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Multivariate Cluster Analysis of the MMPI-2 and MMPI-2-RF Scales in Spine Pain Patients with Financial Compensation: Characterization and Validation of Chronic Pain Subgroups

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Different psychosocial factors influence the experience and adaptation to pain. Previous cluster analytic studies using the Minnesota Multiphasic Personality Inventory-2nd edition described psychologically different subgroups of pain patients that had been shown valuable in determining outcome. However, these studies had limited applicability to medico-legal pain populations because they did not use newly developed scales or describe important medico-legal factors that have large effects on symptom endorsement. Using three methods of clustering, the current investigation explored the subgroups that resulted when using all the MMPI-2 and the newly developed MMPI-2-RF (Restructured Form) scales on a large and well-described population of medico-legal spine pain patients. Result demonstrated that the best solution for the current sample was the two-cluster solution when a traditional method was used. However, the best solution was the three-cluster solution when all MMPI-2 scales and a method that used all MMPI-2-RF scales were used. Thus, the three-cluster solution was considered the most adequate solution to differentiate patients in medico-legal settings. Moreover, results demonstrated that subgroup membership was not conditioned to spine related organic factors. Instead, malingering, education, ethnic background and legal status differentiated pain subgroups. Lastly, results demonstrated a dose-response relationship between perceived outcome and subgroup profile elevation. The current results are relevant for understanding the circumstances that can influence spine pain recovery and for informing decisions regarding possible interventions.

Keywords: MMPI-2; MMPI-2-RF; spine pain, disability, psychological overlay, cluster analysis, pre-surgical screening, malingering.

INTRODUCTION

Patients with primary complaints of spine pain often present with a number of symptoms and disabilities that result in a great deal of patient's suffering and economic loss. Although spine pain has been typically considered a "medical illness", the presence of physical pathology does not reliably predict levels of pain and disability in the individual patient. As a result, there is a growing interest in the role of different psychosocial factors in the experience and adaptation to pain. Among these, somatization, emotional distress, and financial compensation are described as some of the most important predictors of pain related disability and further examination on their role in pain outcome would likely guide interventions.

The Minnesota Multiphasic Personality Inventory (MMPI) and its second version, the MMPI-2, are widely-recognized and reliable measures of psychological problems, including somatization and emotional distress. These instruments also contain a number of validity scales that are shown to be reliable in identifying manipulation of the patient's clinical presentation, including the identification of those patients that intentionally exaggerate their report to obtain significant financial reward (i.e. malingering). Thus, these instruments are often used to both, describe the psychological differences among those patients with good and poor pain outcome, and distinguish between pain patients with valid profiles and those that exaggerate their report.

Previous cluster analytic studies using the MMPI and MMPI-2 traditional validity and standard clinical scales describe psychologically different subgroups of pain patients. These subgroups have been shown valuable in determining patient response to treatment and in decision-making regarding whether to perform surgery. However, there is limited application of these results to pain populations where patients are involved in legally compensable events. This is because previous studies do not describe important medico-legal factors which may have large

effects in symptom endorsement (e.g., injury characteristics, legal representation or malingering status) and do not use all the available validity scales. Using three methods of clustering, the current investigation explored the stability of MMPI-2 subgroup solutions in a large and well-described population of spine pain patients that are involved in legally-compensable processes. This investigation also expands previous investigations by adding to the clusters analyses the recently developed MMPI-2 validity scales and the MMPI-2 restructured form (MMPI-2-RF) clinical (RC) and validity scales. The results from the current investigation are expected to increase the clinical application of the MMPI-2 and the MMPI-2-RF in medico-legal pain populations.

CHAPTER I

Pain and Disability

Spine pain, which is pain originating in the back and/or neck, is an extremely prevalent condition. The lifetime occurrence of back pain is 11 to 84 percent (Walker, 2000), while neck pain occurs in 10 to 15 percent of the population (Hardin & Halla, 1995). It is estimated that 70 million Americans experience some form of acute, recurrent, or chronic spine pain each year and that 10 percent of the population report the presence of spine pain at least 100 days a year (Cassidy, Cote, Carroll, & Kristman, 2005; Covington, 2007). Spine pain complaints result in millions of physician office visits per year (Hing, Cherry & Woodwell, 2006), and as many as 150 million lost work days (Guo, Tanaka, Halperin, & Cameron, 1999). Given its impact it has become increasingly important to study the factors that influence pain perception and pain related disability.

In 1979, the International Association for the Study of Pain (IASP) published its first working definition of pain : "An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" (p. 249, Fields, 1987). Based on this definition, pain has two functions: It serves as a signal to warn of danger or tissue damage; and it compels individuals to avoid worsening the damage, allowing the process of restoration of damaged tissues to begin (DeLeo, 2006). However, in some individuals, pain can be an extremely debilitating problem as it has been reported to create "suffering" in patients and families as its result (Aronoff, 1991).

Chronic spine pain, especially, has a high impact on the sufferer's everyday functioning, as a range of their activities are often severely limited, leading to difficulties with daily chores, social life, and work (Abdel-Moty et al., 1993; Aronoff, 1991; Faucett & McCarthy, 2003;

Nurmikko, Nash, & Wiles, 1998).Chronic pain disability is defined as "diminished capacity for everyday activities and gainful employment" or the "limitation of a patient's performance compared to a fit person's of the same demographic characteristics" (e.g. age, gender; p. 24; Gatchel, 2006). The total economic load of chronic pain-related disability in the U.S. is reported to exceed $150 billion a year (Gatchel & Okifuji, 2006; Mayer, Gatchel, & Polatin, 2000). Thus, determination of the factors that influence chronic spine pain and related outcome is practically important for both a patient care and an economical standpoint.

Individual Differences in Pain and Disability

There are remarkable individual differences when it comes to perceiving and recovery from spine pain. These individual differences are quite understandable when one acknowledges that pain and disability are interdependent and complex experiences influenced by multiple interactive biopsychosocial processes (Gatchel, Peng, Peters, Fuchs, & Turk, 2007). Especially when one considers the multitude of biological and psychosocial factors that increase/decrease individual recovery time including vulnerability to nociception, tissue healing, pain sensation/report, as well as factors that affect the ability of the individual to cope effectively with the challenges faced during recovery (Gatchel et al., 2007). Specifically, pain recovery is influenced by a range of pre-and post- injury medical, biological, psychological and social factors, which interact with injury, pain perception, and demographic characteristics to modulate individual report of symptoms and subsequent disabilities (Gatchel et al., 2008).

Physical Pathology and Spine Pain

Physical pathology has important contributions to spine pain and disability (Ochoa, 2002). For example, herniated nucleus pulposus, foraminal stenosis, and nerve root impingement are all associated with pain generation (Burchiel, 2002). Other common spine pathologies that

result in pain include facet joint disorders, vertebral fracture, and musculo-ligamentous injuries (see Appendix A for brief descriptions of selected conditions).

However, in chronic pain only a small proportion of pain perception and disability can be attributed to physical pathology (Gatchel, Peng, Peters, Fuchs & Turk, 2007; Gatchel & Okifuji, 2006; Waddell, Pilowsky, & Bond, 1989; Tait, 1990). Also, nearly 40% of chronic pain patients seen in primary care clinics do not benefit from traditional pain/surgical procedures suggesting that modification of the physical pathology does not always alleviate pain/disability (Block et al., 2003). Thus, in an important number of chronic pain patients, pathophysiology does not have a direct causal relationship with pain perception/disability, nor does it reliably predict who will have pain in the future.

Psychosocial Factors in Spine Pain

Recent research has implicated that a number of psychosocial factors are related to poor pain outcome, especially in the transition between acute and chronic pain. The following sections discuss the impact of somatization, emotional distress, and financial incentive on individual differences of spine pain symptomatology and recovery. These psychosocial factors were selected for review because they are often assessed in comprehensive psychological pain evaluations.

Somatization

Somatization, and related terms (e.g. somatoform disorder), is a central factor in understanding pain and disability attributed to pain (Allen, Gara, Escobar, Waitzkin, & Silver, 2001; Lamberty, 2008). Somatization refers to the way "certain patients use their physical symptoms as a way of dealing with, and communicating about, their emotional lives . . . in this type of symptom magnification, physical symptoms may be easier to accept as causing current

unhappiness and discontent than admitting that some psychological reason is contributing to it" (Gatchel, 2004; p. 204). In other words, somatization is the expression of psychological problems or stress manifested in physical symptoms and complaints.

Several empirical and review studies demonstrate that patients with high levels of measured somatization report higher levels of pain perception and significant disabilities in daily chores, social life, and work (e.g., Bacon et al., 1994; Birket-Smith, 2001; Shorter, 1997). Furthermore, high levels of somatization are found to predict greater perceived disability one year after the injury above and beyond injury characteristics (Gatchel, Polantin, Mayer & Garcy, 1994), and are likely to have poor response to surgery and conservative care (Block, Vanharanta, Ohnmeiss, & Guyer, 1996).This demonstrates that somatization is not a pure physiological phenomenon, but is a result of the psychological mechanisms of pain. In short, somatization may be viewed as a potentially maladaptive trait or coping style that contributes to excess pain symptoms and pain-related disability.

Emotional distress

People who experience chronic pain also experience a wide variety of associated emotions (Gaskin, Greene, Robinson, & Geisser, 1992). The most common emotional problems are depression and anxiety disorders, which occur in 30% to 84% and 14 to 40% of chronic pain patients, respectively (Arnow et al., 2006; Aguera, Failde, Cervilla, Diaz-Fernandez & Mico, 2010; Gaskin, Greene, Robinson & Geisser, 1992; Manchikanti et al., 2002).

A number of studies reveal a significant relationship between self-reported pain intensity and depressive symptoms (Carleton, Abrams, Kachur & Asmundson; Hoff, Palermo, Schluchter, Zebracki & Drotar, 2006; Weijenborg, Ter Kuile, Gopie & Spinhoven, 2009). Levels of depression are recognized to have a direct relation to nociception and inverse relation to tissue

recovery (Gur et al., 2002). Moreover, patients with high numbers of helplessness behaviors and catastrophizing thoughts - key elements of depression - also report significantly more pain than other patients with similar injury characteristics but fewer depression symptoms (Arnow et al., 2006; Bair et al., 2008; Borsbo et al., 2008; Geisser et al., 1994; Roth, Lowery & Hamill, 2004). In an important study, Holzberg, Robinson, Geisser, and Gremillion (1996) demonstrated that self- reported disability was directly influenced by levels of depression, whereas pain levels did not have a direct effect on self-report of function.

It is also common for patients with pain to be anxious and worried. People with chronic pain may be anxious about the meaning of their symptoms and for their futures (Gatchel, 2004). People with pain also experience anxiety about partaking in activities that may exacerbate their symptoms (Bair et al., 2008). Clinical levels of anxiety may significantly increase the perceived intensity of painful stimuli by directly impacting the physiological aspects that contribute to pain perception (Colloca & Benedetti, 2007). Excessive anxiety may also negatively impact outcome during treatment or following surgery by increasing avoidance behaviors, as higher level of anxiety is associated with lack of cooperation during rehabilitation sessions and hypervigilance to the occurrence of pain (Robb, Williams, Duvivier & Newham, 2006; Vadalouca et al., 2009; Velanovich, 2006).

Levels of catastrophization

Patients' overestimation of the association between physical symptoms and negative outcomes (i.e. catastrophization) is central to most models of poor outcome after pain injury (Severeijns, Vlaeyen, van den Hout, & Weber, 2001). Catastrophizing is a cognitive process that refers to a tendency to emphasize and exaggerate the negative appraisal of current or future situations (Sullivan & D'Eon, 1990). Pain catastrophizing has been shown to be a mediator of the relationship between negative emotions and illness behaviors and recovery, which suggest that

catastrophizing is the core determinant of entering into a negative pain-disability cycle (Lackner & Quigley, 2005). Factor analytic studies have revealed three primary components of pain catastrophizing: magnification, rumination, and helplessness (Van Damme, Crombez, Bijttebier, Goubert, & Van Houdenhove, 2002).

The evidence for the role of catastrophization and its components in outcome after painful injuries is overwhelming and has been summarized in several reviews (Block & Brock, 2008; Jensen, Turner, & Romano, 2001; Leeuw et al., 2007). Cross-sectional studies across clinical and non-clinical populations have demonstrated that subjects with high levels of catastrophization show increased pain, lower treatment benefits, and physical and psychological dysfunctions (Epker & Block, 2001; Edwards, Smith, Stonerock, & Haythornthwaite, 2006; Martorella, Cote, & Choiniere, 2008; Turner, Jensen, Warms, & Cardenas, 2002). Prospective studies indicated that levels of catastrophization may predict the development of chronic musculoskeletal pain in the general population (Myers et al., 2008) and of more intense pain and slower recovery after a spine injury and surgical interventions (Granot & Lavee, 2005; Block et al., 2008). Catastrophization has also been shown to be a significant predictor of illness behaviors, a core component of disability, despite some overlap with emotional distress (Sullivan et al., 1990).There is evidence that pain catastrophization is a precursor to the development of pain-related fear (Leeuw et al., 2007).Moreover, several studies have shown that cognitive restructuring therapy for catastrophization can reduce pain intensity and improve pain outcome (Hanley, Raichle, Jensen & Cardenas, 2008). Thus, levels and treatment of catastrophization have shown to be key elements in individual recovery from painful injuries.

Pre or Post Morbid Debate

Although the existence of diagnosable psychological overlay among those patients with poor pain outcome is certain, the etiology of such problem is controversial (Gamsa, 1990). Some

researchers have argued that psychological disturbances are primarily a reaction to the injury and pain (Gamsa, 1994). This is supported by early studies that reported an increase in emotional distress after an injury (Gamsa & Vikis-Freibergs, 1991) and studies that reported that treatment-related pain relief is accompanied by a reduction in emotional difficulty (Snow, Gusmorino, Pinter, Jimenez, & Rosenblum, 1988; Stein, Peri, Edelstein, Elizur & Floman, 1996).

Psychological problems are also theorized to predispose patients to have poor outcome after a painful injury. This is supported by longitudinal studies reporting that individuals with documented pre- injury depressive emotions and anxiety tend to interpret a given sensation as painful and are prone to develop pain problems (for review see, Gatchel, Polantin & Mayer, 1995). For example, Bigos, Battie and Fisher (1991) found that individuals with high levels of depression were at a significantly higher risk of developing occupational back complaints over a four year period compared to those without such elevations. Holzberg, Robinson, Geisser and Gremillion (1994) also found that pre-injury anxiety and depression were included among the factors that have the most important influence, above and beyond physical abnormalities, of future pain and pain-outcome.

Further, several studies have demonstrated that patients that report a number of psychological problems preceding spine injury have poorer reaction to spine surgery (for review see Block, 1996 and Block, 2002). Block, Ohnmeiss, Guyer, Rashbaum and Hochschuler (2001) also found that psychological treatment prior to the spine injury contributed significantly to reduce surgical outcome. In summary, whether pre or post-injury, emotional stability is an essential part of recovery from spine pain. Therefore, measuring distress very likely helps the determination of patients that are "at risk" for poor pain recovery by pointing out the origin of symptoms and disabilities, as well as potential treatment effectiveness.

Compensation

Patients who are in pain have many reasons to seek legal recourse (Hing, Cherry & Woodwell, 2006). Often pain make patients unable to work or significantly decreases their ability to function in their jobs (Guo et al., 1995; Guo, Tanaka, Halperin, & Cameron, 1999).Social security disability benefits, workers' compensation and/or litigation may be the only way to regain some of their lost income. In fact, spine pain is the most common reason for filing a workers' compensation claim (Guo et al., 1999).

Compensation settings are often complex and stressful psychosocial environments which may aggravate pain problems. In general, patients seen in financially-compensatory contexts report significantly more pain, depression, disability, as well as a decreased treatment efficacy and productivity (Harris et al., 2005; Rainville, Sobel, Hartigan, Monlux & Bean, 1997; Rohling, Binder, & Langhinrichsen-Rohling, 1995; Vaccaro, Ring, Scuderi, Cohen, & Garfin, 1997) even when compared to patients with similar spine pathologies who are not in financially compensatory contexts (Atlas et al., 2000 & Atlas et al., 2006).

There are several factors from which compensation (or the process of getting compensated) can negatively impact outcome (Teasell, 2001). Workplace-relate factors, such a blaming the employer for the injury, job dissatisfaction, and occupational stress have been reported to negatively influence recovery (Guo, 2002; Hagen et al., 2002; Menzel, 2007; Shaw et al., 2005). Delays of treatment caused by workers' compensation regulations can also increase the extent of the injury or the time required for recovery (Rich, 2008). Moreover, financial stress caused by the injury can divert the patient's focus away from rehabilitation efforts and instead place it on economic survival (Ballamy, 1997).

Malingering

However, there is evidence that at least some of the negative relationship between compensation and outcome is due to patients' intentional exaggeration of symptoms and disabilities. Important base rate studies report a sizeable minority of compensable pain patients (20% to 50%) intentionally exaggerate their clinical presentation in order to obtain significant monetary reward (i.e. malingering; Greve, Ord, Bianchini & Curtis, 2009; Mittenberg et al 2002). These rates are consistent among different compensated populations such as social security disability evaluations (Chafetz, 2008), toxic exposure (Greve, Bianchini, Black et al., 2006), and traumatic brain injury (Larrabee, 2003). Thus suggesting that malingering in medico-legal settings is not a rare phenomenon and should be taken into consideration.

Malingering becomes a problem when determining proper intervention as it can potentially lead to inaccurate conclusions regarding the patient's status. As such, researchers have developed ways to better identify those that are malingering. One such classification method that has been recently developed is the Malingering Pain Related Disability criteria (MPRD; Bianchini, Greve & Glynn, 2005). MPRD is defined as "the intentional exaggeration or fabrication of cognitive, emotional, behavioral, or physical dysfunction attributed to pain for the purposes of obtaining financial gain, to avoid work, or to obtain drugs (Bianchini, et al., 2005). There are three key points of the criteria; first, is that malingerers intentionally over report symptoms and disabilities due to external incentives; second, is that malingerers may present symptoms and/or impairments in multiple ways and; third, malingering relates not only to symptoms but also to the disability that is attributed to the pain (Bianchini et al., 2005). Thus, Bianchini et al. (2005) suggest that when determining that a specific subject is malingering one requires to evaluate "intent" in a comprehensive manner by considering multiple, highly improbable events (e.g. symptoms, disabilities, behaviors). Therefore, using the Bianchini et al.

(2005) MPRD criteria to identify or rule out malingering in both clinical or research settings would likely maximize confidence that results of psychological measures, diagnoses, and recommendations are based on the legitimate problems/concerns of the pain patient.

Summary

Spine pain and disability affect, and are affected by, multiple interactive biomedical and psychosocial factors. In the psychosocial area, somatization, chatasthrophization, emotional distress, and financial compensation have proven to negatively impact recovery. Malingering must also be taken into consideration, as an important number of compensated pain patients exaggerate their symptom and disability reports to obtain financial awards. Thus, it is important to have reliable measures that can help identify the individual problems or concerns of the pain patient while considering altered patient symptom presentation. Reliable assessment of psychosocial factors of pain could potentially help determine the best possible intervention for the individual patient as well as to help cut enormous costs involved in medico-legal pain management approaches.

CHAPTER II

The Minnesota Multiphasic Personality Inventory

The Minnesota Multiphasic Personality Inventory (MMPI; Hathaway & McKinley, 1943) and its revision: The Minnesota Multiphasic Personality Inventory-second edition (MMPI-2; Butcher, Dahlstrom, Graham, Tallegen & Kraemmer, 1989), are the most widely-used measures to study psychological disturbances including somatization, depression, and anxiety in pain settings and other health areas (Keller & Butcher, 1991; Rabin, Barr & Burton, 2005). The widespread use of the original MMPI and MMPI-2 in these settings is attributable to several factors, including their simplicity of scoring and administration, an objective response format important for research designs, manuals with useful applications, and thousands of empirically-established investigations (for review see; Butcher & William, 2000; Friedman, Lewak, Nichols & Webb, 2001; Graham, 2006).

Original MMPI

The original MMPI consists in 566- true- false items which result in three traditional validity scales and ten standard clinical scales (Hathaway & McKinley, 1943). The validity scales were included in the original MMPI to assist in recognizing test records produced by uncooperative or deceptive participants with different test-taking attitudes (e.g. under-reporting or over-reporting of symptoms) or participants who have difficulty comprehending the test items. The clinical scales were developed primarily to assist in determining the type and severity of psychiatric conditions. A secondary goal of the standard clinical scales was to provide an objective means of estimating therapeutic effects and other changes in the status of patient's conditions across time (Dahlstrom, Welsh, & Dalstrom, 1972; Keller & Butcher, 1991).

Traditional Validity Scales

The traditional validity scales created by Hathaway and McKinley (1943) in the original MMPI are: the Cannot Say score, the L (Lie) scale, the F (Infrequency) scale, and the K (Correction) scale. The Cannot Say score is the number of items that either are omitted or are answered as both true and false. It is important to assess the Cannot Say score because omission of many items will invalidate the test. The L scale was designed to spot individuals who present in overly favorable way (Meehl & Hathaway, 1946). Patients who have a high L score may have difficulty admitting even minor flaws. The F scale was designed to recognize unusual, deviant, and atypical ways of approaching the MMPI test items (Meehl & Hathaway, 1946). Graham (1993) described three important functions of the F scale: 1) recognizing abnormal test-taking sets; 2) gauging the severity of psychopathology; and 3) suggesting other clinically-relevant information about an individual. The K scale was developed to detect individuals who attempt to portray themselves in either an overly favorable or unfavorable manner (Meehl & Hathaway, 1946). Elevated scores can suggest defensiveness; lower scores can suggest a perceive inability to manage difficult circumstances (Graham, 1993).

Some MMPI users consider a protocol invalid or non-interpretable if it has more than 30 omitted items or has a T score greater than 70 on Scales L and K (Graham, 1993). For Scale F, score at or above 90 increases the possibility of an invalidating response set due to symptom over-reporting. However, scores at or above this level in Scale F could also suggest serious psychopathology (Graham, 1993).

Standard Clinical Scales

Since the MMPI's publication, hundreds of studies have examined the relationship between the clinical scales and relevant extra-test characteristics, such as symptoms personality

traits, diagnosis, and response to treatment. These studies were conducted in a variety of nonclinical, mental health, and correctional settings (for a comprehensive review see, Butcher, 1989).The gathered results suggest that the MMPI clinical scales are meaningfully related to conceptually relevant extra-test characteristics. For example, individuals with elevated scores in Scale 1 (Hypochondriasis) often demonstrate somatic concerns, somatic symptoms, and undefined complains, such as gastric upset, fatigue, pain, and physical weakness. High scorers on Scale 2 (Depression) are seen as depressed, unhappy, dysphonic, pessimistic, and sluggish. Individual who score high on Scale 3 (Hysteria) tend to react to stress by developing physical symptoms such as headaches, chest pains, weakness and tachycardia. These individuals sometimes develop physical problems in reaction to stress (Graham, 1993). Classically, elevations on Scales 1 and 3 have been ascribed to somatization (Block et al, 2003; Blumetti & Modesti, 1976; Friedman, Gleser, Smeltzer, Wakefield, & Schwartz, 1983; Marks & Seeman, 1963), while Scales 2 and 7 have been linked to depression and anxiety, respectively (Graham, 2006).

In general, clinical scales with T scores equal or greater than 70 are considered clinically-elevated in the original MMPI. However, higher scores are associated with more severe symptoms and problems (e.g. depression for Scale 2). A study by Graham, Ben-Porath, Forbey, and Sellbom (2003) using the MMPI-2 supported this notion. Patients with very high scores on the clinical scales had more severe symptoms and problems than those with moderately high scores.

The Minnesota Multiphasic Personality Inventory-2

In 1989, the original MMPI was revised into the MMPI-2. One goal of the MMPI-2 was to preserve the established original MMPI clinical correlates while expanding the item pool to

cover additional areas (Butcher, et al., 1989; Keller & Butcher, 1991). Items that had objectionable content were removed or rewritten. New items were added to cover content areas that were underrepresented in the original MMPI. In its final form, the MMPI-2 has 567 items and item membership of the traditional validity (L, F and K) and standard scales (1-0) are largely equivalent to the original MMPI (Butcher et al., 1989). As discussed by Keller and Butcher (1991), the largest difference between the MMPI and the MMPI-2 are likely result from differences in norming procedures. The other major difference is that the scores for standard clinical scales were considered elevated at or above T score 65, instead of 70 (Keller & Butcher, 1991).Validity scales are generally considered elevated at or above T score 75 (Graham, 2006).

Although the MMPI-2 has not been revised since its publication in 1989, several developments should be noted. New scales were created to determine inconsistent responding, and under- or over- reporting of symptoms (discussed below; Graham, 2006). Another recent development after the publication of the MMPI-2 is the development of the Restructured Clinical (RC) scales (Tallegen et al., 2003) and the RF validity scales, which now comprise the compose Minnesota Multiphasic Personality Inventory-2-Restructured Form (MMPI-2-RF; Tallegen & Ben-Porath, 2008). For a description of all validity and clinical scales refer to Table 1.Descriptions and discussion of these new scales is presented next.

Table 1

Minnesota Multiphasic Personality Inventory-2nd edition Scales

Validity Scales		
F	Infrequency	Infrequent responses in the general population first half of the test
Fb	Infrequency back	Infrequent responses in the general population second half of the test
Fp	Infrequency psychopathology	Infrequent responses in psychiatric population
FBS	Symptom Validity Scale	Non-credible somatic and cognitive complains
L	Lie	Uncommon virtues
K	Correction	Uncommonly high levels of psychological adjustment
S	Self-Presentation	Defensiveness presentation
Clinical Scales		
1	Hypochondriasis	Somatic concerns, somatic symptoms, and undefined complains
2	Depression	Depressed, unhappy, dysphonic, pessimistic, and sluggish.
3	Hysteria	Reaction to stress by developing physical symptoms
4	Psychopathic Deviate	Antisocial behavior, rebellious attitudes.
5	Masculinity-Femininity	Gender interests
6	Paranoia	Reactions of others, suspicious and guarded, and are hostile, resentful, and argumentative
7	Psychasthenia	Tend to be anxious, tense and agitated
8	Schizophrenia	Psychotic behaviors, confusion, disorganization, and disorientation.
9	Hypomania	Hyperactive and/or have accelerated speech and may have hallucinations or delusions of grandeur
0	Social Introversion	Social introversion and low scores reflect social extroversion

MMPI-2 New Validity Scales

Inconsistent reporting Scales. Validity Response Inconsistency (VRIN; Butcher, 1989, 2001) was developed for the MMPI-2 as an additional validity indicator. It provides an indication of a tendency to respond inconsistently to MMPI-2 items. The MMPI-2 manual (Butcher, 1989, 2001) suggests that a $T \geq 80$ indicates inconsistent responding that invalidates the resulting protocol.True Response Inconsistency (TRIN; Butcher, 1989, 2001) was developed for the MMPI-2 to identify persons who respond inconsistently to items giving true responses to items indiscriminately (acquiescence) or by giving false responses to items indiscriminately (non-acquiescence). The MMPI-2 manual also suggests that TRIN scale of $T \geq 80$ indicates inconsistent responding that invalidates the resulting protocol. Subsequent to the publication of the MMPI-2, several empirical studies have confirmed that VRIN and TRIN scale are sensitive to random responding (Archer, Fontaine, & McCrae, 1998; Greiffenstein, Baker, Tsushima, Bonne, & Fox, 2010; Lees-Haley, 1997; Pinsoneault, 2007).

Under Reporting or Defensiveness. Butcher and Han (1995) developed the Superlative Self Presentation (Scale S) to assess the tendency of some persons to present themselves on the MMPI-2 as high virtuous, responsible individuals, who are free of psychological problems, have few or no moral flaws, and get along extremely well with others. Butcher and Han (1995) reported that there are five major content dimensions in the S scale items: 1) belief in human goodness; 2) serenity, 3) contentment with life; 4) patient and denial of irritability and anger; and 5) denial of moral flaws. Higher Scale S scorers in the MMPI-2 are reported to be unrealistically reporting positive attributes and good adjustment (Archer, Handel & Couvadelli, 2004; Butcher & Han, 1995; Baer & Wetter, 1997; Baer & Miller, 2002).

Over-reporting. With the introduction of the MMPI-2 it was recognized that the traditional Scale F is based on items that occur early in the booklet; thus, it did not assess the

validity of items that appeared later in the booklet. Scale Infrequency Back (Fb; Butcher et al., 1989, 2002) was developed to determine the validity of items appearing after item 350. Elevated Scale Fb score could indicate that the test taker responded to items in the second half of the test booklet in an invalid manner. It was also recognized in some clinical settings that high scores on Scale F are often due, or at least in part, to severe psychopathology of those who take the MMPI-2.Thus, Arbisi & Ben-Porath (1995) developed the Infrequency Psychopathology (Fp) scale as supplement to the Scale F in identifying infrequent psychiatric responding. The 27 items in Scale Fp are ones that were answered infrequently by both psychiatric inpatients and persons in the MMPI-2 normative sample. The resulting Scale Fp is less likely to reflect psychopathology than the Scale F items (Archer, Handel, Greene, Baer & Elkins, 2001).

Specifically for personal injury claimants, Lees-Haley, English, and Glenn (1991) developed the Symptom Validity Scale (FBS) to detect invalid responding of emotional distress. FBS is probably the best studied and validated scale across a range of medical and psychological conditions (For reviews see, Greiffenstein, Fox, & Lees-Haley, 2006; Nelson, Sweet, & Demakis, 2006). FBS is sensitive to a response set that is goal directed and designed to:1) appear psychologically normal except for the influence of the alleged injury; 2) minimize pre-injury psychopathology; and 3) appear honest and present a plausible degree of injury or disability (Larrabee, 1998).

The over-reporting validity scales (including Scale F) of the MMPI-2 are effective in identifying persons who intentionally exaggerate their symptoms (for reviews see in particular Rogers, Sewell, Martin, & Vitacco, 2003, and Lees-Haley, Iverson, Lange, Fox, & Allen, 2003). The MMPI-2 validity scales have been shown effective in differentiating non-clinical individuals, typically college students, who took the test under standard instructions from those

instructed to malinger (simulators; e.g., Berry et al., 1996). Later studies have also demonstrated that the over-reporting validity scales can differentiate known-malingerers from other types of responding. Larrabee (2003), Greve et al. (2006), and Bianchini et al. (2008), for instance, used a criterion validation (or known groups) design to determine the classification accuracy of a number of MMPI-2 validity scales and indicators in the detection of cognitive malingering in traumatic brain injury (TBI) and pain-related disability (PRD), and demonstrated the ability of these scales to accurately differentiate non-malingerers from malingerers. Note that the above studies involved patients with similar levels of physical pathology suggesting that differences in malingering classification explained the differences in MMPI-2 scores.

The Minnesota Multiphasic Personality Invetory-2-Restructured Form

The Minnesota Multiphasic Personality Inventory-2-Restructured Form (MMPI-2-RF; Tellegen & Ben-Porath, 2008) is now offered as alternative to the MMPI-2. The MMPI-2-RF was developed to be a less time-consuming update of the MMPI-2 (Tellegen & Ben-Porath, 2008). The restructured form consists of 338 items. The MMPI-2-RF has no new or changed items, nor has it been re-standardized. Instead, the original standardization sample from the MMPI-2 was used to construct or restructure 50 new and revised scales, with the Restructured Clinical (RC) and the restructured validity scales at the core. See Table 2 for a detailed description of the RC and RF validity scales.

Table 2

Minnesota Multiphasic Personality Inventory-2nd edition Restructured Form

Restructured Form Validity Scales		
F-r	Infrequency restructured	Infrequent responses in the general population
Fp-r	Infrequency psychopathology restructured	Infrequent responses in psychiatric population
Fs	Infrequency somatic symptoms	infrequent somatic complains in medical patient population
FBS-r	Symptom Validity Scale	Non-credible somatic and cognitive complains
L-r	Lie	Uncommon virtues
K-r	Correction	Uncommonly high levels of psychological adjustment
Restructured Clinical Scales		
RCd	Demoralization	General dissatisfaction, unhappiness, hopelessness, self doubt, inefficacy
RC1	Somatic Complains	Self-reported neurological, gastrointestinal, and pain related complains
RC2	Low Positive Emotions	Lack of, or incapacity to experience positive emotions. Core vulnerability factor for depression
RC3	Cynism	Non-self-referential belief in human badness
RC4	Antisocial Behavior	Including, juvenile misconduct, family problems, substance misuse
RC6	Ideas of Persecution	Self-referential persecutory ideation
RC7	Dysfunctional Negative Emotions	Including, anxiety, irritability, anger, over-sensitivity, vulnerability
RC8	Aberrant Experiences	Unusual perceptual and thought processes
RC9	Hypomanic Activation	impulsivity, grandiosity, aggression, and generalize activation

Restructured Scales

There are nine restructured clinical (RC) scales, all of which are derived from selective

items included in the standard clinical scales. Tallegen et al., (2003) report that the RC scales for the MMPI-2 were constructed to "preserve the important descriptive properties of the existing MMPI-2 clinical scales while enhancing their distinctiveness" (p. 10).Initially, the authors identified and separated items from the clinical scales that detected a "general complaint or malaise factor (i.e. demoralization)" (p.11), and created a single scale, RCd, to separate this nonspecific factor that seems to pervade throughout the original clinical scales. The remaining RC scales correspond roughly with the numerical order of the MMPI-2 traditional clinical scales (e.g. RC1 is the updated version of scale 1, Hysteria). The profile includes the Demoralization scale (RCd), the Somatic Complains scale (RC1), the Low Positive Emotions scale (RC2), the Cynism scale (RC3), the Antisocial Behavior scale (RC4), the Ideas of Persecution scale (RC6), the Dysfunctional Negative Emotions scale (RC7), the Aberrant Experiences scale (RC8), and the Hypomanic Activation scale (RC9). Standard clinical Scale 5 (Masculinity-Feminity) and Scale 0 (Social Inhibition) are not represented in the RC scales profile (Tallegen et al., 2003).

When comparing reliability and validity of the RC scales with the clinical scales, RC scales have demonstrated lower intercorrelations, increased reliability, and less saturation with demoralization (Tallegen et al., 2003). The RC scales also show markedly-refined discriminant validity and proportional, and in some cases significantly improved, convergent validity than the standard clinical scales (Arbisi, Sellbom, & Ben-Porath, 2008; Ben-Porath & Tallegen, 2008; Forbey & Ben-Porath, 2008; Osberg, Haseley, & Kamas, 2008; Tallegen et al., 2003). In a comparison study, Sellbom, Ben-Portah, McNulty, Arbisi, and Graham (2006) examined the frequency, origins, and interpretative implications of elevation differences between the RC scales and the standard clinical scales. Analyzing data from mental health inpatients and outpatients, they found that the RC scale and its original counterpart will more often agree than disagree as a

dichotomous variables (i.e. elevated v. not elevated score). When differences did occur, they were attributable in the vast majority to some combination of demoralization, the K-correction, and subtle items to scores on the standard clinical scales. With respect to interpretative implications of these differences, Sellbom et al., (2006) described that in cases where the standard clinical scale is elevated but its RC counterpart was not, the patient was less likely to present a the specific psychological problem in collateral information . Conversely, when an RC scale was elevated and its original counterpart was not, the patient was most likely to present the psychopathology in collateral data.

Reformed Validity

The MMPI-2-RF includes eight validity indicators, revised versions of the MMPI-2 Response Inconsitency (VRIN-r) and True Response Inconsistency (TRIN-r) scales, Uncommon Virtues (L-r) and the Correction scale, now labeled Adjustment Validity (K-r). The MMPI-2-RF also has four over-reporting indicators: the Infrequent Responses (F-r) scale serves as a general over-reporting indicator and is comprised of 32 items rarely endorsed by the MMPI-2-RF normative sample. Unlike the MMPI-2 F scale, which was developed with the original MMPI, F-r is more similar to the Fb scale of the MMPI-2, which is composed of items infrequently endorsed in 1989 normative sample.

The Infrequent Psychopathology Responses (Fp-r) scale is the MMPI-2-RF indicator of over-reported symptoms of severe psychopathology. Fp-r is shorter than its counterpart the MMPI Fp, consisting of 21 items. A revised version of the Symptom Validity (FBS-r) scale is the same as its counterpart MMPI-2 FBS, and assesses non-credible somatic and neurocognitive complains. Finally, Somatic Response (Fs) was added to the MMPI-2-RF to measure over-reporting of somatic complains using the traditional infrequency approach. Wygant, Ben-Porath,

and Arbisi (2004) developed Fs by identifying 16 items with somatic content that were endorsed by less than 25% of patients in two large archival medical samples and an archival chronic pain sample.

To this end, only one study (Wygant, Ben-Porath, Arbisi et al., 2009) has specifically used the MMPI-2-RF validity scales to differentiate intentional symptom over reporting from other types of symptom report in financially-compensated settings. Wygant, et al., (2009) examined the MMPI-2-RF scores of 151 personal injury and disability claimants. Out of these, 16% experienced painful injuries. Wygant and colleagues found that all four MMPI-2-RF over-reporting validity scales were useful in detecting simulated and known intentional symptom exaggeration. Specifically, these authors demonstrated all validity scales reliably differentiate criterion-determined malingerers from not-malingering.

Summary

The MMPI and the MMPI-2 are widely recognized and reliable measures of psychological problems and alterations in patient's clinical presentation. These measures traditionally contained three validity scales (L, F, and K) and ten clinical scales (1-0). With (and after) the introduction of the MMPI-2 new scales have been developed, including scales that measure misinterpretation of test (VRIN and TRIN), under-reporting (S) and over-reporting (Fb, Fp and FBS) of symptoms. Moreover, shorter and divergent clinical (RC) and validity (RF validity) were recently developed to minimize completion time as well as to reduce scale overlap. The use of the MMPI variables have helped clarify how psychological overlay influences pain perception and pain related outcome. Research on the MMPI in pain is presented in the next chapter.

CHAPTER III

The MMPI and Pain

The MMPI and MMPI-2 have been frequently and extensively used in the assessment of patients with pain (Keller & Butcher, 1991; Snyder, 1990; Vendrig, 2000). These instruments have been used to describe the characteristics of the typical pain patient (Costello, Hulsey, Schoenfeld & Rammamurty, 1987; Keller and Butcher, 1991; Block, Gatchel, Deardoff & Guyer, 2004) and to determine differences among those patients that recover from those that do not recover to pre-injury levels (for review see Robinson, 2000 and Deardorff, 2000). Such descriptions and determinations have been demonstrated to have relevance for a) disclosing etiologic factors in chronic pain stages, b) guiding clinicians in development general treatment programs, and c) predicting the development of pain problems (Butcher & Rouse, 1996; Gatchel, 2008; Block, et al., 2004).

MMPI Pain Subgroups

One important contribution of the MMPI research in pain is the description of subgroups that differ significantly in psychological characteristics and pain-related outcome. Sternbach (1978) originally proposed the existence of four homogeneous and distinctive pain subgroups based on clinical appreciation profiles on the original MMPI. The patients in the first group reported elevations on scales 1, 2, and 3, with scale 2 being the highest. This subgroup was described as "depressive" because patients tended to be dissatisfied with their condition or situation. The next group reported equal elevations on scales 1, 2 and 3. These patients were categorized as "hypochondriacs" as patients were consumed by somatic concerns. A third group

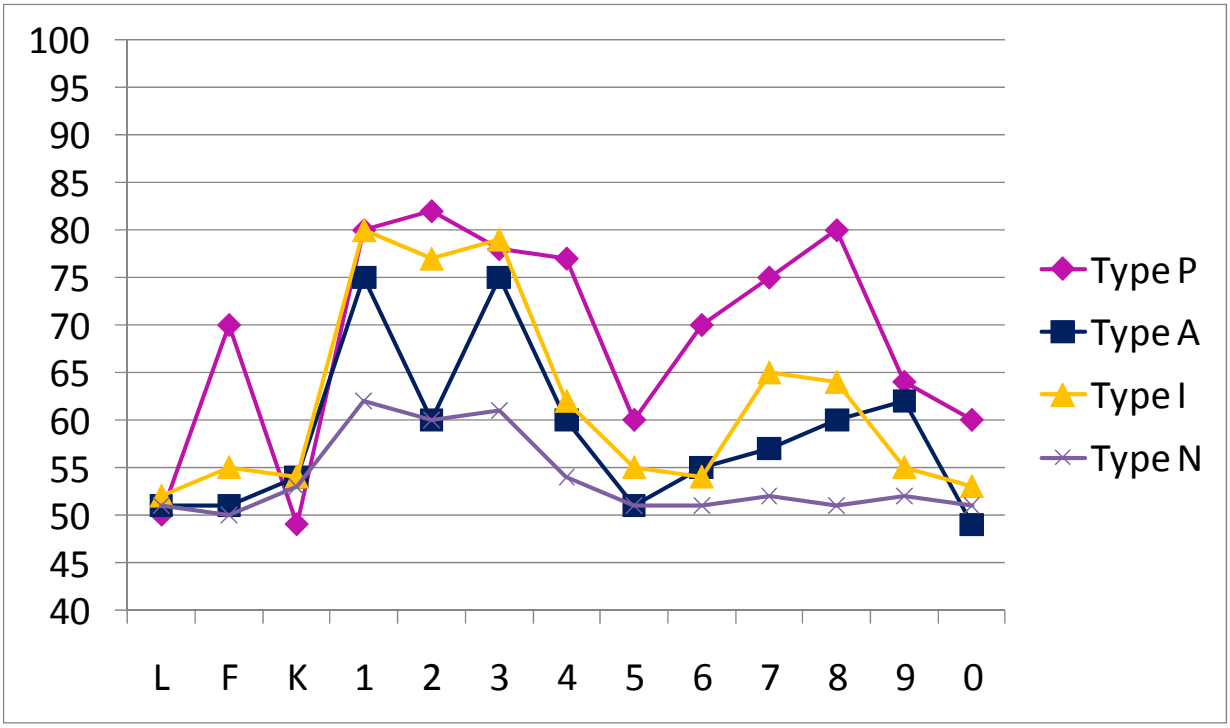
demonstrated a profile with medium elevations only on scales 1, 3 but not on Scale 2.These patients were characterized as “Conversion V” and they did not present any particular psychopathology. The “manipulative reactions” group was the last profile and was characterized by multiple scale elevations, especially on Scale 4. These patients tended to be “game-player manipulators” (p.330) and were thought to use the services of health care professionals for secondary gain.

Subsequently, Sternbach’s ideas were tested using cluster analysis[1], a more objective or empirical method of group classification. For example, Bradley and colleagues (Bradley et al., 1981) used hierarchical agglomerative cluster analysis on all the original MMPI scales and found a four-cluster solution for females and three-cluster solution for males. In both sexes, a subgroup with elevations on scales 1, 2, and 3 was common. A second common subgroup in both sexes was one that had all scales within normal limits, although borderline elevations or less than two standard deviations above the mean were obtained on scales K, 1 and 3. A third but less frequently seen pattern in both sexes was multiple scale (four or more) elevations. Finally, in women only, a group was found having elevations on scales 1 and 3 but not on scale 2.

McGill, Lawlis, Selby, Mooney, and McCoy (1983) confirmed these results examining 92 patients in an inpatient program for treatment of low back pain. The investigators reported that they replicated the clusters solution that Bradley et al., (1983) found for men and women alike. Moreover, the profile subgroups appeared to differ with regard to the duration of pain, the presence of clear precipitant, the number of days in hospitalization, the number of back surgeries and pretreatment pain estimate. Those with elevations on multiple scales consistently had worse outcome than the other groups.

Costello, Hulsey, Schoenfeld and Rumamurthy (1987) summarized the type profile categorizations or cluster solutions from 10 studies on the original MMPI scales using a meta-analytic technique. Authors used the acronym PAIN to describe the different typologies of previously found clusters (See Figure 1). Type P involved elevations on most of the clinical scales and appeared to be the most disturbed profile. The profile was associated with difficulty in the realms of psychological, educational, and vocational functioning. Type A was the conversion V profile which reported no significant pain problems. Type I appeared to be a hypochondriac profile associated with physical impairment, multiple surgical procedures, and multiple hospitalizations. Type N patients were described as relatively normal.

Figure 1. Costello et al., (1987) illustration of cluster solution

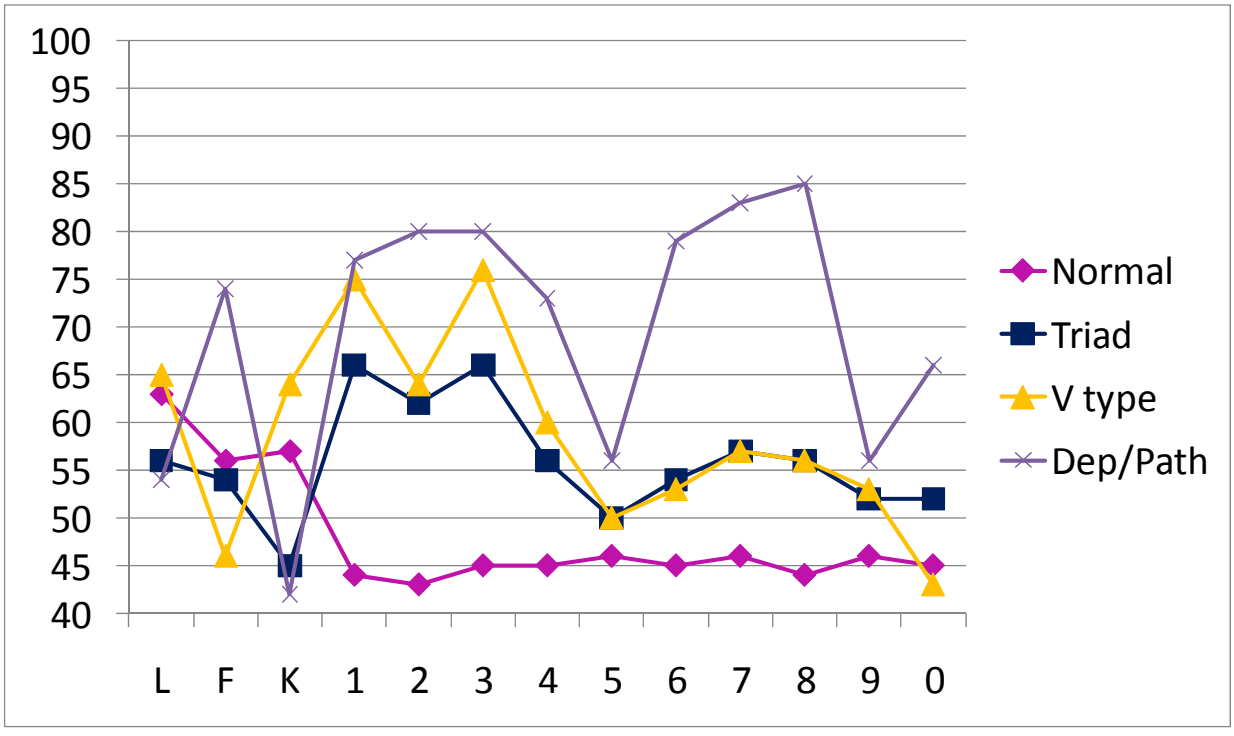


Note. L: Lie, *F*, Infrequency; K: Correction; 1: Hypochondriasis; 2: Depression; 3: Hysteria; 4: Psychopathic Deviate; 5: Masculinity-Femininity; 6: Paranoia; 7 : Psychasthenia; 8: Schizophrenia; 9 : Hypomania; 0 : Social Introversion.

MMPI-2 Pain Subgroups

When the MMPI-2 was introduced, several researchers found important to investigate if subgroups solutions replicate when using the newer instrument. Riley, Robinson, Geisser and Wittmer (1993) investigated whether the MMPI-2 cluster solutions would replicate those from the original MMPI. Riley et al. use hierarchical agglomerative clustering procedure to examine the profiles of 201 low back pain patients using the ten clinical scales and traditional validity Scales L, F, and K. Four homogeneous clusters were identified: the largest group with all MMPI-2 scales within normal limits ("Normal"); the second largest group with elevations on Scales 1, 2, and 3 ("Triad" group); the third group with elevations on Scales 1 and 3 only ("Conversion V" group); and a small fourth group with elevations on four or more scales (Depressed-Pathological"). See Figure 2 for an illustrative scale description of Riley et al. subgroups. In general, Riley et al. confirmed the existence of four pain subgroups when using the MMPI-2.

Figure 2. Riley et al., (1993) illustration of cluster solution



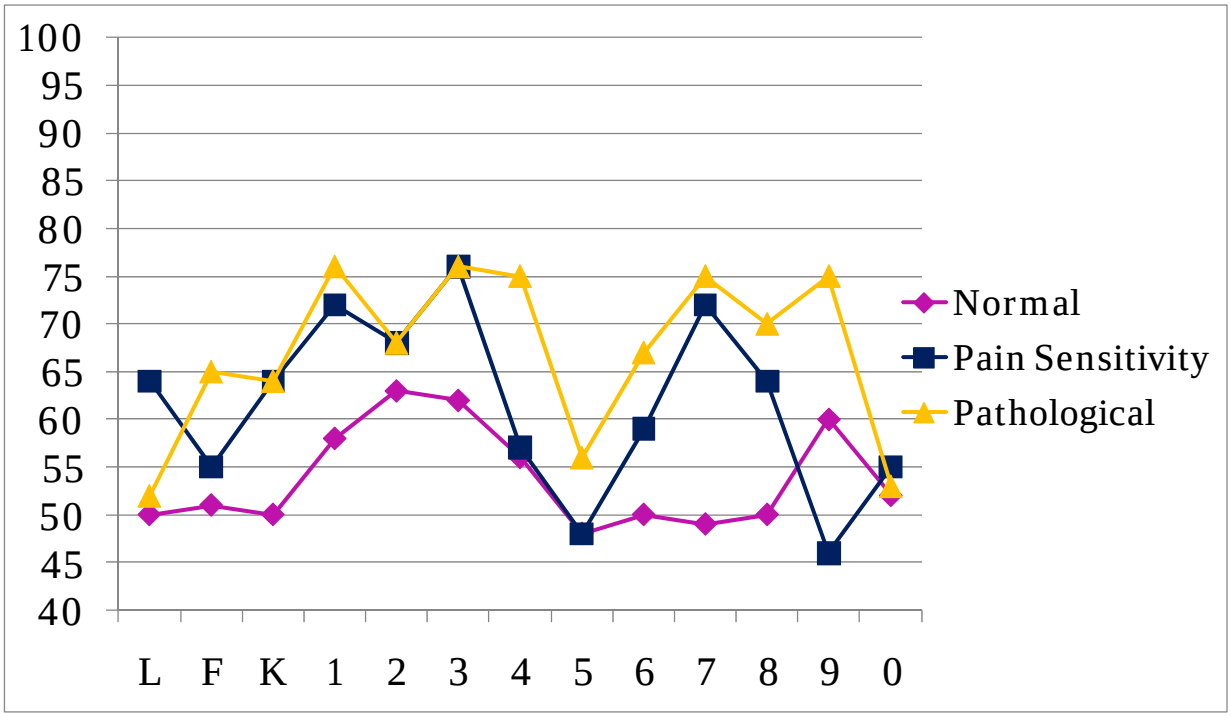
Note. L: Lie, *F*, Infrequency; K: Correction; 1: Hypochondriasis; 2: Depression; 3: Hysteria; 4: Psychopathic Deviate; 5: Masculinity-Femininity; 6: Paranoia; 7 : Psychasthenia; 8: Schizophrenia; 9 : Hypomania; 0 : Social Introversion.

Subsequently, Riley, Robinson, Geisser, Wittmer, and Smith, (1995) tested the predictive validity of their previously found subgroups by evaluating the outcome of 71 patients (out of the 201 group) 6 months after surgery. Results demonstrated significant differences in recovery time. Those patients classified as "Normal" obtained significant improvements. A similar outcome was obtained by those leveled as "Triad". The patients leveled as "Conversion V" achieved poorer surgical results than did the normal and triad groups. Finally, the "Depressed-Pathological" patients demonstrated the least improvements and diminished surgical results among all the patients.

Gatchel, Mayer, and Eddington (2006) also support the utility of Riley's MMPI-2 pain sub-groups (constructed based on clinical appreciation) for predicting nonsurgical treatment outcomes in musculoskeletal disorders. Gatchel et al. (2006) clinically classified 1,489 pain patients into one of four Riley et al.'s subgroups based on their elevations ($T \geq 65$) on the MMPI-2 clinical scales; and these groups were compared on socioeconomic, psychopathological, and pain measures. Patients in the "Normal" group were twice more likely to return to work and less likely to have psychopathological complications than the other three groups. The "Pathological" group was 14 times more likely to report more pain and psychopathology than the normal group. The "Triad" group was 6.6 times more likely to report pain and psychopathology than the normal group. The "Conversion V" group did not show any significant differences from the Normal group or the Triad group.

Other cluster analytic studies have demonstrated somewhat similar results. Block and Ohnmeiss (2000) also used hierarchical agglomerative clustering procedure on the MMPI-2 to group spine surgery candidates and determine associated outcome. All patients had spinal damage or findings. Similarly to Riley et al. study, Block and Ohnmeiss used the ten standard clinical scales and the traditional validity Scales L, F, and K. A three-cluster solution was found to be the best solution in examining the profiles of 222 pain patients. The described clusters were: a within the "Normal" limits profile (n = 114) with no scale elevations, a "Pain Sensitivity" profile (n = 86) that showed elevations in Scales 1,2 and 3 which resembles the "Triad" group, and a "Pathological" profile (n = 22) which had elevations in four or more MMPI-2 clinical scales resembling the Depressed-Pathological group. Interestingly, Block et al., did not find the typical "Conversion V" group. In terms of surgical outcome, the "Pathological" subgroup obtained the least improvements in functional ability and pain reduction. The within "Normal" profile achieved the best surgery results. The "Pain Sensitivity" profile reported more pain but similar improvement in functional ability when compared to the within "Normal" limits group.

Figure 3. Block and Ohnmeiss (2000) illustration of cluster solution

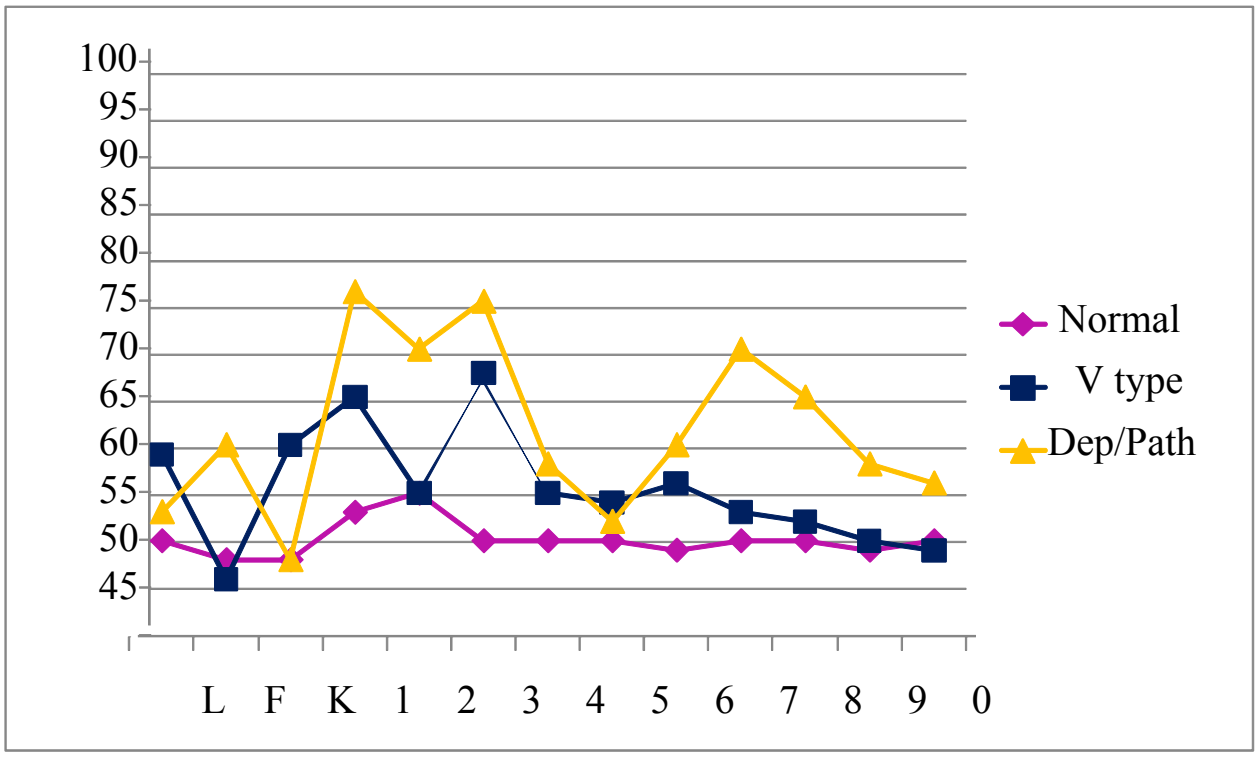


Note. L: Lie, *F*, Infrequency; K: Correction; 1: Hypochondriasis; 2: Depression; 3: Hysteria; 4: Psychopathic Deviate; 5: Masculinity-Femininity; 6: Paranoia; 7 : Psychasthenia; 8: Schizophrenia; 9 : Hypomania; 0 : Social Introversion.

Marters, Shearer, Ogles, and Schleudener (2003) examined whether empirically-derived cluster profiles based on scores on the MMPI-2 predicted outcome of surgery one year for low back pain. Similar to Riley et al. and Block and Ohnmeiss, this study used hierarchical agglomerative clustering procedure on the ten standard clinical scales and the traditional validity scales. The authors found that the best solution was the three subgroups solution. These consisted of a "Pathological-Neurotic" type with high elevations on Scales 1,2, and 3 and medium elevations on Scales 7 and 8, a "double V" which resembles the "Conversion V" type with medium elevations in Scales 1 and 3, and the "Normal" type which demonstrated no elevations. See Figure 4 for an illustrative description of Masters et al. cluster solutions. Patients in the normal type were significantly more likely to report satisfaction with surgery and best surgical

results than the other clusters. The “double V” group did not differ from the “Pathological-Neurotic” group in any of the outcome variables.

Figure 4. Martens et al., (2002) illustration of cluster solution



Note. L: Lie, *F*, Infrequency; K: Correction; 1: Hypochondriasis; 2: Depression; 3: Hysteria; 4: Psychopathic Deviate; 5: Masculinity-Femininity; 6: Paranoia; 7 : Psychasthenia; 8: Schizophrenia; 9 : Hypomania; 0 : Social Introversion.

Summary

A number of hierarchical agglomerative cluster analytic studies have helped determine the existence pain patient subgroups that arise from common patterns of responding on the original MMPI and the MMPI-2. These subgroups were a valuable addition in determining differences in pain perception, and patient response to treatment, as well as in decision making regarding whether to perform surgery. Specifically, these studies revealed a three or four subgroup solutions describing a “Normal” group which is characterized by no clinical scales

elevations and good outcome; a “Pathological” group characterized by multiple clinical scales elevation and poor outcome; and “Pain Sensitivity”, “Conversion V” and/or “Triad” groups which are distinguished by elevations in Scales 1, 3 and/or 2 and, in general, show better outcome than the “Pathological” group but worse than the “Normal” group.

Despite the significance of previous results, the clusters were identified not taking into consideration differences in severity and type of the physical injuries and other factors that can influence symptom report such as financial compensation and malingering. Moreover, the above studies only included scales L, F, and K to determine the best cluster solution not considering the newly developed MMPI-2 validity scales. Including the new validity scales in the determination of subgroups could further enhance the reliability of the subgroups by increasing assurance regarding valid patient presentation of symptoms/disabilities. Thus, it is important to expand previous studies by conducting an exploratory cluster analysis on all relevant MMPI-2 scales over a well characterized sample in terms of the medical and legal factors that could influence recovery to further enhance the generalization of the results.

In the same way, it is also important to investigate whether the subgroup solutions replicate when using the newly developed MMPI-2-RF scales. Investigating whether cluster solutions using the MMPI-2-RF scales resemble the MMPI-2 subgroups could provide a clearer understanding of the strength of this instrument to determine psychological differences between pain subgroups and thus, increment its utility as a diagnostic tool.

Purpose

The main goal of this investigation was to expand previous cluster analytic studies by determining the best cluster solution using MMPI-2 and MMPI-2-RF variables on a large and well characterized pain subgroups that were seen in medico-legal contexts. Specifically, this

study examined, thoroughly described and compared: 1) the subgroups that arise when using the MMPI-2 standard clinical and traditional validity scales (the traditional clustering method); 2) the subgroups that arise when the cluster analysis is conducted also including the new validity scales Fb, Fp and FBS (the MMPI-2 clustering method); and 3) the subgroups that arise when conducting a cluster analysis on the recently developed MMPI-2-RF scales (the MMPI-2-RF clustering method).

End Notes

[1]Cluster analysis is a generic name for a variety of mathematical methods, numbering in the hundreds, which in the behavioral sciences are often used to group patients that have similar data.

CHAPTER IV
METHODS

Participants

Patients were culled from the archival records of a pull of approximately 847 sequential cases seen for psychological pain evaluations at a large clinical psychology practice in the Southeastern United States from 1998 through 2008. All patients were referred by physicians, workers compensation companies, and attorneys. Extensive medical records were reviewed in the context of these evaluations to provide objective medical diagnostic test results, as well as physicians' clinical diagnoses and injury descriptions. The inclusion criteria were: 1) referral for persisting spine pain-related complaints, 2) presence of significant external incentive primarily in the form of workers' compensation claims or a personal injury law suit, and 3) completion of the MMPI-2. Because all items of the MMPI-2-RF are included in the MMPI-2, it was possible to score MMPI-2-RF scales for all those patients that have all MMPI-2 items available. Exclusion criteria were: 1) age lower than 18 and greater than 59; 2) time since injury of less than 6 months or more than 15 years; 3) a head injury accident more severe than a concussion (as defined by the Mild Traumatic Brain Injury Committee of the Head Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine, 1993). Finally, patients were screened according to their MMPI-2 VRIN scale, TRIN scale and Cannot Say score. Cases were excluded if VRIN or TRIN are greater or equal 80 or Cannot Say is equal or greater than 30 (Butcher et al., 1989).

The final sample was comprised of 608 cases. The mean age for the full sample was 42.4 years (sd = 8.8). The sample had completed an average of 11.7 years of education (sd = 2.5) and were 38.2 months post injury (sd = 29.3). The sample was 64.6% male and 65.6% Caucasian

(African-American = 28.1%; other or not indicated = 5.3%). At the time of the interview the patients rated their pain at 6.7 (sd = 1.9) out of a maximum of 10. Less than half (40.5 %) of patients had objective evidence of pathology involving the spine or spinal cord. Spine surgery was present in a quarter to one third of cases. Comorbid pain syndromes (e.g., fibromyalgia, complex regional pain syndrome) were rare (less than 10%).

Of the full sample, patients had external incentive primarily in the form of workers compensation claims (82.6%) or a personal injury law suit (15.3%). Over half (55.9%) were represented by an attorney though less than a quarter (23.8%) were attorney-referred. The remainder were referred by clinicians (usually medical doctors; 28.8%) or case managers / adjusters (47.8%). Based on Bianchini et al. (2005) Malingered Pain-Related Disability (MPRD) criteria, 37.2% were classified as Not MPRD, 29.9% were Possible MPRD, 25.3% were Probable MPRD and 7.6% were Definite MPRD.

Measures, Variables and Characterization

MMPI Variables

The Minnesota Multiphasic Personality Inventory 2nd edition **(**MMPI-2; Butcher et al. 1989) is a widely used emotion and personality measure. The MMPI-2 consists of 567 items. Variables that were used in this study are validity scales: Cannot Say, VRIN, TRIN, L, F, Fb, Fp, FBS and K, (scale S was not included because it was not collected for all patients); and clinical scales 1 thru 0. Refer back to Table 1 for a detailed description of the MMPI-2 clinical and validity scales.

T-scores were analyzed for all variables. Based on manual recommended interpretation cutoffs, T scores were classified as May be exaggerated or May be invalid for all for validity scales and High or Very high scores for all clinical scales. See Table 3 for T scores classification

categories by MMPI-2 scale. For details regarding cutoff, scales and indicators, the reader is referred to the MMPI-2 manual (Butcher et al., 1989) and Lees-Haley et al. (2003) as well as other standard MMPI-2 texts (e.g., Greene, 2000; Graham, 1990; Freidman, Lewak, Nichols, & Webb, 2001).

Table 3
T scores at or above (≥) the interpretative cutoff based on the Lees-Haley et al. (2003) MMPI-2 manual

Validity Scales		
	May be exaggerated	May be invalid
F	70	90
Fb	80	90
Fp	70	100
FBS	80	100
L	65	80
K	--	65
Clinical Scales		
	High	Very High
All Clinical Scales (1-0)	65	75

Note. F: Infrequency; Fb: Infrequency back; Fp: Infrequency psychopathology; FBS: Symptom Validity scale; L: Lie; K: Correction; scales 1-0: 1: Hypochondriasis; 2: Depression; 3: Hysteria; 4: Psychopathic Deviate; 5: Masculinity-Femininity; 6: Paranoia; 7 : Psychasthenia; 8: Schizophrenia; 9 : Hypomania; 0 : Social Introversion.

The Minnesota Multiphasic Personality Inventory 2nd edition-Restructured Form (MMPI-2-RF; Ben-Porath and Tallegen, 2008). The restructured form consists of 338 items. Variables that were used in this study are RF validity scales: L-r, K-r, F-r, Fp-r, Fs and FBS-r; and clinical scales: RCd thru RC9. Refer back to Table 2 for a detailed description of the RC and RF validity scales. T-scores were analyzed for all variables.

T-scores were analyzed for all variables. Based on manual recommended interpretation cutoffs, T scores were classified as Maybe exaggerated or May be invalid for all for validity scales and High or Very high for all clinical scales. See Table 4 for Diagnostic Cutoffs by

MMPI-2-RF scale. For details regarding cutoffs, scales and indicators, the reader is referred to the MMPI-2-RF manual (Ben-Porath and Tallegen, 2008).

Table 4

T scores at or above (≥) the interpretative cutoff based on the Ben-Porath and Tallegen (2008) MMPI-2-RF Manual

RF Validity Scales		
	May be exaggerated	*May be invalid*
F-r	90	100
Fp-r	70	80
Fs	80	90
FBS-r	80	90
L-r	70	80
K-r	66	70
Clinical Scales		
	High	*Very high*
All RC Scales (RCd-RC9)	65	80

Note. F-r: Infrequency restructured; Fp-r: Infrequency psychopathology restructured; Fs: Infrequency somatic symptoms; FBS-r: Symptom Validity scale restructured; L: Lie restructured; K: Correction restructured; scales RCd-RC9: RCd: Demoralization; RC1: Somatic Complains; RC2: Low Positive Emtions; RC3: Cynism; RC4: Antisocial Behavior; RC6: Ideas of Persecution;RC7: Dysfunctional Negative Emotions; RC8: Aberrant Experiences; RC9: Hypomanic Activation.

Non-MMPI variables

Demographics variables that were examined in this study are age, gender, education level, race, time since injury.

Symptom/Injury characteristics variables that were examined are pain symptoms by area of the body, spine findings, spinal surgery and other pain-related diagnoses. In addition, an *Injury Severity* scale was created to serve as a rough linear approximation of the degree or severity of spine-related medical findings. Based on a review of medical records each case was assigned a score of 0 to 4 as follows: no findings = 0; degenerative disc(s) or joint(s) = 1; bulging or protruding disc(s) = 2; herniated disc(s) = 3; and 4) neural impingement(s) = 4. Note that spine

severity scores were not cumulative; patients received the highest single score for which findings were observed.

Medico-legal variables that were examined are status of legal representation, referral source, and claim type. *Malingering status* was also described for all patients. *Malingering status* was based on the criteria for the diagnosis of MPRD (Bianchini et al., 2005). Classification relied on performance on psychometric indicators and examination of available records. Patients were classified as MPRD based on two criteria. MPRD[a] was based on performance on psychometric indicators not including the MMPI-2 variables. MPRD[b] was based on performance on psychometric indicators including the MMPI-2 variables. See appendix C for a description of psychometric indicators, cutoffs and operationalization of the malingering classification systems. This system results in patients being classified into one of four groups: 1) Not MPRD; 2) Possible MPRD (some findings but insufficient for a higher level diagnosis); 3) Probable MPRD; 4) "Definite MPRD". "Definite MPRD" is defined by the presence of a significantly below-chance finding. "Probable MPRD" is defined in terms of two or more psychometric findings consistent with malingering or two or more qualitative inconsistencies along with one or more psychometric findings. Cases that had psychometric findings or two or more qualitative inconsistencies but who did not meet these criteria were considered "Possible MPRD". Cases who do not meet any of the above criteria were classified as "Not MPRD." Finally, the Probable and Definite MPRD patients were combined as "All MPRD" group as both are considered malingering in the MPRD criteria.

Pain Perception and Predictors of Outcome variables

Pain Perception was examined by patients' report of their level of pain on a scale ranging from 0 (No Pain) to 10 (Worst Pain Imaginable) at the time of the interview (current), when they

had the least amount of pain (best) and when they had the most amount of pain (worst) after the injury.

The Pain Catastrophizing Scale (PCS; Sullivan et al., 1995) was be used to measure the construct of pain catastrophization which includes a hypervigilance, threat magnification, and feeling of helplessness related to pain. PCS consists of 13 statements related to pain that are each rated (0-4) as to the degree felt during painful experiences. PCS T scores were used in this study. It is important note that the PCS was introduced to the psychological practice in 2005 and only 140 patients included in this study have scores.

Perceived Disability was measure using the Pain Disability Index (PDI; Pollard, 1984) assesses pain disability in seven areas (occupational, home/family, recreational, social, sexual, activities of daily living, life support), all rated on 11-point Likert-type scales (0, no disability; 10, complete disability ; see appendix B). Raw scores were used for this study because T scores were not available. The PDI has had widespread use since its introduction because it is brief and has strong psychometric properties, including evidence for validity (Jerome & Gross, 1991; Tait, Chibnall, & Krause, 1990; Tait, Pollard, Margolis, Duckro, & Krause, 1987), reliability (Gronblad et al., 1993), and sensitivity to change (Strong, Ashton, & Large, 1994). The PDI was introduced to the psychological practice in 2004 and only 241 patients included in this study have PDI scores.

Analysis Strategy

Using three different methods, exploratory two-step cluster analyses[1] were conducted to group the participants. The two-step cluster analysis was selected as the clustering method because is often the method preferred for large data sets as hierarchical clustering do not scale efficiently when number of subjects is very large e.g. n > 200 (Milligan& Hirtle, 2003).

Method 1. (the traditional clustering method) used the MMPI-2 standard clinical scales and the traditional validity scales *L, F* and *K*. to test whether the previously found pain subgroups are also found in the present medico-legal sample.

Method 2. (the MMPI-2 clustering method) used all the MMPI-2 standard clinical scales and all the validity scales including *L, F, K, Fb, Fp* and *FBS* to test whether the inclusion of the over reporting validity scales in the cluster analysis impact the number and the characteristics of pain subgroups in the current medico-legal sample (the MMPI-2 clustering method).

Method 3. (the MMPI-2-RF clustering method) used the MMPI-2-RF *RCd- RC9* and *RF* validity scales to test whether a cluster analysis using the newly developed MMPI-2-RF scales influence the previously found MMPI-2 cluster number and characteristics.

For each method, it was determined the best cluster solution (number of clusters) from the autoclustering technique of the Statistical Package for the Social Sciences- 14th edition (SPSS 14). Then, Multivariate Analysis of Variance (MANOVA), Analysis of Variance (ANOVA) or Chi squared analysis were conducted, where appropriate, to determined differences between the resulted subgroups in several important variables: MMPI-2, MMPI-2-RF, demographics, injury severity, legal status, malingering status, pain perception and predictors of poor outcome.

End Notes

[1]Two-step cluster analysis is often preferred Clustering method for large datasets, since hierarchical and k-means clustering do not scale efficiently when n is very large

CHAPTER V
RESULTS

Preliminary Analyses

Before running the cluster analyses, assumptions of normality and independence of variables were evaluated. The distributions presented in Table 5 indicated that all MMPI-2 and MMPI-2-RF variables were relatively normally distributed (Skewness and Kurtosis < + or -2.0; Shapiro & Wilk, 1965). However, FBS demonstrated an elevated Kurtosis statistic of 2.66. Results also indicated that most MMPI-2 variables meet the assumption of independence of variables ($r < .80$; Tabachnick & Fidell, 2001). However, there was high multicollinearity between scales Fb and 8 ($r = .81$) and between scales 7 and 8 ($r = .85$).

All the MMPI-2-RF scales showed low to medium correlations between each other, meeting the assumption of independence of variables ($r < .80$; Tabachnick & Fidell, 2001). Therefore, the assumptions of normality and independence of variance were not fully met for all the MMPI-2 variables; these assumptions were met for the MMPI-2-RF variables. Despite the MMPI-2 results, all the proposed cluster analyses were performed because the two-step cluster analysis is fairly robust even when the normality and independence of variables assumptions are violated (Milligan& Hirtle, 2003).

Table 5
Normality statistics for the MMPI-2 and MMPI-2-RF variables

	Skewness		Kurtosis	
MMPI-2 Scales	Statistic	Standard Error	Statistic	Standard Error
L	0.54	0.10	0.39	0.20
F	0.98	0.10	0.55	0.20
Fb	0.33	0.10	-0.73	0.20
Fp	0.66	0.10	-0.75	0.20
FBS	1.48	0.10	2.66	0.20
K	-0.04	0.10	-0.46	0.20
1	-0.10	0.10	-0.21	0.20
2	-0.38	0.10	-0.41	0.20
3	-0.05	0.10	-0.25	0.20
4	0.28	0.10	-0.41	0.20
5	0.21	0.10	0.04	0.20
6	0.51	0.10	-0.17	0.20
7	-0.02	0.10	-0.47	0.20
8	0.34	0.10	-0.43	0.20
9	0.71	0.10	0.12	0.20
0	0.19	0.10	-0.70	0.20
MMPI-2-RF Scales				
L-r	0.31	0.11	-1.12	0.23
F-r	1.29	0.11	1.69	0.23
Fp-r	0.56	0.11	-0.54	0.23
Fs	0.02	0.11	-0.68	0.23
FBS-r	0.31	0.11	-0.20	0.23
K-r	0.29	0.11	-0.65	0.23
RCd	-0.35	0.11	-0.74	0.23
RC1	0.09	0.11	-0.84	0.23
RC2	0.13	0.11	-0.73	0.23

Table 5 Cont.

RC3	0.34	0.11	-0.88	0.23
RC4	0.59	0.11	-0.25	0.23
RC6	0.88	0.11	0.25	0.23
RC7	0.27	0.11	-0.79	0.23
RC8	0.58	0.11	-0.24	0.23
RC9	0.72	0.11	0.99	0.23

Note. F: Infrequency; Fb: Infrequency back; Fp: Infrequency psychopathology; FBS: Symptom Validity scale; L: Lie; K: Correction; scales 1-0: 1: Hypochondriasis; 2: Depression; 3: Hysteria; 4: Psychopathic Deviate; 5: Masculinity-Femininity; 6: Paranoia; 7 : Psychasthenia; 8: Schizophrenia; 9 : Hypomania; 0 : Social Introversion. . F-r: Infrequency restructured; Fp-r: Infrequency psychopathology restructured; Fs: Infrequency somatic symptoms; FBS-r: Symptom Validity scale restructured; L: Lie restructured; K: Correction restructured; scales RCd-RC9: RCd: Demoralization; RC1: Somatic Complains; RC2: Low Positive Emtions; RC3: Cynism; RC4: Antisocial Behavior; RC6: Ideas of Persecution;RC7: Dysfunctional Negative Emotions; RC8: Aberrant Experiences; RC9: Hypomanic Activation.

Method 1: Traditional Clustering Method

Defining the Number of Clusters

In Method 1 an exploratory two-step cluster analysis was conducted using the MMPI-2 traditional validity scales L, F and K and the ten clinical scales. As mentioned above, the autoclustering selection from SPSS 14 was used to select the best cluster solution. As a rule of thumb, the SPSS autoclustering will select as the best solution the one with the lowest information criterion measure (the Schwarz Bayesian Information Criterion; BIC) and the highest ratio of distance measures (RDM; "SPSS 14", 2005).

Because autoclustering solution is affected by order of the data (Milligan& Hirtle, 2003), first, autoclustering was conducted on the full data set ordering the data ascendingly by patient's ID number. Results showed that the optimal number of clusters was the two cluster solution. In support of the two-cluster solution, there was dramatic jump in variance explained from the one (*BIC* = 5412.4) to two (*BIC* = 4422.7; *RDM* = 2.8) cluster solution with only modest increases

when three (*BIC* = 4170.0; *RDM* = 2.1) and four clusters (*BIC* =4098.7, *RDM* = 1.4) solutions were isolated.

Then, full data set was sorted descendingly by patient's ID number. This time it was determined that the optimal number of clusters was the three-cluster solution. In support of the three-cluster solution, there was dramatic jump in variance explained from one (*BIC* = 5007) to two (*BIC* = 4525.6; *RDM* = 2.2) cluster solution and a similar jump from two to three (*BIC* = 4202.7, *RDM* = 2.0) cluster solution with only a modest decrease when four (*BIC* = 4127.2; *RDM* = 1.7) and five clusters (*BIC* =4135.5; *RDM* = 1.1) solutions were isolated.

Selection of Best Cluster Solution

To select the "best" cluster solution, 50 cluster analyses were all run after randomly sorting the data set using 70% of the total sample. Out of the 50 runs, autoclustering determined that the two-cluster solution was more adequate 33 times (66 %) while the three-cluster solution was the most adequate 10 times (20%) and a four-cluster solution was most adequate 7 times (14%). Results using Binomial Tests demonstrated significant differences between observed proportion and the expected proportion between the appearance of the two and three-cluster solution and the two and four-cluster solutions ($p < .001$). Thus, the two-cluster solution was considered the most adequate number of groups for Method 1. The two-cluster solution was composed by a group with 342 participants and a group with 267 participants and these were further described in a number of MMPI, non-MMPI, pain perception and predictor of outcome variables.

Characterization of Pain Clusters based on all MMPI Variables

MMPI-2 Variables. First, the two subgroups were described and compared on all available MMPI-2 variables, this included the over reporting scales Fb, Fp and FBS even when these were

not used to determine the groups. Multivariate Analysis of Variance (MANOVA) demonstrated overall differences in MMPI-2 variables between the two groups [Wilk's Lambda; F (16, 564) = 10784.0, p<.001, Eta^2=.99]. Subsequent Analysis of Variance (ANOVA) and Tukey's b post hoc analyses demonstrated significant differences between the two groups in all the MMPI-2 variables. Table 6 presents means and standard deviations for all MMPI-2 scales by each subgroup. Figure 5 illustrates the profiles of the two subgroups based on the variables used to create the clusters. As can be seen in Figure 5, one subgroup had no elevated validity scales and three scales (scales 1, 2 and 3) with very high mean scores (this group was called *Method 1-Triad*). The second group, on the other hand, had two mean scores (scales F and FBS) in the may be exaggerated range, one score (scale Fb), in the may be invalid range, two scales (scales 4 and 0) with high mean scores, and six scales (scales 1, 2, 3, 6, 7 and 8) with very high mean scores (this subgroup was called *Method 1-Pathological*).

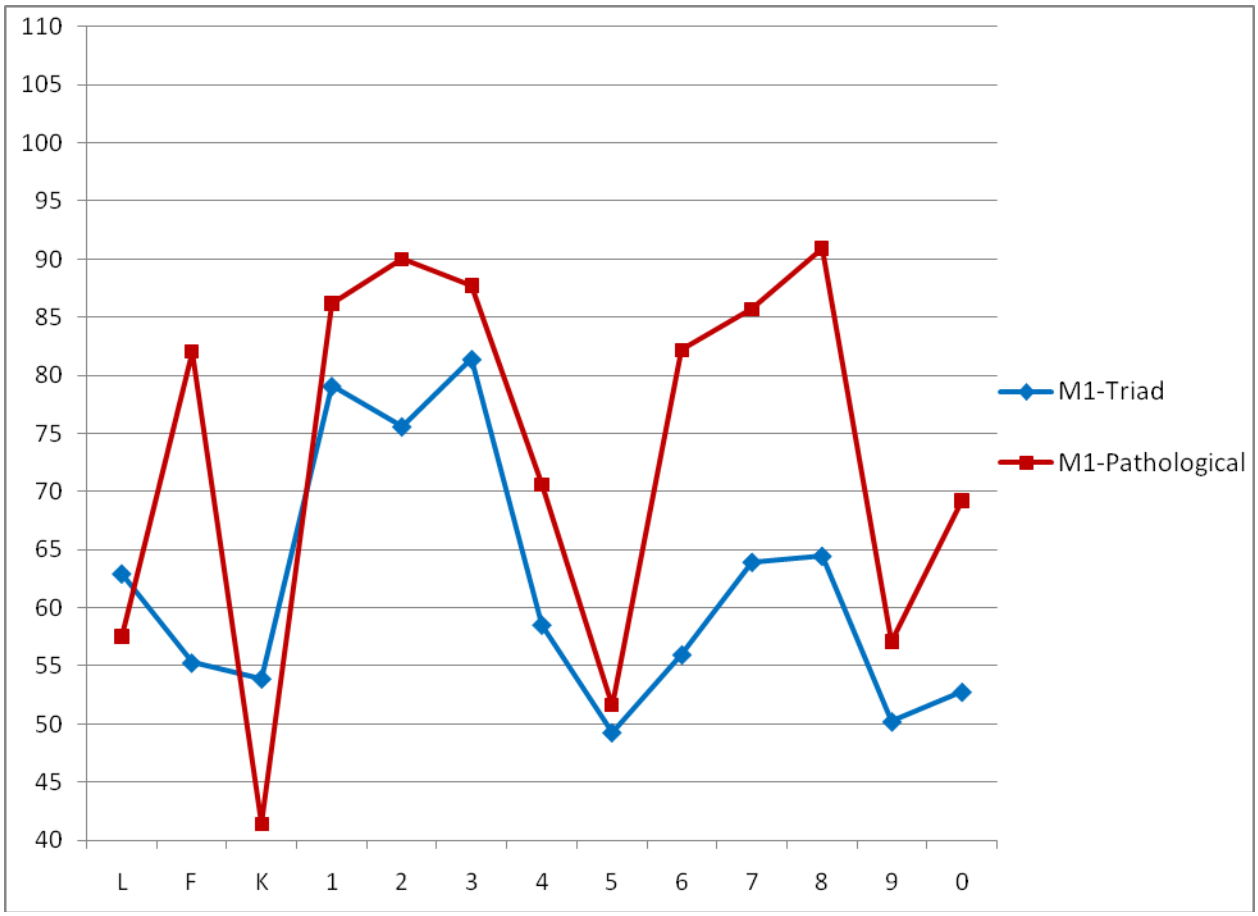
Table 6

Method 1 MMPI-2 mean, standard deviations, and statistical differences by subgroup

	M1-Triad M(sd)	*M1-Pathological M(sd)*	*F*	*p<*	*Eta²*
L	63.0(11.7)	57.4 (10.2)	35.6	.001	0.06
F	55.3(8.9)	82.0 (16.9)	604.2	.001	0.51
Fb	55.6(8.9)	91.9 (19.2)	744.5	.001	0.56
Fp	51.4(9.7)	64.0(15.9)	140.4	.001	0.20
FBS	75.9(13.6)	90.7(12.0)	185.6	.001	0.24
K	53.9(10.5)	41.4(7.9)	248.3	.001	0.30
1	79.0(10.4)	86.2(8.5)	77.8	.001	0.12
2	75.6(12.6)	90.0(9.5)	234.5	.001	0.29
3	81.4(15.3)	87.7(12.9)	27.6	.001	0.05
4	58.6(10.1)	70.6(11.8)	174.8	.001	0.23
5	49.3(10.1)	51.6(8.1)	8.7	.003	0.02
6	56.0(11.9)	82.2(15.3)	539.3	.001	0.48
7	63.9(11.3)	85.7(10.1)	575.5	.001	0.49
8	64.5(9.9)	91.0(12.2)	831.7	.001	0.59
9	50.2(9.2)	57.2(11.5)	64.8	.001	0.10
0	52.8(8.6)	69.2(9.4)	479.9	.001	0.46

Note. M1-Triad: M1 subgroup with a Triad profile; Method 1-Pathological : Method 1subgroup with a Pathological profile; F: Infrequency; Fb: Infrequency back; Fp: Infrequency psychopathology; FBS: Symptom Validity scale; L: Lie; K: Correction; scales 1-0: 1: Hypochondriasis; 2: Depression; 3: Hysteria; 4: Psychopathic Deviate; 5: Masculinity-Femininity; 6: Paranoia; 7 : Psychasthenia; 8: Schizophrenia; 9 : Hypomania; 0 : Social Introversion.

Figure 5. Method 1 illustration of the profiles of the two subgroups described by all the MMPI-2 scales



Note. M1-Triad: Method 1 subgroup with a Triad profile; M1-Pathological : Method 1subgroup with a Pathological profile; F: Infrequency; Fb: Infrequency back; Fp: Infrequency psychopathology; FBS: Symptom Validity scale; L: Lie; K: Correction; scales 1-0: 1: Hypochondriasis; 2: Depression; 3: Hysteria; 4: Psychopathic Deviate; 5: Masculinity-Femininity; 6: Paranoia; 7 : Psychasthenia; 8: Schizophrenia; 9 : Hypomania; 0 : Social Introversion.

The number of patients that scored at or above the selected scores was also different between the two groups. As can be seen in Table 7, the *Method 1-Pathological* subgroup had significantly more patients scoring at the may be exaggerated and maybe invalid ranges than *Method 1-Triad* subgroup; exceptions were scales L and K where the *Method 1-Triad* had more patients than the *Method 1-Pathological* at those ranges. *Method 1-Triad* and *Method 1-Pathological* subgroups had similar number of patients with high mean scores on scales 1, 2, and

3. However, the *Method 1-Pathological* had a higher percentage of patients than *Method 1-Triad* with very high mean scores on the same scales. The most noticeable differences in the clinical scales were in scales 4, 6, 7, 8 and 0 where the *Method 1-Pathological* had at least four times more patients than the *Method 1-Triad* with very high mean scores.

Table 7

Method 1 percentage of cases that fall above the interpretative cutoff per MMPI-2 variable

	Maybe exaggerated		Maybe invalid	
Scale	*M1-Triad*	*M1-Pathological*	*M1-Triad*	*M1-Pathological*
F	7	77	0	28
Fb	4	67	2	55
Fp	5	35	0	4
FBS	41	85	6	23
L	47	28	8	2
K	15	2	2	0
	High scores		*Very high scores*	
	M1-Triad	*M1-Pathological*	*M1-Triad*	*M1-Pathological*
1	94	97	68	90
2	78	100	54	96
3	85	96	67	83
4	28	68	6	37
5	8	6	1	0
6	23	86	7	67
7	47	99	18	87
8	53	99	16	93
9	10	27	2	9
0	10	69	1	25

Note. M1-Triad: Method 1 subgroup with a Triad profile; M1-Pathological : Method 1subgroup with a Pathological profile; F: Infrequency; Fb: Infrequency back; Fp: Infrequency psychopathology; FBS: Symptom Validity scale; L: Lie; K: Correction; scales 1-0: 1: Hypochondriasis; 2: Depression; 3: Hysteria; 4: Psychopathic Deviate; 5: Masculinity-Femininity; 6: Paranoia; 7 : Psychasthenia; 8: Schizophrenia; 9 : Hypomania; 0 : Social Introversion.

MMPI-2-RF Variables. The two subgroups were also characterized using all MMPI-2-RF scales. This was done to determine similarities and differences between the two MMPI versions when testing pain patient subgroups. MANOVA demonstrated overall differences in MMPI-2-RF mean scores between the two groups [Wilk's Lambda; F (15, 434) =18428.8, p<.001,

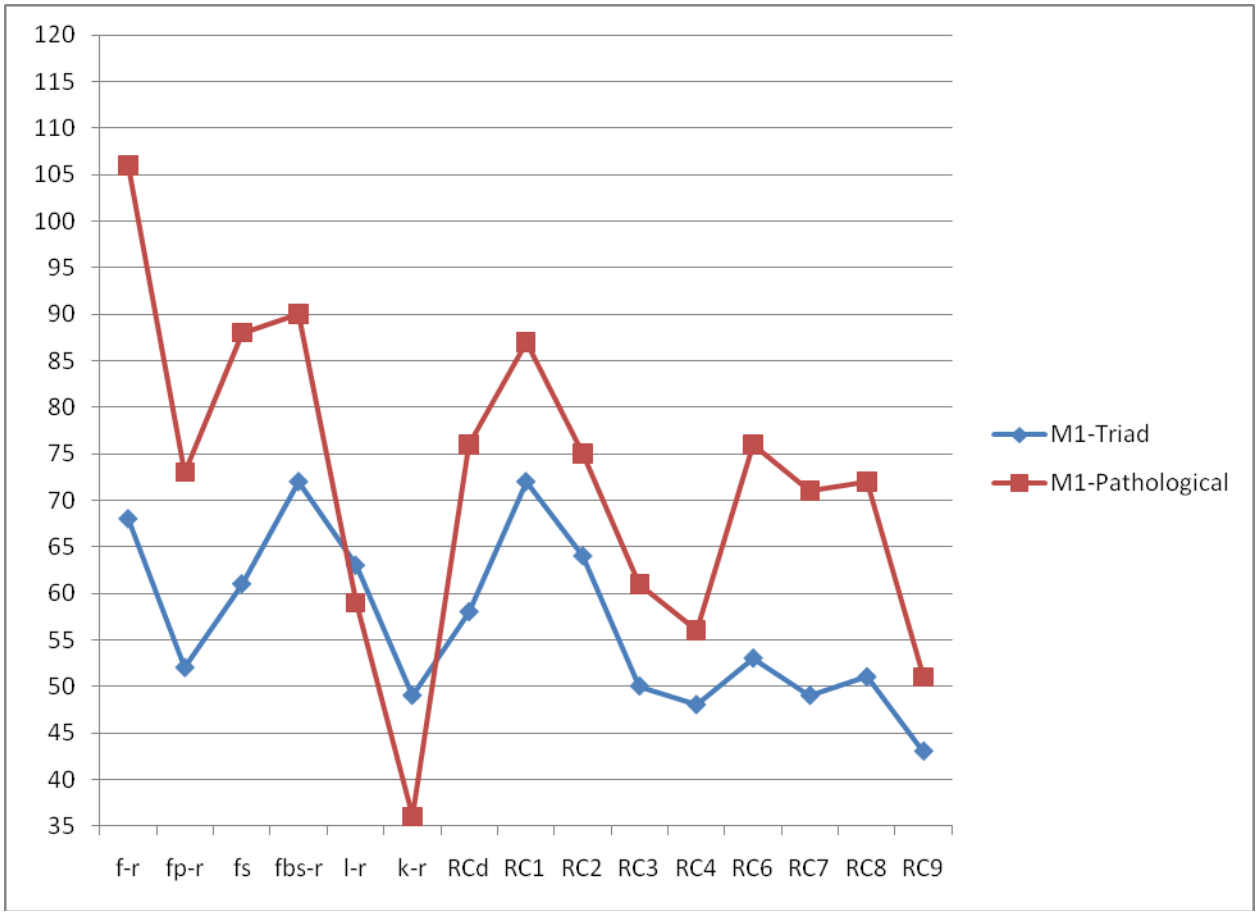
Eta^2=1.00]. Subsequent ANOVA and Tukey's b post hoc analyses demonstrated that there were significant differences between the groups in all the MMPI-2-RF variables. Table 8 presents scales mean and standard deviations for each group. Figure 6 illustrates the two subgroups based on MMPI-2-RF variables. Table 8 and Figure 6 show that the *M1-Triad* has no elevated validity scales and only one scale with very high mean score (RC1). The *M1-Pathological*, on the other hand, had two mean scores in the may be exaggerated range (scales Fs and FBS-r), one score in the may be invalid range (scale F-r), four high mean scores (RCd, RC2, RC6, RC7, RC8), and one very high mean score (scale RC1).

Table 8
Method 1 MMPI-2-RF mean, standard deviations, and statistical differences by subgroup.

	M1-Triad M(sd)	*M1-Pathological M(sd)*	*F*	*p*<	Eta^2
L-r	62.9 (12.2)	60.1 (11.6)	6.1	.014	0.01
F-r	66.4(12.0)	102.5 (15.8)	458.5	.001	0.63
Fp-r	51.0(8.9)	70.7(17.5)	239.5	.001	0.35
Fs	60.3(14.6)	83.9(19.1)	219.5	.001	0.33
FBS-r	71.8(13.4)	88.1(12.1)	180.0	.001	0.29
K-r	49.6(9.9)	37.9(7.5)	192.5	.001	0.30
RCd	56.6(9.8)	74.8(7.1)	488.1	.001	0.52
RC1	71.6(9.8)	85.3(9.5)	223.4	.001	0.33
RC2	61.9(11.2)	75.9(12.1)	158.1	.001	0.26
RC3	50.0(12.3)	54.5(12.1)	67.5	.001	0.13
RC4	46.1(50.6)	56.2(11.8)	61.4	.001	0.12
RC6	53.1(9.9)	73.3(116.6)	279.6	.001	0.38
RC7	48.4(9.2)	68.6(10.8)	461.1	.001	0.51
RC8	50.8(9.2)	69.5(13.9)	292.8	.001	0.40
RC9	42.7(9.2)	49.6(9.5)	57.2	.001	0.11

Note M1-Triad: Method 1 subgroup with a Triad profile; M1-Pathological : Method 1subgroup with a Pathological profile; . F-r: Infrequency restructured; Fp-r: Infrequency psychopathology restructured; Fs: Infrequency somatic symptoms; FBS-r: Symptom Validity scale restructured; L: Lie restructured; K: Correction restructured; scales RCd-RC9: RCd: Demoralization; RC1: Somatic Complains; RC2: Low Positive Emtions; RC3: Cynism; RC4: Antisocial Behavior; RC6: Ideas of Persecution;RC7: Dysfunctional Negative Emotions; RC8: Aberrant Experiences; RC9: Hypomanic Activation.

Figure 6. Method 1 illustration of the profiles of the two subgroups described by all the MMPI-2-RF scales.



Note. M1-Triad: Method 1 subgroup with a Triad profile; M1-Pathological: Method 1subgroup with a Pathological profile; . F-r: Infrequency restructured; Fp-r: Infrequency psychopathology restructured; Fs: Infrequency somatic symptoms; FBS-r: Symptom Validity scale restructured; L: Lie restructured; K: Correction restructured; scales RCd-RC9: RCd: Demoralization; RC1: Somatic Complains; RC2: Low Positive Emtions; RC3: Cynism; RC4: Antisocial Behavior; RC6: Ideas of Persecution;RC7: Dysfunctional Negative Emotions; RC8: Aberrant Experiences; RC9: Hypomanic Activation.

In addition, as can be seen in Table 9, the *Method 1-Pathological* had at least ten times more patients scoring at the may be exaggerated and maybe invalid ranges than the *Method 1-Triad* on the over-reporting validity scales. *Method 1-Triad* and *Method 1-Pathological* had similar number of patients with high mean scores on scale RC1. However, the *Method 1-Pathological* had noticeably more patients than the *Method 1-Triad* with very high mean scores

on the same scale. The most visible differences between the groups were in scales RCd, RC6, RC7, and RC8 where *Method 1-Triad* had about 10% of patients scoring at the high scores range while the *Method 1-Pathological* had more than 60% of patients scoring at the same range.

Table 9

Method 1 percentage of Cases that fall above the selected cutoff per MMPI-RF variable

	May be exaggerated		May be invalid	
Scale	*M1 -Triad*	*M1- Pathological*	*M1- Triad*	*M1- Pathological*
F-r	3	70	0	61
Fp-r	1	26	0	13
Fs	13	58	6	44
FBS-r	32	81	8	42
L-r	30	23	12	6
K-r	7	0	0	0
	High scores		Very high scores	
	M1- Triad	*M1- Pathological*	*M1- Triad*	*M1- Pathological*
RCd	24	91	0	31
RC1	79	99	20	72
RC2	45	83	9	43
RC3	14	42	2	3
RC4	8	24	0	2
RC6	15	70	1	34
RC7	6	65	0	20
RC8	7	62	0	22
RC9	3	7	0	1

Note. M1-Triad: Method 1 subgroup with a Triad profile; M1-Pathological : Method 1subgroup with a Pathological profile; F-r: Infrequency restructured; Fp-r: Infrequency psychopathology restructured; Fs: Infrequency somatic symptoms; FBS-r: Symptom Validity scale restructured; L: Lie restructured; K: Correction restructured; scales RCd-RC9: RCd: Demoralization; RC1: Somatic Complains; RC2: Low Positive Emtions; RC3: Cynism; RC4: Antisocial Behavior; RC6: Ideas of Persecution;RC7: Dysfunctional Negative Emotions; RC8: Aberrant Experiences; RC9: Hypomanic Activation.

Non-MMPI Characteristics of Pain Clusters

Demographics. Differences between the two resulted groups in demographic report were tested using ANOVA or Chi squared analysis where appropriate. Table 10 presents demographic data by group. The *Method 1-Triad* patients were significantly shorter post- injury and had a

higher education than those in the *Method 1-Pathological* subgroup. *Method 1-Pathological* subgroup also had less number of male participants and Caucasians. Indeed, odd ratios analysis indicated that the *Method 1-Pathological* subgroup was 1.4 times (95% C.I. = 1.3-1.5) less likely to be male and 2.0 times (95% C.I. = 1.5-1.3) less likely to be Caucasian than the *Method 1-Triad* subgroup.

Table 10
Method 1 demographic characteristics by subgroup

	M1-Triad M(*sd*)	*M1-Pathological M*(*sd*)	*F*	*p*≤	*Eta2*
Age	42.6 (8.9)	42.5(8.5)	0.2	NS	0.00
Education	12.0(2.5)	11.5(2.4)	6.7	.012	0.11
Time since Injury	35.7(27.7)	41.8(30.8)	3.2	.013	0.00
	(%)	(%)	X^2	*p*≤	
Gender (male)	68.9	60.2	4.7	.031	
Race (white)	72.6	57.0	20.4	.001	

Note. M1-Triad: Method 1 subgroup with a Triad profile; M1-Pathological : Method 1subgroup with a Pathological profile

Injury Severity. Univariate ANOVA demonstrated that there are not differences in the *Injury Severity* scale between *Method 1-Triad* (*M* = .79; *sd* = 1.2) and *Method 1-Pathological* (*M* = .81; *sd* = 1.1) [*F* (1, 583) = 0.06, *p* > .05, *Eta2*=0.01]. Table 11 presents the injury and symptom characteristics of the sample as a function of group membership. Differences between the two groups in injury/symptom characteristics were also tested using Chi squared analysis. As can be seen, groups did not differ in injury type, location, or etiology.

Table 11
Method 1 percentage of patients with specific Injury/Symptom characteristics by pain group

	M1-Triad	*M1-Pathological*	X^2	*p<*
Primary back/spine injury	91.6	88.9	1.8	NS
Head injury in accident	8.3	8.0	3.9	NS
Other Pain symptoms / area of body				
Head	23.9	30.2	4.3	NS
Chest / abdomen	5.0	9.3	3.7	NS
Upper extremity	42.2	42.0	1.3	NS
Lower extremity	69.4	66.0	0.5	NS
Spine Findings				
any spine findings	40.0	36.4	0.5	NS
degenerative disc/spine	20.0	21.6	0.3	NS
herniated nucleus pulposus	5.6	5.6	0.6	NS
disc bulge/protrusion	26.7	22.8	0.8	NS
neural impingement	2.8	3.1	1.7	NS
Spinal Surgery				
discectomy / fusion	26.7	30.9	3.2	NS
decompression/laminectomy	11.7	17.9	2.8	NS
Other pain diagnoses				
Complex regional pain syndrome	2.8	3.7	1.0	NS
Fibromyalgia	2.8	3.1	0.9	NS
Myofascial pain syndrome	1.7	6.2	4.7	NS

Note. M1-Triad: Method 1 subgroup with a Triad profile; M1-Pathological : Method 1subgroup with a Pathological profile

Legal Status. Differences between the two subgroups in legal characteristics were tested using Chi squared analysis. Table 12 presents the legal status of the sample as a function of group membership. Groups did not differ in the status of legal representation, referral source or type of legal claim.

Table 12
Method 1 medico-legal characteristics of the chronic pain sample as a function of group membership.

	M1-Triad	*M1-Pathological*		
	%	%	X^2	*p*=
Status of legal representation				
No Attorney	29.8	27.1		
Represented by attorney	57.4	55.7	0.55	NS
Attorney status unknown	15.5	14.5		
Referral source				
doctor	28.0	27.1		
case manager / adjuster	49.8	47.9	0.66	NS
attorney	4.4	3.6		
district attorney	18.3	19.9		
Claim type				
workers compensation	87.3	81.9	3.60	NS
personal injury	11.6	17.2		
disability	0.8	0.6		

Note. M1-Triad: Method 1 subgroup with a Triad profile; M1-Pathological : Method 1subgroup with a Pathological profile

Malingering Diagnosis. Differences between the two subgroups in MPRD[a] and MPRD[b] diagnosis were also tested using Chi squared analysis. Table 13 presents the malingering diagnosis of the sample as a function of group membership. The two subgroups differed significantly in MPRD status: MPRD[a] [X^2 (4,583) = 104.5, $p < .001$].Odd ratios analysis indicated that the *Method 1-Pathological* was 10.5 times (95% C.I. = 10.6-10.5) more likely to be MPRD than *Method 1-Triad* subgroup when not using the MMPI variables as malingering indicators. When the MMPI variables were included as indicators the odds ratio increased to 27.8 (95% CI = 27.8- 27.5).

Table 13
Method 1Malingering status by pain group

Method 1 MPRD[a] status by subgroup

	M1-Triad %	*M1-Pathological* %	X^2	*p*<
Not MPRD	43.4	14.2		
Possible MPRD	26.5	33.9	104.5	.001
Probable MPRD	15.4	39.8		
Define MPRD	4.8	12.0		
All MPRD	*20.2*	*51.8*		

Method 1 MPRD[b] status by subgroup

	M1-Triad %	*M1-Pathological* %	X^2	*p*<
Not MPRD	42.2	3.6		
Possible MPRD	32.8	31.1	138.9	.001
Probable MPRD	20.2	53.4		
Define MPRD	4.8	12.0		
All MPRD	*25.0*	*65.4*		

Note. M1-Triad: Method 1 subgroup with a Triad profile; M1-Pathological : Method 1subgroup with a Pathological profile MPRD[a]: Malingered Pain Related Disability not including the MMPI-2 variables; MMPI[b]: Malingered Pain Related Disability including the MMPI-2 variables

Pain Report and Predictors of Outcome. Finally, to determine differences in pain report and predictors of outcome, pain reports, levels catastrophization and functional capacity were compared among the two subgroups. Differences between the two groups in pain report, PCS and PDI scores were tested using ANOVA. Pain reports were available for all patients. PCS scores were available for 72 participants from the *Method 1-Triad* subgroup and for 68 participants from the *Method 1-Pathological* subgroup. PDI data was available for 118 participants from the *M1-Triad* subgroup and 95 participants from the *M1-Pathological* subgroup. Table 14 presents data for these variables by group. Results showed that the *Method 1-Pathological* reported significantly higher levels of "best" pain, catastrophization and perceived disability than those in the *Method 1-Triad*.

Table 14
Method 1 current, best, worst pain report, PCS and PDI scores as a function of pain group

	M1-Triad *M*(*sd*)	*M1-Pathological* *M*(*sd*)	*F*	*p*<	*Eta2*
Current Pain	6.4(2.0)	6.7(1.8)	2.2	NS	0.10
Best Pain	4.6(2.1)	5.1(2.2)	4.7	.032	0.10
Worst Pain	9.2(1.5)	9.2(1.3)	0.1	NS	0.00
PCS	69.3(14.5)	80.9(13.3)	24.2	.001	0.15
PDI	48.6(13.1)	55.5(10.0)	17.4	.001	0.08

Note. M1-Triad: Method 1 subgroup with a Triad profile; M1-Pathological : Method 1subgroup with a Pathological profile.

Method 1 Summary and Conclusions

After conducting several exploratory two step cluster analyses using the MMPI-2 traditional validity scales L, F and K and the 10 clinical scales it was determined that the best solution was the two-cluster solution because it was picked by SPSS autoclustering significantly more frequently as the best solution than the other solutions. The two-cluster solution was characterized by two homogeneous groups that differed drastically in the number and type of MMPI-2 scales elevated as well as the number of patients with elevations. The first subgroup elevated only on scales 1, 2 and 3; thus it was called *Method 1-Triad*. The second subgroup had elevations on scales F, 1,2,3,4,6,7,8 and 0 and it was called *Method 1-Pathological*. Note that the scores on scales 1, 2 and 3 were significantly higher in the *Method 1-Pathological* than the *Method 1-Triad* subgroup.

Differences between the subgroups were seen also in scales Fb, Fp and FBS although these scales were not used as variables to create the groups. This suggests that the new over-reporting scales not only have an important relationship with the other scales (e.g., scale *F*) but also present important information regarding the validity of the symptom presentation by patients in the *Method 1-Pathological* subgroup. Moreover, the two determined pain subgroups differed

on the MMPI-2-RF scales. Like the MMPI-2, the *Method 1-Pathological* reported higher mean score and a larger number MMPI-2-RF scale scores than the *Method 1-Triad*. However, some differences between the versions were observed. The *Method 1-Triad* had only one very high mean score (RC1) on the MMPI-2-RF as opposed to three scales with very high scores (scales 1, 2, and 3) on the MMPI-2. This shows that there are differences in describing the same *Method 1-Triad* profile when using the MMPI-2 and the MMPI-2-RF. Furthermore, while the *Method 1-Pathological* demonstrated similar profiles between the MMPI test versions, on the MMPI-2-RF two mean clinical scales were not elevated (RC3 and RC4) that were elevated on the MMPI-2. Thus, the changes done for RC3 and RC4 (from scales 3 and 4) make the scales less sensitive to report of pain symptoms related to the *Method 1-Pathological* profile.

When the groups were compared on demographic, injury/symptom characteristics, legal status and malingering diagnosis, differences were found only on few variables. The *Method 1-Pathological* was less educated, had more time post- injury, had less Caucasians, less males, and more malingerers than the *Method 1-Triad*. In fact, *Method 1-Pathological* patients were 10 to 28 times more likely to be diagnosed as malingerers than the *Method 1-Triad* patients. These results reveal that group membership was not conditioned to injury/ symptom severity or legal status. Instead, group membership was related to some demographic characteristics and malingering diagnosis. Finally, best pain report levels, level of catastrophization and perceived disabilities were significantly higher for the *Method 1-Pathological* than the *Method 1-Triad*. These results support the idea that those with *Method 1-Pathological* profiles are more likely to have poorer outcome than *Method 1-Triad* profiles.

Method 2: MMPI-2 Clustering Method

Defining the Number of Clusters

In Method 2, an exploratory two step cluster analysis was conducted using the MMPI-2 validity scales F, Fb, Fp, FBS, L and K and the ten clinical scales. As done in Method 1, SPSS autoclustering was used to determine the best cluster solution. Again, the full data set was first ordered ascendingly by patient's ID number when the autoclustering was performed. It was determined that the optimal number of clusters was the two-cluster solution. In support of the two-cluster solution, there was a dramatic jump in variance explained from the one (*BIC* = 6639.2) to two (*BIC* = 5358.9; *RDM* = 2.4) cluster solution with only modest increases when three (*BIC* = 5108.5; *RDM* = 1.9) and four-cluster (*BIC* =4977.9; *RDM* = 1.3) solutions were isolated.

Then, the data was sorted ascendingly by ID and autoclustering determined that the three-cluster solution was the optimal solution. In support of the three-cluster solution, there was a dramatic jump in variance explained from one (*BIC* = 6639.17) to two (*BIC* = 5426.8; *RDM* = 1.9) and a greater dramatic jump from two to three (*BIC* = 4998.3; *RDM* = 2.4) cluster solution with only modest increases when four (*BIC* = 4970.2; *RDM* = 2.1) and five cluster (*BIC* =5001.5; RDM = 1.0) solutions were isolated.

Selection of Best Cluster Solution. To select the "best" cluster solution, 50 cluster analyses were run after randomly resorting the data set using 70% of the total sample. Out of the 50 runs, autoclustering determined that the two-cluster solution was most adequate 23 times (46 %), the three-cluster solution was also the most adequate 23 times (46%) and a four-cluster solution was most adequate only 4 times (8%). Results using Binomial Tests showed that there were no

significant differences between observed proportion and the expected proportion between the appearance of the two-cluster and three-cluster solutions ($p > .05$). The two-cluster and the three-cluster solutions appeared significantly more times than the four-cluster solution ($p < .001$). This suggests that the two-cluster solution and the three-cluster solution can be considered equally adequate when using the all the validity MMPI-2 as a clustering method.

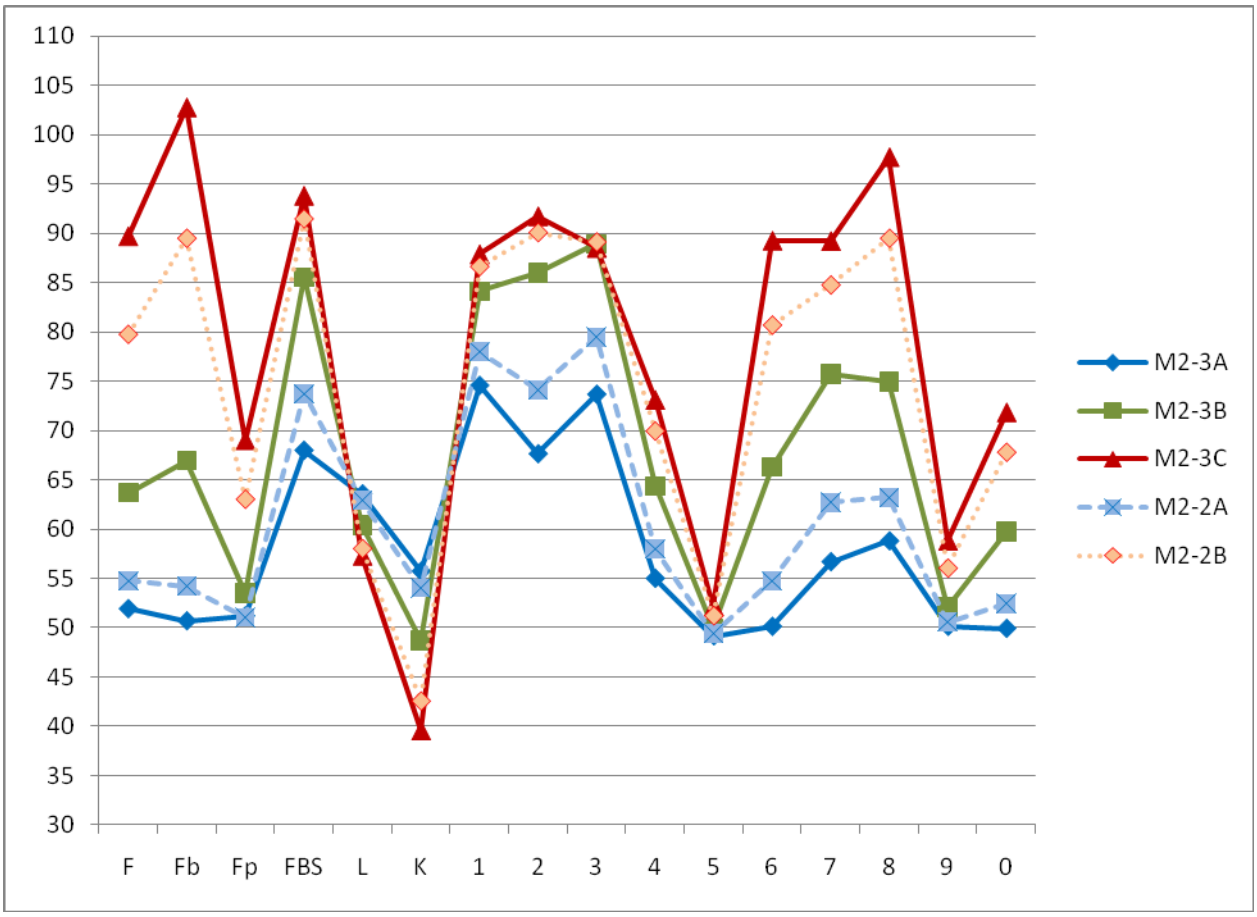
The two subgroups found in the two-cluster solution for Method 2 were: a group (*Method 2- solution 2-A*) with 323 participants and a group (*Method 2- solution 2-B*) with 258 participants. The three subgroups identified in the three-cluster solution were: a group (*Method 2-solution 3-A*) with 180 participants, a group (*Method 2-solution 3-B*) with 251 participants and a group (*Method 2-solution 3-C*) with 150 participants. Using crosstab analysis it was determined that all subjects classified in subgroup *Method 2-solution 3-A* were originally in subgroup *Method 2- solution 2-A*. Similarly, all subjects classified as *Method 2-solution 3-C* were originally in subgroup *Method 2-solution 2-B*. Subgroup *Method 2-solution 3-B* was composed by 49% of subjects that were in subgroup *Method 2-solution 2-A* and 51% of subjects that were in *Method 2-solution 2-B*.

Figure 7 presents the MMPI-2 profiles for the subgroups that resulted from the two-cluster and the three-cluster solutions. As can be seen, when compared to the two-cluster solution, the three-cluster solution presents *Triad* and *Pathological* profiles that differ substantially in the elevation of scores. Moreover, the three-cluster profile demonstrated the existence of a *Moderate* profile that is comprised of those patients that scored in the upper end of the two-cluster *Triad* profile and those that scored in the lower end of the two-cluster *Pathological* profile.

Therefore, since the three-cluster solution provides 1) the most number of groups, 2) information about a *Moderate* subgroup, and 3) creates larger separation between the *Triad* and

Pathological profiles, the three-cluster solution was determined as the most comprehensive fit for Method 2. As a result, the three subgroups that resulted from this solution were further described using a number of MMPI, non-MMPI, pain perception and predictor of outcome variables.

Figure 7. presents the MMPI-2 profiles for the subgroups that resulted from the two-cluster and the three-cluster solutions



Note. F: Infrequency; Fb: Infrequency back; Fp: Infrequency psychopathology; FBS: Symptom Validity scale; L: Lie; K: Correction; scales 1-0: 1: Hypochondriasis; 2: Depression; 3: Hysteria; 4: Psychopathic Deviate; 5: Masculinity-Femininity; 6: Paranoia; 7 : Psychasthenia; 8: Schizophrenia; 9 : Hypomania; 0 : Social Introversion.

Characterization of Pain Clusters based on all MMPI Variables

MMPI-2 Variables. As expected, MANOVA demonstrated overall differences in MMPI-2 mean scores between the three groups [Wilk's Lambda; $F(16, 563) = 13532.5$, $p<.001$,

Eta2=.99]. Subsequent ANOVA and Tukey's b post hoc analyses demonstrated that there were significant differences between the three subgroups on all the MMPI-2 variables. Table 15 presents scale means and standard deviations for each group. Figure 8 illustrates the subgroup profiles.

As can be seen in Table 15 and Figure 8, the first subgroup (called above *Method 2-Solution 3-A*) had no elevated validity scales, two scales (scales 2 and 3) with high mean scores and one scale (scale 1) with a very high mean score; thus this group was referred *Method 2-Triad*. The second subgroup (called above *Method 2-Solution 3-B*) had one mean score (FBS) in the may be exaggerated range, one scale (scale 6) with a high mean score, and five scales (scales 1, 2, 3, 7 and 8) with high mean scores; this group was referred as *Method 2-Moderate*. Finally, the last subgroup (called above *Method 2-Solution 3-C*) had three scores (scale F, Fb and FBS) in the may be invalid range, two high mean scores (scales 4 and 0), and six scales (scales 1, 2, 3, 6, 7 and 8) with high mean scores; this group was referred as *Method 2-Pathological*).

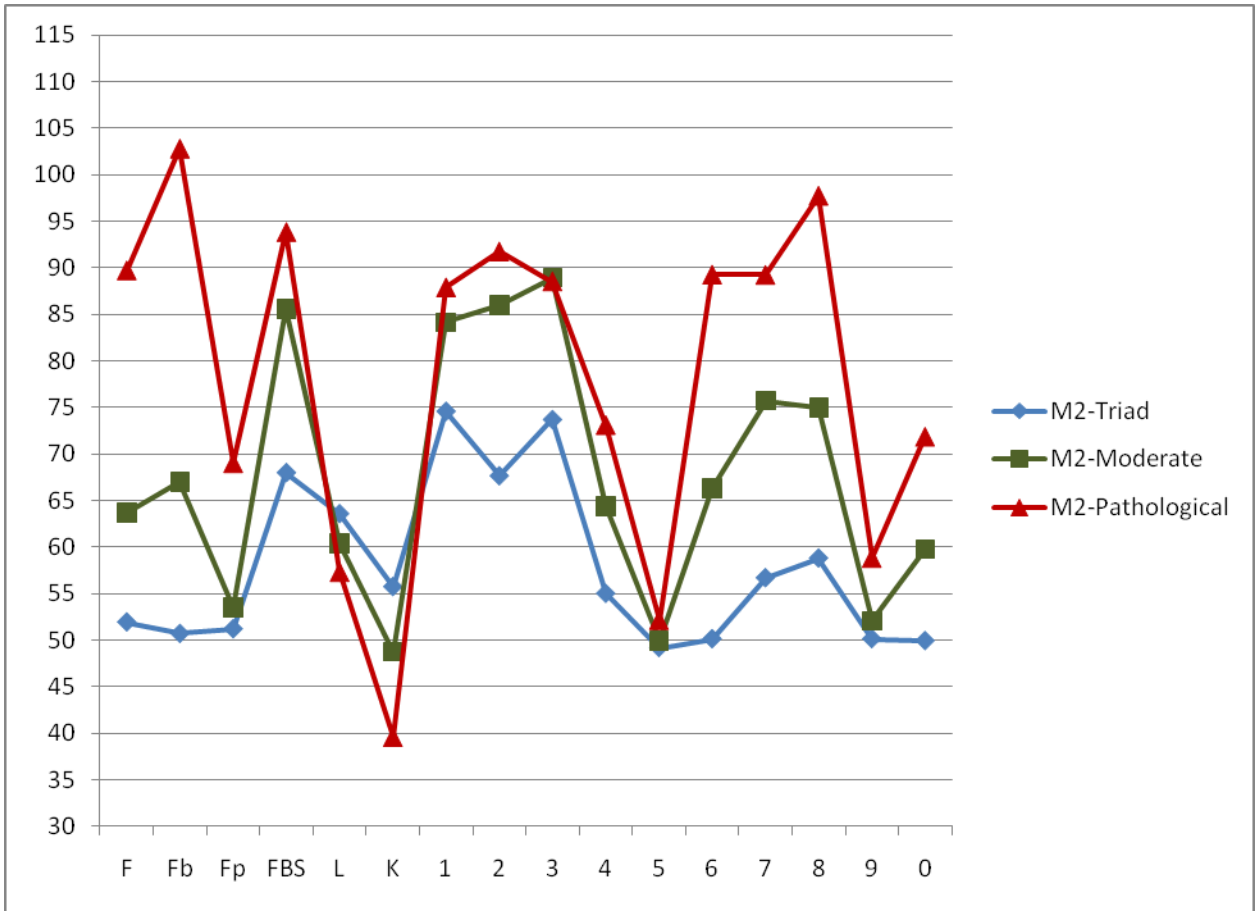
Table 15

Method 2 MMPI-2 scales means and standard deviations by group

	M2-Triad M(sd)	*M2-Moderate M(sd)*	*M2-Pathological M(sd)*	*F*	*p≤*	*Eta2*
L	63.6(12.4)[a]	60.4(10.7)[b]	57.3 (10.5)[c]	12.8	.001	0.04
F	51.9(8.0)[a]	63.7(10.8)[b]	89.7(15.9)[c]	445.8	.001	0.61
Fb	50.7(8.0)[a]	63.7(10.8)[b]	89.7(15.9)[c]	632.8	.001	0.69
Fp	51.2(10.8)[a]	53.5(9.4)[a]	69.0(17.0)[b]	103.5	.001	0.26
FBS	68.0(9.7)[a]	85.5(11.5)[b]	93.8(11.4)[c]	247.2	.001	0.46
K	55.7(10.6)[a]	48.7(10.3)[b]	39.6(6.9)[c]	114.7	.001	0.28
1	74.6(8.3)[a]	84.1(9.4)[b]	87.9(8.2)[c]	105.5	.001	0.27
2	67.6(9.2)[a]	86.0(8.8)[b]	91.7(9.2)[c]	339.9	.001	0.54
3	73.7(11.4)[a]	88.9(14.5)[b]	88.5(11.6)[b]	85.6	.001	0.23
4	55.0(8.7)[a]	64.4(11.0)[b]	73.1(11.0)[c]	126.2	.001	0.30
5	49.2(11.0)[a]	50.0(8.7)[a]	52.2(7.9)[b]	4.6	.011	0.02
6	50.1(9.5)[a]	66.3(11.4)[b]	89.3(13.7)[c]	475.3	.001	0.63
7	56.7(8.5)[a]	75.7(8.6)[b]	89.2(9.9)[c]	557.7	.001	0.66
8	58.8(8.3)[a]	75.0(8.5)[b]	97.7(75.8)[c]	796.4	.001	0.73
9	50.1(9.2)[a]	52.0(10.5)[a]	58.8(11.2)[b]	32.0	.001	0.10
0	49.9(8.0)[a]	59.7(9.6)[b]	71.8(8.4)[c]	251.5	.001	0.47

Note. M2-Triad: Method 2 subgroup with a Triad profile;M2-Moderate: Method 2 subgroup with a Moderate profile; M2-Pathological : Method 2subgroup with a Pathological profile; F: Infrequency; Fb: Infrequency back; Fp: Infrequency psychopathology; FBS: Symptom Validity scale; L: Lie; K: Correction; scales 1-0: 1: Hypochondriasis; 2: Depression; 3: Hysteria; 4: Psychopathic Deviate; 5: Masculinity-Femininity; 6: Paranoia; 7 : Psychasthenia; 8: Schizophrenia; 9 : Hypomania; 0 : Social Introversion

Figure 8 illustrates the subgroup profiles for the Method 2 most comprehensive solution by MMPI-2 scales



Note. M2-Triad: Method 2 subgroup with a Triad profile;M2-Moderate: Method 2 subgroup with a Moderate profile; M2-Pathological : Method 2subgroup with a Pathological profile; F: Infrequency; Fb: Infrequency back; Fp: Infrequency psychopathology; FBS: Symptom Validity scale; L: Lie; K: Correction; scales 1-0: 1: Hypochondriasis; 2: Depression; 3: Hysteria; 4: Psychopathic Deviate; 5: Masculinity-Femininity; 6: Paranoia; 7 : Psychasthenia; 8: Schizophrenia; 9 : Hypomania; 0 : Social Introversion

The number of patients that scored at or above the interpretative cutoffs was also different between the three groups. As can be seen in Table 16, the *Method 2-Pathological* had considerably more patients scoring at the may be exaggerated and maybe invalid ranges than the

Method 2-Triad and the *Method 2-Moderate*. The *Method 2-Moderate* had consistently more patients with elevated scores than the *Method 2-Triad* in all over-reporting scales, especially on FBS. However, on scales L and K, the *Method 2-Triad* had more patients with elevated scores than the other subgroups. All subgroups had similar number of patients with high mean scores on scales 1, 2, and 3. However, the *Method 2-Moderate* and the *Method 2-Pathological* had more patients than the *Method 2-Triad* with very high mean scores on the same scales. The most noticeable differences in the clinical scales were in scales 6, 7 and 8 where the *Method 2-Triad* had less than 5%, the *Method 2-Moderate* had about 50%, and the *Method 2-Pathological* had more than 85% of patients with very high mean scores.

Table 16
Method 2 percentage of cases that fall above the selected cutoff per subgroup and MMPI-2 variable

	Maybe exaggerated			Maybe invalid		
	M2-Triad	*M2-Moderate*	*M2-Pathological*	*M2-Triad*	*M2-Moderate*	*M2-Pathological*
Scale						
F	3	28	92	0	2	43
Fb	1	17	91	0	8	81
Fp	7	8	47	0	0	5
FBS	13	73	93	0	13	33
L	48	38	29	10	4	3
K	-	-	-	18	7	0
	High Scores			Very High Scores		
	M2-Triad	*M2-Moderate*	*M2-Pathological*	*M2-Triad*	*M2-Moderate*	*M2-Pathological*
1	91	99	99	54	86	93
2	60	99	99	25	91	96
3	77	94	96	48	82	87
4	16	48	76	1	16	46
5	28	32	37	2	0	1
6	5	55	97	2	24	85
7	16	90	99	1	53	93
8	27	90	100	2	52	100
9	11	14	31	1	4	11
0	4	31	79	1	8	37

Note. M2-Triad: Method 2 subgroup with a Triad profile;M2-Moderate: Method 2 subgroup with a Moderate profile; M2-Pathological : Method 2subgroup with a Pathological profile; F: Infrequency; Fb: Infrequency back; Fp: Infrequency psychopathology; FBS: Symptom Validity scale; L: Lie; K: Correction; scales 1-0: 1: Hypochondriasis; 2: Depression; 3: Hysteria; 4: Psychopathic Deviate; 5: Masculinity-Femininity; 6: Paranoia; 7 : Psychasthenia; 8: Schizophrenia; 9 : Hypomania; 0 : Social Introversion

MMPI-2-RF Variables. The three groups were also characterized using all the MMPI-2-RF scales. Again, this was done to determine similarities and differences between the two MMPI versions assessing MMPI-2 based groups. MANOVA demonstrated overall differences in MMPI-2-RF mean scores between the three groups [Wilk's Lambda; $F(15, 431)=21374.5$, $p<.001$, $Eta2=1.00$]. Subsequent ANOVA and Tukey's b post hoc analyses demonstrated that there were significant differences between the groups on all the MMPI-2-RF variables. Table 17

presents scale means and standard deviations for each group. Figure 9 illustrates the profiles of the three subgroups based on all MMPI-2-RF variables.

Table 17 demonstrates that the *Method 2-Triad* had no elevated validity scales and only one scale with high mean scores (scale RC1). The *Method 2-Moderate*, had one mean score in the may be exaggerated range (FBS-r), two high mean scores (RCd and RC2), and one very high mean score (RC1). Finally, the *Method 2-Pathological* had one scale in the may be exaggerated range (Fs), two scores in the may be invalid range (F-r and FBS-r), four high mean scores (RCd, RC2, RC7 and RC8), and two scales with very high mean scores (RC1 and RC6).

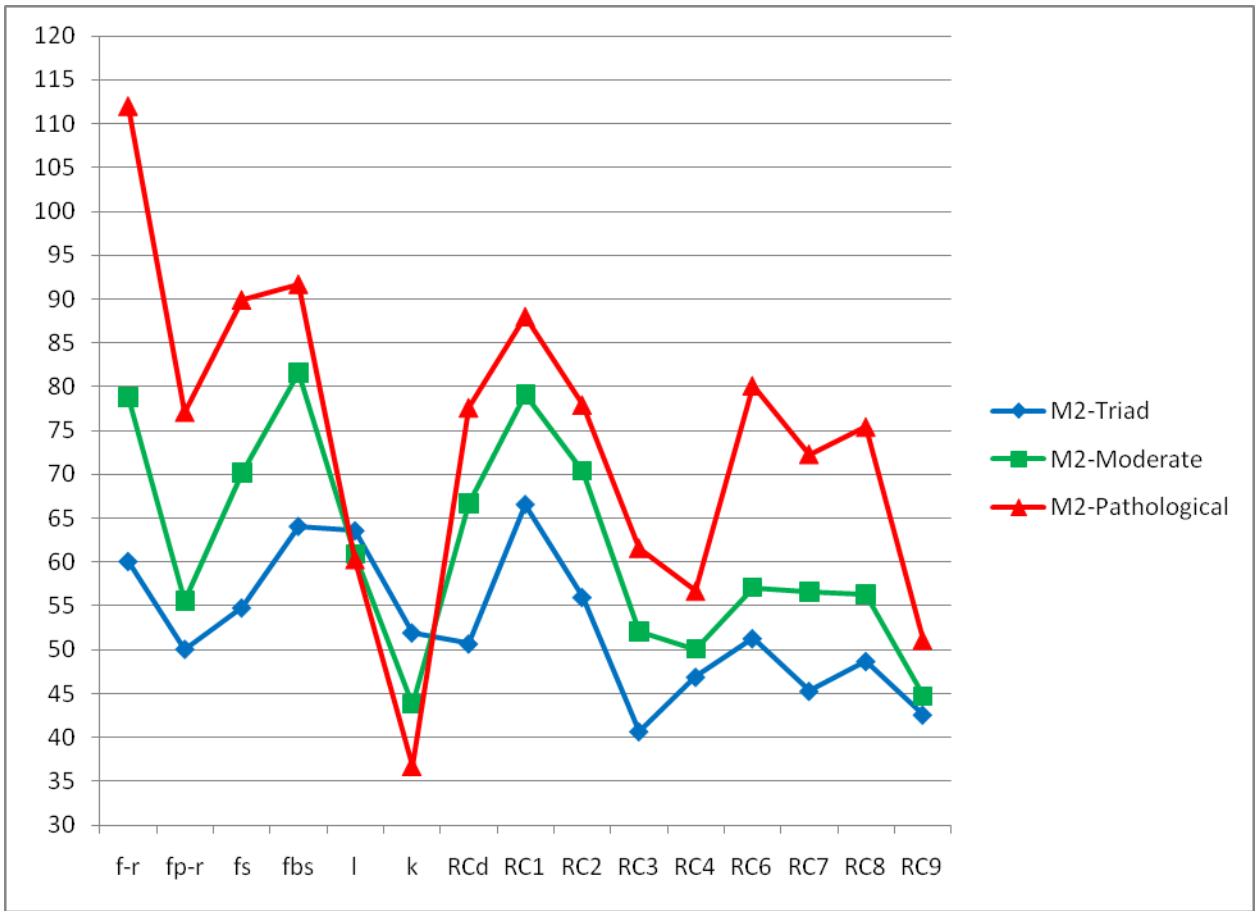
Table 17

Method 2 MMPI-2-RF mean, standard deviations, and statistical differences by pain group

	M2-Triad	*M2-Moderate*	*M2-Pathological*	*F*	*p≤*	*Eta2*
L-r	63.6 (12.9)[a]	60.9(13.0)[b]	60.3(11.7)[b]	3.0	.050	0.01
F-r	60.1(8.9)[a]	79.8(13.0)[b]	112.0(9.7)[c]	723.0	.001	0.77
Fp-r	50.1(9.1)[a]	55.6(10.7)[b]	77.1(17.7)[c]	165.5	.001	0.43
Fs	54.8(11.2)[a]	70.2(17.1)[b]	89.9(17.1)[c]	164.4	.001	0.43
FBS-r	64.1(9.6)[a]	81.6(11.3)[b]	91.7(11.4)[c]	217.7	.001	0.50
K-r	51.9(10.2)[a]	43.8(9.1)[b]	36.7(7.1)[c]	92.9	.001	0.30
RCd	50.7(7.8)[a]	66.7(7.5)[b]	77.6(5.8)[c]	459.3	.001	0.68
RC1	66.6(6.7)[a]	79.1(9.6)[b]	88.0(8.7)[c]	204.9	.001	0.48
RC2	56.0(8.8)[a]	70.4(10.4)[a]	77.9(11.9)[b]	149.9	.001	0.40
RC3	40.7(12.5)[a]	52.1(11.0)[b]	61.6(11.8)[c]	33.9	.001	0.13
RC4	46.9(10.0)[a]	50.1(10.4)[b]	56.7(12.1)[c]	27.5	.001	0.11
RC6	51.3(10.4)[a]	57.1(11.1)[b]	80.1(15.8)[c]	195.5	.001	0.47
RC7	45.3(8.7)[a]	56.6(10.3)[b]	72.3(10.1)[c]	245.9	.001	0.53
RC8	48.7(8.7)[a]	56.3(10.9)[b]	75.4(12.0)[c]	217.2	.001	0.50
RC9	42.6(9.6)[a]	44.7(9.6)[a]	51.1(9.8)[b]	27.2	.001	0.11

Note. M2-Triad: Method 2 subgroup with a Triad profile;M2-Moderate: Method 2 subgroup with a Moderate profile; M2-Pathological : Method 2subgroup with a Pathological profile . F-r: Infrequency restructured; Fp-r: Infrequency psychopathology restructured; Fs: Infrequency somatic symptoms; FBS-r: Symptom Validity scale restructured; L: Lie restructured; K: Correction restructured; scales RCd-RC9: RCd: Demoralization; RC1: Somatic Complains; RC2: Low Positive Emtions; RC3: Cynism; RC4: Antisocial Behavior; RC6: Ideas of Persecution;RC7: Dysfunctional Negative Emotions; RC8: Aberrant Experiences; RC9: Hypomanic Activation.

Figure 9. Method 2 illustration of the profiles of the three-cluster solution described by theMMPI-2-RF scales



Note. M2-Triad: Method 2 subgroup with a Triad profile;M2-Moderate: Method 2 subgroup with a Moderate profile; M2-Pathological : Method 2subgroup with a Pathological profile; . F-r: Infrequency restructured; Fp-r: Infrequency psychopathology restructured; Fs: Infrequency somatic symptoms; FBS-r: Symptom Validity scale restructured; L: Lie restructured; K: Correction restructured; scales RCd-RC9: RCd: Demoralization; RC1: Somatic Complains; RC2: Low Positive Emtions; RC3: Cynism; RC4: Antisocial Behavior; RC6: Ideas of Persecution;RC7: Dysfunctional Negative Emotions; RC8: Aberrant Experiences; RC9: Hypomanic Activation.

As can be seen in Table 18, the *Method 2-Pathological* had significantly more patients scoring at the may be exaggerated and maybe invalid ranges than the *Method 2-Moderate*; and, in turn, the *Method 2-Moderate* had more patients in the same ranges than the *Method 2-Triad*. Exceptions were scales L-r, K-r where all groups had similar number of subjects with elevations. Similarly, all groups differed in the RC scales. While 66% of patients in the *Method 2-Triad*

scored high on RC1, the *Method 2-Moderate* and the *Method 2-Pathological* had more than 95% of patients with high mean scores on the same scale. The *Method 2-Moderate* and the *Method 2-Pathological* differences can be seen at higher RC1scores. The *Method 2-Pathological* had 85% patients with very high mean scores while *Method 2-Moderate* had 46%. The most noticeable differences between the groups in the RC scales were in RC7 and RC8, where the *Method 2-Triad* had less than 5%, the *Method 2-Moderate* has about 20% and the *Method 2-Pathological* has more than 75% of patients with high mean scores

Table 18

Method 2 percentage of cases that fall above the selected cutoff per group by MMPI-2-RF variable

	May be exaggerated			May be invalid		
Scale	*M2-Triad*	*M2-Moderate*	*M2-Pathological*	*M2-Triad*	*M2-Moderate*	*M2-Pathological*
F-r	1	16	95	0	7	90
Fp-r	4	8	37	1	4	37
Fs	4	31	69	2	16	57
FBS-r	8	64	88	0	21	54
L-r	31	25	24	16	7	6
K-r	11	1	0	0	0	0
	High scores			Very high scores		
	M2-Triad	*M2-Moderate*	*M2-Pathological*	*M2-Triad*	*M2-Moderate*	*M2-Pathological*
RCd	3	63	96	0	4	47
RC1	66	96	99	4	46	85
RC2	22	75	85	1	22	53
RC3	20	20	51	0	1	3
RC4	7	11	30	0	1	2
RC6	16	27	85	2	3	51
RC7	4	23	77	0	2	30
RC8	2	22	80	0	3	33
RC9	3	4	8	1	0	2

Note. M2-Triad: Method 2 subgroup with a Triad profile;M2-Moderate: Method 2 subgroup with a Moderate profile; M2-Pathological : Method 2subgroup with a Pathological profile; . F-r: Infrequency restructured; Fp-r: Infrequency psychopathology restructured; Fs: Infrequency somatic symptoms; FBS-r: Symptom Validity scale restructured; L: Lie restructured; K: Correction restructured; scales RCd-RC9: RCd: Demoralization; RC1: Somatic Complains; RC2: Low Positive Emtions; RC3: Cynism; RC4: Antisocial Behavior; RC6: Ideas of Persecution;RC7: Dysfunctional Negative Emotions; RC8: Aberrant Experiences; RC9: Hypomanic Activation.

Non-MMPI Characteristics of Pain Clusters

Demographics. Differences between the three subgroups in demographics were tested using ANOVA or Chi squared analysis where appropriate and Tukey's post hoc analysis was conducted when necessary. Table 19 presents demographic data by subgroup. The *Method 2-Triad* patients were significantly more educated than the *Method 2-Moderate* and *Method 2-Pathological* patients. The *Method 2-Triad* and *Method 2-Moderate* had more Caucasians than the *Method 2-Pathological*. Subgroups did not differ in any other demographic variables. Odd ratios analysis indicated that the *Method 2-Pathological* subgroup was 2.3 (95% C.I. = 2.4-2.3) less likely to be Caucasian than the other subgroups.

Table 19
Method 2 demographic characteristics by pain group

	M2-Triad *M*(*sd*)	*M2-Moderate* *M*(*sd*)	*M2-Pathological* *M*(*sd*)	*F*	*p*≤	*Eta2*
Age	42.5 (9.0)	42.5 (8.8)	42.4(8.2)	0.1	NS	0.00
Education	12.3 (2.5)[a]	11.6 (2.4)[b]	11.4 (2.5)[b]	6.4	.002	0.02
Time since Injury	34.0 (27.9)	40.7 (30.9)	39.5 (27.7)	2.9	.055	0.01
	(%)	(%)	(%)	X^2	*p*≤	
Gender (male)	58.3	65.3	68.7	4.1	NS	
Race (white)	71.1[a]	70.9[a]	51.3[b]	28.9	.001	

Note. M2-Triad: Method 2 subgroup with a Triad profile;M2-Moderate: Method 2 subgroup with a Moderate profile; M2-Pathological : Method 2subgroup with a Pathological profile.
[abc] row means with the same letter are not significant at alpha < .05 using Tukey's b post-hoc test.

Injury Severity. ANOVA demonstrated that there were no differences in *Injury Severity* mean scores between the *Method 2-Triad* (*M* = .82; *sd* = 1.1), *M2-Moderate* (*M* = .85; *sd* = 1.2), and *Method 2-Pathological* (*M* = .72; *sd* = 1.1)[*F* (1, 583) = 0.06, *p* > .05, *Eta2*=0.01]. Table 20 presents the injury and symptom characteristics of the sample as a function of group

membership. Differences between the three subgroups in injury/symptom characteristics were tested using Chi squared analysis. As can be seen, subgroups differed in the number of head pain complaints. *Method 2-Moderate* had significantly more participants than *Method 2-Triad* and *Method 2-Pathological* with head pain complains. Subgroups did not differ in other injury type, location, or etiology variable.

Table 20
Method 2 percentage of patients with specific Injury/Symptom characteristics by pain group

	M2-Triad	*M2-Moderate*	*M2-Pathological*	X^2	*p<*
Primary back/spine injury	91.6	88.4	87.3	1.8	NS
Head injury in accident	9.4	10.8	10.7	0.2	NS
Other Pain symptoms / area of body					
Head	23.3[b]	35.1[a]	27.3[b]	7.4	.025
Chest / abdomen	5.0	6.4	7.3	0.8	NS
Upper extremity	41.7	39.8	38.7	0.4	NS
Lower extremity	68.3	70.5	63.3	2.2	NS
Spine Findings					
any spine findings	40.0	40.2	34.7	1.4	NS
degenerative disc/spine	20.0	20.7	19.3	0.1	NS
herniated nucleus pulposus	5.6	5.2	4.0	0.5	NS
disc bulge/protrusion	26.1	26.3	22.7	0.7	NS
neural impingement	2.8	4.8	3.3	1.3	NS
Spinal Surgery					
discectomy / fusion	26.1	35.5	30.7	4.2	NS
decompression/laminectomy	11.7	15.1	20.0	4.4	NS
Other pain diagnoses					
Complex regional pain syndrome	2.2	2.4	4.0	1.2	NS
Fibromyalgia	2.8	2.0	2.7	0.3	NS
Myofascial pain syndrome	1.7	3.6	6.7	5.7	NS

Note. M2-Triad: Method 2 subgroup with a Triad profile;M2-Moderate: Method 2 subgroup with a Moderate profile; M2-Pathological : Method 2subgroup with a Pathological profile.
[abc] row means with the same letter are not significant at alpha < .05 using Tukey's b post-hoc test.

Legal Status. Table 21 presents the legal status of the sample as a function of group membership. Differences between the three subgroups in legal characteristics were tested using

Chi squared analysis. Groups differed only in the type of legal claim. *Method 2-Moderate* had less patients claiming workers compensation than the *Method 2-Triad* and *Method 2-Pathological*. The *Method 2-Triad* and *Method 2-Pathological* did not differ on this variable. Odds ratio analysis indicated that the *Method 2-Moderate* was 1.4 (95% CI = 1.4-1.3) and 3.3 (95% CI = 3.4-3.2) less likely to be involved in Workers Compensation than the *Method 2-Triad* and *Method 2-Pathological*, respectively.

Table 21
Method 2 percentage of patients per group by legal status.

	M2-Triad %	*M2-Moderate* %	*M2-Pathological* %	X^2	*p*=
Status of legal representation					
No Attorney	34.4	22.7	31.3		
Represented by attorney	50.6	62.5	53.3	8.6	NS
Attorney status unknown	15.0	14.7	15.3		
Referral source					
doctor	30.6	25.5	27.3		
case manager / adjuster	48.9	45.4	54.0	14.4	NS
attorney	3.9	3.6	4.7		
district attorney	15.6	25.5	13.3		
Claim type					
workers compensation	83.9 [ab]	79.3 [b]	92.7 [a]	16.3	.012
personal injury	14.4	19.9	6.7		
disability	0.6	0.0	0.7		

Note. M2-Triad: Method 2 subgroup with a Triad profile;M2-Moderate: Method 2 subgroup with a Moderate profile; M2-Pathological : Method 2subgroup with a Pathological profile.
[abc] row means with the same letter are not significant at alpha < .05 using Tukey's b post-hoc test.

Malingering Diagnosis. Table 22 presents the malingering diagnosis of the sample as a function of group membership. Differences between the three subgroups in malingering diagnosis were tested using Chi squared analysis. The three subgroups differed significantly in the status of the malingering diagnosis in MPRD[a] [$X^2(4,583) = 104.5$, $p < .001$].More than half (56-71%) of patients in the *Method 2-Pathological* were formally diagnosed as malingering compared to 31-42 % patients in the *Method 2-Moderate* and 18% of *Method 2-Triad* patients.

Odd ratios analysis indicated that the *Method 2-Pathological* was 25.1 times (95% C.I. = 25.3-25.0) more likely to be MPRD than *Method 2-Triad* subgroup when not using the MMPI variables as malingering indicators. Similarly, *Method 2-Pathological* was 8.1 times (95% C.I. = 8.2-7.9) more likely to be MPRD than *Method 2-Moderate* subgroup when not using the MMPI variables as malingering indicators. The *Method 2-Moderate* was 3.1 times (95% C.I. = 8.2-7.9) more likely to be MPRD than *Method 2-Triad* subgroup when not using the MMPI variables as malingering indicators. When the MMPI variables were used as indicators the odd ratio to be MPRD increased to 218.4 (95% C.I. = 219.5-217.4) for the *Method 2-Pathological* to the *Method 2-Triad*, to 34.7 (95% C.I. = 35.7-33.6) for *Method 2-Pathological* to *Method 2-Moderate.* The likelihood to be MPRD for the *Method 2-Moderate* increased to 6.3 (95% C.I. = 6.4-6.2) when compared to the *Method 2-Triad*.

Table 22
Method 2 malingering status by pain group

Method 2 MPRD[a] status by subgroup

	M2-Triad %	*M2-Moderate* %	*M2-Pathological* %	X^2	*p*<
Not MPRD	58.9[a]	35.5[b]	11.3[c]		
Possible MPRD	23.3	32.7	32.7	92.4	.001
Probable MPRD	13.3	25.9	41.3		
Definite MPRD	4.4	6.0	14.7		
All MPRD	*17.7*	*31.9*	*56.0*		

Method 2 MPRD[b] status by subgroup

	M2-Triad %	*M2-Moderate* %	*M2-Pathological* %	X^2	*p*<
Not MPRD	54.0[a]	19.2[b]	1.0[c]		
Possible MPRD	26.7	38.2	28.7	163.7	.001
Probable MPRD	13.9	36.7	56.0		
Definite MPRD	4.4	6.0	14.7		
All MPRD	*18.3*	*42.7*	*70.7*		

Note. M2-Triad: Method 2 subgroup with a Triad profile;M2-Moderate: Method 2 subgroup with a Moderate profile; M2-Pathological : Method 2subgroup with a Pathological profile.
MPRD[a]: Malingered Pain Related Disability not including the MMPI-2 variables
MMPI[b]: Malingered Pain Related Disability including the MMPI-2 variables

Pain Report and Outcome. Differences in pain report and predictors of outcome were determined by comparing current, best, and worst pain as well as catastrophization and functional disability among the three subgroups. Differences between the three groups in pain perception, PCS and PDI scores were tested using ANOVA. Pain perception data was available for all patients. PCS scores were available for 38 participants from the *Method 2-Triad* subgroup, 59 participants from the *Method 2-Moderate* subgroup and for 41 participants from the *Method 2-Pathological* subgroup. PDI data was available for 61 participants from the *Method 2-Triad* subgroup, 94 participants from the *Method 2-Moderate* subgroup and for 56 participants from the *Method 2-Pathological* subgroup.

Table 23 presents data for these variables by group. There was a significant group effect for "current" pain rating with *Method 2-Triad* reporting less subjective least amount of pain than the *Method 2-Pathological*. The *Method 2-Moderate* did not differ from the *Method 2-Triad* or the *Method 2-Pathological* in current pain ratings. Moreover, results showed that those in *Method 2-Pathological* had significantly higher mean scores than *Method 2-Moderate*, and *Method 2-Moderate* had significantly higher mean scores than *Method 2-Triad* on the PC and PDI scales.

Table 23
Method 2 current, best and worst pain, PCS and PDI scores as a function of pain group

	M2-Triad M(sd)	*M2-Moderate M(sd)*	*M2-Pathological M(sd)*	*F*	*P<*	*Eta2*
Current Pain	6.2 (1.9)[a]	6.3 (1.9)[ab]	6.9 (2.0)[b]	3.5	.032	0.03
Best Pain	4.6 (2.0)	5.1 (2.2)	5.4 (2.3)	2.9	NS	0.02
Worst Pain	9.3 (1.1)	9.3 (1.3)	9.1 (1.6)	0.2	NS	0.01
PCS	64.2(16.0)[a]	74.8(12.7)[b]	84.6(10.2)[c]	24.2	.001	0.26
PDI	46.0(15.4)[a]	52.1(9.9)[b]	61.6(8.9)[c]	13.5	.001	0.12

Note. M2-Triad: Method 2 subgroup with a Triad profile;M2-Moderate: Method 2 subgroup with a Moderate profile; M2-Pathological : Method 2subgroup with a Pathological profile.PCS = Pain Catastrophizing Scale; PDI = Pain Disability Index
[abc] row means with the same letter are not significant at alpha < .05 using Tukey's b post-hoc test.

Method 2 Summary and Conclusions

After running several exploratory two-steps cluster analyses using the MMPI-2 scales F, Fb, Fp, FBS, L and K and the ten clinical scales, two and three-cluster solutions were determined to be appropriate solutions when using Method 2. Nevertheless, the three-cluster solution was selected to be the "best" solution because it provided information over the two-cluster solution and thus, it was further characterized.

The three-cluster solution was distinguished by three homogeneous subgroups that differed considerably in the number and type of MMPI-2 scales elevated as well as the number of patients

with scale elevations. *Method 2-Triad* elevated on scales 1, 2 and 3 and did not show over-reporting of symptoms. *Method 2-Moderate* elevated on one validity scale (FBS) and six clinical (scales 1, 2,3,6,7, and 8). Finally, *Method 2-Pathological* was characterized by mean elevations on all over-reporting validity scales (i.e. F, Fp, Fb and FBS) and on eight out of the ten clinical scales (i.e.1,2,3,4,6,7,8 and 0). Thus, when compared to Method 1, *Method 2-Triad* demonstrated a lower profile (lower scores on the same elevated scales) than the *Method 1-Triad*; *Method 2-Pathological* showed a higher profile (higher scores on the same elevated scales) than the *Method 1-Pathological*; and there was the existence of a *Method 2-Moderate* subgroup that likely comprise those patients that scored in the upper end of the two-cluster *Method 1-Triad* profile and those that scored in the lower end of the two-cluster *Method 1-Pathological* profile. Thus, in addition to the two profiles found with Method 1, using all MMPI-2 variables, as used in Method 2, was able to consistently identify a new group (*Method 2-Moderate*) of patients that reported moderate psychological difficulties.

When the three subgroups were compared on the MMPI-2-RF scales, these had similar characteristics as the MMPI-2; that is, they differ in mean score and proportion of subjects with elevated scales. However, MMPI-2-RF scales (RC3 and RC4) were less likely to be elevated by the *Method 2-Moderate* and *Method 2-Pathological* even when they were elevated in the MMPI-2. In fact, these were shown insensitive to "Moderate" profiles.

As Method 1, the three subgroups were also compared in demographic, pain report, injury/symptom characteristics, legal status and malingering diagnosis. Differences were found in education, current pain report, head complains, claim type and malingering diagnosis. Thus, again, subgroup membership was not conditioned to the type/severity of the injury. *Method 2-Triad* was described as a highly educated group, which reported low current pain. *Method 2-*

Triad also had the lowest number of patients diagnosed as malingerers. *Method 2-Moderate* was described as a low educated group, with the highest proportion of patients with head complains. *Method 2-Moderate* had the higher number of patients with personal injury claims and these patients were 3 times more likely to be diagnosed as malingerers than those in the *Method 2-Triad*. Finally, *Method 2-Pathological* was described as low educated and diverse than the other subgroups as it had the lowest grade completed and proportion of Caucasians. Finally, the *Method 2-Pathological* was 25 and 8 times more likely to be diagnosed as malingering than the *Method 2-Triad* and *Method 2-Moderate* respectively, when the MMPI variables were not used as malingering indicators. The likelihood increased significantly when the MMPI variables were used as indicators.

In terms of predictors of outcome, *Method 2-Triad* reported the lowest level of current pain, catastrophization and perceived disability followed *by Method 2-Moderate* and then the *Method 2-Pathological.* Thus, the results again supported the idea that MMPI-2 Triad profiles tend to report better outcome than MMPI-2 Pathological profiles (as found in Part 1). Moreover, it can be concluded that the new Moderate profile reports poor outcome levels but these levels are lower than the Pathological profile.

Method 3: MMPI-2-RF Clustering Method

Defining the Number of Clusters

Method 3 applied an exploratory two steps cluster analysis using the MMPI-2-RF validity scales F-r, Fp-r, Fs, FBS-r, L-r and K-r and the nine RC scales. Again, SPSS autoclustering was used to determine the best solution. Like the previous two methods the data was first ordered ascendingly by patient's ID number before running the autoclustering analysis. When the data was ordered this way it was determined the optimal number of clusters was the two-cluster solution. In support of the two-cluster solution, there was a dramatic jump in variance explained from one (*BIC* = 4865.0) to two (*BIC* = 3901.6; *RDM* = 2.7) cluster solutions with only modest increases when three (*BIC* = 3665.6; *RDM* = 1.6) and four-clusters (*BIC* =3578.8; *RDM* = 1.7) solutions were isolated.

When sorting the full data set descendingly by patient's ID number, it was determined that the optimal number of clusters was the three-cluster solution. In support of the three cluster solution, the *BIC* showed a dramatic jump in variance explained from one (*BIC* = 4865.0) to two (*BIC* = 3846.9; *RDM* = 2.8) and a similar dramatic jump from two to three (*BIC* = 3594.0; *RDM* = 2.4) cluster solution with only modest increases when four (*BIC* = 3595.6; *RDM* = 1.2) and five clusters (*BIC* =3622.9; *RDM* = 1.0) solutions were isolated.

Selection of Best Cluster Solution. To select the "best" cluster solution, 50 cluster analyses were all run after randomly resorting the data set using 70% of the total sample. Out of the 50 runs, *BIC* determined that the two cluster solution was the most adequate 25 times (50 %), the three-cluster solution was the most adequate 23 times (46 %) and a four-cluster solution was most adequate only 2 times (4 %). Results using Binomial Tests showed no significant

differences between observed proportion and the expected proportion between the appearance of the two and three solutions ($p > .05$). The two-cluster and the three-cluster solutions appeared significantly more times than the four-cluster solution ($p < .001$). This suggests that the two-cluster solution and the three-cluster solution are equally adequate for the current sample using Method 3. As with Method 2, since the two and a the three-cluster solutions seemed to be adequate, the three-cluster solution was selected as the "best fit" because it provides more theoretical information over the two cluster-solution.

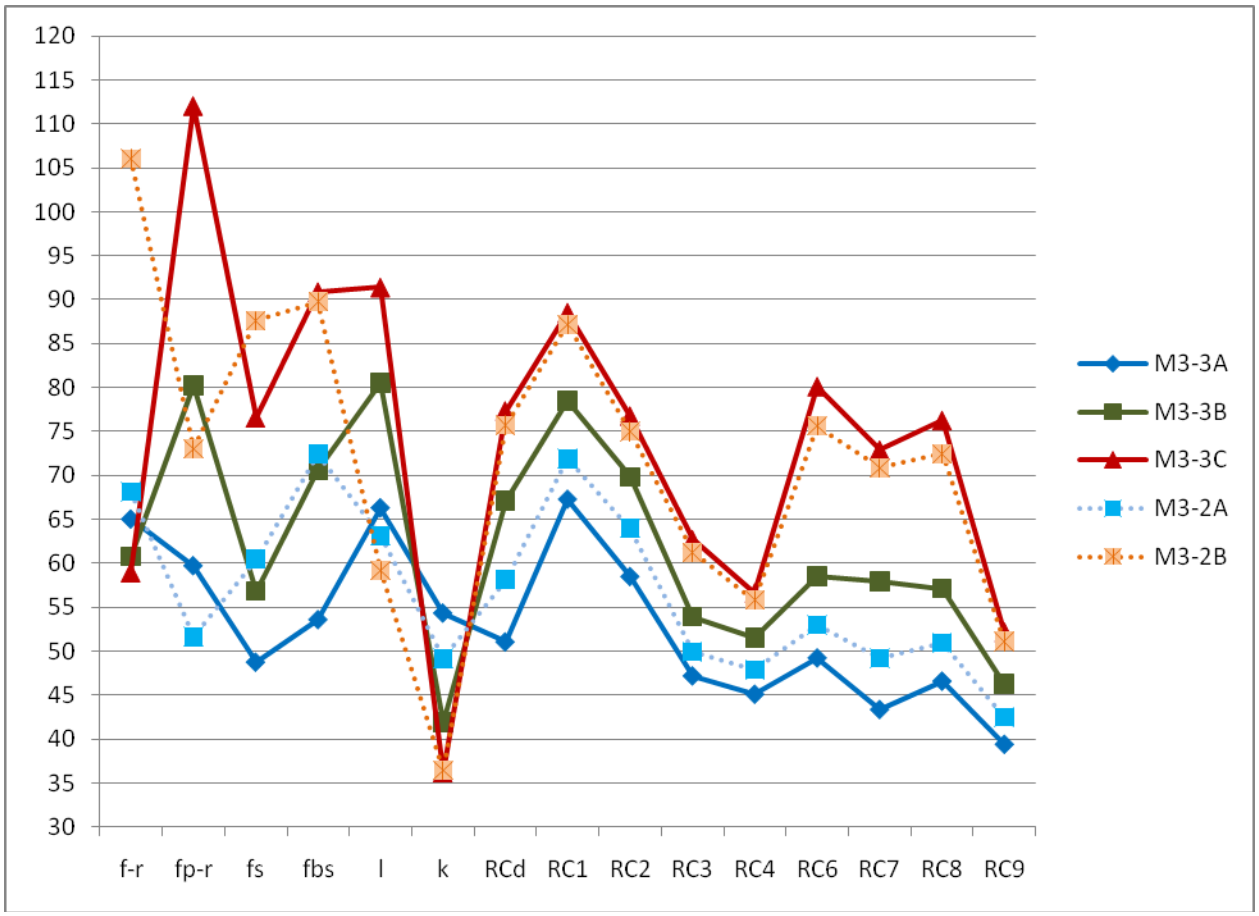
The two subgroups found in the two-cluster solution were: a group *(Method 3-Solution 2-A*) with 277 participants and a group *(Method 3- Solution 2-B)* with 174 participants. The three subgroups identified in the three-cluster solution were: a group *(Method 3-Solution 3-A)* with 143 participants, a group *(Method 3-Solution 3-B)* with 180 participants and a group (*Method 3-Solution 3-C*) with 128 participants. Using crosstab analysis it was determined that all subjects classified as in subgroups *Method 3-Solution 3-A* were originally in subgroup *Method 3-Solution 2-A*. Similarly, all subjects classified as *Method 3-Solution 3-C* were originally in subgroup *Method 3-Solution 2-B*. Subgroup *Method 3-Solution 3-B* was composed by 74.4% of subjects that were in subgroup *Method 3-Solution 2-A* and 25.6% of subjects that were in *Method 3-Solution 2-B*.

Figure 10 presents the MMPI-2 profiles for the subgroups that resulted from the two-cluster and the three-cluster solutions. As can be seen, when compared to the two-cluster solution, the three-cluster solution presents S*omatic* and *Pathological* profiles that differ substantially in the elevation of scores. Moreover, the three-cluster profile demonstrated the existence of a *Depressed* subgroup due to its elevations on the demoralization, somatic and depressed scales in

addition to FBS profile that is comprised of those patients that scored in the upper end of the two-cluster Somatic.

Therefore, since the three-cluster solution provides 1) the most number of groups, 2) information about a "Depressed" subgroup, and 3) creates larger separation between the Somatic and Pathological profiles, it was determined the three-cluster solution was the most comprehensive fit for Method 3. As a result, the three subgroups that resulted from this solution were further described on a number of MMPI, non-MMPI, pain perception and predictor of outcome variables.

Figure10 presents the MMPI-2 profiles for the subgroups that resulted from the two-cluster and the three-cluster solutions.



Note. F-r: Infrequency restructured; Fp-r: Infrequency psychopathology restructured; Fs: Infrequency somatic symptoms; FBS-r: Symptom Validity scale restructured; L: Lie restructured; K: Correction restructured; scales RCd-RC9: RCd: Demoralization; RC1: Somatic Complains; RC2: Low Positive Emtions; RC3: Cynism; RC4: Antisocial Behavior; RC6: Ideas of Persecution;RC7: Dysfunctional Negative Emotions; RC8: Aberrant Experiences; RC9: Hypomanic Activation.

Comparison of MMPI-2 and MMPI-2-RF Clustering Methods. Before, describing the Method 3 subgroups, a crosstab comparison was performed between the MMPI-2 versus the MMPI-2-RF methods used the in classification of pain patients into the subgroups. This was done to understand the differences between the tests versions since it was determined that the three-cluster solution was the most comprehensive fit for both methods. As can be seen in Table 24, 85% of the subjects who were classified as *Method 3-Somatic* were also classified as *Method 2-Triad*. *Method 3-Depressed* was composed of 77% of the subjects classified as *Method 2-*

Moderate. Finally, *Method 3-Pathological* was composed of 88% of subjects that were classified as *Method 2-Pathological.* This demonstrates that although there is an important overlap among the classification methods, the methods did not agree for a range of 12-25% of the cases depending on the subgroup profile.

Table 24
Crosstab on the percentage of cases that overlap between the clustering methods

		Method 2		
		M2-Triad %	*M2-Moderate* %	*M2-Pathological* %
Method 3	*M3-Somatic*	85.2	14.8	0.0
	M3-Depressed	14.7	77.4	7.9
	M3-Pathological	0.0	8.9	88.2

Note. M2-Triad: Method 2 subgroup with a Triad profile;M2-Moderate: Method 2 subgroup with a Moderate profile; M2-Pathological : Method 2 subgroup with a Pathological profile; M2-Somatic: Method 2 subgroup with a Somatic profile;M3-Depressed: Method 3 subgroup with a Depressed profile; M3-Pathological : Method 3 subgroup with a Pathological profile.

Characterization of Pain Clusters based on all MMPI Variables

MMPI-2-RF Variables. MANOVA demonstrated overall group differences in the MMPI-2-RF [Wilk's Lambda; $F(15, 434)=22230.3$, $p<.001$, $Eta2=1.00$]. Subsequent ANOVA and Tukey's b post hoc analyses demonstrated significant differences between the groups in all the MMPI-2-RF variables. Table 25 presents scale means and standard deviations for each group. Figure 11 illustrates the subgroup mean profiles.

Table 25 and Figure 11 show that *Method 3-3A* subgroup only had high mean scores on RC1 (this group will be referred *Method 3-Somatic*). The *Method 3-3B* subgroup had one mean scores in the may be exaggerated range on FBS-r, and three high mean scores on RCd, RC1 and RC2 (this subgroup will be referred as *Method 3- Depressed*). Finally, *Method 3--3B* subgroup had one scale in the may be exaggerated range on Fp-r, three scores in the may be invalid range

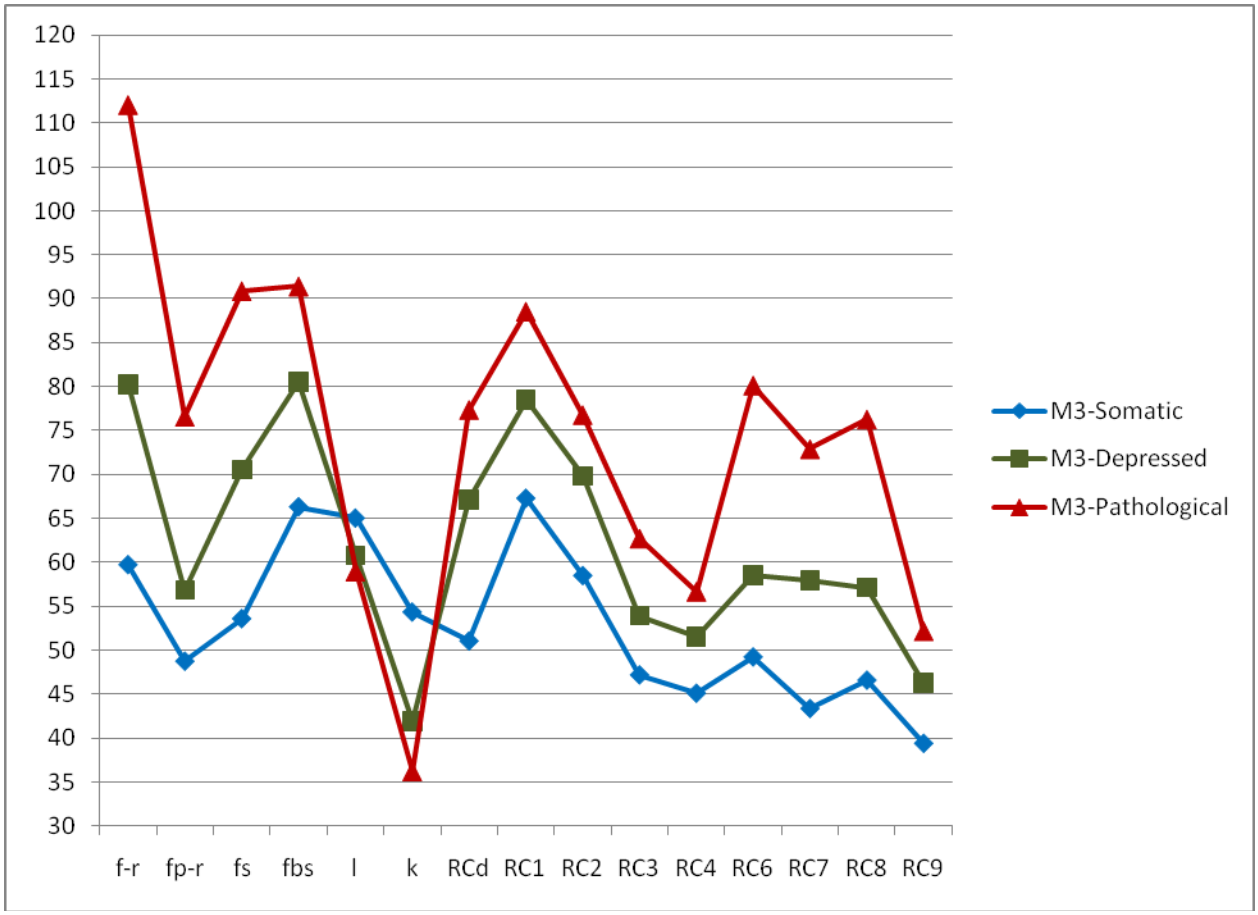
on F-r, Fs and FBS-r, four high mean scores on RCd, RC2, RC7 and RC8, and two scales with very high mean scores on RC1 and RC6 (this group will be referred as *M3-Pathological*).

Table 25
Method 3 MMPI-2-RF mean, standard deviations, and statistical differences by pain subgroup

	M3-Somatic	*M3-Depressed*	*M3-Pathological*	*F*	*p<*	*Eta2*
L-r	65.0 (12.9)[a]	60.8(11.0)[b]	59.0 (11.4)[b]	9.6	.001	0.04
F-r	59.7(8.5)[a]	80.2(11.3)[b]	112.1(9.6)[c]	935.1	.001	0.81
Fp-r	48.8(7.8)[a]	56.8(11.0)[b]	76.6(17.7)[c]	176.3	.001	0.44
Fs	53.6(10.4)[a]	70.6(15.6)[b]	90.9(16.9)[c]	221.2	.001	0.50
FBS-r	66.3(10.4)[a]	80.6(12.7)[b]	91.4(11.3)[c]	160.5	.001	0.42
K-r	54.3(8.2)[a]	41.9(8.3)[b]	36.3(6.8)[c]	193.5	.001	0.46
RCd	51.1(7.8)[a]	67.0(7.3)[b]	77.4(6.0)[c]	475.4	.001	0.68
RC1	67.3(7.3)[a]	78.5(9.2)[b]	88.6(8.7)[c]	214.1	.001	0.49
RC2	58.5(9.8)[a]	69.8(11.8)[b]	76.8(12.6)[c]	89.4	.001	0.29
RC3	47.2(10.7)[a]	53.9(10.8)[b]	62.7(11.4)[c]	67.8	.001	0.23
RC4	45.1(8.8)[a]	51.5(10.6)[b]	56.7(11.8)[c]	41.7	.001	0.16
RC6	49.2(8.9)[a]	58.5(10.5)[b]	80.2(15.6)[c]	244.5	.001	0.52
RC7	43.4(6.7)[a]	57.9(8.9)[b]	72.9(9.4)[c]	415.7	.001	0.65
RC8	46.6(7.7)[a]	57.1(8.7)[b]	76.3(11.5)[c]	351.8	.001	0.61
RC9	39.4(6.9)[a]	46.3(9.9)[b]	52.2(9.5)[c]	69.9	.001	0.24

Note. M3-Somatic: Method 3 subgroup with a Somatic profile;M3-Depressed: Method 3 subgroup with a Depressed profile; M3-Pathological : Method 3 subgroup with a Pathological profile . F-r: Infrequency restructured; Fp-r: Infrequency psychopathology restructured; Fs: Infrequency somatic symptoms; FBS-r: Symptom Validity scale restructured; L: Lie restructured; K: Correction restructured; scales RCd-RC9: RCd: Demoralization; RC1: Somatic Complains; RC2: Low Positive Emotions; RC3: Cynism; RC4: Antisocial Behavior; RC6: Ideas of Persecution;RC7: Dysfunctional Negative Emotions; RC8: Aberrant Experiences; RC9: Hypomanic Activation.
[abc] row means with the same letter are not significant at alpha < .05 using Tukey's b post-hoc test.

Figure 11. Illustration of the profiles of the three subgroups described by the MMPI-2-RF scales.



Note. M3-Somatic: Method 3 subgroup with a Somatic profile; M3-Depressed: Method 3 subgroup with a Depressed profile; M3-Pathological : Method 3 subgroup with a Pathological profile . F-r: Infrequency restructured; Fp-r: Infrequency psychopathology restructured; Fs: Infrequency somatic symptoms; FBS-r: Symptom Validity scale restructured; L: Lie restructured; K: Correction restructured; scales RCd-RC9: RCd: Demoralization; RC1: Somatic Complains; RC2: Low Positive Emotions; RC3: Cynism; RC4: Antisocial Behavior; RC6: Ideas of Persecution;RC7: Dysfunctional Negative Emotions; RC8: Aberrant Experiences; RC9: Hypomanic Activation.

As can be seen in Table 26, the *Method 3-Pathological* also had significantly more patients scoring at the may be exaggerated and maybe invalid ranges than the *Method 3-Depressed*; and the *Method 3-Depressed* in turn had more patients in the same ranges than the *Method 3-Somatic*. Interestingly, *the Method 3-Pathological* had 91% of patients in the F-r may be invalid range, compared to 5% of *Method 3-Depressed* and 0% of *Method 3-Somatic*. In the

under-reporting scales L-r and K-r, *Method 3-Somatic* had slightly higher number of subjects with elevations than the other groups. Differences between the groups were identified in all RC scales at both elevation levels. While 66% of patients in *Method 3-Somatic* scored high on RC1, the *Method 3-Depressed* and *Method 3-Pathological* had more than 95% of patients with high mean scores on scales RC1. The *Method 3-Pathological* and the *Method 3-Depressed* differences can be seen at higher RC1scores where the *Method 3-Pathological* had 85% patients with very high mean scores while the *Method 3-Depressed* had 44%. The most noticeable differences between the groups in the RC scales were in RC6, RC7 and RC8, where the *Method 3-Somatic* had less than 8%, the *Method 3-Depressed* has about 25% and the *Method 3-Pathological* has more than 81% of patients with high mean scores.

Table 26
Method 3 percentage of Cases that fall above the selected cutoff per MMPI-RF variable

	May be exaggerated			May be invalid		
Scale	*M3-Somatic*	*M3-Depressed*	*M3-Pathological*	*M3-Somatic*	*M3-Depressed*	*M3-Pathological*
F-r	0	16	95	0	5	91
Fp-r	2	11	54	0	0	12
Fs	2	31	72	1	15	59
FBS-r	14	62	88	1	22	52
L-r	38	24	18	18	6	5
K-r	11	0	0	0	0	0
	High scores			Very high scores		
	M3-Somatic	*M3-Depressed*	*M3-Pathological*	*M3-Somatic*	*M3-Depressed*	*M3-Pathological*
RCd	4	64	97	0	3	47
RC1	69	95	99	6	44	85
RC2	32	72	83	2	24	49
RC3	11	23	56	0	0	4
RC4	4	14	29	0	1	2
RC6	8	32	86	1	3	52
RC7	0	24	81	0	2	30
RC8	1	19	84	0	1	34
RC9	0	6	9	0	1	2

Note. M3-Somatic: Method 3 subgroup with a Somatic profile;M3-Depressed: Method 3 subgroup with a Depressed profile; M3-Pathological : Method 3 subgroup with a Pathological profile . F-r: Infrequency restructured; Fp-r: Infrequency psychopathology restructured; Fs: Infrequency somatic symptoms; FBS-r: Symptom Validity scale restructured; L: Lie restructured; K: Correction restructured; scales RCd-RC9: RCd: Demoralization; RC1: Somatic Complains; RC2: Low Positive Emotions; RC3: Cynicism; RC4: Antisocial Behavior; RC6: Ideas of Persecution;RC7: Dysfunctional Negative Emotions; RC8: Aberrant Experiences; RC9: Hypomanic Activation.

MMPI-2 Variables. The three subgroups were also characterized using the all MMPI-2 scales. Once more, this was done to determine similarities and differences between the two MMPI versions, but this time assessing MMPI-2-RF method to determine the subgroups. MANOVA demonstrated overall differences in MMPI-2 mean scores between the three groups [Wilk's Lambda; $F(16, 430) = 8320.8$, $p<.001$, $Eta2=1.0$). Subsequent ANOVA and Tukey's b post hoc analyses demonstrated that there are significant differences between the three groups in

all the MMPI-2 variables. Table 27 presents scales mean and standard deviations for each group. Figure 11 illustrates the three subgroup mean profiles based on the MMPI-2 variables.

Table 27 and Figure 12 show that *Method 3-Somatic* had no elevated validity scales, one scale with high mean scores (scale 2) and two scales with a very high mean score (scales 1 and 3) demonstrating a Triad profile. *Method3-Depressed* had one mean scores in the may be exaggerated range (FBS), two high mean scores (scale 6 and 7), and four scales with very high mean scores (scales 1, 2, 3 and 8) demonstrating a Moderate profile. Finally, *Method 3-Pathological* had three scores in the may be invalid range (scale F, Fb and FBS), two high mean scores (scales 4 and 0), and six scales with very high mean scores (scales 1, 2, 3,6, 7 and 8) demonstrating a Pathological profile.

Table 27

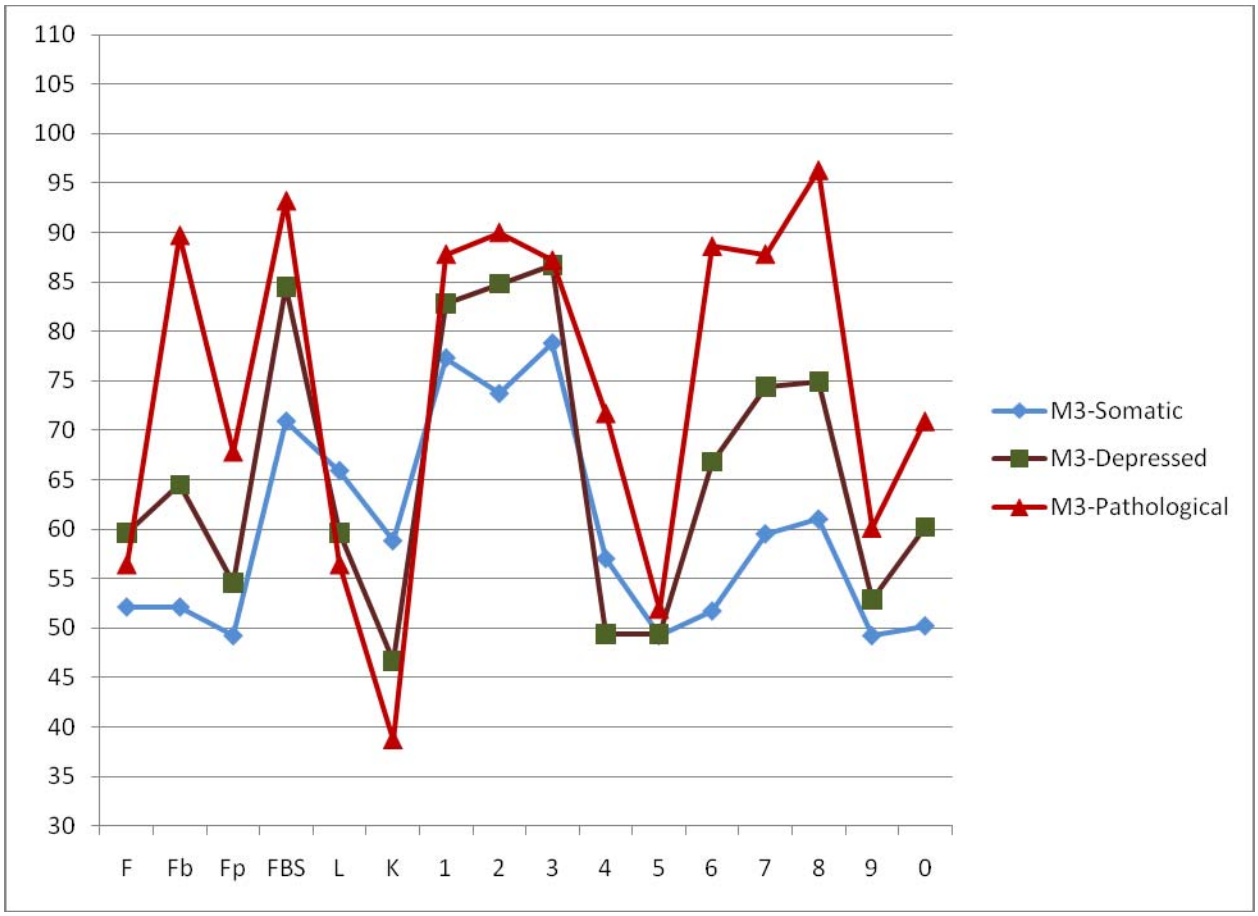
MMPI-2 scales means and standard deviations by Method 3 groups

	M3-Somatic M(sd)	*M3-Moderate M(sd)*	*M3-Pathological M(sd)*	*F*	*p<*	*Eta2*
L	65.9(12.2)[a]	59.6(10.5)[b]	56.4 (10.1)[c]	27.1	.001	0.11
F	52.1(7.0)[a]	64.5(9.8)[b]	89.7(16.4)[c]	378.5	.001	0.63
Fb	49.2(7.3)[a]	69.7(14.2)[b]	100.2(17.4)[c]	484.4	.001	0.69
Fp	50.8(10.4)[a]	54.6(11.1)[b]	67.8(16.9)[c]	65.5	.001	0.23
FBS	70.9(11.1)[a]	84.5(14.2)[b]	93.2(11.0)[c]	112.4	.001	0.34
K	58.8(8.7)[a]	46.7(9.3)[b]	38.7(6.6)[c]	197.2	.001	0.47
1	77.3(9.4)[a]	82.8(10.4)[b]	87.8(8.6)[c]	40.2	.001	0.15
2	73.7(11.4)[a]	84.8(11.0)[b]	90.0(9.2)[c]	114.1	.001	0.34
3	78.8(13.0)[a]	86.7(16.8)[b]	87.2(11.9)[b]	15.4	.001	0.07
4	57.0(9.5)[a]	49.4(8.4)[b]	71.7(11.4)[c]	58.0	.001	0.21
5	49.2(10.6)[a]	49.4(8.4)[a]	51.9(8.8)[b]	3.7	.025	0.02
6	51.7(10.1)[a]	66.8(12.7)[b]	88.6(14.4)[c]	295.9	.001	0.57
7	59.5(10.5)[a]	74.4(10.7)[b]	87.8(10.0)[c]	247.9	.001	0.53
8	61.0(8.7)[a]	74.9(10.5)[b]	96.3(10.6)[c]	424.4	.001	0.66
9	49.2(8.4)[a]	52.9(10.4)[a]	60.1(11.3)[b]	40.5	.001	0.15
0	50.2(8.1)[a]	60.2(9.9)[b]	70.9(8.9)[c]	176.2	.001	0.44

Note. M3-Somatic: Method 3 subgroup with a Somatic profile;M3-Depressed: Method 3 subgroup with a Depressed profile; M3-Pathological : Method 3 subgroup with a Pathological profile . F: Infrequency; Fb: Infrequency back; Fp: Infrequency psychopathology; FBS: Symptom Validity scale; L: Lie; K: Correction; scales 1-0: 1: Hypochondriasis; 2: Depression; 3: Hysteria; 4: Psychopathic Deviate; 5: Masculinity-Femininity; 6: Paranoia; 7 : Psychasthenia; 8: Schizophrenia; 9 : Hypomania; 0 : Social Introversion

[abc] row means with the same letter are not significant at alpha < .05 using Tukey's b post-hoc test.

Figure 12. Illustration of the profiles of the three subgroups described by the MMPI-2 scales.



Note. M3-Somatic: Method 3 subgroup with a Somatic profile;M3-Depressed: Method 3 subgroup with a Depressed profile; M3-Pathological : Method 3 subgroup with a Pathological profile . F: Infrequency; Fb: Infrequency back; Fp: Infrequency psychopathology; FBS: Symptom Validity scale; L: Lie; K: Correction; scales 1-0: 1: Hypochondriasis; 2: Depression; 3: Hysteria; 4: Psychopathic Deviate; 5: Masculinity-Femininity; 6: Paranoia; 7 : Psychasthenia; 8: Schizophrenia; 9 : Hypomania; 0 : Social Introversion

As can be seen in Table 28, the *Method 3-Pathological* had significantly more patients scoring at the may be exaggerated and maybe invalid ranges on all the validity scales than *Method 3-Somatic* and *Method 3-Depressed*. The most noticeable difference between all subgroups was on scale Fb where the *Method 3-Pathological* had 89% of patients scoring at may be exaggerated range compared to 0% in the other two groups. *Method 3-Somatic* and *Method 3-Depressed* had similar proportion of patients on scales F, Fb and Fp. On FBS, *Method 3-*

Depressed had a higher proportion of patients than the *Method 3-Somatic* in the may be exaggerated and may be invalid ranges. On the clinical scales, the most noticeable differences were in scales 7 and 8 where the *Method 3-Somatic* had less than 10%, the *Method 3-Depressed* had about 50% and the *Method 3-Pathological* had more than 90% of patients with very high mean scores. The *Method 3-Somatic, Method 3-Depressed and Method 3-Pathological* had similar number of patients with high mean scores on clinical scales 1, 2, and 3. However, *Method 3-Depressed* and *Method 3-Pathological* had more patients than the *Method 3-Somatic* with very high mean scores on the same scales.

Table 28
Method 3 percentage of Cases that fall above the selected cutoff per M1-Pathologicaly MMPI-2 variable

	Maybe exaggerated			Maybe invalid		
	M3-Somatic	*M3-Moderate*	*M3-Pathological*	*M3-Somatic*	*M3-Moderate*	*M3-Pathological*
Scale						
F	1	30	91	0	2	43
Fb	0	0	89	0	0	78
Fp	2	4	21	1	1	12
FBS	26	67	94	1	15	28
L	39	18	11	13	5	2
K	-	-	-	22	3	0
	High scores			Very high scores		
	M3-Somatic	*M3-Moderate*	*M3-Pathological*	*M3-Somatic*	*M3-Moderate*	*M3-Pathological*
1	92	96	99	67	79	91
2	71	94	99	39	85	98
3	85	89	96	62	75	88
4	22	50	73	4	20	40
5	11	2	9	2	0	1
6	8	57	97	2	26	81
7	25	85	99	8	51	90
8	39	84	100	5	54	99
9	8	15	34	0	4	12
0	4	31	79	1	8	37

Note. M3-Somatic: Method 3 subgroup with a Somatic profile;M3-Depressed: Method 3 subgroup with a Depressed profile; M3-Pathological : Method 3 subgroup with a Pathological profile . F: Infrequency; Fb: Infrequency back; Fp: Infrequency psychopathology; FBS: Symptom Validity scale; L: Lie; K: Correction; scales 1-0: 1: Hypochondriasis; 2: Depression; 3: Hysteria; 4: Psychopathic Deviate; 5: Masculinity-Femininity; 6: Paranoia; 7 : Psychasthenia; 8: Schizophrenia; 9 : Hypomania; 0 : Social Introversion

Non-MMPI Characteristics of Pain Clusters

Demographics . Differences between the three subgroups in demographic were tested using ANOVA or Chi squared analysis where appropriate and Tukey's post hoc analysis was conducted when necessary. Table 29 presents demographic data by subgroup. There was a

significant group effect for education and race with the *Method 3-Somatic* having higher education and *Method 3-Pathological* having less percentage of Caucasians than the other groups. Groups did not differ on any other demographic variables. Odd ratios analysis indicated that the *Method 3-Pathological* subgroup was 2.6 (95% C.I. = 2.6-2.5) and 2.3 (95% C.I. = 2.3-2.2) less likely to be Caucasian than the *Method 3-Somatic* and *Method 3-Depressed* subgroups, respectively.

Table 29
Method 3 Demographic characteristics by MMPI-2-RF based subgroups

	M3-Somatic M(sd)	*M3-Moderate M(sd)*	*M3-Pathological M(sd)*	*F*	*p≤*	*Eta2*
Age	43.5(8.8)	42.7 (9.0)	43.1(8.2)	0.3	NS	0.00
Education	12.3(2.5)[a]	11.7 (2.5)[b]	11.6 (2.6)[b]	3.4	.034	0.02
Time since Injury	35.6(28.7)	41.5 (30.3)	40.1 (27.3)	2.9	NS	0.01
	(%)	(%)	(%)	X^2	*p≤*	
Gender (male)	56.6	67.8	64.8	4.4	NS	
Race (white)	73.3[a]	70.6[a]	51.6[b]	19.2	.014	

Note. M3-Somatic: Method 3 subgroup with a Somatic profile;M3-Depressed: Method 3 subgroup with a Depressed profile; M3-Pathological : Method 3 subgroup with a Pathological profile .
[abc] row means with the same letter are not significant at alpha < .05 using Tukey's b post-hoc test.

Injury Severity. ANOVA demonstrated that there were no differences in Injury Severity mean scores between *Method 3-Somatic* (*M* = .82; *sd* = 1.1), *Method 3-Depressed* (*M* = .85; *sd* = 1.2), and *Method 3-Pathological* (*M* = .72; *sd* = 1.1) [*F* (1, 583) = 0.06, p > .05, *Eta2*=0.01]. Table 30 presents the injury and symptom characteristics of the sample as a function of group membership. Differences between the three groups in injury/symptom characteristics were tested using Chi squared analysis. As can be seen, groups did not differ in other injury type, location, or etiology variable.

Table 30

Percentage of patients with specific Injury/Symptom characteristics by pain group

	M3-Somatic	*M3-Moderate*	*M3-Pathological*	X^2	*p<*
Primary back/spine injury	89.4	93.0	87.5	2.3	NS
Head injury in accident	10.6	11.9	14.8	2.3	NS
Other Pain symptoms / area of body					
Head	28.2	40.8	31.0	1.4	NS
Chest / abdomen	37.0	22.2	40.7	2.4	NS
Upper extremity	40.1	31.9	28.0	0.1	NS
Lower extremity	39.3	34.1	26.6	2.9	NS
Spine Findings					
any spine findings	39.2	35.3	25.5	2.7	NS
degenerative disc/spine	36.1	36.1	27.8	1.4	NS
herniated nucleus pulposus	32.0	44.0	24.0	1.9	NS
disc bulge/protrusion	42.7	33.6	23.8	2.2	NS
neural impingement	36.8	31.6	31.6	0.1	NS
Spinal Surgery					
discectomy / fusion	44.1	28.7	27.2	1.5	NS
decompression/laminectomy	14.4	13.3	21.1	3.6	NS
Other pain diagnoses					
Complex regional pain syndrome	2.8	2.1	3.1	0.3	NS
Fibromyalgia	1.7	3.5	2.3	1.1	NS
Myofascial pain syndrome	5.0	1.4	5.5	3.7	NS

Note. M3-Somatic: Method 3 subgroup with a Somatic profile;M3-Depressed: Method 3 subgroup with a Depressed profile; M3-Pathological : Method 3 subgroup with a Pathological profile .

[abc] row means with the same letter are not significant at alpha < .05 using Tukey's b post-hoc test.

Legal Status. Table 31 presents the legal status of the sample as a function of group membership. Differences between the three subgroups in legal characteristics were tested using Chi squared analysis. Groups did not differ in the status of legal representation or referral source. Groups differed in the type of legal claim. *Method 3-Depressed* had less patients claiming workers compensation than *Method 3-Somatic* and *Method 3-Pathological*. *Method 3-Somatic* and *Method 3-Pathological* did not differ on this variable. Odds ratio analysis indicated that the

M3-Depressed was 1.4 (95% CI = 1.5-1.4) and 2.9 (95% CI = 3.1-2.8) less likely to be involved in Workers Compensation than the *Method 3-Somatic* and *Method 3-Pathological*, respectively.

Table 31
Method 3 medico-legal characteristics of the chronic pain sample as a function of Cluster membership.

	M3-Somatic %	M3-Moderate %	M3-Pathological %	X^2	$p=$
Status of legal representation					
No Attorney	26.1	36.4	31.3		
Represented by attorney	61.1	51.7	55.5	4.1	NS
Attorney status unknown	12.8	11.9	13.3		
Referral source					
doctor	23.3	23.1	33.6		
case manager / adjuster	45.0	52.4	49.2	14.9	NS
attorney	4.4	2.8	5.5		
district attorney	26.1	21.0	11.7		
Claim type					
workers compensation	82.5[ab]	76.7 [b]	90.6 [a]	16.3	.04
personal injury	17.5	21.7	9.4		
disability	0.0	1.1	0.0		

Note. M3-Somatic: Method 3 subgroup with a Somatic profile;M3-Depressed: Method 3 subgroup with a Depressed profile; M3-Pathological : Method 3 subgroup with a Pathological profile .
[abc] row means with the same letter are not significant at alpha < .05 using Tukey's b post-hoc test.

Malingering Diagnosis. Table 32 presents the malingering diagnosis of the sample as a function of group membership. The three subgroups differed significantly in the status of the malingering diagnosis in MPRD [$X^2(4,583) = 135.3$, $p< .001$]. More than half (59-71%) of patients in the *Method 3-Pathological* were formally diagnosed as malingering compared to 37-43 % patients in the *Method 3-Depressed* and 18-20% of *Method 3-Somatic* patients.

Odd ratios analysis indicated that the *Method 3-Pathological* was 34.7 times (95% C.I. = 34.9-34.5) more likely to be MPRD than *Method 3-Somatic* subgroup when not using the MMPI

variables as malingering indicators. Similarly, *Method 3-Pathological* was 9.4 times (95% C.I. = 9.7-9.2) more likely to be MPRD than *Method 3-Depressed* subgroup when not using the MMPI variables as malingering indicators. The *Method 3-Depressed* was 3.7 times (95% C.I. = 3.8-3.6) more likely to be MPRD than *Method 3-Somatic* subgroup when not using the MMPI variables as malingering indicators. When the MMPI variables were used as indicators the odd ratio to be MPRD increased to 132.1 (95% C.I. = 133.1-131.4) for the *Method 3-Pathological* to the *Method 3-Somatic*, to 18.2 (95% C.I. = 19.3-17.1) for *Method 3-Pathological* to *Method 3-Depressed.* The likelihood to be MPRD for the *Method 3-Depressed* increased to 7.3 (95% C.I. = 7.4-7.1) when compared to the *M3-Somatic*.

Table 32
Method 3 malingering status by pain group

Method 3 MPRD[a] status by subgroup

	M3-Somatic %	*M3-Depressed* %	*M3-Pathological* %	X^2	*p*<
Not MPRD	56.0[a]	28.3[b]	7.0[c]	85.0	.001
Possible MPRD	24.5	34.4	33.6		
Probable MPRD	14.7	30.0	45.3		
Definite MPRD	4.9	7.2	14.1		
All MPRD	*19.6*	*37.2*	*59.4*		

Method 3 MPRD[b] status by subgroup

	M3-Somatic %	*M3-Depressed* %	*M3-Pathological* %	X^2	*p*<
Not MPRD	49.7[a]	12.8[b]	0.0[c]	135.3	.001
Possible MPRD	28.7	42.8	28.9		
Probable MPRD	16.8	37.2	57.0		
Definite MPRD	4.9	7.2	14.1		
All MPRD	*18.3*	*42.7*	*71.1*		

Note. M3-Somatic: Method 3 subgroup with a Somatic profile;M3-Depressed: Method 3 subgroup with a Depressed profile; M3-Pathological : Method 3 subgroup with a Pathological profile .
MPRD[a]: Malingered Pain Related Disability not including the MMPI-2 variables
MMPI[b]: Malingered Pain Related Disability including the MMPI-2 variables
[abc] row means with the same letter are not significant at alpha < .05 using Tukey's b post-hoc test.

Pain Report and Outcome. To determine differences in report of pain and outcome, levels of current pain, best pain and worst pain, as well as catastrophization and functional capacity were compared among the three subgroups. Pain report was available for all patients. PCS scores were available for 56 *Method 3-Somatic* patients, 42 *Method 3-Depressed* participants and 43 *Method 3-Pathological* participants. PDI data was available for 68 *Method 3-Somatic* participants, 88 *Method 3-Depressed* participants and 58 *Method 3-Pathological* participants. Table 33 presents data for these variables by group. There was a significant group effect for "current" pain rating with *Method 3-Somatic* reporting less subjective least amount of pain than the *Method 3-Pathological*. The *Method 3-Depressed* did not differ from the *Method 3-Somatic* or the *Method 3-Pathological* in current pain ratings. Moreover, results showed that those in *Method 3-Pathological* had significantly higher mean scores than *Method 3-Depressed*, and *Method 3-Depressed* had significantly higher mean scores than *Method 3-Somatic* on the PC and PDI scales.

Table 33
PCS and PDI scores as a function of pain group

	M3-Somatic	*M3-Depressed*	*M3-Pathological*			
	M(sd)	M(sd)	M(sd)	*F*	*p*≤	Eta^2
Current Pain	6.2(2.0)	6.5(1.9)	6.8 (1.9)	2.0	NS	0.01
Best Pain	4.6 (2.1)[a]	4.7(2.2)[ab]	5.3(2.3)[b]	2.7	.04	0.02
Worst Pain	9.3(1.5)	9.3(1.0)	9.2(1.5)	0.2	NS	0.00
PCS	63.6(14.4)[a]	76.5(13.4)[b]	83.8(10.1)[c]	24.3	.001	0.28
PDI	48.8(12.7)[a]	50.3(12.7)[b]	57.2(9.0)[c]	8.7	.001	0.08

Note. Note. M3-Somatic: Method 3 subgroup with a Somatic profile;M3-Depressed: Method 3 subgroup with a Depressed profile; M3-Pathological : Method 3 subgroup with a Pathological profile .
[abc] row means with the same letter are not significant at alpha < .05 using Tukey's b post-hoc test.

Method 3 Summary and Conclusions

An exploratory two steps cluster analysis was conducted using the MMPI-2 scales *F*-r, Fp-r, Fs, FBS-r, L-r and K-r and the nine RC scales. As Method 2, two and three cluster solutions were determined to be appropriate solutions for the current sample. The three cluster solution was selected to be further described because it provides valuable information over the two-cluster solution. The three cluster solution was characterized by three homogeneous groups that differed drastically in the number and type of MMPI-2-RF scales elevated as well as the number of patients with elevation. Note that Method 3 classification agreed with Method 2 classification for about 75% of the cases demonstrating that there was an important overlap in how the MMPI-2-RF and the MMPI-2 variables classify participants into subgroups.

The first subgroup was called *Method 3-Somatic* because it showed elevations only on RC1 and did not show over-reporting of symptoms. The second subgroup was called *Method 3-Depressed* because elevated on one validity scale (FBS-r) and on the deception, somatic complains and depression scales (RCd, RC1 and RC2). Finally, the last subgroup was called *Method 3-Pathological* because it was characterized by having elevations in all over-reporting validity scales (i.e. F-r,Fp-r, Fs, FBS-r) and five out of the nine RC scales (i.e. RCd, RC1,RC2,RC7, RC9).

The three groups also differed in all MMPI-2 scales, demonstrating the relationship between the MMPI-2- RF scales and its original counterpart. However, like Method 2, some MMPI-2-RF scales (i.e. RC3, RC4 and RC6) were less likely to be elevated by the pain subgroups than the MMPI-2 counterparts. The three groups were also different in the Non-MMPI variables: level of education, race, and malingering diagnosis. The *Method 3-Somatic* was described as a highly educated group, which had the lowest number of patients diagnosed as malingerers. The *Method 3-Depressed* was described as a low educated group, with the highest

proportion of patients with personal injury claims and were 4 times more likely to be diagnosed malingerers than *Method 3-Somatic*. Finally, *Method 3-Pathological* was described was less educated and diverse than the *Method 3-Somatic* and it was the subgroup with the lowest number of Caucasians. Finally, the *Method 3-Pathological* was 35 and 9 times more likely to be diagnosed as malingering than the *Method 3-Somatic* and *Method 3-Depressed* respectively, when the MMPI variables were not used as malingering indicators. The likelihood increased significantly when the MMPI variables were used as indicators. In terms of outcome, *Method 3-Pathological* also demonstrated the highest level of catastrophization and perceived disabilities followed by the *Method 3-Depressed* and then the *Method 3-Somatic.* Thus, the results again supported the previously found dose response relationship between subgroup profile elevations and malingering and outcome report.

CHAPTER VI

DISCUSSION

The general purposes of this study were 1) to establish through cluster analysis subgroups and profiles from a large pain patient population evaluated in medico-legal settings using the MMPI-2 and MMPI-2-RF; 2) to determine the relationship between subgroup membership and selected non-MMPI variables, including pain perception and perceived outcome. Exploratory two-step cluster analyses were conducted to group the participants using three different methods. Method 1 used the MMPI-2 standard clinical scales and the traditional validity scales L, F and K to test whether the previously found pain subgroups were also found in the present medico-legal sample. Method 2 used all of the MMPI-2 scales to test whether the inclusion of all the available scales impacted the number and the characteristics of pain subgroups. Finally, Method 3 used the MMPI-2-RF scales to test whether a cluster analysis using these newly developed scales influenced the previously found MMPI-2 cluster number and characteristics.

Method 1

Result demonstrated that the best natural "fit" for the current sample was the two-cluster solution when Method 1 was used. The subgroups presented a *Triad* (high elevations on scales 1, 2, and 3) and a *Pathological* (extremely high elevations on multiple validity and almost all clinical scales) profiles. These results are relatively similar to previous cluster analytic investigations (i.e. Riley et al., 1993, Block & Ohnmeiss, 2000; Marters et al., 2002), which used the same method to cluster pain patients. The only exception is that the current investigation did not find a subgroup described by no clinical scale elevations (*Normal*).

Method 2

When Method 2 was used, the most comprehensive solution was the three-cluster solution. This solution found that in addition to a *Triad* and *Pathological* subgroups, there was a *Moderate* subgroup. The *Moderate* subgroup was formed by 49% of patients originally classified as *Triad* using Method 1, and 51% of patients classified as *Pathological* using Method 1. The Moderate subgroup scored in the exaggeration range on FBS and had elevations on most clinical scales; though these were not as extreme as the *Pathological* profile. With the appearance of this *Moderate* subgroup, the Method 2 *Triad* and *Pathological* subgroups had more extreme scores compared to the Method 1 subgroup counterpart. That is, the *Triad* subgroup scores were lower and the *Pathological* subgroup scores were higher on all scales compared to their Method 1 counterparts.

Method 3

Finally, using Method 3 the most comprehensive solution was the three-cluster solution, which described a *Somatic*, *Depressed*, and *Pathological* profiles. These subgroups were described based on their RC elevations (see Tallegen et al., 2003 for more information). The *Somatic* profile was defined based on elevations on scales that resemble somatization (RC1); the *Depressed* profile was defined based on elevations on scales that resembles demoralization, negative mood and somatization (RCd, RC1 and RC2); and the *Pathological* profile was defined based on its multiple clinical elevations (Tallegen et al., 2003). When compared to Method 2, 85% of *Somatic* patients were also classified as *Triad*; 77% of *Depressed* patients were in the *Moderate* subgroup; and 88% of *Pathological* patients were classified as *Pathological* in Method 2. Thus, MMPI-2-RF subgroups were composed, for the most part, of the same patients that were identified in their Method 2 counterpart.

MMPI-2 vs. MMPI-2-RF

Interestingly, the MMPI-2-RF subgroups resembled the MMPI-2 profiles when these were described in terms of the MMPI-2 variables. That is, the *Somatic* group resembled an MMPI-2 *Triad* profile; the *Depressed* subgroup resembled the MMPI-2 *Moderate* profile, and the *Pathological* subgroup was similar to the MMPI-2 *Pathological* profile. However, there are some differences between the test versions that are worth noting. For all profiles, there was an apparent lack of relationship observed between scale 3 and its RC counterpart (RC3). One explanation is that many somatic components of scale 3 are now represented in RC1 and not RC3 (Tallegen et al., 2003). In fact, in three different community and psychiatric samples, correlations between scale 3 and RC1 ranged from .60 to .70 while correlations between scale 3 and RC3 only ranged from .01 to -.20 (Tallegen et al., 2003).

The other most identifiable difference was that the *Moderate* subgroup elevated on scales 4,6, 7 and 8 but did not elevate on their RC counterparts. These differences may be because, like scale 3, items related to somatization on clinical scales 4, 6, 7 and 8 are now part of RC1. This may demonstrate an ability of the MMPI-2-RF to capture the main components of somatization on one scale. Similarly, items related to the component "demoralization" were removed from these scales and located in RCd (Tallegen et al., 2003). According to Tallegen et al (2008) demoralization was an important component of all clinical scales, so for the RC scales these items were removed from the individual scales and combined to form the new RCd scale, suggesting that RCd captures a core element of people with psychopathology. Thus the fact that RCd was elevated by the *Moderate* subgroup when this was profiled by the MMPI-2-RF may demonstrate that an important characteristic of this profile is demoralization.

Interpretation of Profiles

Triad/Somatic Profile

The *Triad* or *Somatic* configurations are classically associated with somatization (for review see Graham, 2006, Deardorff, 2000, Robinson, 2000; Tallegen et al., 2003). Patients with this profile are vulnerable to developing physical symptoms in response to stress. They seek medical explanations for their problems and lack insight into the psychological factors that may underlie or influence the problems (Graham, 2006). Individuals with this profile may also manifest depression as episodes of tension, distress, and complaints about weakness and fatigue (Friedman et al., 2001). Somatization is also classically associated with medically unexplained symptoms, poorer response to treatment, and future development of disability (Graham, 2006). Therefore, in general, pain patients with *Triad/Somatic* profiles have maladaptive trait or coping styles that in the present subgroups may be responsible for the limited recovery seen at least six months after the injury.

It is important to note that the present investigation does not differentiate between the *Triad* and the previously reported *conversion V* profiles differentiated by Graham(2006). Although scales 1 and 3 were higher than scale 2 in the current study (see Figure 5), which defines the *conversion V* profile, these were in the same descriptive range (i.e. Very High scores). As discussed by several authors, the major difference between the *Triad* profile and the *conversion V* profile is that the first may represent patients who are experiencing depression secondary to adjustment to significant pain symptomology (Graham, 2006). However, this differentiation has to be used with caution because as Keller and Butcher (1991) suggested, while somatizers consistently endorse items reflecting somatic distress, they may be more

variably endorsing depressive items. Thus, regardless of how they are labeled, the main psychological problem of this subgroup is somatization.

Moderate/Depressed Profiles

The interpretation of the *Moderate/Depressed* profiles is more difficult than the *Triad/Somatic* profile because these had not been identified by previous investigations. *Moderate/Depressed* profiles should certainly be associated with higher levels of psychological overlay than the somatic subgroups because they report high elevations in more number of scales including scales that measure depression, anxiety, and demoralization, among others. However, these profiles are also characterized by elevations on FBS/FBS-r suggesting that these patients also exaggerate some symptoms. Elevations on FBS suggest that there is exaggeration of physical and cognitive symptoms; a type of exaggeration that is not captured by the other over-reporting scales. As mentioned by Lees-Haley et al. (1991) FBS was created to detect exaggeration of somatic and/or non-psychotic symptoms whereas the other over-reporting scales (F,Fb and Fp) collectively termed F family, may be more sensitive to rare psychotic or other rarely endorsed psychological symptoms. Exaggeration of symptoms is supported by the important number of known malingerers that were classified in the *Moderate/Depressed* (~ 35%), suggesting that a significant number of these patients also purposefully underperformed and/or exaggerated symptoms on other psychological measures. Therefore, patients with *Moderate/Depressed* configurations may have important and diverse psychological problems and exaggerated non-psychotic symptoms.

Pathological Profiles

Several studies have interpreted *Pathological* profiles (e.g., Riley, 1995; Block & Ohmeiss, 2004, Gatchel et al., 2006). Research has shown that patients with this profile suffer

from severe psychopathologies (Costello, 1997). These investigations have suggested that their very high scores demonstrate severe pre-morbid psychological issues (Graham, 2006) and fewer resources to cope with physical symptoms compared to those with *Normal* or *Triad* profiles (Riley, 1995). In a recent study, subjects with Pathological profiles were six times more likely to have an Axis 1 clinical disorder (such as major depressive or anxiety disorders) and three times more likely to have an Axis II personality disorder compared to those with Triad profiles (Gatchel, et al., 2006).

However, and perhaps more importantly, the present *Pathological* subgroup also demonstrated elevations on all of the over-reporting validity scales, a finding that was not described or discussed by previous investigators. These elevations demonstrate that patients with *Pathological* profile exaggerate a multiple array of symptoms. In fact, the majority of these patients were known malingerers (~ 65%), indicating that patients with *Pathological* profiles are likely intentionally exaggerating these symptoms. Thus, significant concerns regarding validity of the report should be raised when patients present *Pathological* profiles in medico-legal pain evaluations.

Summary

The two-cluster solution was considered the best solution when it was used the traditional method (Method 1). However, the three-cluster solution was considered the most comprehensive in the methods that used the most complete set of scales (i.e. Method 2 and Method 3). Thus, the three-cluster solution is considered the most adequate solution when using the MMPI-2 or MMPI-2-RF to differentiate patients with financial compensation seen in medico-legal settings. There was significant patient overlap between the MMPI-2 and the MMPI-2-RF subgroups/clusters. However, in general, the MMPI-2-RF seems to be simpler than its original

counterpart in terms of capturing pain related problems by combining somatization into one scale and by increasing scale distinctiveness when removing demoralization. Yet, much research is needed in this area in order to determine if because of this simplification important pain related information is lost. In general, the MMPI-2/MMPI-2-RF three-cluster solutions described a *Triad/Somatic, Moderate/Depressed* and *Pathological* profiles. Subjects with *Triad/Somatic* profiles are shown to have a tendency to express psychological problems or stress in physical symptoms and complains. Patients with *Moderate/Depressed* profiles are expected to have more diverse and moderate psychological problems that may be related to exaggeration of non-psychotic symptoms. Finally, those with *Pathological* profiles have diverse and severe psychological problems that are due, for the most part, to malingering.

CHAPTER VII

Factors Related to Subgroup Membership

Injury Severity

For each method, differences between the resulting subgroups were compared on several important variables. Results showed that subgroup membership was not conditioned to any spine- related organic factor. Thus, differences in MMPI reporting were not due to organic changes consistent with several investigations (e.g. Schade, Semmer, Main, Hora, & Boos, 1999). Instead, elevated profiles were related to malingering status and a variety of other socio-demographic variables, including low education, ethnic diversity and legal status. The following sections provide some discussion about the relationship between group membership and these external variables.

Malingering Status

This study demonstrated an exponential increase in the number of malingerers with profile elevations. That is, the number of malingerers increased from 15% in the Triad/Somatic to 30% in the *Moderate/Depressed* subgroups and to 65% in the *Pathological* subgroups. Odd ratio analysis also indicated that if a patient has a *Pathological* profile he/she is about 30 times more likely to be malingering than a patient with *Triad/Somatic* profile; and about 7 times more likely than a patient with a *Moderate/Depressed* profile. Similarly, a patient with *Moderate/Depressed* profiles is about 3.5 times more likely to be malingering than a patient that presents a Triad/Somatic profile. Thus, the more elevated the MMPI profile the greater should be the concern regarding the motivation of the individual to report their symptoms.

This dose response relationship also supported two fundamental assumptions in malingering research. First, that methods to assess psychological abilities and problems are

vulnerable to intentional exaggeration (Bush et al., 2005).Second, the more inconsistencies a patient presents across multiple or relatively independent domains (i.e. cognitive, physical, emotional), the more likely it is that his/her performance reflects deliberate efforts to misrepresent their symptoms on a self-report measure (Bianchini et al., 2005; Larrabee, Greiffenstein, Greve, & Bianchini, 2007).

In addition, it is important to note that physical findings, symptom report or type/number of surgeries were not related to invalid symptom presentation on the MMPI, and thus malingering status. This supported the assertions that persons with confirmed spine pathology can and sometimes do malinger (Bianchini and Greve, 2009) and constrated the view of Bogduk (2004) which indicated that a diagnosis of malingering "can be refuted if a genuine source of pain can be established" (p. 409). These results are also consistent with Bianchini and Greve (2009), which reported definite malingering in patients with objective physical findings who had, in fact, had surgery. Thus, even willingness to undergo invasive procedures such as spinal surgery should not rule out malingering (Bianchini, Curtis, & Greve, 2006).

Obviously, malingering was not caused by the physical injury which has become the subject of the legal claim of these patients. However, malingering was shown to co-exist with other psychosocial factors and these psychosocial factors can certainly exist in the absence of malingering. The next sections explain these factors' relation to elevated MMPI profiles and to symptom exaggeration/malingering.

Education and Ethnicity

Analyzing the nature of the relationship between ethnicity and education with elevated MMPI profiles (i.e. *Moderate/Depressed* and *Pathological* profiles) is complicated by a large number of confounding variables. While it is certainly possible that there is a direct relationship

between education and ethnicity on symptom report, it is also possible that other related variables are indirectly involved. For instance, patient differences in pre-morbid cognitive and emotional functions, stress regulation, as well as their financial needs- all variables that have shown to be highly correlated with low education and ethnic diversity -are shown to play significant role in the manifestation of symptoms and the ability to cope with difficulties (Guillen et al., 2010; Kirmayer, Groleau, Looper & Dao, 2004). Thus, it is still not clear at this point exactly how low education and ethnicity influence MMPI pain reporting.

Nevertheless, results from this and other investigations suggest that education and ethnicity may be highly associated with exaggerated report of symptoms (e.g. Binder, Kelly, Villanueva, & Winslow, 2003; Salazar, Lu, wen & Boone, 2007l; Victor & Boone, 2007) although not necessarily with malingering (Salazar, Lu, wen & Boone, 2007; victor & Boone, 2007). One potential explanation is that persons with lower education and minorities may employ less sophisticated exaggeration strategies, making them easier to distinguish from real injury profiles (Franzen & Martin, 1996). Another explanation is that education and ethnicity are highly linked to low socio-economic status which may increase the decision to exaggerate symptoms. Socioeconomic status may affect the perception of a particular settlement or disability payment, with low socio-economic status perceiving a higher relative gain (Tait, Chibnall, Andresen & Hadler, 2006). Adding to this, sufferers with low economical resources may view a settlement and/or disability payments as essential for basic support due to having fewer alternatives such as post-injury employment (Boyer et al., 2009).

Non Work- Related Claims

Interestingly, results from this investigation suggested that *Moderate/Depressive* profiles are linked to claims that are non-work (e.g., personal injury) related. Specifically, the

Moderate/Depressed subgroups were 1.3 to 3.3 less likely to be involved in workers compensation claims than the other subgroups. One reason for these results may be a positive relationship between non-working legal status and symptom report (Rosomoff, 1995). A potential explanation is that those with non-work claims are more likely to be sophisticated malingerers (since malingering was not related to non-working claims). Patients in non-working claims may have more law suit opportunities making them more familiar with malingering indicators (Lanyon & Almer, 2002). Patients in non-work claims may also be more often coached than those in working claims as they are more likely to have an active attorney present on their case (Gunstad & Suhr, 2001). Reports have suggested that many validity scales are vulnerable to familiarity and coaching (eg., Dunn, Shear, Howe & Ris, 2003; Gunstad & Suhr, 2001; Powell,Gfeller, Hendricks & Sharland, 2004; Rose,Hall, Szalda & Bach, 1998) including reports that show that the "F family" scales do not differentiate those with real injuries from those that are properly coached (Storm & Graham, 2000). This may explain why those with *Moderate/Depressed* profiles do not elevate on the F family scales. However, neither coaching nor number of litigations were assessed in this study, and thus, the actual relationship could not be determined.

Outcome

Results from this investigation show that subgroup membership was an important predictor of scores in current pain reports and outcome measures. Specifically, the *Triad/Somatic* subgroups had the best scores in current pain, catastrophizing and perceived disability, the *Moderate/Depressed* subgroups had worst outcome scores than the *Triad/ Somatic* profile, but better than the *Pathological* subgroup, a subgroup that reported the highest scores on the outcome measures. Consequently, it can be inferred that those with *Triad/Somatic* profiles would

have best recovery from a spine injury followed by those with *Moderate/Depressed* and then the *Pathological* profiles. These results are consistent with several other investigations (e.g. Block & Ohnmeiss, 2000; den Boer, Oostendorp, Beems, Munneke, & Evers, 2006; Kidner, Gatchel, & Mayer, 2010) that have demonstrated that MMPI-2 profile elevations are associated with increasing pain perception, disability and with poorer outcome from traditional and unilateral treatment interventions.

However, there are some important issues that need to be taken into consideration when associating outcome to MMPI profile. First, while the *Triad/Somatic* profiles had best predictive outcome scores in this study, this is not to say that patients with this profile had "good" outcomes. In fact, previous investigations have shown that patients with *Triad* profiles have the tendency to report high levels of catastrophizing , take long disability times (Asmundson, & Carleton , 2009; Bigos et al., 1991; Vendrig & Lousberg,1997) and not recover properly from surgery (Block, Gatchel, Deardorff, & Guyer, 2003) when compared to normal profiles. Second, due to large exaggeration report and/or malingering in both the *Moderate/Depressed* and the *Pathological* subgroups it is difficult to infer if outcome report is due to the injury or incentives. Indeed, the magnitude of outcome is a central forensic issue in that how disabled or how impaired a person is or claims to be dramatically affects the monetary value of his or her claim (Bianchini et al., 2005). In this view, subjects are as or more likely to exaggerate their outcome report as well as their pain or symptom complaints.

Summary

Subgroup membership was not conditioned to any spine related organic factor. Instead, malingering status had a strong dose-response relationship with subgroup profile elevations suggesting that the more elevated the MMPI profile the greater the chance that an individual is

malingering. Education, ethnic background and legal status were also different among pain subgroups. However, while these psychosocial factors can certainly influence symptom perception in the absence of malingering, these may also increase the likelihood of symptom exaggeration. Lastly, there was a dose-response relationship between perceived outcome and MMPI subgroup profile elevation, suggesting that the more elevated MMPI-2 profile is the less likely the patient is to recover properly from spine injuries.

CHAPTER VIII

Implications

In this study, psychological factors and non- organic factors were responsible for symptom report and, in turn, responsible for perceived outcome. This is consistent with the abundance of scientific/empirical evidence demonstrating that psychological factors, and not physical characteristics of spine injuries, explain the presence of pain symptoms or disability in medico-legal chronic pain patients (Gatchel & Kishino, 2011; Saastamoinen, Laaksonen, Leino-Arjas & Lahelma, 2009). As a result, failure to examine psychosocial issues in pain patients may lead to inappropriate conclusions regarding causality and severity of symptoms, as well as ability to return to work or recover from surgery (Gatchel et al., 2006; Gatchel & Kishino, 2011).

Moreover, this study demonstrated a strong relationship between malingering and subgroup membership above and beyond physical findings/surgery. Since malingering can lead to diverse and severe symptom complaints, it can largely affect decisions and conclusions regarding the presence, nature, cause, treatment, and functional implications of pain-related disability (Aronoff et al., 2007). As a result, before any questions regarding pain- related disability can be addressed, the information obtained from a psychological assessment of validity / malingering must be rigorously examined. As stated in a recent position paper from the National Academy of Neuropsychology, "Adequate assessment of response validity is essential in order to maximize confidence in the results of neurocognitive and personality measures and in the diagnoses and recommendations that are based on the results" (Bush et al., 2005, p. 419).

Results from this study further support the importance of pre-surgical/procedure psychological screenings. Block et al. (2003) have argued that pre-surgical psychological

screening is an essential component in the medical diagnostic process of spine surgery candidates, especially when the major goal is pain reduction and improved functionality. However, it is also important that psychological pre-surgical/procedure screenings take into consideration the psychosocial factors related to high- risk profiles in this study (i.e. education, ethnicity, legal status, malingering). A psychological pre-surgical/procedure screening that considers these factors may be able to answer the questions related to not only whether a certain case is likely to have a poor outcome but also whether psychosocial problem(s) influence the compensable injury and whether those factors contribute in a meaningful way to the patient's alleged disability.

Similarly, the present study may be used as a guide in active pain management programs after malingering has been ruled out. That is, by identifying those patients with high risk profiles, conservative or functional interventions such as cognitive behavioral interventions may be recommended as more adequate than relatively independent physical treatments (Gatchel & Okifuli, 2006).

Limitations and Future Studies

There are some limitations to this investigation. One limitation is that the current sample may not be representative of all spine pain patients. This sample was composed of patients with chronic pain (patients that have not recovered six months after the injury), a type of pain episode that has been linked to emotional distress (Turk & Melzack, 2003). This explains why this study did not find a profile with no psychological overlay or Normal profile. Although another possibility for not finding this profile might be that all those with monetary compensation have elevated MMPI profiles (Rohling, Binder & Langhinrichsen-Rohling, 1995; Meyers et al., 2002). Therefore, in order to better clarify the role of spine injury on symptom report, future cluster

analysis investigation should also include medico-legal patients with acute or recurrent pain episodes.

Another limitation is that the current study only used self-report measures of outcome, instead of practical measures of outcome such as length of return to work or surgery recovery. Future studies may increase the predictive validity of the current findings by evaluating these practical outcome variables in patients that present the above profiles. Future studies could also identify how low-socioeconomic and legal statuses influence MMPI pain symptom and malingering report – specifically, how non-malingering spine patients with different socioeconomic and legal statuses perform on psychological measures. Finally, it is important to conduct similar cluster analytic studies on other psychological measures (i.e. Personality Assessment Inventory, Millon Clinical Multiaxial Inventory) as they might provide further insight on the emotional similarities/differences of spine pain subgroups.

CONCLUSION

This study expands on previous cluster analytic investigations by better describing the physical, psychological, and socio-legal factors that influence MMPI-2 and MMPI-2-RF based subgroups of spine pain patients. The present study also illustrates the clinical circumstances that can influence a given patient (based on their MMPI profile) to recover from a spine injury, specifically those patients that are seen in medico-legal contexts. As a result, the current study is relevant for informing decisions regarding possible physical interventions including pre-surgical screening and choosing between conservative and more invasive physical interventions.

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APPENDIXES

Appendix A: Common Physical Impairments that Cause Spine Pain

Muscle Ligament Injuries are relatively common consequences of strenuous physical activity. Sprains are injuries involving ligaments. Sprains are usually caused by trauma that displaces a joint resulting in stretching or tearing of the associated ligament(s).

In *disc bulge and herniation,* pain that may result directly from the annulus tears, from irritation caused by the release of chemicals from the nucleus, or by compression of the nerve root.

Myofascial pain syndrome refers to musculoskeletal pain arising from localized trigger points in a rigid band of muscle. These focal trigger points are tender to palpation may cause muscle weakness or reduced range of motion.

Radiculopathy /Sciatica refers to a disruption of (or near) the nerve root that can result in pain as well as sensory or motor disturbances. An important feature of radiculopathy is that symptoms are often referred to the limb associated with the disrupted nerve.

Spinal Stenosis refers to a narrowing of the spinal canal, nerve root canal, or foraminal openings from which nerve roots exit the canal. Symptoms typically occur when these nerve fibers become impinged.

Spondylolysis refers to a stress fracture of the pars interarticularis, the narrow bridge between the upper and lower facet joint of a vertebrae. A condition known as spondylolisthesis can occur if the fracture is bilateral and the vertebrae slip out of alignment. When pain is present it is thought to be caused by nerve root compression, intervetebral disc pain, or facet joint pain.

Spondylosis is a condition caused by age-related disc degeneration that causes a number of pathological processes that can ultimately result in a narrowing of the spinal canal.

Whiplash-associated disorder (WAD) refers to a collection of symptoms resulting from rapid hyperextension/flexion of the neck, often associated with motor vehicle accidents.

Appendix B:The Pain Disability Index

The rating scales below are designed to measure the degree to which several aspects of your life are presently disrupted by chronic pain. In other words, we would like to know how much your pain is preventing you from doing what you would normally do, or from doing it as well as you normally would. Respond to each category by indicating the *overall* impact of pain in your life not just when the pain is at its worst.

For each of the 7 categories of life activity listed, please circle the number on the scale which describes the level of disability you typically experience. A score of 0 means no disability at all, and a score of 10 signifies that all of the activities in which you would normally be involved have been totally disrupted or prevented by your pain.

(1) Family / home responsibilities

This category refers to activities related to the home or family. It includes chores or duties performed around the house (e.g., yard work) and errands or favors for other family members (e.g., driving the children to school).

0 1 2 3 4 5 6 7 8 9 10

no disability total disability

(2) Recreation

This category includes hobbies, sports, and other similar leisure time activities.

0 1 2 3 4 5 6 7 8 9 10

no disability total disability

(3) Social activity

This category refers to activities which involve participation with friends and acquaintances other than family members. It includes parties, theater, concerts, dining out, and other social functions.

0 1 2 3 4 5 6 7 8 9 10

no disability total disability

(4) Occupation

This category refers to activities that are a part of or directly related to one's job. This includes non-paying jobs as well, such as that of a housewife or volunteer worker.

0 1 2 3 4 5 6 7 8 9 10

no disability total disability

(5) Sexual behavior

This category refers to the frequency and quality of one's sex life.

0 1 2 3 4 5 6 7 8 9 10

no disability total disability

(6) Self-care

This category includes activities which involve personal maintenance and independent daily living (e.g., taking a shower, driving, getting dressed, etc.).

0 1 2 3 4 5 6 7 8 9 10

no disability total disability

(7) Life-support activity

This category refers to basic life-supporting behaviors such as eating, sleeping, and breathing.

0 1 2 3 4 5 6 7 8 9 10

no disability total disability

Appendix C: Pain Chatastrophizing Scale

We are interested in your thoughts and feelings related to pain and distress. While responding to the following 13 items, please think of your physical pain. With this experience in mind, rate the frequency with which you experienced each of the following thoughts and feelings. Use the following scale (from 0 to 4) to indicate how frequently you had each thought or feeling during your experience of pain, and mark your frequency rating on the blank line to the left of the item.

0 (not at all) 1 2 3 4 (all the time)

_____ 1. I worry all the time about whether the pain will end

_____ 2. I feel I can't go on

_____ 3. It's terrible and I think it's never going to get any better

_____ 4. It's awful and I feel that it overwhelms me.

_____ 5. I feel I can't stand it anymore

_____ 6. I become afraid that the pain may get worse

_____ 7. I think of other painful experiences

_____ 8. I anxiously want the pain to go away

_____ 9. I can't seem to keep it out of my mind

_____ 10. I keep thinking about how much it hurts

_____ 11. I keep thinking about how badly I want the pain to stop

_____ 12. There is nothing I can do to reduce the intensity of the pain

_____ 13. I wonder whether something serious may happen

Appendix D: Malingering Classification Method

Determination of malingering status (i.e. MPRD[a] and MPRD[b]) was based on the criteria proposed by Bianchini et al., (2005). Classification relied on performance on psychometric indicators and examination of available records.

Psychometric indicators. The cutoffs for the indicators used for MPRD classification were based on examination of classification accuracy data derived from published criterion-groups' validation (known-groups) traumatic brain injury studies and in consideration of the general literature on specific indicators. In all cases, the cutting scores were based on the performance of patients seen for neuropsychological evaluation for claims of brain injury and the samples included patients with objectively documented brain pathology.

Classification accuracy data for the psychometric indicators used in this study were obtained from: 1) Test of Memory Malingering (TOMM, Tombaugh, 1996) data from Greve, Bianchini, and Doane (2006); 2) Portland Digit Recognition Test (PDRT; Binder, 1993) data from Greve and Bianchini (2006); 3) Word Memory Test (WMT; Green 2005; Green Allen & Astner, 1996) data from Greve, Ord, Curtis, Bianchini, and Brennan (2008); 4) Reliable Digit Span, Digit Span, Working Memory and Processing Speed Indexes from the Wechsler Adult Intelligence Scale –III (WAIS-III; Wechsler, 1997) data from Etherton, Bianchini, Heinly, & Greve (2006ab), Etherton, Bianchini, Ciota, Heinly, and Greve (2006), and Heinly et al., (2005) ; 5) Recognition Hits raw score data were from the California Verbal Learning Test (CVLT; Delis, Kramer, Kaplan, & Ober, 1987, 2000) data of Curtis, Greve, Bianchini, and Brennan (2006); 6) Millon Clinical Multiaxial Inventory-III (MCMI-III; Millon, 1994) data from Aguerrevere, Greve, Bianchini and Ord (under review). 8) F, Fb, Fp and Symptom Validity

Scale (FBS; Lees-Haley, English, & Glenn, 1991) from the MMPI-2 TBI data of Greve, Bianchini, Love, Brennan, and Heinly (2006). Regarding the CVLT, data showed that the classification accuracy of Recognition Hits is equally accurate in CVLT-1 and CVLT-2 at the selected cutoffs (Greve, Curtis, Bianchini, & Ord, 2009).

Selected Cutoffs. Table A presents the data on the classification accuracy of the selected cutoffs for each indicator. Also reported in Table A is Positive Predictive Power (+PP) for the weakest value that were considered positive for each variable and Negative Predictive Power (-PP) for the weakest variable values that were considered negative. The predictive values were derived using a hypothetical malingering baserate of 35% (based on Mittenberg, Patton, Canyock, & Condit, 2002). +PP and -PP provide a concrete index of confidence that a patient is malingering or not malingering, respectively. Application of this system results in each score being classified as 1) a negative indication of response bias or malingering; 2) an ambiguous indication of response bias or malingering; or, 3) a positive indication of response bias or malingering.

Table A
Cutoffs and Malingering Indicators for MPRD[a] and MPRD[b]

Indicator	Negative	-PP	Ambiguous	Positive	+PP
Test of Memory Malingering					
Trial 2	50-49	.82	48-45	44-0	.85
Retention	50-49	.83	48-45	44-0	.91
Portland Digit Recognition Test					
Easy	36-28	.86	27-23	22-0	.97
Hard	36-23	.86	22-18	17-0	.93
Total	72-50	.88	49-45	44-0	.95
Word Memory Test					
IR	100-80	.83	78.5-72.5*	70-0	.86
DR	100-80	.83	78.5-72.5*	70-0	.85
CNS1	100-75	.83	72.5-57.5*	55-0	.88
Wechsler Adult Intelligence Scale					
RDS	17-8	.87	7	6-0	.84
DS	30-8	.85	7-5	4-0	1.00
WMI	155-81	.88	80-76	75-45	.86
PSI	155-76	.84	75-71	70-45	.89
California Verbal Learning Test					
Rec Hits	16-12	.82	11-10	9-0	.91
Millon Multiaxial Clinical Inventory-III					
Disclosure	0-55	.85	56-70	71-115	.84
Debasement	0-65	.86	66-70	71-115	.88
Desirability	115-60	.77	59-55	54-0	.87
Minnesota Multiphasic Personality Inventory-II (only for MPRD[b])					
F	0-65	.82	66-80	81-130	
Fb	0-65	.80	66-85	81-130	
Fp	0-65	.73	66-80	81-130	
FBS(raw)	0-24	.84	24-28	29-32	

*The WMT scores are recorded in increments of 2.5% so scores between 80 and 78.5 and between 72.5 and 70 are not possible.

-PP = Negative Predictive Power, the minimum probability that a negative score was produced by a non-malingering case assuming a malingering baserate of .35; +PP = Positive

Predictive Power, the minimum probability that a positive score was produced by a .malingering case assuming a malingering baserate of .35; CN1 = consistency of recall between IR and DR from the Word Memory Test; DR = delayed recall trial from the Word Memory Test; DS = Digit Span scales score; IR = immediate recall trial from the Word Memory Test; PSI = Processing Speed Index; Rec Hits = Recognition Hits from the California Verbal Learning Test; WMI = Working Memory Index.

Significantly Below Chance Performance. A statistically significantly below-chance result on a forced-choice SVT is definitive evidence of intentional exaggeration of cognitive deficits (Bianchini et al., 2001; Frederick & Speed, 2007; Reynolds, 1998). This has been recognized in both published systems for diagnosing malingering (Bianchini et al., 2005; Slick, Sherman, & Iverson, 1999). A below chance result "is not a random or chance occurrence but represents a purposive distortion by the examinee" (Reynolds, 1998; p. 272; emphasis added). In this study, below chance results were possible on the PDRT, TOMM and/or WMT. For the TOMM, two tests a score of 17/50 or less was considered significantly below chance (below the lower bound of the 95% confidence interval around a score of 25/50). For the PDRT, scores of 11/36 on Easy and Hard, and 27/72 on Total were considered significantly below chance. For the WMT, below chance was 13/40 on Immediate and Delayed Recognition.

Qualitative Inconsistencies. Four kinds of inconsistencies were considered as part of the MPRD classification: 1) non-organic or functional findings on physical examination (exclusive of Functional Capacity Evaluation [FCE]); 2) an inconsistency between the patient's behavior during examination and their behavior when they do not believe they are being observed; 3) inconsistencies between the patient's subjective report of symptoms or history and their documented history; and, 4) evidence of submaximal effort, symptom magnification, or non-

organic / function findings on a formal FCE. Multiple inconsistencies are required to contribute to a diagnosis of MPRD to account for their qualitative nature.

Operationalization of MPRD. The operationalization of the MPRD criteria results in a given score being considered positive, negative, or indeterminate (neither clearly positive nor negative). Moreover, because at least two qualitative inconsistencies are required to reach at least the Possible designation, patients with only one inconsistency are not clearly classifiable. Thus, the cases who do not meet criteria for an MPRD diagnosis were further divided into three groups: 1) those with no positive psychometric findings or inconsistencies; 2) those with no more than one ambiguous psychometric finding and no inconsistencies; 3) those with two or more ambiguous psychometric findings and/or only one inconsistency. In summary, using the above described system, patients were initially placed into one of the following six groups:1) negative on all indicators used.2) a single ambiguous finding with no qualitative inconsistencies present and otherwise negative.3) more than one ambiguous psychometric finding but no positive psychometric findings or a single inconsistency.4) at least one positive psychometric finding or one or more inconsistencies but did not meet full criteria for malingering.5) met criteria for probable malingering.6) met criteria for definite malingering.

For purpose of this study, patients in groups 2 and 3 were combined into a single *Incentive-Only group*. The group 4 cases were referred to as *Indeterminate* while groups 5, 6, and 7, were called *Possible, Probable*, and *Definite MPRD*, respectively. See Table B

Table B

Group	Initial Malingering Classification
1	negative on all indicators
2	only one ambiguous finding
3	more than one ambiguous finding but no positive findings
4	at least one positive finding but does not meet criteria for malingering
5	meets criteria for Probable MPRD
6	meets criteria for Definite MPRD

Final Malingering Classification
Not Malingering (groups 1 and 2)
Indeterminate (group 3)
Possible MPRD (group 4)
Probable MPRD (group 5)
Definite MPRD (group 6)
All MPRD (groups 5 and 6)

University Committee for the Protection of Human Subjects in Research
University of New Orleans

Campus Correspondence

Principal Investigator:	Kevin Greve
Co-Investigator:	Luis Aguerrevere
Date:	October 4, 2010
Protocol Title:	"Biopsychosocial factors in chronic spine-related pain: Contributions to pane intensity and perceived disability"
IRB#:	06Dec09

The IRB has deemed that the research and procedures are compliant with the University of Ne w Orleans and federal guidelines. The above referenced human subjects protocol has been reviewed and approved using expedited procedures (under 45 CFR 46.116(a) category (8).

Approval is only valid for one year from the approval date. Any changes to the procedures or protocols must be reviewed and approved by the IRB prior to implementation. Use the IRB number listed on this letter in all future correspondence regarding this proposal.

If an adverse, unforeseen event occurs (e.g., physical, social, or emotional harm), you are required to inform the IRB as soon as possible after the event.

Best wishes on your project!

Sincerely,

Robert D. Laird, Ph.D., Chair
UNO Committee for the Protection of Human Subjects in Research

VITA

Luis E Aguerrevere, was born in Barquisimeto, Venezuela, received his B.S. from Tennessee Technological University in 2004 and his M.S. from the University of New Orleans in 2007. He joined the University of New Orleans to pursue a Ph.D. in Applied Biopsychology, and became a member of Professor Jill Daniel and Professor Kevin Greve's research groups in 2005 and 2006, respectively.