International Journal of Psychology and Cognitive Science
2019; 5(2): 49-52
http://www.aascit.org/journal/ijpcs
ISSN: 2472-9450 (Print); ISSN: 2472-9469 (Online)

AASCIT American Association for Science and Technology

Factor Analysis of the Post-Concussion-Whiplash Spectrum in Survivors of Car Accidents

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Citation

Zack Cernovsky, Larry Litman, James Mendonca, Yves Bureau, Paul Istasy. Factor Analysis of the Post-Concussion-Whiplash Spectrum in Survivors of Car Accidents. *International Journal of Psychology and Cognitive Science.* Vol. 5, No. 2, 2019, pp. 49-52.

Received: February 28, 2019; **Accepted**: April 3, 2019; **Published**: April 16, 2019

Abstract: Background and Objective: Recent studies by neuropathologists such as Omalu showed that cerebral concussions can occur even without visible head injuries and without a full loss of consciousness or loss of ability to perform simple tasks. Undiagnosed concussions remain a major public health problem, especially in patients who experience a complete Lew's Polytrauma Clinical Triad (persistent post-concussion syndrome, pain, and PTSD). The present study focussed only on the posttraumatic neuropsychological symptoms and evaluated which components (i.e., symptom groupings) within the spectrum of post-concussion and whiplash symptoms can be detected via factor analysis. Method: The principal component analysis was carried out on 6 initial symptoms of cerebral concussion, on all 16 items of the Rivermead post-concussion scale, and on 8 other post-accident neurological symptoms (hand tremor, tingling, numbness, or loss of feeling in the limbs, impaired bladder or bowel control, impaired muscular control over upper or lower limbs). The analysis included data from 90 adult survivors of car accidents (mean age 42.0 years, SD=13.6; 33 males, 57 females) interviewed at 2 to 33 months after their accident. Only component loadings above .450 were included in the interpretations. Results: The first factor explained 25.9% of the variance and primarily consisted of classical signs of the post-concussion syndrome (cognitive and visual impairments, headaches, dizziness, nausea, and restlessness). The second factor explained 9.4% of the total variance and consisted solely of paresthesia in the limbs (tingling or numbness). Discussion: This study did not include measures of pain and of PTSD which are also an important part of the post-accident spectrum of symptoms. Factor-analytic or inter-correlational studies on all elements of Lew's Polytrauma Clinical Triad would be of interest in further research.

Keywords: Cerebral Concussion, Post-Concussion Syndrome, Whiplash, Polytrauma Clinical Triad, Spinal Injury, Axonal Shearing, Car Accidents

1. Introduction

The neuropathological-histological research by Bennet Omalu [1, 2] and by Mez et al. [3] shows that cerebral damage in concussions occurs with sudden acceleration/deceleration of the head even in those who neither sustained visible head injuries nor fully lost consciousness and still appear able to perform at least some simple tasks. The gray and the white part of the brain slide over each other during such impacts and axonal shearing occurs with subsequent neurotoxicity and microvascular injuries. The seminal work of Omalu [1, 2] was carried out in autopsies of American football players. Survivors of serious car accidents and injured war veterans were exposed to more forceful sudden jolts than those occurring in football players.

The diagnosis of cerebral concussion is often missed by busy emergency room physicians when examining patients injured in motor vehicle accidents (MVA). Recently, a brief scale was published [4] consisting of 6 items (dazed, stunned, confused, disoriented, dizzy, loss of consciousness) to enable the physicians to make rapidly a tentative diagnosis of cerebral concussion, while post facto interviewing the patients about symptoms experienced within the first minutes after their MVA. The scale can be used even in interviews taking place several months or years after the MVA: it was designed for retrospective recall of the symptoms.

Longitudinal changes of post-concussion symptoms over months or years can be assessed via Rivermead Scale [7] which contains a list of 16 symptoms, rated as follows: 0=symptom not experienced at all, 1=no more of a problem, 2=a mild problem, 3=a moderate problem, and 4=a severe problem. The 16 symptoms are: headaches, dizziness, nausea/vomiting, oversensitivity to loud noise, sleep disturbance, fatigue, irritability/anger, depression, frustration/impatience, impaired memory, poor concentration, slow speed of thinking, blurred vision, oversensitivity to bright lights, double vision, and restlessness. The patients who suffered a major impact in their MVA frequently report cervicalgia and dorsalgia (neck and back pain), i.e., symptoms in the whiplash spectrum, in addition to the classical post-concussion syndrome. They also usually experience the PTSD. It should be noted that post-MVA pain may persist for many years following the MVA. The pain and PTSD combine to impair sleep by shortening the actual sleep duration or by interfering with the normal restorative quality of sleep. In turn, the insomnia usually slows down the recovery from post-concussion symptoms.

Clinical evaluations of soldiers who sustained mild traumatic brain injuries led to the concept of Polytrauma Clinical Triad [5] consisting of persistent post-concussive symptoms, pain, and PTSD, as these three occur very often jointly. This triad is not unique to military patients, but is also common in post-MVA patients. An investigation of the polytrauma triad in survivors of MVAs was published in 2018 by Peixoto's scientific team [6].

In clinical work with survivors of MVAs, the whiplash phenomena should be assessed in details, including whiplash symptoms resulting from injuries to efferent or afferent nerves, those exiting or entering the vertebral column at different points of the spine. In interviews with patients who suffer from post-concussion and whiplash symptoms, the patients usually have difficulties recalling and listing all of their post-accident neuropsychological symptoms because their memory and concentration are impaired and their information processing is slowed down noticeably. Their task is more easy if the psychologist administers to them a full list of such symptoms and asks them to identify which ones they experience. The post-concussion syndrome in such assessments can be evaluated via the Rivermead scale. The other post-MVA neurological symptoms such as those within the whiplash spectrum (i.e., symptoms other than those already listed in Rivermead) can be measured via our recently published scale of Post-MVA Neurological Symptoms (PMNS) [8, 9]. The most recent version of this PMNS scale now includes 13 following symptoms: impaired balance, hand tremor, instances of impaired muscular control over legs, instances of impaired muscular control over arms or hands, tingling in the limbs, numbness in the limbs, loss of feeling in the limbs, loss of bladder control, loss of bowel control, stutter, the syndrome of word finding difficulty, difficulty articulating words, and tinnitus. All 13 PMNS items are to be scored in the same manner from 0 to 4 as already reported here for the Rivermead scale.

Early in 2019, Barker-Collo's team [10] published a factor analysis of the Rivermead scale on a sample of patients with mild traumatic brain injuries assessed 4 years after their injury and also on a control sample of normal adults. Their factor analysis determined that, in both samples, the first factor included all Rivermead items.

It is of theoretical interest to examine factor-analytic outcomes on data involving not only the classical post-concussion symptoms such as those listed in the Rivermead, but also the PMNS items that quantify other symptoms of post-MVA neuropsychological impairment such as those within the whiplash spectrum. The present study evaluates which factors can be detected in the principal component analysis (factor analysis) of the items including the 6 initial symptoms of cerebral concussion (as listed in Cernovsky at al. [4]), the 16 items of the Rivermead post-concussion scale [7], and the PMNS scale of other posttraumatic neurological symptoms.

2. Materials and Method

We administered the 6 item scale of immediate concussion symptoms [4] and the Rivermead scale (Eyres et al. [5]) to 90 survivors of car accidents (mean age 42.0 years, SD=13.6; 33 males, 57 females). Patients in this sample also completed an early version of the PMNS scale [8, 9] consisting of 8 post-MVA neurological symptoms other than concussion, i.e., of symptoms other than those already listed in the Rivermead. In the present study, data on only 8 following PMNS items were available: hand tremor, instances of impaired muscular control over legs, instances of impaired muscular control over arms or hands, tingling in the limbs, numbness in the limbs, loss of feeling in the limbs, loss of bladder control, loss of bowel control. The most recent update to PMNS scale has been an addition of 5 more items, but these were not yet included in the present study.

The patients were assessed at 2 to 33 months after their accident. Their data were analysed via principal component analysis, orthogonal rotation. To simplify the interpretation of the factors, we list only component loadings >.450 and we interpret only those factors that explain at least 7% of total variance.

3. Results

The results are listed in Table 1: only two factors are listed here because the others explained less than 7% of variance. The first factor explains 25.9% and the second 9.4% of the total variance.

The first factor involves essential post-concussive symptoms: complaints about impaired cognitive functioning, vision problems, dizziness, headaches, tremor, fatigue, and impaired mood. This factor is consistent with the post-concussion syndrome.

The second factor consists exclusively of numbness and tingling in the limbs, i.e., of peripheral paresthesia.

Table 1. *Factor loadings (only loadings >.45 are included in the lists).*

Loadings: Component 1

Variables:	Loadings:
Impaired memory	.758
Blurred Vision	.755
Poor Concentration	.747
Instances of impaired control over arm or hand muscles	.709
Slow speed of thinking (problem solving)	.704
Oversensitivity to bright lights	.704
Dizziness	.698
Headaches	.685
Double vision	.680
Restlessness	.677
Nausea and/ or vomiting	.672
Tremor	.598
Sleep disturbance	.596
Loss of feeling in the limbs	.594
Fatigue	.593
Feeling depressed or tearful	.561
Being Irritable, easily angered	.553
Feeling Frustrated or Impatient	.521
Tingling in the limbs	.521
Numbness in the limbs	.520
Oversensitivity to loud noise	.493
Numbness in the hands	.479
Tinnitus	.468
Feeling dizzy within first minutes after the accident	.460

Loadings: Component 2

Variables:	Loadings:
Numbness in the legs	.537
Numbness in the hands	.503
Tingling in the limbs	.486
Numbness in the limbs	.476

4. Discussion

The strongest factor emerging from the data encompasses primarily typical signs of the post-concussion syndrome. Its highest loadings (those >.6) involve impaired memory and concentration, slow speed of thinking, visual impairment (blurred or double vision, oversensitivity to bright lights), dizziness, headaches, nausea, and restlessness. This finding is consistent with factor-analytic results recently published by Barker-Collo's team [10]: in their study, the first factor included all Rivermead items.

In the present study, the second strongest factor involved exclusively peripheral paresthesia (tingling and numbness in the limbs).

It is noteworthy that almost no items from the 6 item scale of the immediate symptoms of cerebral concussion [4] loaded sufficiently highly on these first 2 factors or on any of the next 3 factors. The published correlational results [4] indicated that ratings of retrospectively recalled immediate symptoms of concussion are only weakly correlated with the Rivermead scores (r=.34), i.e., with the scope or intensity of the subsequent post-concussion syndrome.

Further research could evaluate if a factor-analysis with the newest 13 item version of the PMNS scale would yield different patterns of components. Similarly, future correlational and factor-analytic studies may include not only symptoms from the concussion or whiplash spectrum but also measures of pain and PTSD, in line with the underlying concept of polytrauma. Peixoto's team [6] determined, in their 2018 study on post-MVA patients, that 52.2% met the criteria for the Polytrauma Clinical Triad [5]. One of confounding factors in such studies could be malingering. The possibility of malingering is of serious concern when post-MVA patients are evaluated in the context of legal litigation, financial compensations, or other benefits. The perhaps most frequent clinical error in this area is the diagnostic reliance, by some psychologists, on the Structured Inventory of Malingered Symptomatology (SIMS) [11, 12]. The SIMS is a 75 item questionnaire that was neither adequately designed to evaluate malingering nor has ever been properly validated on polytrauma patients [13]. Most importantly, the SIMS lacks content validity as a tool for detection of malingering: more than 30 SIMS items erroneously list symptoms that are frequently and legitimately reported by patients who experience the Polytrauma Clinical Triad, symptoms such as: "I have trouble sleeping," "I am depressed all the time," "… my brain is injured," or complaints about tinnitus, headaches, dizziness, memory problems (e.g., not recalling what day of the week it is or what date it is), lack of energy, signs of impaired concentration, post-whiplash symptoms (e.g., numbness in the limbs, some loss of feeling in hands, somewhat impaired muscular control over arms or legs), etc. Since these items describe real medical symptoms, the SIMS can not and does not differentiate between malingerers and patients with such legitimate medical symptoms. Each of these 30 or more items counts one point towards SIMS cutoff score of 14: the more of such legitimate items are endorsed, the more likely is the legitimate patient falsely labelled as a malingerer [13].

Fifteen SIMS items were originally designed for a subscale to measure malingering of psychosis: these items may appear bizarre in their content. The empirical test of that particular SIMS subscale on real psychotic patients was a failure, the same as clinical tests of other SIMS subscales on other diagnostic groups of real patients [14].

The authors of SIMS claim their test was "validated," but their procedure was only comparing SIMS responses of healthy college undergraduates instructed to malinger medical symptoms to responses of healthy college undergraduates instructed to respond honestly [12]. From the logical perspective, this unusual "validation" procedure of the SIMS causes the reporting of its medical symptoms, whether malingered or legitimate, to result in the person being classified as a malingerer. An appropriate test validation must follow the Standards of Educational and Psychological Testing [15] as published by the American Psychological Association (APA) to demonstrate that the test indeed meaningfully differentiates between patients with legitimate symptoms (such as war veterans or post-MVA patients) and healthy malingerers. Unfortunately, thousands of legitimate patients have already been deprived of their legally due insurance benefits or denied treatments via SIMS.

5. Conclusions

The strongest two factors that emerged from the analysis of patients with cerebral concussion and other post-accident neurological symptoms were a factor consisting primarily of post-concussion symptoms and a factor involving exclusively peripheral paresthesias. The highest loadings on the first factor (loadings >.60) were on symptoms of impaired memory, impaired concentration, slow speed of thinking, blurred or double vision, dizziness, headaches, nausea, and restlessness, i.e., typical post-concussion symptoms. The loadings on the second factor (peripheral paresthesias) were lower (between .4 and .6) and involved only tingling and numbness in the limbs.

Inter-correlational or factor-analytic studies on all elements of Lew's Polytrauma Clinical Triad (Pain, Post-Concussion Syndrome, and PTSD) would be of interest in further clinical studies.

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