CLUSTER ANALYSIS OF THE MMPI-2

IN A CHRONIC LOW-BACK PAIN

POPULATION

THESIS

Presented to the Graduate Council of the
University of North Texas in Partial
Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

By

Roger J. deBeus, B.A.

Denton, Texas

December, 1997
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The Minnesota Multiphasic Personality Inventory (MMPI) is the most frequently used psychological measure in the assessment of chronic pain. Since the introduction of the MMPI-2 in 1989 only two published studies have focused on cluster analysis of chronic pain patients. This study investigated MMPI-2 cluster solutions of chronic low-back pain patients. Data was collected from 2,051 chronic low-back pain patients from a multidisciplinary pain clinic in the southwestern United States. A hierarchical clustering procedure was performed on K-corrected T-scores of the MMPI-2 using the three validity and ten clinical scales. Four relatively homogeneous subgroups were identified for each sex with the MMPI-2. In general, these results replicated the findings of previous researchers using both the MMPI and MMPI-2.
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CHAPTER I

CLASSIFYING CHRONIC PAIN PATIENTS

WITH THE MMPI

The Need for Classification

Classifying chronic pain has moved far beyond a model of pain as a sensory signal of tissue injury. The enormous complexity of chronic pain must be approached as a psychosocial as well as physiological phenomenon. The chronic pain patient can only be understood when the interaction of affective, cognitive, life history, learning and conditioning, social modeling, physiological, psychiatric, and systems influences is taken into account. Current pain treatment programs take a pragmatic, eclectic view of the problem and attempt to address as many facets of the chronic pain syndrome as possible (Chapman & Bonica, 1985; Fordyce, 1976; Turk & Flor, 1984).

Adequate classification of chronic pain patients can help to address many of the problems inherent in the complex multidimensional models of chronic pain etiology and approaches to treatment. Two major goals of classification strategies should be to describe the characteristics of the typical pain patient and personality, and to describe the differences among pain patients (Keller & Butcher, 1991). The relevance of typical pain patient descriptions have guided clinicians in discovering the etiologic and maintaining factors in chronic pain states, in developing general treatment programs that address all
these components of chronic pain, and potentially for predicting the development of pain problems premorbidly (Prokop, 1988).

Multidisciplinary treatment approaches have required an enormous financial investment and the involvement of many professionals from diverse backgrounds (Aronoff, 1985). Adequate classification of the constellation of factors contributing to a particular client’s pain problem could potentially cut these costs by accurately predicting who might benefit from such a program (Turk & Flor, 1984). However, even more helpful would be the ability to identify groups of patients with certain factors in common who will respond best to certain treatment components. Research on chronic pain patients has generally conformed to the same "uniformity myth" (Keisler, 1966) that has pervaded psychotherapy outcome research in general. If subgroups of patients who have certain etiologic or maintaining factors in common could be identified, matching them to an appropriate treatment could simultaneously cut costs and improve outcome statistics.

Classification goals have been most consistently addressed using the Minnesota Multiphasic Personality Inventory (MMPI and MMPI-2). At this point other assessment instruments and approaches have not received enough attention in the literature to provide comparably extensive data. A survey by Hickling, Sison, and Holtz (1985) reported that the MMPI was the most commonly used assessment tool in the pain clinic and used by 77.7 percent of all clinics. The MMPI has clearly played a major role in the classification of chronic pain patients.

The MMPI is a 566-item true-false self-report questionnaire. Items have been grouped into scales which were originally developed in the 1940s to discriminate
empirically between groups of patients with various psychiatric diagnoses and a group of ‘normal’ adults. Raw scores on the scales have been transformed into standardized ‘T-scores,’ designed to have a mean of 50 and a standard deviation of 10 in the original normative sample. These scores obtained are plotted on a test profile. While diagnostic systems have changed and interpretive strategies are now based more on profile patterns of scores (“codetypes”) and item content than on single scale scores, three validity scales and ten clinical scales have remained the standard set of MMPI scores reported across studies in a wide variety of patient populations (Dahlstrom, Welsh, & Dahlstrom, 1975; Graham, 1987; Greene, 1988, 1991).

The MMPI-2 (Butcher, Dahlstrom, Graham, Tellegen, & Kaemmer, 1989) represents the restandardization of the MMPI that was needed to provide current norms for the inventory, develop a nationally representative sample, provide appropriate representation of minority groups, and update item content where needed (Greene, 1991). The MMPI-2 was standardized on a sample of 2,600 individuals (1138 men and 1462 women) selected to reflect national census (1980 U.S. Census) parameters on age, marital status, ethnicity, and so on. The items on the validity and clinical scales of the MMPI were essentially unchanged on the MMPI-2 except for the elimination of 13 items based on item content and the rewording of 68 items. Another difference between the MMPI and MMPI-2 is the conversion of raw scores into T-scores. The MMPI’s T-scores were linear transformations of the raw score distributions while the MMPI-2’s T-scores were developed to be ‘uniform’ by combining the raw scores of the eight clinical scales (Hs, D, Hy, Pd, Pa, Pt, Sc, and Ma) into a composite distribution, then regressing the component
scales against the composite to obtain T-score conversion formulas (Tellegen, 1988). In addition, the 'critical' level of elevation has been changed to a T-score of 65 (instead of 70 in the MMPI), appearing to be the optimal point for separating the normative sample from various clinical groups (Butcher, Dahlstrom, Graham, Tellegen, & Kaemmer, 1989).

Total Group Descriptions

The majority of researchers have classified and treated chronic pain patients as a homogeneous group whose shared personality characteristics await discovery (Keller & Butcher, 1991). Many of these personality characteristics are based on correlates of MMPI mean profiles: the pattern of scale scores found when the MMPIs of a group of patients are averaged together. Studies reporting mean profiles of pain patients show great consistency in reporting one of two similar configural patterns. The first common profile is a "conversion-V": highest elevations (T scores usually > 70) on scales Hs and Hy, with a relative absence of elevation on D (Love & Peck, 1987; McGrath & O'Malley, 1986; Murray, 1982; Southwick & White, 1983). This configuration is interpreted as "converting personally distressing troubles into more rational or socially acceptable problems; that is, the person is converting psychological problems into somatic complaints...The emphasis on physical complaints along with the denial of any psychological basis for them makes all members of this group poor candidates for any form of psychological treatment" (Greene, 1991, pp. 148-149).

The other common mean profile is characterized by elevations on Hs, Hy, and D known as the "neurotic triad" (Adams, Heilbronn, Silk, Reider, & Blumer, 1981; Beals & Hickman, 1972; Murray, 1982; Sternbach, Wolf, Murphy, & Akeson, 1973). This profile
is interpreted as emphasizing passive-dependency, low self-esteem, anxiety, avoidance of performance demands, and masked hostility (Snibbe, Peterson, & Sosner, 1980).

Butcher and Tellegen (1978) cautioned that interpretation of MMPI mean profiles is complicated by the content heterogeneity of the standard scales. They suggested analyzing individual item content or subscales to provide a more accurate interpretation of the overall profile. While all studies have found high endorsement of items directly reflecting somatic distress and pain-related disability with chronic pain patients, their findings have differed on the more psychological components of the composite pain patient profile. For example, Watson (1982) concluded that pain patients are hypochondriacal and depressed, but that item analysis showed little evidence of hysteroid denial, repression, and defensiveness. In contrast, Franz, Paul, Bautz, Choroba, and Hildebrandt (1986) reported that the average pain patient described himself as even more socially competent and self-confident than did normal controls, denied anger and aggressiveness, and did not possess hypochondriacal tendencies. Other researchers have shown that similar elevations on scales such as Hs and Sc may in fact reflect quite different combinations of item content, suggesting that these items may mean different things for different patients (McGrath & O'Malley, 1986; Moore, McFall, Kivlahan, & Capestany, 1988; Prokop, 1986).

These inconsistent results have reflected the heterogeneity of chronic pain patients. The greatest problem with research addressing the chronic pain personality is that mean profiles and group averages have obscured individual differences and possible pain patient subgroups (Keller & Butcher, 1991). Fordyce (1976) has warned of the "illusion of
homogeneity" in both patients and treatments: researchers and clinicians have too often assumed that labeling a person as a "chronic pain patient" or treatment as "cognitive" means that the patient and treatment have conformed to the typical characteristics of each. In order to move away from obscuring individual differences and the illusion of homogeneity, the MMPI literature has reflected a growing tendency to look beyond group averages and concentrate on pattern analysis and subgrouping of pain patient profiles.

Subgrouping Approaches

Several different classification approaches have been identified in attempting to subgroup, and better understand, the chronic pain patient. Some of these approaches have included, but are not limited to, functional versus organic pain and compensation status. The major dichotomy into which researchers have tried to classify patients is "functional" versus "organic" pain. Functional has implied that the pain problem has been caused or maintained by psychosocial factors, whereas organic has assumed a physiologic basis (Keller & Butcher, 1991).

Hanvik (1949) first described a method of discriminating functional and organic pain patients on the basis of MMPI profiles. He found that patients classified as functional tended to score higher on scales Hs, Hy, Pt, Sc, and Pd, with the overall profile characterized by a "conversion-V" pattern of hypochondriasis and hysteria with relatively little depression. Other researchers have reported that functional patients are characterized by elevated profiles, evidence of greater psychopathology, and a "conversion-V" or "neurotic-triad" pattern (Freeman, Calsyn, & Louks, 1976, Lair & Trapp, 1962; McCrea, Turner, & Dawson, 1977). However, these researchers and
others have cautioned that "conversion-V" profiles occur in the organic population as well, and the degree of overlap between organic and functional groups have made it impossible to use such profiles for individual diagnoses (Adams, Heilbronn, Silk, Reider, & Blumer, 1981; Osborne, 1985). Other researchers, in contrast to Hanvik, have failed to find differences between organic and functional groups even when using mean profiles (Cox, Chapman, & Black, 1978; Hendler, Mollett, Talo, & Levin, 1988; Leavitt, 1985).

In general, classification of patients into organic and functional categories has not proven particularly replicable or useful in treatment planning.

Another way to classify patients has been based on evidence of secondary gain as exemplified by studies of compensation status. Elevated pain reports and elevated Hs, D, Hy, and Pd scales on the MMPI have been associated with ongoing compensation or litigation (Beals & Hickman, 1972; Pollack & Graineey, 1984; Shaffer, Nussbaum, & Little, 1972). However, other investigators have found no differences between compensation claimants and nonclaimants on various measures including reports of pain severity, MMPI patterns, level of psychological disturbance, or treatment outcome (Chapman, Brena, & Bradford, 1981; Mendelson, 1984; Trief & Stein, 1985). Just as with the previous classification schemes discussed, grouping patients by compensation status alone is probably too simplistic to result in reliable, meaningful patient correlates and treatment predictions.

Given the multifaceted determined nature of chronic pain problems, it has seemed unlikely that subgrouping patients along single dimensions will lead to more than minimal improvements in the accuracy with which treatment efficacy can be predicted (Keller &
Butcher, 1991). One way to address this complexity would be to abandon the search for the chronic pain personality and instead look for subgroups of patients who are similar to each other in their pattern of scores on the MMPI.

Although the classification approaches cited above show promise in defining subgroups of patients with shared treatment-relevant characteristics, they were based on preconceived classification schemes with little empirical validation that these characteristics actually form reliable and meaningful patient groups. Recently, several investigators have employed cluster analysis to explore the complex relationships inherent in an entire profile of assessment data, with the hope of discovering empirically which patient characteristics are reliably associated with each other and can be used to classify treatment-relevant subgroups of patients.
Cluster Analysis

Cluster analysis techniques have been used to partition a set of objects into relatively homogeneous subsets based on the inter-object similarities. The procedure begins by measuring each of a set of n objects on each of k variables. In this case, participants and MMPI scale scores respectively. Next, a measure of the similarity - or, alternatively, the distance or difference - between each pair of objects must be obtained. Then some algorithm, or set of rules, must be employed to cluster the objects into subgroups based on the inter-object similarities. The ultimate goal is to arrive at clusters of objects (participants) which display small within-cluster variation, but large between-cluster variation (Kachigan, 1986).

There are several methods of performing a cluster analysis. Most studies of chronic pain patients have used a hierarchical clustering procedure while others have used iterative partitioning methods (i.e, k-means). The hierarchical procedure starts by treating each individual as a separate cluster and then progressively combines similar individuals into larger and larger clusters, ending with the total sample (Tryon & Bailey, 1970). The k-means procedure begins with an initial partition of the data set into some specific number of clusters that is user specified and then computes the centroids of these clusters.
randomly. Next, each data point(s) is allocated to the cluster that has the nearest centroid. The new centroids of the clusters are computed and clusters are not updated until there has been a complete pass through the data. The last two steps keep occurring until no data points change clusters and all cases have been assigned to the nearest cluster centroids (Aldenderfer & Blashfield, 1984). Since cluster solutions vary with the computer program used, similarity measure chosen, and the procedure used to determine the optimal number of clusters, it is important for researchers to describe their procedure and assumptions carefully (Blashfield, 1980).

The studies reviewed below use MMPI and MMPI-2 scales as their variables with both mixed chronic pain and chronic low-back pain populations. Table 1 shows a summary of these studies: number of participants, setting, statistical procedure used, and results. To better organize the literature review, the studies will be broken up into patient populations and test versions. The purpose of differentiating between mixed pain patients and low-back pain patients is twofold. First, not all mixed pain studies include low-back pain patients, and second, it is pragmatic in understanding the differences between the two groups. The following review will first discuss the MMPI used in mixed pain populations and then low-back pain populations. Finally, the MMPI-2 will be covered with mixed pain and then low-back pain populations.
Table 1

Summary Chart of MMPI and MMPI-2 Chronic Pain Population Cluster Analysis Studies

<table>
<thead>
<tr>
<th>Investigators</th>
<th>Date</th>
<th>Site</th>
<th>N</th>
<th>Procedures</th>
<th>Clusters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MMPI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mixed Pain</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sternbach</td>
<td>1974</td>
<td>VA Hospital</td>
<td>N/A</td>
<td>Conceptual</td>
<td>4 Male</td>
</tr>
<tr>
<td>Prokop, et al.</td>
<td>1980</td>
<td>Univ. Hospital</td>
<td>237</td>
<td>H-Group</td>
<td>3 Female</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3 Cohorts)</td>
<td></td>
<td></td>
<td>4 Male</td>
</tr>
<tr>
<td>Armentrout, et al.</td>
<td>1982</td>
<td>VA</td>
<td>240</td>
<td>Cluster</td>
<td>3 Male</td>
</tr>
<tr>
<td>Bernstein, et al.</td>
<td>1983</td>
<td>Private Clinic</td>
<td>77</td>
<td>H-Group</td>
<td>5 Female</td>
</tr>
<tr>
<td>Hart</td>
<td>1984</td>
<td>Univ. Hospital</td>
<td>70</td>
<td>K-means</td>
<td>4 Male</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(seeded)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Costello, et al.</td>
<td>1987</td>
<td>Univ. Clinic</td>
<td>170</td>
<td>Waverage/cosine</td>
<td>3 Female</td>
</tr>
<tr>
<td>Bombardier, et al.</td>
<td>1993</td>
<td>Univ. Hospital</td>
<td>517</td>
<td>FastClus</td>
<td>4 Mixed</td>
</tr>
<tr>
<td><strong>Low-Back Pain</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bradley, et al.</td>
<td>1978</td>
<td>Univ. Hospital</td>
<td>548</td>
<td>H-Group</td>
<td>4 Female</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3 Cohorts)</td>
<td></td>
<td></td>
<td>3 Male</td>
</tr>
<tr>
<td>McGill, et al.</td>
<td>1983</td>
<td>Private Clinic</td>
<td>92</td>
<td>H-Group</td>
<td>4 Female</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(seeded)</td>
<td></td>
<td></td>
<td>4 Male</td>
</tr>
<tr>
<td>Bradley, et al.</td>
<td>1984</td>
<td>Univ. Hospital</td>
<td>314</td>
<td>H-Group</td>
<td>4 Female</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 Male</td>
</tr>
<tr>
<td>McCreary</td>
<td>1985</td>
<td>Univ. Hospital</td>
<td>401</td>
<td>K-means</td>
<td>5 Female</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2 Cohorts)</td>
<td></td>
<td></td>
<td>4 Male</td>
</tr>
<tr>
<td><strong>MMPI-2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mixed Pain</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Keller and Butcher</td>
<td>1991</td>
<td>Pain Clinic/Rehab Hospital</td>
<td>502</td>
<td>SPSS Hier</td>
<td>3 Female</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(2 Cohorts)</td>
<td>3 Male</td>
</tr>
<tr>
<td><strong>Low-Back Pain</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riley, et al.</td>
<td>1993</td>
<td>Pain Clinic</td>
<td>201</td>
<td>Hierarchical/agglomerative</td>
<td>4 Mixed</td>
</tr>
</tbody>
</table>
MMPI and Mixed Pain Populations

Sternbach (1974) was the first to configurally subgroup chronic pain patients based on MMPI scales. He described four profile types that he commonly encountered in his clinical practice. He labeled the first profile type "Hypochondriasis," defined by a primary elevation on Hs and secondary elevations on Hy and D, forming a "neurotic triad." The second profile type was labeled "Reactive Depression," defined with an elevation on D. The third type was called "Somatization Reaction," which is similar to the "conversion-V" profile. The last profile was named "Manipulative Reaction," defined by an elevation on Pd in addition to the "neurotic" scales (Hs, D, and Hy). Other than using his clinical experience, Sternbach's patient population and classification rules were not clearly described. However, these four profile types have been cited for comparison in numerous subsequent studies.

A study by Prokop, Bradley, Margolis, and Gentry, (1980) addressed the replicability of Sternbach's (1974) patient clusters in other samples of chronic pain patients. These researchers studied a sample of patients with multiple pain complaints, ranging from headaches and pain in the extremities to total body pain but excluded patients with low-back pain alone. The authors replicated the procedure used by Bradley, Prokop, Margolis, and Gentry, (1978), dividing the male and female samples into three cohorts corresponding to year of admission, performing separate hierarchical cluster analyses on each of these cohorts, and then looking for clusters that were replicated across the groups.
For the female sample (N = 221), no subgroups were replicated across all three cohorts. However, three clusters did replicate across two of the cohorts: a "neurotic-triad" profile, a "normal-limits" profile, and a "conversion-V" profile. For the male sample (N = 123) replicable clusters were found only across two of the three cohorts. Four clusters were identified for the male sample. The first and second were similar to the female sample's "neurotic-triad" and "normal-limits" profiles. The third cluster was marked by a peak on the D scale and the fourth was characterized by elevations on most of the clinical scales.

Armentrout, Moore, Parker, Hewett, and Feltz, (1982), gave the MMPI to 240 male chronic pain patients over a three-year period at a VA hospital. The subjects varied considerably in age, years of education, years in pain chronicity, and site of pain. The authors performed a hierarchical clustering procedure which identified three subgroups closely resembling those identified by Bradley et al. (1978). The first subgroup (N = 61) contained "normal-limits" profiles while the second subgroup (N = 139) had "neurotic-triad" patterns. The third subgroup (N = 40) had "psychopathologic" profiles with elevations above a T score of 70 on scales D, Hs, Sc, Hy, Pt, Pd, F, and Pa in descending order.

Bernstein and Garbin (1983) derived five clusters from the MMPI profiles of 77 female pain-clinic patients. Their first three clusters were very similar to the "neurotic-triad," "normal-limits," and "conversion-V" profiles found by Bradley et al. (1978) and by Prokop et al. (1980) in their female samples. The first and last of these are similar to Sternbach's "hypochondriasis" and "somatization" profiles. A fourth cluster seemed to
correspond to the general-elevation profile found by Bradley et al. (1978) for both men and women, and by Prokop et al. (1980) and Armentrout, Moore, Parker, Hewett, and Feltz (1982) for men only. A fifth cluster, not identified in other studies, was characterized by elevations on Hs, D, Hy, and Pd, and was described as similar to Sternbach's "hypochondriacal" and "manipulative" profiles combined.

Hart (1984) cluster analyzed the MMPIs of 70 male patients referred to a university medical center for treatment of chronic pain. A K-means clustering procedure was used with initial seeding by four marker profiles designed to match Bradley et al.'s (1978) solution. Four profile groups were found for the male population: "neurotic-triad"; subclinical elevation on Hs and Hy; "generally elevated" profile; and "conversion-V" profile. The results replicated previous studies in finding these profile configurations identifiable within a heterogeneous pain-patient population. This study also confirmed some previous studies (McGill, Lawlis, Selby, Mooney, & McCoy, 1983) finding that the "conversion-V" pattern can be reliably identified in men as well as women.

Costello, Hulsey, Schoenfeld, and Ramamurthy, (1987) performed two different studies. The first looked at MMPI profiles of female chronic pain patients. In the first study 170 profiles were collected of females who were being evaluated and/or treated for a variety of chronic pain complaints in a multidisciplinary pain clinic. An agglomerative hierarchical clustering method was utilized. In particular, cosine, a pattern similarity measure, was chosen to construct a proximities matrix while the clustering method chosen was waverage which averages the linkages within groups. The cosine proximities matrix was constructed for a sample of 85 MMPI profiles and for a replication sample of 85.
Three cluster replications were discovered. The first cluster had a "normal limits" profile with slight (between 60 and 70 on the MMPI) elevations on Hy and Hs. The second group had the "conversion-V" configuration. The third cluster can be described as a "general elevation" group.

Costello et al.'s (1987) second study combined the results of 10 investigative teams and summarized a four cluster typology from the literature. A total of 57 profile types were reported from the literature. These 57 profile types were meta-clustered and produced a solution of four types and subsequently labeled P-A-I-N. Type P is the most "psychopathological" type as nearly all the clinical scales were elevated. Type A is where the "conversion-V" is prominent. Type I contains an elevation on the "neurotic-triad" scales Hs, D, and Hy. Type N is a "normal" profile with no scale elevated above 70. The authors concluded that these profile types are now well established.

Bombardier, Divine, Jordan, Brooks, and Neelon, (1993) looked at two independent samples ($N = 254$ and $N = 263$) of chronically ill patients with heterogeneous medical conditions. Patients in both samples were administered Form R of the MMPI, except 7 percent of both samples utilized the 168-version of the MMPI. Cluster analyses were performed on K-corrected MMPI T-scores from both samples using the FASTCLUS procedure from SAS (1985). FASTCLUS is a cluster optimization technique which does not assume a hierarchical relationship among clusters and allows relocation of cases throughout the clustering process. Four clusters were chosen. Three elevated and one unelevated profiles emerged. The first cluster is an extreme version of the "psychopathological" profile. It has an extreme elevation on Scale 8, along with most
clinical scales above a T-score of 80. The second cluster had significant elevations on Scales 7 and 8, and slightly lower, but still significant, elevations on Scales 1, 2, and 3. The third profile had significant elevations on Scales 1, 2, and 3. The final cluster resembles a "normal limits" profile.

Starting with Sternbach (1974) the profiles found in the previous clustering studies on mixed pain populations have seemed straightforward. The clusters that predominantly emerged for both males and females included the within-normal-limits, conversion-V, neurotic triad, and elevated profiles. These were generally summarized with Costello et al.'s (1987) P-A-I-N classification scheme.

MMPI and Low-Back Pain Populations

The first study integrating the cluster analysis procedure was done by Bradley, Prokop, Margolis, and Gentry (1978). MMPI scores were obtained on 233 male and 315 female low-back pain patients admitted to a university medical center during a 3-year period (1973-1975). The male and female samples were divided into three cohorts, consisting of all patients evaluated in a particular year. Within the male sample the cohorts consisted of 65, 79, and 89 patients while the female sample were composed of 99, 89, and 127 patients. A hierarchical cluster analysis utilizing Euclidean distances and Ward's amalgamation method was performed separately for each cohort using the three validity scales and ten clinical scales of the MMPI. The researchers decided to examine only those solutions consisting of five or fewer subgroups, because of the suggestion of Sternbach (1974) that chronic pain patients could be characterized by four principle
profiles. Cluster solutions for the cohorts were then compared to identify subgroups which replicated across the three cohorts.

Four general profile types were found to replicate across the female samples. The first subgroup (23% of the sample) was characterized by elevations on the neurotic-triad scales. The second group (39%) was a normal-limits profile with relative (in relation to the other scales - usually 5 to 10 points higher) high points on scales K, Hs, and Hy. The third group (13%) might be described as a "general elevation" group, with Hs, D, Hy, Pt, and Sc all clinically elevated. The final group (24%) was characterized by the conversion-V pattern.

The male cohorts resulted in three replicated groups. The first subgroup (44% of the sample) were characterized by elevations on the neurotic triad. The second subgroup (46%) was a normal-limits profile with relative elevations on K, Hs, and Hy. The third subgroup contained elevations on F, Hs, D, Hy, and Sc (10%). In addition to Sternbach's (1974) profile types, these mean MMPI profiles derived for the four female and three male clusters have been the basis of comparison in all subsequent clustering studies.

McGill et al. (1983) designed a study in an attempt to replicate Bradley et al.'s (1978) four MMPI profile clusters. Forty-six females and 46 males were selected at random from patients at a multimodal low-back-pain treatment program during a one-year period. A hierarchical cluster analysis was performed on the total sample, with four profiles designed to match those found by Bradley et al. (1978) added to seed the clustering process. This procedure resulted in the identification of four clusters corresponding to the three profiles for both male and female cohorts found in Bradley et
al. (1978), plus the conversion-V profile found only in the female sample. This fourth group also had a clinical elevation on Pd, similar to the somatization/manipulative reaction group noted by Bernstein and Garbin (1983) and Sternbach (1974). McGill et al. repeated their analysis separately for males and females and found the same four profile groups.

Bradley and Van Der Heide (1984) studied 96 male and 218 female patients from a university back-pain clinic in a large northeastern city. A hierarchical clustering method was used to identify homogeneous MMPI profile subgroups within the male and female cohorts of the patient sample. A four-group solution for both the male and female cohorts were found. The first male profile subgroup was characterized by elevations (T-score ≥ 70) on scales D, Pd, Pt, and Sc. The second profile subgroup contained elevations on scales Hs, D, Hy, and Sc. The third subgroup was marked by subclinically high scores on scales Hs, D, and Hy. The fourth male group was a within-normal-limits profile. The first female subgroup was characterized by elevations on scales Hs, D, Hy, Pd, and Sc. The second female subgroup was marked by elevations on scales Hs, D, Hy, and a relatively (score between 65 and 75 for the MMPI) high score on Pd. The third profile subgroup was marked by relatively (between 40 and 50) low scores on all scales with the exception of D (T-score = 68). The fourth group was a within-normal-limits profile.

McCready (1985) utilized 401 patients with chronic low-back pain in treatment at a university hospital orthopedic clinic located in an urban area of southern California. The first 271 subjects composed the original sample, and a subsequent cohort of 130 patients composed the cross validation sample. A K-means clustering procedure was used to obtain five homogeneous subgroups of male and female cohorts on the original sample,
and replicated on the cross-validation sample. It is interesting to note that the author did not give his rationale for choosing five subgroups for his analysis. The first cluster contained a general-elevation profile. The second cluster had elevations on the Hs, Hy, and D scales. The third cluster had an within-normal-limits profile with slight (5 to 10 points higher than the other scales) elevations on the Ma, Hs, Pd, and Hy scales. These three clusters were found in both men and women on both samples. A fourth cluster had elevations on Hs and Hy, and occurred only in the female cohort of both samples. The fifth cluster had relatively (in relation to other scales) unelevated profiles with highest scores on the Hy, D, and Hs scales, and was found in both men and women in both samples. Overall, there were 5 female subgroups and 4 male subgroups.

Bradley et al.'s (1978) study has statistically set the standard for clustering studies in the chronic pain literature although there have been other directions to pursue (i.e., k-means). Although most of the low-back pain population did replicate the mixed pain population clustering results, there were more variations of the profiles. These variations included not seeing a conversion-V in male samples, finding different types of elevated profiles, and finding a Hs and Hy elevation only in a female cohort. Now that the MMPI literature has been reviewed the focus will turn to the limited clustering studies on the MMPI-2.

MMPI-2 and Mixed Pain Population

Keller and Butcher (1991) obtained 502 MMPI-2 profiles derived from the AX form of the MMPI from patients admitted to a chronic pain rehabilitation program. The AX form was the adult experimental version of the MMPI developed specifically for use in
the restandardization research project to create the MMPI-2 (Butcher, 1989). The
disabled patients reported a variety of pain complaints with back pain being the most predominant.

A hierarchical cluster analysis was performed using a procedure similar to Bradley et al. (1978). Analyses were run separately for men and women and within each sex two
cohorts were generated for replication purposes. Two to six clusters were examined to
find how many replicated across the two cohorts within each sex. For both men and
women only the three cluster solution provided replicability of all cluster across cohorts.
Cluster 1 in the male sample was described as a general-elevation pattern (25% of the
men). Cluster 2 was an elevated neurotic-triad profile (57%). The third male cluster was
within-normal limits profile (19%). The first cluster for the women was a neurotic-triad
pattern with a subclinical peak on Pt (37% of the women). Cluster 2 of the women was a
general-elevation profile (30%). The third female cluster was a low conversion-V profile
(33%).

According to Keller and Butcher (1991), examination of these results strongly
suggested that this method of subgrouping resulted in separation on the basis of profile
elevation rather than profile shape. That is, for both sexes, the three replicated profiles
differ primarily in their degree of elevation. This elevation pattern also seems to be
present in other studies, with most researchers identifying a normal-limits profile, a general
elevation profile, and various elevations of the neurotic triad scales.

One pattern that has re-emerged from the MMPI studies was the inability to find a
conversion-V profile for males in this mixed pain study. However, previously the male
conversion-V shortage occurred only in the low-back pain MMPI studies. Reasons for
this discrepancy may include patient inclusion criteria, or a representative sample that is too small. Next, the only MMPI-2 study (at least known to the author) that has focused on low-back pain patients will be discussed.

**MMPI-2 and Low-Back Pain Population**

Riley, Robinson, Geisser, and Wittmer (1993) utilized the MMPI-2 in 201 chronic low-back pain patients from a multidisciplinary pain clinic in the southeastern United States. A hierarchical agglomerative clustering procedure was performed on K-corrected T-scores of the MMPI-2 using the three validity scales and nine clinical scales (Mf scale was not used). Slightly different than Keller and Butcher (1991), Riley used Ward's clustering method with squared Euclidean distances (instead of Euclidean distances) as the similarity measure chosen to permit sensitivity to differences in elevation as well as profile shape. Percentage change in the agglomeration coefficient was used for determining the optimal number of clusters.

The four cluster solution was chosen according to the agglomeration coefficient. The first cluster (44%) contained elevations on the three scales of the neurotic triad with all other clinical scales below the cutoff of 65. The second cluster contained a general elevation profile (10%). The third cluster was considered within normal limits (24%). The fourth cluster contained clinical elevations of Hypochondriasis and Hysteria elevated 10 points above Depression which made this the conversion-V profile (22%).

As this literature review has shown there has been a disparity among researchers as to both the amount and type of clusters that exist in the mixed pain as well as low-back pain populations. The MMPI mixed pain clusters that predominantly emerged for both
males and females included the within-normal-limits, conversion-V, neurotic triad, and elevated profiles. The MMPI low-back pain populations replicated the mixed pain population clustering results, although there were more variations of the profiles. These variations included not seeing a conversion-V in male samples, finding different types of elevated profiles, and finding a Hs and Hy elevation only in a female cohort. The MMPI-2 mixed pain study (Keller & Butcher, 1991) was unable to find a conversion-V profile for males although this only occurred previously in the low-back pain MMPI studies. The MMPI-2 low-back pain study (Riley, et al., 1993) results returned to the clearly delineated four profiles evident in the MMPI mixed pain literature highlighted by Costello et al, (1987). As these results have shown, it is important to determine the similarities and differences between the MMPI and MMPI-2, and to differentiate chronic mixed pain from chronic low-back pain populations. Being aware of these differences will help to make the classification process of patients more efficient.
CHAPTER III

PURPOSE OF THIS STUDY

As noted in the previous literature review there has been at least eleven MMPI clustering studies involving pain populations but only two MMPI-2 clustering studies with the same populations. This study has been designed to investigate three purposes. First, whether MMPI-2 cluster solutions would replicate those found by previous researchers with the MMPI and the two MMPI-2 studies. Specifically, four cluster profiles identified by a number of earlier investigators and highlighted by Costello, Hulsey, Schoenfeld, and Ramamurthy (1987), and Riley, Robinson, Geisser, and Wittmer (1993), or the three profile solution found by Keller and Butcher (1991). The second purpose was to obtain robustness of multivariate assumptions by using the largest chronic low-back pain population (more than 2000 participants) in the literature to date. Although there are no absolute guidelines on the exact sample size required with multiple dependent variables, it is generally agreed that from 10 to 15 subjects per variable is minimal. Thus, at least 130 subjects are needed in each group (i.e., each cohort) if examining for differences in performance on the standard validity and clinical scales (Greene, 1988). The final purpose is to extend the MMPI-2 knowledge base by adding another study utilizing the MMPI-2 in chronic low-back pain populations.

There are three major hypotheses to be tested in this study. First, there are three clusters in the male and female samples of this chronic low-back pain population. Second,
there are four clusters in the male and female samples of this chronic low-back pain population. Third, there are a combination of three, four, or more clusters in the male and female samples of this chronic low-back pain population. These hypotheses will be tested using K-corrected T-scores of the three validity scales and ten clinical scales of the MMPI-2. Males and females will be analyzed separately and each sex in turn will be randomly divided into four cohorts. The additional cohorts will serve as replication samples for each sex. The clustering method will be hierarchical integrating Euclidean as the distance measure and Ward’s method of amalgamation or linkage. The Euclidean distance instead of the squared Euclidean distance will be used because Euclidean places equal weight on objects whereas squaring the Euclidean distance places progressively greater weight on objects that are further apart (StatSoft, 1995). Ward’s method will be employed because it is distinct from all other methods because it uses an analysis of variance approach to evaluate the distances between clusters and is also regarded as being very efficient (Morey, Blashfield, & Skinner, 1983; Ward, 1963).
CHAPTER IV

METHODS

Participants

Participants were part of an inpatient low-back pain treatment program based in the southwestern United States. Each patient had a primary diagnosis of chronic low-back pain and had experienced back pain for more than six months at the L1 level or below. There were 2051 chronic low-back pain patients, 1109 males and 942 females, evaluated between 1990 and 1994. Within the male sample the cohorts randomly consisted of 277, 277, 277 and 278 patients while the female sample cohorts were composed of 235, 235, 236 and 236 patients. Please see Table 2 for demographic information on patients for whom this information was available.

Instrument

Each patient was required to complete an MMPI-2 as part of their orientation after admission into various low-back pain programs. The MMPI-2 is a 567 item true/false self-report questionnaire. Norms for the MMPI-2 were based on a large national sample (2600 individuals) chosen to match general demographic characteristics of the 1980 U.S. census. Scores from this sample provided the raw-score distributions used to develop T-score transformation tables for each scale. To convert raw scores, the MMPI-2 incorporates a new approach called "uniform" T scores developed by Tellegen (1988).
<table>
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<th>Demographics of Low-Back Pain Population</th>
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<td><strong>Age</strong></td>
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<td><strong>Education (years)</strong></td>
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<td>Missing Cases</td>
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Note. Available demographics shown for 942 females (46% of sample) and 1109 males (54% of sample). Some subjects did not fill out various demographic information on the answer sheets.
Out of this new approach, the "critical" level of elevation has been changed to a T-score of 65, appearing to be the optimal point for separating the normative sample from various clinical groups (Butcher, Dahlstrom, Graham, Tellegen, & Kaemmer, 1989).

Procedure

All questionnaires were administered as part of the initial admissions procedure, following the standard instructions for the test. Data was collected from patients entering the clinic from 1990 to 1994. All MMPI-2s were scored utilizing a computerized scoring program designed for the MMPI-2 (National Computer Systems, Inc., 1989). MMPI-2 scores were then analyzed by a statistical package called Statistica (StatSoft, 1989).

Statistics

A hierarchical clustering procedure was performed on K-corrected T scores of the MMPI-2 using the three validity scales and ten clinical scales. Ward's clustering method with Euclidean distances as the distance measure was chosen to allow sensitivity to differences in elevation as well as profile shape (Morey, Blashfield, & Skinner, 1983; Ward, 1963). Males and females were analyzed separately. In order to replicate results, each sex was placed randomly into four cohorts. Two to six clusters were examined to find how many replicated across at least three of the four cohorts within each sex. Statistica (StatSoft, 1995, Ver 5.1) was the statistical software used for analysis.
CHAPTER V

RESULTS

Female Clusters

The clustering procedure produced four relatively homogeneous cluster profiles across all four cohorts in the female sample. Please see Figure 1 for a breakdown by cohorts and Figure 2 for a breakdown of profiles. The results will be discussed in relation to profiles. The first cluster was a within-normal limits profile which replicated across all four cohorts \(N = 232, 25\%\) of females. All scores remained under the clinical cut-off of 65. The second cluster contained the conversion-V profile (Hs and Hy 10 points > D) with some variations across cohorts \(N = 332, 35\%\). Cohort #2 also had slight (between 65 and 70 on the MMPI-2) elevations on the Pt and Sc scales. Another cohort (#4) produced a smaller conversion-V elevation, that is Hs and Hy were only 5 points higher than D. The third cluster produced neurotic triad elevations across all four cohorts \(N = 247, 26\%\). However, one cohort (#2) contained a subclinical Hy score of 61. The fourth cluster produced a generally elevated profile with some variations \(N = 131, 14\%\). All cohorts contained clinically elevated scales of F, Hs, D, Hy, Pd, Pa, Pt, and Sc. Two cohorts (#2 and #3) contained elevations of Ma and two separate cohorts contained elevations of Mf (#2) and Si (#4).
Figure 1.

MMPI-2 Results of Female Clusters by Cohorts

LOW-BACK PAIN FEMALES (N = 235)
1st Cohort - 4 Clusters

LOW-BACK PAIN FEMALES (N = 235)
2nd Cohort - 4 Clusters
Figure 1 (continued).

**MMPI-2 Results of Female Clusters by Cohorts**

**LOW-BACK PAIN FEMALES (N = 236)**

**3rd Cohort - 4 Clusters**

- Cluster #1: N = 26
- Cluster #2: N = 71
- Cluster #3: N = 87
- Cluster #4: N = 52

**LOW-BACK PAIN FEMALES (N = 236)**

**4th Cohort - 4 Clusters**

- Cluster #1: N = 55
- Cluster #2: N = 94
- Cluster #3: N = 62
- Cluster #4: N = 25
Figure 2.

MMPI-2 Results of Female Clusters by Profiles

LOW-BACK PAIN FEMALES (N = 232)
Within-Normal-Limits Profiles - 4 Cohorts

LOW-BACK PAIN FEMALES (N = 31)
Elevated Profiles - 4 Cohorts
Figure 2 (continued).

MMPI-2 Results of Female Clusters by Profiles

LOW-BACK PAIN FEMALES (N = 247)
Neurotic Triad Profiles - 4 Cohorts

LOW-BACK PAIN FEMALES (N = 332)
Conversion-V Profiles - 4 Cohorts
Male Clusters

The clustering procedure produced four relatively homogeneous cluster profiles across all four cohorts in the male sample. In addition, two of the four cohorts produced a fifth cluster. Please see Figure 3 for a breakdown by cohorts and Figure 4 for a breakdown of profiles. The first cluster was a within-normal limits profile which replicated across all four cohorts (N = 274, 25% of males). All scores remained under the clinical cut-off of 65. The second cluster contained a generally elevated profile with one variation (N = 197, 18%). All cohorts contained clinically elevated scales of F, Hs, D, Hy, Pd, Pa, Pt, and Sc. In addition, cohort #2 contained an elevation of Ma. The third cluster produced neurotic triad elevations with other elevations (N = 225, 20%). One cohort (#3) also had an elevation of Pt while another cohort (#2) had a subclinical peak at Hy. The fourth cluster produced the conversion-V profile (N = 259, 23%) with two cohorts (#2 and #4) having a slight (between 65 and 70) elevation on the Pt scale and one cohort (#2) on the Sc scale. The same cohorts with these slight elevations also produced a reduced elevation on the "V" profile. That is, the distance between the D scale and Hs and Hy scales was more than 5 points but not more than 10 points.

In two of the four cohorts five clusters were found. This fifth profile can be considered a "slight elevations" profile (N = 154, 14%). The Hs scale was between 65 and 70 for both cohorts while the Hy scale was below 65 in one cohort (#4). The rest of the scales were not clinically significant.
Figure 3.

MMPI-2 Results of Male Clusters by Cohorts

LOW-BACK PAIN MALES (N = 277)
1st Cohort - 4 Clusters

LOW-BACK PAIN MALES (N = 277)
2nd Cohort - 5 Clusters
Figure 3 (continued).

MMPI-2 Results of Male Clusters by Cohorts

LOW-BACK PAIN MALES (N = 277)
3rd Cohort - 4 Clusters

LOW-BACK PAIN MALES (N = 278)
4th Cohort - 5 Clusters
Figure 4.

**MMPI-2 Results of Male Clusters by Profiles**

**LOW-BACK PAIN MALES (N = 274)**

Within-Normal-Limits Profiles - 4 Cohorts

![Graph showing within-normal-limits profiles for male cohorts](image)

- Cohort #1
  - N = 96
- Cohort #2
  - N = 48
- Cohort #3
  - N = 84
- Cohort #4
  - N = 46

**LOW-BACK PAIN MALES (N = 197)**

Elevated Profiles - 4 Cohorts

![Graph showing elevated profiles for male cohorts](image)

- Cohort #1
  - N = 60
- Cohort #2
  - N = 27
- Cohort #3
  - N = 51
- Cohort #4
  - N = 59
Figure 4 (continued).

**MMPI-2 Results of Male Clusters by Profiles**

**LOW-BACK PAIN MALES (N = 225)**

**Neurotic Triad Profiles - 4 Cohorts**

![Graph showing neurotic triad profiles for 4 cohorts.](image)

- Cohort #1
  - N = 64
- Cohort #2
  - N = 28
- Cohort #3
  - N = 71
- Cohort #4
  - N = 62

**LOW-BACK PAIN MALES (N = 259)**

**Conversion-V Profiles - 4 Cohorts**

![Graph showing conversion-V profiles for 4 cohorts.](image)

- Cohort #1
  - N = 57
- Cohort #2
  - N = 87
- Cohort #3
  - N = 71
- Cohort #4
  - N = 44
Figure 4 (continued).

MMPI-2 Results of Male Clusters by Profiles

LOW-BACK PAIN MALES (N = 154)
Slight Elevations Profiles - 4 Cohorts

MMPI-2 Scales

K-Corrected Scores

L F K Hs D Hy Pd Mf Pa Pt Sc Ma Si

Cohort #2
N = 87

Cohort #4
N = 67
The multivariate clustering procedure used in this thesis was successful in classifying relatively homogeneous MMPI-2 profile subgroups within male and female samples of low-back pain patients. In both the female and male groups four different profiles emerged across all cohorts. Furthermore, these results replicated the four cluster solution found by previous researchers and specifically identified by Costello, Hulsey, Schoenfeld, and Ramamurthy (1987) and Riley, Robinson, Geisser, and Wittmer (1993). Keller and Butcher (1991), in reporting three clusters within each gender, failed to find the conversion-V profile for men and within-normal-limits profile for women. It is possible that some bias was introduced into their sample by the screening out of a large percentage of their referrals, or that their sample size was not representative of a true low-back pain population.

The four profiles classified in this thesis and common to both female and male patient samples were the within-normal-limits profile, conversion-V profile, Neurotic triad profile, and generally elevated profiles. The within-normal-limits profile showed no scores above the clinical cut-off of 65. In addition, in both groups the profile constituted 25% of their respective sample. This is a profile that was found by researchers in both the mixed and low-back pain populations (Costello et al., 1987; Riley et al., 1993).
The second profile, conversion-V (Hs and Hy 10 points > D), in the female group (35% of females) showed additional clinical elevations on the Pt and Sc scales in one cohort while having a diminished conversion-V (Hs and Hy 5 points > D) in another cohort. The Pt and Sc elevations were also found in Bombardier, Divine, Jordan, Brooks, and Neelon's (1993) mixed pain sample of males and females. In the male group (23% of males) two cohorts showed a slight elevation on the Pt scale and one of those also had a Sc scale elevation. The same cohorts with these slight elevations also produced a reduced elevation on the conversion-V profile. That is, the distance between the D scale and Hs and Hy scales was more than 5 points but not more than 10 points as usually expected in this profile configuration.

The neurotic triad in the female group (26%) replicated across all cohorts with the exception of one cohort where the Hy scale was at 61. In the male group (20%), some cohorts of the neurotic triad profiles contained different elevations. One cohort also had an elevation of Pt while another cohort had a subclinical peak at Hy.

The elevated profiles seemed to show more variability in the female than male groups. In the female sample (14%), all cohorts had clinical elevations of F, Hs, D, Hy, Pd, Pa, Pt, and Sc. Two cohorts also contained elevations of Ma while two separate cohorts had elevations of Mf and Si. The female profiles in this study have more elevated scales than those found by others who separated females from males (Bernstein & Garbin, 1983; Bradley, Prokop, Margolis, & Gentry, 1978; Bradley & Van Der Heide, 1984; Costello et al., 1987). In the male sample (18%) all cohorts contained clinically elevated scales of F, Hs, D, Hy, Pd, Pa, Pt, and Sc. In addition, only one cohort contained an
elevation of Ma. The male profiles seem to be more in line with previous results found with researchers that separated males from females in their analyses (i.e., Armentrout, Moore, Parker, Hewett, & Feltz, 1982; Keller & Butcher, 1991), and those who had mixed pain populations in their analyses (Bombardier et al, 1993; Riley et al., 1993).

In two of the cohorts in the male group of this study there were some additional profiles, called "slight elevations," which interpretively were between a neurotic triad, conversion-V, and within-normal-limits profiles. The Hs scale was between 65 and 70 for both cohorts, the Hy scale was below 70 in one cohort, and the rest of the scales were not clinically significant. McCreary's (1985) study found a similar elevation of the Hs and Hy scales in the female sample. Other than that instance, this profile has not emerged in the literature before and may have been overlooked due to the fact that it is very close to the neurotic triad, conversion-V, and within-normal-limits profiles. In addition, it may also have been missed due to the lack of a large sample population.

Overall, the presence of a core of four profiles that classify both males and females in the chronic low-back pain population were found. This supports the findings of other researchers who have analyzed the MMPI and MMPI-2. In particular, these profiles were the within-normal-limits profile, conversion-V profile, Neurotic triad profile, and generally elevated profile.

This study does not include information about onset of injury, premorbid functioning, social economic status, number of previous surgeries, length of low-back pain prior to program involvement, or post-treatment follow-up measures. This information would serve a useful purpose for clinicians to compare against their own populations.
While specific information on each patient's compensation status was not included, approximately 98% of this population were patients with work related injuries. The clinic served as a tertiary care center for this population.

The strengths of this study come from having the largest population to date and utilizing more cohorts (four in each sex) than any other studies. The previous largest population, at least to the author's knowledge, has been 548 patients. The rationale for the four cohorts in each sex is twofold. First, due to limitations of the statistical package, and second, to increase replicability of the data. The primary benefit comes from the use of cluster membership to increase the understanding of the patient's experience with chronic low-back pain and the information it provides for more effective treatment planning. It is hoped that the classifications found in this study with the MMPI-2 will help to address and clarify these issues. These classifications and the information obtained can be used to design future research and to provide a basis for clarifying the interpretation of the MMPI-2 in chronic low-back pain populations.

This study has found four female and four male homogeneous cluster profiles from the largest group of low-back pain patients to date. These results have also provided evidence suggesting that the clinical application of the MMPI-2 with chronic low-back pain patients has little loss in interpretation when compared with the MMPI. Furthermore, although additional studies are warranted, much of the MMPI empirical database with chronic low-back pain patients is also applicable to the MMPI-2. It is hoped that this study and future research will continue to help define the usefulness and validity of the MMPI-2 in classifying chronic low-back pain patients.
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