I try to do something.	T - F
189	I feel weak all over much of the time.	T - F
190	I have very few headaches.	F - T
207	I enjoy many different kinds of play and recreation.	F - T
242	I believe I am no more nervous than most others.	F - T
243	I have few or no pains.	F - T
259	I have difficulty in starting to do things.	T - F
272	At times I am full of energy.	F - T
273	I have numbness in one or more regions of my skin.	T - F
285	Once in a while I laugh at a dirty joke.	F - T
296	I have periods in which I feel unusually cheerful without any special reason.	F - T

Table V

<u>T scores for subscales of Hy</u>

		Male	Female
Hy 1	(Denial of Anxiety)	T=34	T=38
Hy 2	(Need for affection)	T=30	T=30
Hy 3	(Lassitude - Malaise)	T=100	T=93
Hy 4	(Somatic complaints)	T=71	T=63