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To read my 2005 REVIEW of this article, go to:
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"A Comprehensive Review of Frequently Misinterpreted
and Misrepresented Restraint Research" PART THREE"

My Comprehensive Review of this article begins by explaining and identifying the rather twisted and bizarre history of how this report of a 1999 study finally became published.

My Comprehensive Review identifies (and provides support for) several LIES – or "Misrepresentations" – made by Chan et al within this September 2004 published report of a study done in 1999. A very FEW examples include explanation and identification of how:

- Chan et al lied about – or misrepresented –
several aspects of the manner in which the 1999 study was conducted.
- Chan et al lied about – or misrepresented – the references offered to support several statements made within the report's discussion.
- Chan et al purposefully published a "conclusion" that semantically down-played the importance of the "negative" information derived from their (albeit inadequately-constructed) study.

Additionally, my Comprehensive Review identifies (and provides support for) the many INADEQUACIES of the 1999 study – explaining how absolutely NO PART of this study's design ever came even CLOSE to representing anything remotely-resembling a realistic investigation of the effects that "weight force during prone restraint" application might have upon the "respiratory function" of an altered level of consciousness or excited delirium victim.

Thus identifying how this study has absolutely NO RELATIONSHIP to "real life" restraint application considerations.

YOURS, CHAS
(Ms. Charly D. Miller)

Weight Force During Prone Restraint and Respiratory Function

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Abstract: Prone maximal restraint position (PMRP, also known as hogtie or hobble) is often used by law enforcement and prehospital personnel on violent combative individuals in the field setting. Weight force is often applied to the restrained individual's back and torso during the restraint process. We sought to determine the effect of 25 and 50 lbs weight force on respiratory function in human subject volunteers placed in the PMRP. We performed a randomized, cross-over, controlled trial on 10 subjects placed in 4 positions for 5 minutes each: sitting, PRMP, PRMP with 25 lbs weight force (PMRP+25), and PRMP with 50 lbs weight force placed on the back (PMRP+50). We measure pulse oximetry, end-tidal CO_2 levels, and forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1). FVC and FEV1 were significantly lower in all restraint positions compared with sitting but not significantly different between restraint positions with and without weight force. Moreover, mean oxygen saturation levels were above 95% and mean end-tidal CO_2 levels were below 45 mm Hg for all positions. We conclude that PMRP with and without 25 and 50 lbs of weight force resulted in a restrictive pulmonary function pattern but no evidence of hypoxia or hypoventilation.

Key Words: restraint, weight force, respiratory function

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Law enforcement and prehospital care personnel often confront violent, dangerous individuals who must be physically restrained to insure the safety of the individual, as well as those around them. A number of physical restraint techniques have been developed to subdue and control such individuals in the field.[1–3] The prone maximal restraint position (PMRP, also known as hobble or hogtie) position has been used extensively by field personnel. This position places a subject prone with wrists handcuffed behind the back, ankles bound together, and wrists and ankles secured together by means of as strap or other device.

Because of reports of the sudden deaths of individuals placed in this restraint position, controversy has arisen regarding the PRMP.[4–7] Some have argued the position adversely impacts respiratory function and places individuals at risk for a so-called "positional" or "restraint" asphyxiation by restricting chest and abdominal movement.[5,8] We previously conducted a study which found that PMRP by itself resulted in a small restrictive pattern on spirometry but had no impact on oxygenation or ventilation in healthy subjects.

It has been suggested that additional weight force pressure placed on the back of individuals during the restraint process can impede chest and abdominal movement further. Some have argued that it is this additional pressure on the torso, along with the PMRP, that causes chest and abdominal constriction and respiratory compromise leading to asphyxiation.[9] In this study, we sought to investigate the impact of weight force on the back on the respiratory function and physiology of individuals placed in PMRP.

METHODS

We conducted a randomized, cross-over, controlled trial at a University Medical Center pulmonary function laboratory. Ten volunteer male subjects between the ages of 18 and 45 years were recruited to participate in the study. Potential subjects were excluded if they were unable to be placed in PMRP. No exclusion was made on the basis of pulmonary or cardiovascular disease or function, or based on body size and weight.

Each subject was placed into 4 different positions: sitting, PMRP with no weight force, PMRP with 25 lbs of weight force on the back (PMRP+25), and PMRP with 50 lbs of weight force on the back (PMRP+50). Subjects were placed in these positions in random order. For the sitting

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position, the subject sat in a chair with feet flat on the floor and back upright against the back of the chair. In the PMRP without weight force, the subject was placed prone on their stomach with head turned to the side on a medical examination table. The subject's wrists were bound together behind the back by means of law enforcement handcuffs. The subject's ankles were bound together and drawn up near the wrists be means of a police restraining cuff device used by local law enforcement, known as the maximal restraint cuff. In PMRP+25, the subject was placed in PMRP and a 25-lb sandbag was placed on the back of the subject between the scapulas. In PMRP+50, the subject was placed in PMRP and a 40-lb sandbag was placed on the back of the subject between the scapulas (Fig. 1). Subjects remained in each position for 5 minutes. After each 5-minute period, the subject rested in the sitting position for 10 minutes before starting the next trial.

Spirometric pulmonary function testing was performed at 1 and 5 minutes into each position for every subject. Measurements of forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1) were obtained using a Medgraphics Cardiopulmonary Diagnostic System (Medical Graphics Corporation, St. Paul, MN) in accordance with the American Thoracic Society's standards for reproducibility and acceptability.[10] Raw spirometric data were converted to percent predicted (%predFVC and %predFEV1) for each subject to normalize for height, gender, age, and race as per standard practice.[11]

Oxyhemoglobin percent saturation (SpO_2) was monitored using a pulse oximeter sensor placed on the index finger (Ohmeda Biox 3740 Pulse Oximeter, Datex-Ohmeda, Helsinki, Finland). Expired end-tidal CO_2 ($etCO_2$) levels were monitored by means of a quantitative CO_2 detector using a Medgraphics Cardiopulmonary Exercise System CPX/D, Medical Graphics Corporation, St. Paul, MN). SpO_2 and $etCO_2$ measurements were recorded every 30 seconds during the 5-minute period for each position.

Statistical analysis was performed using an analysis of variance for repeated measures, with position and time as factors. A probability value of less than 0.05 was considered statistically significant. Data analysis was performed by means of a computerized statistical software package software package (STATA 6.0).

Clinically, data were also analyzed as absolute values in comparison with normal values defined prior to the start of the study. Hypoxemia was defined as SpO_2 less than 95%. Hypercapnia was defined as $etCO_2$ levels greater than 45 mm Hg. Spirometric measurements were considered abnormal if they fell below 1.65 standard deviations of established predicted values. The research design and methods of this study were approved by our University Human Subjects Committee and institutional review board.

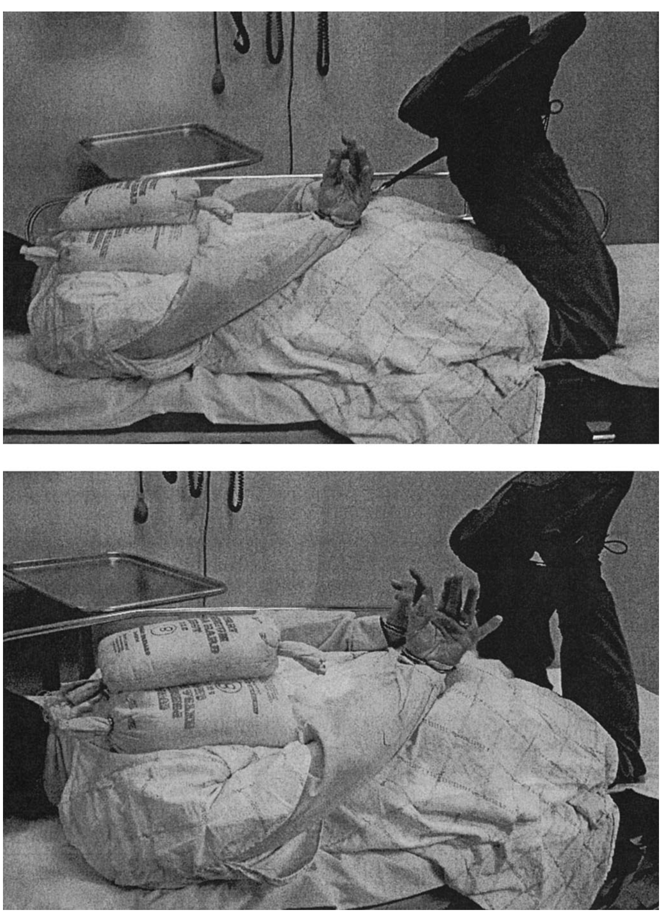

FIGURE 1. Top, Bottom, Subject placed in PMRP with weight force on back.

RESULTS

All 10 subjects recruited for this study completed each of the 4 position trials. Subjects ranged in age from 21 to 40 years, and body mass index ranged from 21.3 to 35.3 kg/m^2. There were no exclusions of any participant or subject data. At 1 minute into each position, mean %predFVC was lower for all restraint positions when compared with sitting: 101% [95% confidence interval (CI) 91.6%-110%] for sitting compared with 87.1% [CI 79.7%-94.6%] for PMRP, 84.7% [CI 76.9%-92.5%] for PMRP+25, and 84.2% [CI 75.5%-93.0%] for PRMP+50. However, there was no difference in mean %predFVC in the PMRP or PMRP with additional weight force of 25 or 50 lbs (Fig. 2). Similarly, mean %predFEV1 was lower for all restraint positions when compared with sitting: 98.2% [CI 89.6%-107%] for sitting compared with 83.4% [77.6%-89.2%] for PMRP, 81.0% [CI 73.5%-88.6%] for PMRP+25, and 80.1% [72.1%-88.1%] for PMRP+50. Again, there was no difference in mean %predFEV1 in the PMRP with and without additional weight force of 25 or 50 lbs (Fig. 3).

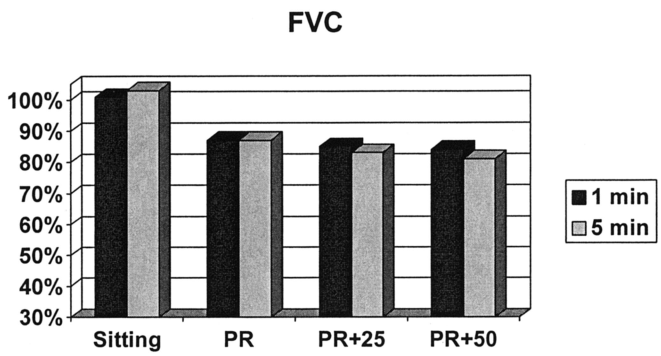

FIGURE 2. Mean %predFVC for subjects at 1 and 5 minutes into each position.

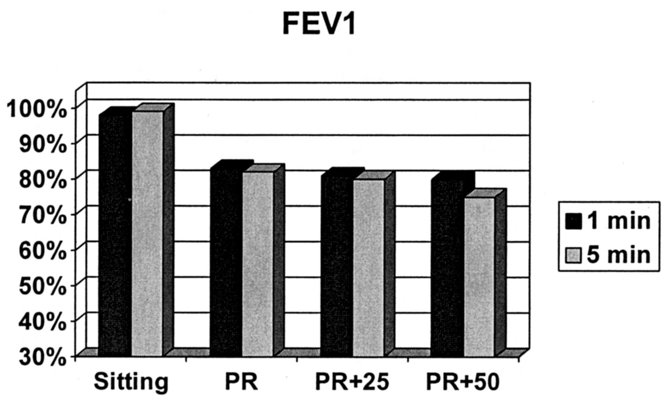

FIGURE 3. Mean %predFEV1 for subjects at 1 and 5 minutes into each position.

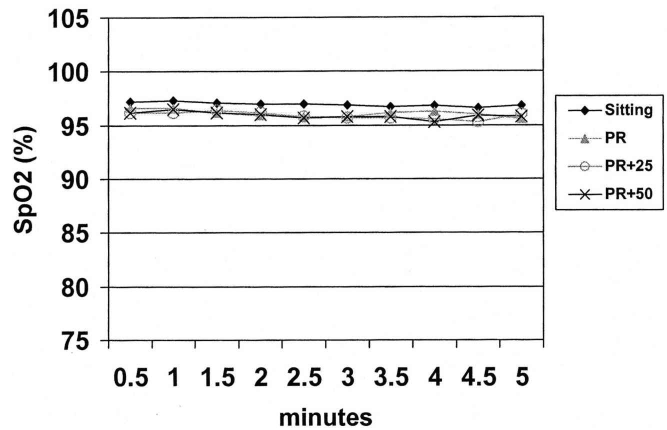

FIGURE 4. SpO_2 during each 5-minute restraint period.

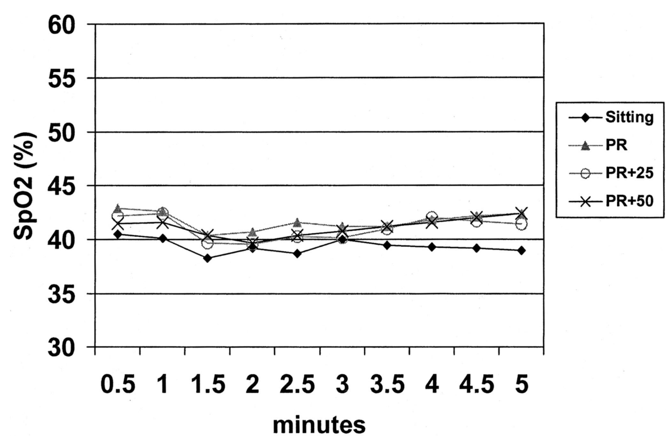

FIGURE 5. SpO_2 during each 5-minute restraint period

At 5 minutes into the position, mean %predFVC was significantly lower for all 3 PMRP position compared with sitting, but there was no difference between the restraint positions with and without weight force: 103% [CI 92.6%-112%] for sitting, 86.8% [CI 79.7%-93.8%] for PMRP, 82.5% [CI 74.0–90.9%] for PMRP+25, and 80.5% [CI 72.5%-88.5%] for PMRP+50 (Fig. 2). Similar findings were seen for % predFEV1 at 5 minutes: 99.3% [CI 90.1%-108%] for sitting, 82.2% [CI 75.0%-88.9%] for PMRP, 79.5% [CI 70.9%-88.0%] for PMRP+25, and 75.0% [CI 66.6%-82.8%] for PRMP+50 (Fig. 3).

Clinically, mean SpO_2 levels remained above 95% and revealed no evidence of hypoxemia throughout the 5-minute trials for each position (Fig. 4). Similarly, $etCO_2$ levels remained below 45 mm Hg and revealed no evidence of hypercapnia throughout the 5-minute trails for each position (Fig. 5).

DISCUSSION

Although sudden deaths have clearly occurred in individuals placed in the hobble, hogtie, or PMRP, the cause of death and the actual role of body position remain controversial. Some have argued that the PMRP prevents adequate chest wall, abdominal, and diaphragmatic movement, leading to hypoventilatory respiratory compromise and risk for death from so-called positional asphyxia.[12] However, case reports and case series of the sudden deaths of restrained individuals do not clearly indicate a specific mechanism.[4–7] Historical as well as autopsy evidence is often unrevealing as to a clear cause of death. Importantly, similar sudden deaths have been reported in patients who were not restraint in the PMRP, but simply in the prone, supine, lateral side, and even sitting positions.[13,14] As a result, some have argued that factors such as drug intoxication, excited delirium, trauma, stress, and catecholamine hyperstimulation are more important causes of sudden death rather than asphyxiation from body position.[15,16]

The theory of positional asphyxia as it relates to sudden deaths in restraint cases has been based primarily on the physiologic study of Reay et al,[8] who found that healthy individuals had a delayed recovery in oxygen saturation following mild exercise. However, this study was limited by the fact that a decrease in oxygen saturation was documented during mild exercise, in opposition to well-established exercise physiology work that has shown arterial oxygenation improves with exercise.[17]

We conducted a more comprehensive randomized physiologic study measuring arterial oxygenation as well as ventilation parameters, including spirometry and CO_2 levels. We found no evidence of desaturation or hypoxia during exercise or PMRP. More importantly, while there was a progressive restrictive pattern on spirometric measurements from sitting to supine to prone to PMRP positions, there was no evidence of hypoventilation or hypercapnia.[18] Other studies have confirmed our spirometric and respiratory measures in relation to PMRP.[19] Additionally, other investigators have not shown evidence of hypoxia or oxygen desaturation as a result of PMRP or restraint body position.[20–22] As a result, many now argue that “the hog-tied prone position should be viewed as not producing significant physiologic respiratory compromise, and it does not produce any serious or life-threatening respiratory effects.”[9]

While body position by itself may not cause asphyxiation, others now argue that PMRP in combination with additional chest and abdominal compression during the restraint process could cause hypoventilatory respiratory compromise.[9] Proponents of this “restraint asphyxia” theory (as opposed to “positional asphyxia”) argue that weight force often applied to the back of an individual restrained in the prone position during the restraint “take-down” process could potentially cause greater constriction of the torso and decrement in ventilatory function to the point of asphyxiation.[23]

Deaths from the application of weight to the torso have been described in the medical literature.[23] The term *traumatic* or *mechanical asphyxiation* has been applied to cases in which extreme weight force was applied to individuals, such as when an automobile runs over the torso of an individual. However, in these cases, there is often pathologic evidence of chest trauma (pulmonary contusion, rib fractures) or increased intrathoracic pressure affecting venous return and cardiovascular function (plethoric facies, edema, and ruptured small blood vessels above the shoulders).[24]

In this study, we sought to determine if additional weight force on the back of an individual in the PMRP resulted in any evidence of respiratory compromise or risk for asphyxiation. Similar to previous studies, we found a restrictive pulmonary function pattern with PMRP but no significant further detriment in spirometric measures of FVC and FEV1 with the addition of 25 and 50 lbs of weight force on the back. More importantly, we found no evidence of hypoxia, oxygen desaturation, hypercapnia, or CO_2 retention from hypoventilation in the PMRP with the additional weight force.

Our study has limitations. First, as this was a laboratory physiology study, we could not reproduce all conditions encountered in the field setting with such cases. In particular, we did not simulate trauma, struggle, drug intoxication, and other physiologic and psychologic stresses that commonly occur with individuals who are being restrained in the field setting.

Second, the amount of weights selected for this study may not reproduce the actual amount of weight force used on individuals during the restraint process. It is possible that heavier amounts of weights would have impacted respiratory function to a greater degree. Similar to traumatic or mechanical asphyxia cases, extreme amounts of weights could have resulted in significant chest wall trauma and marked elevations in intrathoracic pressure that could have impacted cardiovascular function. To our knowledge, this is the first laboratory investigation studying the effects of weight force during restraint. As a result, we chose weight amounts which we felt would approximate weight force used in the field setting, heavy enough to indicate any trends if respiratory function was impacted, but not so heavy as to potentially place our subjects at risk for injury.

CONCLUSION

We conducted a study on the impact of weight force placed on the back of individuals in the PMRP on pulmonary and respiratory function. We found that weight force of 25 and 50 lbs did not result in evidence of hypoxia or hypoventilatory respiratory compromise in our study subjects.

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