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What evidence exists about the safety of
physical restraint when used by law
enforcement and medical staff to control
individuals with acute behavioural
disturbance?

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THE CLEARING HOUSE FOR HEALTH OUTCOMES AND
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LEVEL OF EVIDENCE CONSIDERED IN TECH BRIEFS

Tech Briefs are rapidly produced assessments of the *best available evidence* for a topic of highly limited scope. They are less rigorous than systematic reviews. Best evidence is indicated by research designs which are least susceptible to bias according to the National Health and Medical Research Council's (NHMRC) criteria (see **Appendix 1**).

Where methodologically acceptable and applicable, appraised evidence is limited to systematic reviews, meta-analyses, evidence-based clinical practice guidelines, health technology assessments and randomised controlled trials (RCTs). Where not available, poorer quality evidence may be considered.

CONFLICT OF INTEREST

None

BACKGROUND

This Tech Brief was requested by Anthony Duncan, Deputy Director of Mental Health, Ministry of Health, New Zealand Government.

The decision whether or not to use physical restraint on acutely behaviourally disturbed persons in crisis situations presents police and medical staff with the risks of using such restraint versus the risks of not. The term physical restraint includes physical force and mechanical devices that involuntarily restrict movement or control behaviour (Busch and Shore, 2000). More extreme restraint hold methods known as “hog-tying” in which wrists and ankles are bound together behind the back and “choke” or “neck” holds have been used particularly in US law enforcement settings (Morrison and Sadler, 2001). The risks of using physical restraint including sudden death while under restraint have been well documented over the past 20 years, particularly in forensic, emergency medicine and psychiatric literature. This includes empirical studies of varied methodological rigour, observational case studies, policy guidelines, expert opinion and theoretical hypotheses (Fisher, 1994).

The most common cause of death proximal to physical restraint is asphyxiation, which has been termed “restraint” or “positional” asphyxia in the literature. These terms have been used somewhat interchangeably, although “restraint” asphyxia has tended to be used to describe deaths in police custody of physically restrained adults who were alcohol or drug intoxicated, or suffering from extreme mania or severe mental illness. These deaths involve a combination of circumstances in which “restraint” has a possible part in causing asphyxiation (Paterson et al. 1998). The term “positional” asphyxia is more specific and relates to the possible role of body position as a risk factor in these deaths (Mohr and Mohr, 2000). Researchers have postulated that inescapable prone restraint position interferes with diaphragmatic movement, ventilatory function and breathing leading to asphyxiation and death (Chan et al. 1998).

The risks of not using physical restraint in contrast are possible serious injury to the behaviourally disturbed person, to others around them or to property. Although there has been abundant literature addressing the possible harms of physical restraint use, little has been written examining the benefits of its use (Connick et al. 2000).

A well publicised case in New Zealand of physical restraint related positional asphyxiation was that of Mathew Innes. His death in 1994 after being transported by police to Kingseat Hospital resulted in a Commission of Inquiry into the circumstances surrounding his death. This concluded that there was a struggle with police, he was restrained and handcuffed behind his back or head in a distressed state and physically restrained during police transport and either through the restraint or accidentally, Mathew became asphyxiated and died one week later in Middlemore Hospital. The so called “Innes Inquiry” recommended that the Mental Health Service and Police instruct staff about positional asphyxia and the dangers of transporting a person in a prone position and instruct staff about appropriate methods of transportation and monitoring. It also recommended that staff training in calming and restraint techniques be investigated (Mason, 1994).

The focus of this Tech Brief is to review what evidence exists about the safety of physical restraint when used by law enforcement, mental health and emergency department staff to control individuals with acute behavioural disturbance requiring immediate response.

SELECTION CRITERIA

Study inclusion criteria

Publication type

Studies published between January 1980 and May 2002 inclusive in the English language, including primary (original) research (published as full original reports) and secondary research (systematic reviews and meta-analyses) appearing in the published literature.

Context

Studies reporting on the use of physical restraint by law enforcement, emergency department and mental health staff on persons exhibiting acute behavioural disturbance requiring immediate response. Experimental studies evaluating the physiological impact of physical restraint on healthy volunteers.

Population of interest

Persons with acute behavioural disturbance requiring urgent physical restraint. Healthy volunteers used in experimental studies.

Acute behavioural disturbance includes extreme agitation, aggression, excitability, disruptive, violent, hostile and destructive behaviour, paranoia, great strength, non-pain compliance, drug/alcohol induced behaviours, psychiatric illness, intellectual disability.

Setting

Use by law enforcement officers in community settings, emergency department staff and mental health staff within inpatient settings.

Intervention

Physical restraint defined as where the movement of a person's body (whole or part) is involuntarily restricted/immobilized by the use of physical force OR external mechanical devices to protect him/herself from injuring self or others or damaging property.

Physical force is inclusive of pre-restraint struggle and takedown, basket holds, floor holds, face-down restraint, hog-tie/hobble/prone maximal restraint, choke/neck holds and other related physical restraint methods.

External mechanical devices include straps, belts, wrist (handcuffs) and ankle cuffs, restrictive clothing such as straitjackets or cloth devices.

Outcomes

Mortality such as death caused by strangulation, asphyxiation or trauma. Morbidity such as pressure ulcers, thrombosis, neuropathy, fractures, bruising, and adverse effects such as psychological distress.

Study design

Systematic review or meta-analysis
Randomised controlled trial (RCT)
Cohort study
Case-control study
Descriptive study (case series, chart review)

Sample size

Studies with at least 10 participants.

Study exclusion criteria

- study population is geriatric patients in a geriatric health care setting
- where the types of restraint are adaptive devices used for postural support, medical and protective immobilization devices used during medical procedures and protective devices used to protect patients from a fall
- study considers physical restraint combined with chemical restraint and/or seclusion and are not separately evaluated
- study has abstract only available
- study is a case review with fewer than 10 cases
- study is expert opinion commentary, a narrative review or book chapter
- study is a qualitative evaluation of staff and/or patient attitudes/experiences with physical restraint
- study is presented as a letter, editorial or comment article
- study did not clearly describe methods and results or had significant discrepancies.

MAIN SEARCH TERMS

Details of the search strategy are presented in **Appendix 2**.

- index terms from Medline: restraint, mental disorders, violence, aggression, self-injurious behavior, police, emergency service-hospital, emergency medical services, emergency services-psychiatry, asphyxia
- index terms from Embase: immobilization, safety, police, aggression, agitation, violence, emergency, emergency health service, emergency ward, emergency medicine, emergency treatment, psychiatric treatment, asphyxia, sudden death
- index terms from Psychinfo: physical restraint, emergency services, violence, patient violence, dangerousness, crisis intervention services, anoxia, agitation, safety
- the above index terms were used as keywords in databases where they were not available and in those databases without controlled vocabulary
- additional keywords (not standard index terms) were used in all databases: restraint, positional asphyxia, agitat\$, emergenc\$.

SEARCH SOURCES

The NZHTA CORE Search was employed. Characteristics of the Core search include: essential sources only, major databases and secondary sources, and mostly published and indexed literature. For more detail about the search sources refer to the NZHTA Search Protocol at <http://nzhta.chmeds.ac.nz/nzhtainfo/protocol.htm> Steps 1-9 (Core sections).

Bibliographic databases

Medline
 Premedline (via Pubmed)
 Embase
 Cinahl
 Current Contents
 Psychinfo
 Science/Social Science Citation Index
 Cochrane Controlled Trials Register
 Index New Zealand
 Proquest

Review databases

Cochrane Database of Systematic Reviews
 Best Evidence
 NHS Centre for Reviews and Dissemination databases (DARE, NHS Economic Evaluation, Health Technology Assessment)

Library catalogues

New Zealand bibliographic database – Te Puna
 US National Library of Medicine
 British Library
 COPAC - combined catalogues of major academic libraries in UK & Ireland
 World Health Organisation
 University of Sydney
 NZ Ministry of Health
 North Thames NHS Regional Catalogue

Websites

Australasia
 New Zealand Ministry of Health
 NZHTA in-house collection and archive
 Australian Department of Health & Aged Care
 Royal Australian and New Zealand College of Psychiatrists
 Australian Institute of Criminology publications

UK

Royal College of Psychiatrists
 Department of Health publications
 TRIP database
 Organised Medical Networked Information (OMNI)
 Police Complaints Authority

United States

American Psychiatric Association
 Centers for Disease Control
 National Criminal Justice Reference Service
 Guidelines.gov
 Primary Care Guidelines
 National Commission on Correctional Health Care

Canada

Health Canada
 Correctional Service Canada
 Canadian Medical Association Infobase

Search engines

Google

Major guideline websites

Articles published in English language only were considered.

The search was restricted to literature published since 1980. Searching was undertaken during May 2002.

APPRAISAL METHODOLOGY

Summaries of appraisal results will be shown in tabular form (known as *Evidence Tables*) which detail study design, study setting, sample, methods, results, reported conclusions and NZHTA reviewer conclusions/comments based on the limitations and validity of the study.

The evidence presented in the selected studies were assessed and classified according to the NHMRC's revised hierarchy of evidence (**Appendix 1**).

RESULTS

From the above search strategy we identified, 218 potentially relevant articles/abstracts of which 58 were retrieved. Of these retrieved articles, 45 were excluded. These studies, annotated with a brief summary and the reason for exclusion, are presented in **Appendix 3**. Studies were excluded for the following reasons: sample size less than 10 cases (14 studies); narrative review (11 studies); expert opinion (seven studies); physical restraint of the elderly (four studies); no data on safety or adverse outcomes (three studies); pepper spray use governed case selection and physical restraint was a secondary outcome (two studies); qualitative survey on physical restraint (one study); no description of study methodology (one study); letter to the editor (one study) and accidental asphyxiation, not relevant to the topic (one study).

Thirteen retrieved articles were appraised (listed in **Appendix 4**). Included papers are presented in each evidence table below in alphabetical order. One included study was a systematic review and graded as level 1 according to the NHMRC's hierarchy of evidence (**Table 1, page 6**). The remaining studies were all graded as level IV evidence including four quasi-experimental studies with a pre and post-test design (**Table 2, pages 7 - 10**) and eight case series reviews (**Table 3, pages 11 - 18**).

Table 1. Evidence table of a systematic review relating to physical restraint in mental health settings

Authors Country Evidence Grading	Sample and Interventions	Methods	Results	Limitations and Conclusions
Sailas and Fenton (2000) Helsinki, Finland Grade: Level 1	<p>Study setting Cochrane Schizophrenia Group.</p> <p>Participants Persons with serious or chronic mental illness.</p> <p>Intervention Restraint defined as restricting patients ability to move by using different design purpose devices or holding down by physical force.</p> <p>Other interventions not relevant to this appraisal include seclusion and prevention of seclusion and restraint use.</p> <p>Comparator Standard care or other alternative interventions.</p>	<p>Study design Systematic Review.</p> <p>Electronic searches from Medline 1966-1999, Cinahl 1982-1999, Embase 1980-1999, Psyclit 1974-1999, Cochrane CT register Issue 1 1999, Cochrane Schizophrenia Group register January 1999, Medic 1979-1999, Biological Abstracts 1989-1999, Sociofile 1974-1999, SPRI & Swemed 1982-1999, Ssci 1996-1999, hand searching reference lists in studies and conference abstracts.</p> <p>Inclusion criteria Randomised Controlled Trials (RCTs) with focus on use of physical restraint (or seclusion) or strategies designed to reduce use of physical restraint (or seclusion) in treatment of serious mental illness.</p> <p>Exclusion criteria People with dementia, illness related cognitive impairment other than psychotic disorders, trials focusing on restraining the elderly from wandering.</p> <p>Outcome measures Relevant measures including physical adverse effects, death, suicide or by other causes, psychological adverse effects.</p>	<p>The search strategy produced 2,155 citations of which 35 articles were retrieved. No studies met the minimum inclusion criteria and no data was synthesized.</p> <p>Most studies focused on restraining elderly confused people to prevent wandering or falls.</p> <p>Author's conclusions There is a complete lack of any controlled trials and no recommendation can be made as to the potential harms or benefits of physical restraint of those with a serious mental illness.</p> <p>Reports of serious adverse effects from restraint (and seclusion) have been reported in qualitative reviews. Alternatives need to be developed.</p> <p>Further research through well designed randomised trials is needed.</p>	<p>Study aim Cochrane group systematic review to estimate the effects of restraint (and seclusion) compared to alternatives for people with a serious mental illness.</p> <p>Limitations Extensive and adequate search strategy and search terms, use of two independent reviewers, consistent application of inclusion and exclusion criteria, study quality assessment, detailed review methodology and summary of findings.</p> <p>Conclusion Comprehensive and rigorous systematic review highlighting the lack of controlled trials addressing the risks and benefits of physical restraint, although adverse effects have been reported in qualitative literature.</p>

Table 2. Evidence table of appraised articles relating to physical restraint safety testing under experimental conditions

Authors Country Evidence Grading	Sample and Interventions	Methods	Results	Limitations and Conclusions
Chan et al. (1997) California, USA. Grade: Level IV	<p>Study setting University-based pulmonary function laboratory.</p> <p>Participants 15 male volunteers, age range 18-40.</p> <p>Intervention Two-phase study where respiratory measurements were obtained from subjects randomly assigned all of either a sitting, supine, prone, restraint ("hobble" or "hog-tie") positions.</p> <p>Then following a four minute exercise period subjects were tested after 15 minutes in a sitting and rested position for pulse, oxygen saturation and arterial blood gases were monitored. Subjects repeated the four minute exercise period and were placed in a restraint position for 15 minutes and similarly monitored.</p> <p>Comparator Subject rested in seated position.</p>	<p>Study design Quasi-experimental crossover study with pre and post test design.</p> <p>Inclusion criteria Good health.</p> <p>Exclusion criteria Positive urine toxicology screen Body Mass Index (BMI) > 30 kg/m² Abnormal pulmonary functioning test.</p> <p>Outcome measures Forced Vital Capacity (FVC) Forced Expiratory Volume in one second (FEV1) Maximal Voluntary Ventilation (MW)</p> <p>Pulse, oxygen saturation and arterial blood gases monitoring measured by pulse oximetry and co-oximetry.</p> <p>Follow-up interval Measurements at 15 minute intervals for seated and restraint positions.</p>	<p>Small statistically significant decline ($p < 0.001$) in respiratory indicators (mean % predicted FVC, FEV1 and MW) when comparing restraint ("hobble" or "hog-tie") with sitting position.</p> <p>Pulmonary Function Testing (PFT) did not fall below 80% PV and were considered to be clinically normal.</p> <p>No evidence of hypoxia (mean oxygen tension $PO_2 < 95$ mm Hg) or (co-oximetry < 96%) in either position.</p> <p>No difference in mean carbon dioxide tension between groups after 15 minutes rest in sitting or restraint position.</p> <p>No significant difference between groups in heart rate recovery or oxygen saturation in sitting or restraint position.</p> <p>Author's conclusion In the study, population restraint position resulted in a restricted pulmonary function pattern but did not result in clinically significant changes in oxygenation or ventilation.</p>	<p>Study aim Experimental study evaluating post-exercise ventilatory function and gas exchange of healthy volunteers in sitting, and restraint ("hog-tie" or "hobble") positions.</p> <p>Limitations Limited generalisability to real physical restraint situation as laboratory setting and controlled conditions.</p> <p>Subject selection bias, paid healthy male volunteers not representative of restraint subjects in medical and law enforcement settings, small sample size, demographic features not well described.</p> <p>Possible measurement bias in restraint group from residual metabolic and respiratory abnormalities from first exercise and rest period. Sitting rest and restraint rest periods not randomised.</p> <p>Conclusion The role of body position alone and positional asphyxia cannot be clearly demonstrated from this study as applicable to actual physical restraint situations.</p>

Table 2. Evidence table of appraised articles relating to physical restraint safety testing under experimental conditions (continued)

Authors Country Evidence Grading	Sample and Interventions	Methods	Results	Limitations and Conclusions
Parkes (2000) Leicester, UK. Grade: Level IV	Study setting Medium-secure mental health hospital. Participants 16 nurse volunteers, valid data for 13. Mean age 35 years (range 25-49), mean Body Mass Index (BMI) 27 (range 21-34.5), 9/13 smokers, 4/13 no exercise, 9/13 at least weekly aerobic exercise. Intervention Bike exercise until pulse rate 120 beats/min then randomly placed in each of a seated (control) position, supine restraint or prone restraint position on floor. Comparator Subject in each other position.	Study design Quasi-experimental study with before and after design. Inclusion criteria Good health, nursing staff who had completed a control and restraint course. Exclusion criteria Unreliable finger-mounted oximeter readings in three subjects, changed to ear-located probe. Outcome measures Repeated measures of rates of recovery from exercise using pulse oximetry and oxygen saturation levels in each position. Follow-up interval None.	No significant difference in recovery time between supine restraint, prone restraint and seated control positions. Significantly ($p < 0.05$) longer recovery time for prone restraint compared with supine restraint position. The supine restraint position recorded shorter recovery time than seated control position, but no significant difference. No significant or consistent lowering of oxygenation levels during exercise found, recovery rate for oxygen saturation could not be calculated. Author's conclusion A highly resistive subject in prone restraint position may have greater difficulty breathing than in supine position and that position may be a contributing factor to death during a restraint situation.	Study aim Experimental study evaluating post-exercise recovery times of healthy volunteers in supine, prone restraint and seated positions. Limitations Limited generalisability to real physical restraint situation, laboratory setting and controlled conditions. Subject selection bias, healthy volunteer nurses working in mental health not representative of restraint subjects in mental health settings. Possible measurement bias from ear-oximeter readings cited from literature, investigators forced to use this due to difficulties with finger probe oximetry. Also possible residual metabolic and respiratory effects from each set of exercise and rest position. Small sample size and method of randomisation to restraint position not described. Conclusion Due to limitations study does not clearly demonstrate a relationship between prone/supine restraint body position and greater recovery time from exercise. Therefore, no strong inference can be made that this translates into real risk of death due to body position during physical restraint.

Table 2. Evidence table of appraised articles relating to physical restraint safety testing under experimental conditions (continued)

Authors Country Evidence Grading	Sample and Interventions	Methods	Results	Limitations and Conclusions
Reay et al. (1988) Seattle, USA. Grade: Level IV	<p>Study setting University-based pulmonary function laboratory.</p> <p>Participants 10 healthy persons, age range not specified, 80% male.</p> <p>Intervention Baseline measurements of peripheral oxygen saturations and heart rate monitoring of subjects at rest in seated position. Subjects exercised using the leg motion component of cross-country ski machine until heart rate exceeded 120 beats/min, then stopped and went back to seated rest position.</p> <p>Sequence then repeated for each subject (baseline measurements and exercise to heart rate of > 120 beats/min) then subject took up prone position and was handcuffed with hands behind back, ankles were bound together and secured to the handcuffs (hog-tie position).</p> <p>Comparator Subject at rest in seated position.</p>	<p>Study design Quasi-experimental study with pre and post-test design.</p> <p>Inclusion criteria None specified.</p> <p>Exclusion criteria None specified.</p> <p>Outcome measures Oxygen saturation and heart rates were monitored continuously measured by pulse oximeter and ear lobe probe.</p> <p>Follow-up interval Continuous measurements until baseline oxygen saturation and steady heart rate returned.</p>	<p>Data comparing mean control and test periods (minutes) of recovery using oxygen saturation and heart rates.</p> <p>Mean recovery oxygen saturation period was longer under restraint conditions in 9 out of 10 subjects. Increases from 2%-469% over control intervals, all significantly different, $p < 0.05$.</p> <p>Mean recovery heart rate period was longer under restraint conditions in 8 out of 9 subjects. Increases from 2%-469% over control intervals, all significantly different, $P < 0.05$.</p> <p>Author's conclusion The study findings show restraint position can prolong recovery from exercise using peripheral oxygen saturation and heart rate measures though these mechanisms remain unclear. Restraint has measurable physiologic effects.</p>	<p>Study aim Experimental study evaluating post-exercise peripheral oxygen saturation and heart rate in healthy subjects in sitting and restraint hog-tie positions.</p> <p>Limitations Limited generalisability to real physical restraint situation as laboratory setting and controlled conditions.</p> <p>Subject selection bias, healthy subjects not representative of restraint subjects in medical and law enforcement settings, small sample size, demographic features and medical histories not described.</p> <p>Possible measurement bias due to reliance on ear-probe pulse oximetry during exercise, debate in literature regarding test validity.</p> <p>Authors reported decreases in oxygen saturation to 85% to 90% in healthy subjects after exercise, a questionable result given exercise physiology literature showing improvements from ventilation. Also no direct measures of ventilatory function were performed.</p> <p>Conclusion In view of study limitations no definitive inference can be made that prolonged recovery times due to physical restraint translate to a real risk of positional asphyxia in actual restraint situations.</p>

Table 2. Evidence table of appraised articles relating to physical restraint safety testing under experimental conditions (continued)

Authors Country Evidence Grading	Sample and Interventions	Methods	Results	Limitations and Conclusions
Schmidt and Snowden (1999) California, USA. Grade: Level IV	<p>Study setting San Diego Regional Public Safety Training Institute.</p> <p>Participants 18 (12 male, 6 female) healthy student volunteers from a regional public safety training institute, age range 21-42 years, all non-smokers, body weight range 50.5 kg-104.5 kg, low to moderate aerobic fitness.</p> <p>Intervention Phase 1: subjects were randomly assigned to either seated unrestrained position or 'hog-tie' position and switched after 15 minutes. Experiment beginning with cycle exercise until steady heart beat > 120 beats/min achieved then immediately placed in seated or restraint position and post-exercise assessments performed. Phase 2: subjects were paired off into role plays of either 'peace officer' or 'suspect' and simulated a pursuit (for 250 meters) and restraint (wrestling for 1 minute) and then 'peace officer' placed unrestrained in seat and 'suspect' placed in maximal restraints position (prone position, handcuffing behind the back, cord-cuffing ankles and waist, connecting ankle and waist cords on front of suspect) and rolled on side, suspect struggled with restraints for 30 seconds.</p> <p>Comparator Subject rested and seated unrestrained positions.</p>	<p>Study design Quasi-experimental, study with pre and post-test design.</p> <p>Inclusion criteria None specified.</p> <p>Exclusion criteria None specified.</p> <p>Outcome measures Phase 1: heart rates and oxygen saturation levels measured every 15 seconds during a 5 minute recovery period using portable electromagnetic heart-rate monitors and a finger probe oxygen saturation analyzer.</p> <p>Phase 2: resting oxygen saturation for both players were measured in seated unrestrained position and alternative maximal restraint after simulated pursuit and struggle scenario immediately at 15 second intervals for a 5 minute recovery period. After rest period (30 minutes minimum). Recovery heart rates monitored but not used as exercise intensity not controlled</p>	<p>Phase 1: post-exercise mean heart rates recovering in either seated or 'hog-tie' positions were not significantly different for minutes 1 to 5 when compared on minute by minute basis.</p> <p>Mean oxygen saturation levels were not significantly different between any position during recovery minutes 2, 3, and 4. For minute 1 with significant difference ($p<0.05$) between 'hog-tie' and other the two positions which were similar. For minute 5, resting and 'hog-tie' restraint oxygen saturation were similar but differed significantly ($p<0.05$) from seated unrestrained position.</p> <p>Small statistically significant ($p<0.05$) mean oxygen saturation differences (~1%) were found in both phase 1 and 2 between resting positions, seated unrestrained, 'hog-tie' and maximal restraint positions.</p> <p>Author's conclusion Within the study population the use of 'hog-tie' and alternative maximal restraint position did not result in any clinical restrictions to heart rate or oxygen saturation recoveries.</p>	<p>Study aim Experimental study examining effects of positional restraint on heart rate and oxygen saturation during recovery from exercise.</p> <p>Limitations Limited study generalisability to real physical restraint situation because of laboratory setting and controlled conditions.</p> <p>Subject selection bias, healthy volunteers not representative of restraint subjects in medical and law enforcement settings, small sample.</p> <p>Possible measurement bias due to use of finger probe pulse oximetry to estimate oxygen saturation, brief test periods, possible residual metabolic abnormalities from phase 1 influencing phase 2 outcomes.</p> <p>Conclusion No definite inference can be made from this study regarding the role of body position in "hog-tie" restraint and recovery from exercise as applicable to real risk in actual physical restraint situations.</p>

Table 3. Evidence table of appraised articles relating to physical restraint safety from case series reviews

Authors Country Evidence Grading	Sample and Interventions	Methods	Results	Limitations and Conclusions
Grant and Cook (2000) Georgia, USA Grade: Level IV	<p>Study setting Emergency ward or neurology clinic in urban teaching hospital.</p> <p>Participants 41 patients with presenting complaint of hand numbness, paresthasias, weakness attributed to handcuffing. Recruitment period, October 1995 to December 1997. Mean age 37 years, 90% male. 35 patients presented in emergency ward in police custody complaining of acute handcuff related symptoms, the other 6 presented in the neurology clinic and attributed their symptoms to remote handcuffing by a police officer.</p> <p>Intervention of interest Application of handcuffs and resultant injury.</p> <p>Comparison group None.</p>	<p>Study design Prospective case series review.</p> <p>Inclusion criteria Patients with presenting complaints of hand sensory or motor dysfunction attributed to handcuffing.</p> <p>Exclusion criteria Neuropathies resulting from a history of non-handcuff dysfunction.</p> <p>Outcome measures Electrodiagnostic testing (Edx), nerve abnormality as determined by electrophysiology, clinical examination with patient complaint of numbness, weakness or paresthasias in conjunction with Sensory or motor loss in nerve distributions.</p> <p>Diagnostic algorithm of injury, neuropathy attributed to over-tightened handcuffs where superficial radial nerve injury, median or ulnar nerve neuropathies with ipsilateral superficial radial neuropathy.</p> <p>A standard form used to obtain history and provide guide for physical examination.</p>	<p>Physical signs of wrist compression including abrasions, lacerations and hand edema were present in 61% of subjects.</p> <p>Only 18 out of 41 patients had Edx testing and the other 23 had a clinical evaluation.</p> <p>Of Edx patients 39% admitted being under the influence of alcohol, 50% had abrasion at the site of handcuff placement, of these 2 had diffuse hand edema. Mean handcuffing duration was 1.8 hours and the mean interval between handcuffing and presentation was 1.8 days.</p> <p>Of the neuropathies Edx tested 100% of radial, 75% median and 69% of ulnar nerve abnormalities were attributed to overtightened handcuffs.</p> <p>Of the 23 patients who had a clinical evaluation mean duration of handcuffing was 1.3 hours. Physical signs of wrist compression including abrasions, lacerations and hand edema were present in 61% of subjects, 56% had sensory or motor loss in at least 1 nerve.</p> <p>Author's conclusions Handcuff induced neuropathies may be more common than first thought, but overall proportion is suggested as being small. A substantial number of people are at risk of overtightened handcuffs and nerve injury given the use of self-tightening cuffs where the ratchet freely advances when little force is applied. Police need to be aware of these potential risks.</p>	<p>Study aim To perform a prospective study of handcuff related nerve injuries of the wrist.</p> <p>Limitations Potential case selection bias as cases from one major teaching hospital based upon self-reported handcuff injury presentation. In outpatient cases (5) mean interval between hand-cuffing and presentation excessive at 305 days which could lead to recall biases.</p> <p>Cases are from a US health setting. Handcuff equipment, use and methods may not necessarily be generalisable to the New Zealand setting.</p> <p>Prospective case review, descriptive analysis, small sample and no comparison control group.</p> <p>Diagnostic assessment inconsistent as large numbers of patients did not return for Edx testing after referral. Only 18 had Edx testing and the other 23 had "clinical evaluation". Possible confounders included patient alcohol intoxication and the presence of other medical conditions.</p> <p>Conclusion Handcuff related neuropathies were evident from the cases examined. The level of risk to a handcuffed person is hypothesised to increase with the degree of resistance while restrained with self-tightening cuffs.</p>

Table 3. Evidence table of appraised articles relating to physical restraint safety from case series reviews (continued)

Authors Country Evidence Grading	Sample and Interventions	Methods	Results	Limitations and Conclusions
Mercy et al. (1990) Non-specified, USA Grade: Level IV	<p>Study setting Police and coroner reports of all in-custody deaths.</p> <p>Participants 20 cases of death associated with control holds during the years 1974 to 1982. Median age 34, age range 19 to 76 years, male 100%, black 74%.</p> <p>Intervention of interest Physical restraint defined as an upper-body control-hold.</p> <p>Comparison group None.</p>	<p>Study design Retrospective case series review.</p> <p>Inclusion criteria Police records screened to identify possible control hold-related deaths. Cases were identified if while in police custody irreversible unconsciousness of victim occurred in combination with the use of control-hold physical restraint by police officers.</p> <p>Exclusion criteria None specified.</p> <p>Outcome measures Police reports providing demographic information, prior arrest record of decedent, narrative and reconstruction of events, type of control hold applied. Date of death, autopsy and toxicologic findings from coroners reports.</p> <p>The cases identified were classified into three categories of association according to three criteria describing the probable strength of association between upper-hold control-holds with death.</p> <p>Stronger association was considered where (a.) police information indicated control-hold use followed by immediate irreversible unconsciousness (b.) the autopsy report provided information indicating damage to neck tissues (c.) the autopsy report indicated that there was no cause of sudden unexpected death independent of control-hold use.</p>	<p>Six cases met all three criteria a.) through c.), and were deemed to have a strong association between the use of control-hold and death.</p> <p>Thirteen cases met one or two criteria a.) to c.) and were deemed to indicate some evidence for an association between the use of control-hold and death.</p> <p>One case met no criteria and it was considered that a relationship between control-hold and death was unlikely and was excluded from the analysis.</p> <p>Police reports indicated that cartoid hold was applied in 42% of cases, bar-arm hold in 42% of cases and both in 11% of cases and in 1 case the type of hold was uncertain. The control-hold rendered immediately a person irreversibly unconscious in 47% of cases, within 15 minutes in 32% of cases and within 25 minutes after application in 21% of cases.</p> <p>Most cases (80%) died on the same or within one day of losing consciousness.</p> <p>Other risk factors present in cases included autopsy evidence of intravascular sickle cell disorder (21%), cardiovascular disease and intoxication with Phencyclidine (PCP), alcohol and other drugs (53%).</p> <p>Author's conclusions There is some possible association between control-hold use and some deaths but this is limited by a lack of objective pathological criteria, inadequate information concerning the overall incidence and prevalence of such deaths and data concerning nonfatal incidents involving control-hold use which would allow for a comparison of risk factors with fatal incidents.</p>	<p>Study aim To examine cases of control-hold physical restraint related deaths to assess the nature of this association and the presence of other risk factors increasing the risk of death.</p> <p>Limitations Limited description of case selection methods because of confidentiality concerns, uncertain as to degree of case selection bias. Possible report bias from police reports and potential litigative nature of material.</p> <p>Cases are all from US law enforcement settings. Police restraint use and methods are not necessarily generalisable to New Zealand settings.</p> <p>Possible classification bias as the causal role of cases were judged according to pre-determined criteria based upon autopsy reports and limited objective pathological criteria.</p> <p>Descriptive case series review with no comparison group or controlling for other confounding risk factors contributing to sudden death. No causal inference can be made that control-hold physical restraint is associated with death because of the presence of other risk factors.</p> <p>Conclusion It is not possible to determine the link between control-hold use and death as no unique objective autopsy features exist and because of the presence of other risk factors in these cases.</p>

Table 3. Evidence table of appraised articles relating to physical restraint safety from case series reviews (continued)

Authors Country Evidence Grading	Sample and Interventions	Methods	Results	Limitations and Conclusions
<p>O'Halloran and Lewman (1993)</p> <p>California, Oregon, USA</p> <p>Grade: Level IV</p>	<p>Study setting Ventura County, California and Portland Oregon and Oregon State Medical Examiners Office records.</p> <p>Participants 11 cases of sudden death of men restrained in a prone position by police. All were exhibiting 'wild, threatening, or bizarre behaviour' considered to be acute excited delirium, age range 14 to 44 years.</p> <p>Intervention of interest Physical restraint in prone position, particularly with the hog-tie method.</p> <p>Comparison group None.</p>	<p>Study design Retrospective case series review.</p> <p>Inclusion criteria None specified.</p> <p>Exclusion criteria None specified.</p> <p>Outcome measures Reason police called, method of prone restraint, cause of delirium, listed cause of death, listed manner of death.</p> <p>Ventura County, California and Portland Oregon and Oregon State Medical Examiners Office records including autopsy results.</p>	<p>All cases except one were considered to be accidents.</p> <p>All cases were restrained in a prone position, 9 were hog-tied.</p> <p>Positional asphyxia was listed as a contributory cause of death in 2 cases.</p> <p>Cocaine toxicity was the primary cause of excited delirium in 6 cases. All persons exhibited excited delirium.</p> <p>One or more risk factors (drug toxicity, obesity, excited delirium, pepper spray, underlying heart condition) for sudden death were present in all cases reviewed.</p> <p>Author's conclusions Drug-induced excited delirium and police confrontation greatly increases catecholamine stress on heart, heart and lung oxygen requirements significantly increase in people with excited delirium struggling with police and against physical restraint, the hog-tie prone positional restraint method impairs breathing in high oxygen demand situations by restricting chest wall and diaphragmatic movement.</p>	<p>Study aim To report cases of sudden death to alert law enforcement agencies and medical and forensic investigators that physical restraint using the "hog-tie" prone position in people with excited delirium can have serious consequences.</p> <p>Limitations No description of case selection methods, or inclusion and exclusion criteria. Small convenience sample with selection bias. No description of case assessment and outcome measure criteria.</p> <p>Wide variation in the terminology used for certifying cause of death. Reliance upon postmortem data where no definite criteria for determining restraint induced sudden death.</p> <p>Cases are from US law enforcement setting where police restraint use and methods may not necessarily be generalisable to New Zealand settings.</p> <p>Descriptive case series analysis with no comparison group or no controlling for other confounding risk factors contributing to sudden death. Weak causal inference that physical restraint contributes to sudden death.</p> <p>Conclusion Multiple risk factors can be attributed to these deaths. The cause of death was stated as "positional asphyxia" in 2 cases. The direct relationship between physical restraint in the prone position and sudden death is not clearly established from these cases.</p>

Table 3. Evidence table of appraised articles relating to physical restraint safety from case series reviews (continued)

Authors Country Evidence Grading	Sample and Interventions	Methods	Results	Limitations and Conclusions
<p>O'Halloran and Frank (2000)</p> <p>California, USA</p> <p>Grade: Level IV</p>	<p>Study setting Ventura County, California Medical Examiners Office records, case histories and autopsies, police and witness interviews.</p> <p>Participants 21 cases of sudden death while being restrained in a prone position, during the years 1992 to 1996. Age range 17 to 45 years.</p> <p>Intervention of interest Physical restraint in prone position.</p> <p>Comparison group None.</p>	<p>Study design Retrospective case series review.</p> <p>Inclusion criteria None specified.</p> <p>Exclusion criteria None specified.</p> <p>Outcome measures Method of restraint, behaviour, cause of behaviour, cause of death, manner of death.</p>	<p>Fourteen cases were considered to be accidents, four homicide, two natural and one undetermined.</p> <p>All cases were acutely disturbed exhibiting delirium or aggressive behaviour, 15 cases involved police and two involved security personnel. One or more risk factors (drug toxicity, obesity, excited delirium, blunt force head injury, pepper spray, underlying heart condition) for sudden death were present in all 21 cases reviewed.</p> <p>All cases were restrained in a prone position, 14 were restrained by body weight and handcuffs, four were hog-tied (All 18 were handcuffed behind the back) and three restrained with just upper body weight to restrain arms, 11 had ankle or lower leg restraints. Pepper spray was used in seven cases prior to restraint, witnesses reported no significant effects of the spray and no cases were identified at autopsy.</p> <p>All cases except one were held involuntarily in prone position until unconscious.</p> <p>Certified cause of death was asphyxia or similar in 13 cases.</p> <p>Author's conclusions Asphyxial deaths can occur in subjects who are held in a prone position with arms and legs restrained and weight applied to the back. Persons with drug or psychotic induced excited delirium are at greater risk of asphyxial death. Pre-existing heart conditions, obesity, and physical exhaustion also increase risk. Autopsy findings on restraint asphyxia can be problematic and non-specific. Proper investigation with detailed autopsy and immediate interviews ascertaining restraint time and mechanics and timing of loss of consciousness are crucial.</p>	<p>Study aim To report cases of sudden death in individuals who were restrained in a prone position and discussion of risk factors.</p> <p>Limitations Non-specific research objectives and no description of case selection methods, other than "except for the four deaths we autopsied all cases came to our attention because of litigation" and no inclusion and exclusion criteria. Convenience sample with selection bias. No description of case assessment and outcome measure criteria.</p> <p>Reliance upon autopsy findings where there are difficulties in diagnosing positional asphyxiation. Many reports had no detailed statements from witnesses or dispatch logs to adequately establish the association between restraint and loss of consciousness.</p> <p>Cases are mostly from US law enforcement settings. Police restraint use and methods are not necessarily generalisable to New Zealand settings.</p> <p>Descriptive case series review, analysis and summary with no comparison group or controlling for other confounding risk factors contributing to sudden death. No direct causal inference can be made that physical restraint contributes to sudden death.</p> <p>Conclusion Case material from autopsy reports and coroners findings show that it is difficult to establish the cause of death related to positional asphyxia with the presence of many other risk factors contributing to these deaths. Asphyxia related deaths were evident from the cases reviewed.</p>

Table 3. Evidence table of appraised articles relating to physical restraint safety from case series reviews (continued)

Authors Country Evidence Grading	Sample and Interventions	Methods	Results	Limitations and Conclusions
<p>Pollanen et al. (1998)</p> <p>Ontario, Canada</p> <p>Grade: Level IV</p>	<p>Study setting Chief Coroner's Office for Ontario records.</p> <p>Participants 21 cases of unexpected death associated with excited delirium between 1988 and 1995. Mean age 33 years and male in 95% of cases.</p> <p>Intervention Cases were analysed to determine the use and method of any physical restraint.</p> <p>Comparator Cocaine related deaths in the absence of physical restraint.</p>	<p>Study design Retrospective case series review.</p> <p>Inclusion criteria Unexpected death in persons with a diagnosis of excited delirium based on case documentation describing behaviour as "bizarre, hyperactive, paranoia, shouting, thrashing, ranting, feats of superhuman strength".</p> <p>Exclusion criteria None stated.</p> <p>Outcome measures Unexpected death associated with excited delirium and physical restraint based on official documents recording eyewitness accounts of restraint use and method, body position at time of death, drug use and psychiatric history, postmortem results and blood toxicological analysis.</p>	<p>In all 21 cases death was associated with restraint in either a prone position (86%) or neck pressure (14%). Deaths in police custody 86%.</p> <p>Prone position restraint with chest suppression (19%), handcuffs (19%), handcuffs and ankle shackles, including 2 'hog-tied' (26%), chest compression, handcuffs and ankle shackles (19%). Pepper spray had been used in 4 (19%) cases.</p> <p>All 21 cases "lapsed into tranquility" while being restrained of whom 90% died at the time of restraint after failing to be resuscitation attempts.</p> <p>Postmortem results showed petechial hemorrhage in 5 cases, 2 had conjunctival petechiae and had suffered neck compression, 3 had subpleural and epicardial petechiae with 1 suffering neck compression and the others prone restraint.</p> <p>Author's conclusions Deaths associated with excited delirium are also associated with physical restraint in the prone position.</p> <p>Acute excited delirium from psychiatric illness or cocaine use was the most important underlying cause of death. Because of the retrospective analysis the study did not have controls and therefore is unable to demonstrate a definitive causal link between unexpected death and restraint in persons with excited delirium.</p>	<p>Study aim To conduct a retrospective case series review to determine the frequency of physical restraint use among people manifesting a state of excited delirium who die unexpectedly.</p> <p>Limitations Possible case selection bias, no data on the number of possible cases identified and outcome of interest (restraint use) known prior to inclusion of each case in study.</p> <p>Reliance upon eyewitness accounts with possible recall bias and issues with validity of post-mortem results. Cause of excited delirium but not cause of death specified.</p> <p>Canadian setting where police restraint use and methods may not necessarily be generalisable to New Zealand.</p> <p>Descriptive analysis, no comparison group and no controlling for other confounding risk factors contributing to the cause of death. Only limited association can be made between excited delirium, restraint and death.</p> <p>Conclusion In the cases examined there is a correlation between excited delirium, physical restraint and sudden death. The exact causal mechanisms are unknown.</p>

Table 3. Evidence table of appraised articles relating to physical restraint safety from case series reviews (continued)

Authors Country Evidence Grading	Sample and Interventions	Methods	Results	Limitations and Conclusions
Ross (1998) Various States, USA Grade: Level IV	<p>Study setting 32 police municipalities across the USA.</p> <p>Participants 61 cases of in-custody deaths where the person exhibited excited delirium during the 1988 to 1997 study period. Mean age 32 (male), 30 (female), ethnicity, 56% white, 41% black, male 97%, mean weight 220 pounds, mean body temperature 104° F.</p> <p>Intervention The use of any physical force measures to subdue the person exhibiting excited delirium.</p> <p>Comparison group None.</p>	<p>Study design Retrospective case series review.</p> <p>Inclusion criteria Cases of unintentional death of an arrestee, showing 'violent and bizarre' behaviour requiring the use of 'physical force measures or equipment' by police to 'subdue' the person. Cases were assessed where death followed a violent struggle with the police, after the use of police control measures, persons exhibited excited delirium induced by cocaine-use, other drugs or mental illness and the victim died at the scene, in transport, at a custody facility or hospital.</p> <p>Exclusion criteria None specified.</p> <p>Outcome measures Decedent demographics, arrest circumstances, police force measures, location of death, cause of death, risk factors and behaviours associated with death were obtained.</p> <p>Case material analysed from police incident reports, legal documentation, medical and autopsy report findings.</p>	<p>The main incident circumstances were disturbance calls in 56% of cases.</p> <p>The physical force measures used by police were mechanical restraints (mostly handcuffs) in 100% of cases, empty hand control techniques, 80%, hog-tying, 38%, impact weapons strikes, 21%, pepper spray, 15%, and neck restraint 9%. A combination of measures were often used.</p> <p>All subjects were restrained after violent struggle, requiring on average 4 or more police officers.</p> <p>Three-quarters (77%) of subjects died at the scene or during police transport.</p> <p>Cause of death was stated as:</p> <ul style="list-style-type: none"> ▪ 'acute cocaine toxicity or drug toxicity with physical restraint in police custody contributory' in 57% of cases ▪ 'positional asphyxiation during restraint for excited delirium', in 20% of cases ▪ 'cardiorespiratory arrest associated with psychotic reaction, struggle, and positional restraint' in 15% of cases. <p>Author's conclusions In all cases suspects fought and were restrained by the police. For most cases excessive toxicity and physical restraint in police custody were contributory to death.</p>	<p>Study aim To undertake a retrospective case content analysis of deaths in police custody associated with excited delirium.</p> <p>Limitations No description of case selection methods, inclusion criteria are described but final sample is one of convenience that has likely bias.</p> <p>Police incident reports and legal documentation for litigation may introduce bias into case content, interpretive difficulties with autopsy findings in diagnosing restraint related positional asphyxiation as a cause of death.</p> <p>US law enforcement setting where police restraint use and methods may not necessarily be generalisable to New Zealand settings.</p> <p>Descriptive content analysis with no comparison group or no controlling for confounding risk factors contributing to sudden death. Only weak causal inference that physical restraint caused sudden death can be made from the risk factors identified.</p> <p>Conclusion Many factors contributed to death in the cases analysed. Physical restraint in association with drug toxicity, excited delirium, struggle and psychotic reaction was a contributory factor to these deaths in custody.</p>

Table 3. Evidence table of appraised articles relating to physical restraint safety from case series reviews (continued)

Authors Country Evidence Grading	Sample and Interventions	Methods	Results	Limitations and Conclusions
Spreat et al. (1986) Philadelphia, USA Grade: Level IV	<p>Study setting University operated residential mental health facility.</p> <p>Participants All 231 clients who were facility residents during two 6-month study periods (May to October). Mean age 27 years, male 64%, mean weight 137 pounds, mean length of residence 6 years, level of mental retardation (AAMD classification) mild, 13%, moderate, 16%, severe, 39%, profound, 33%. Approved planned restrictive procedures for disturbed behaviour were in use for 24% of clients and 49% of clients had medication to control behaviour.</p> <p>Intervention of interest Contingent physical restraint defined as personal or mechanical restraint. Restraint was categorised as either planned or emergency.</p> <p>Comparison group Personal and mechanical restraint.</p>	<p>Study design Retrospective case record review</p> <p>Inclusion criteria Personal restraint defined as continuous holding of a client by at least one staff member including holding client on the ground until calm, basket holds, corner and cross-armed restraints. Mechanical restraint defined as application of ankle or wrist cuffs, corsets, bed restraint, or restraint chairs.</p> <p>Exclusion criteria Use of time-out room. Pre-existing client injuries prior to restraint application.</p> <p>Outcome measures Data on planned restraint use were obtained from the Restrictive Procedure Log form. Data on emergency use were obtained from the Emergency Restraint form. Injury data were obtained from facility incident reports. These were filled out immediately after the incident and were reviewed by administrative staff daily.</p>	<p>The incidence of client injury was 48 per 1000 restraints for all personal restraints. The injury rate for all mechanical restraints was 15 per 1000 restraints, a statistically significant difference, $p < 0.001$.</p> <p>Both forms of mechanical restraint were considered to be safer than personal restraint, $p < 0.001$ and planned restraint safer than emergency restraint $p < 0.001$.</p> <p>The average mechanical restraint duration was 4 minutes longer than personal restraint. The variance of mean restraint duration showed significant variation, $p < 0.01$.</p> <p>Serious injury was defined as a fracture, lost or broken tooth, respiratory distress, hypertension, or laceration with sutures accounted for 9% of reported injuries. There was little variation (no significant difference) across restraint types and procedures.</p> <p>Author's conclusions The use of personal restraint had a significantly higher injury rate than mechanical restraint. Restraint use in emergency situations resulted in more injuries than planned restraint use.</p>	<p>Study aim To compare client injury rates associated with personal (physical force) and mechanical restraint. A secondary comparison compared planned and emergency use of physical restraint.</p> <p>Limitations Retrospective review of institutional case records, possible information bias associated with accuracy of reported data and classification bias from inadequate transcription and coding. A limited validation check of data performed on 12% of records by an independent reviewer. A 98% index of agreement reached concerning the frequency of restraint use.</p> <p>Cases are from a US institutional mental health setting. Restraint protocols and methods may not necessarily be generalisable to New Zealand institutional mental health settings.</p> <p>Descriptive case record review providing injury incidence data. No controlling for other confounding risk factors contributing to injury.</p> <p>Conclusion The data suggest that mechanical restraint used in planned situations is safer than personal restraint used in emergency situations.</p>

Table 3. Evidence table of appraised articles relating to physical restraint safety from case series reviews (continued)

Authors Country Evidence Grading	Sample and Interventions	Methods	Results	Limitations and Conclusions
Stratton et al. (2001) California, USA Grade: Level IV	<p>Study setting Los Angeles County Emergency Medical Service Agency database and records from the Los Angeles Coroners Office records.</p> <p>Participants 18 cases of excited delirium death and associated restraint witnessed by EMS staff out of 216 restrained excited delirium subjects requiring out of hospital assistance during the 1992 to 1998 study period. Mean age 32 years, mean weight 91kg, mean BMI 30, African American, Hispanic, Caucasian each 33%.</p> <p>Intervention Physical restraint procedures using hobble type restraint with either a loser form of total appendage restraint procedure (TARP) and hog-tying.</p> <p>Comparison group None.</p>	<p>Study design Retrospective case series review.</p> <p>Inclusion criteria Cases of excited delirium with respiratory or cardiac arrest witnessed by EMS personnel.</p> <p>Exclusion criteria Deaths identified through autopsy with no obvious cause or where person suffered cardiac arrest prior to EMS arrival.</p> <p>Outcome measures Prior to data collection EMS personnel were instructed (and again mid-way during study period) for all cases of restrained individuals to document mental responsiveness, method of restraint, use or prone versus lateral positioning, respiratory rate and breathing quality, cardiac rhythm, use of capsicum spray, taser or choke hold and victim resistance.</p> <p>Coroners reports with data on subject demographics, toxicological tests, evidence of injury, use of choke holds, capsicum spray, other disease states.</p> <p>Data were collected and validated as cases occurred. Missing data were ascertained by telephone interviews with involved EMS staff. Analysis was delayed one year to avoid clashes with pending litigation.</p>	<p>All 18 cases of sudden death identified had excited delirium and after struggle were placed in a hobble restraint and found in a prone position with wrists and ankles tied together behind the back.</p> <p>All subjects had struggled with law enforcement personnel and received minor abrasions and contusions to the body.</p> <p>A positive drug toxicology test was identified in 78% of cases, autopsy evidence of chronic disease in 56%, obesity (BMI>29) in 56%, chronic cocaine use history 45%, capsicum spray use pre-restraint in 33%, primary cardiac dysrhythmia 8% (% of confirmed rhythms).</p> <p>All 216 surviving and sudden death cases were restrained using a form of hobble restraint and 89% of those not suffering death were restrained in a prone position.</p> <p>Author's conclusions Study findings indicate an association for risk of sudden death in persons with excited delirium that requires physical restraint. This does not refute or support prone position during hobble restraint being independently associated with sudden death.</p>	<p>Study aim To identify and rank the risk factors associated with sudden death of persons requiring restraint during excited delirium episodes.</p> <p>Limitations Likely case selection bias as only those cases attended by EMS personnel were included in study. Many cases were taken by law enforcement directly into custody or hospital. Excited delirium not defined and EMS data collection form not pre-tested or validated. Some items required subjective descriptive response.</p> <p>Unknown number of telephone follow-ups of EMS personnel for missing information and possible recall bias. Assessment of cardiac rhythm delay of 30-190 seconds due to time required for release of restraints. Hyperthermia data, an important risk factor was not collected. Coroners cause of death findings not described.</p> <p>US setting where police restraint use and methods are not necessarily generalisable to New Zealand settings.</p> <p>Descriptive analysis with no comparison group or no controlling for confounding risk factors contributing to sudden death. No independent causal inference about hobble positional restraint can be made given the risk factors identified. No analysis or comparison of risk factors for group surviving excited delirium with physical restraint.</p> <p>Conclusion The risk factors identified in this case series indicate an association for risk of sudden death of those with excited delirium that require physical restraint using the hobble method, however an independent association cannot demonstrated.</p>

OVERVIEW

Study designs and levels of evidence

The evidence tables summarise the appraised literature that satisfies the study inclusion and exclusion criteria and examines the evidence regarding the safety of physical restraint use. Overall, the level and quality of the study evidence for the safety of physical restraint use was almost entirely restricted to lower Level IV evidence according to the NHMRC hierarchy of evidence (consisting of 12 studies, see **Table 2, pages 7 – 10 and Table 3, pages 11 - 18**). Only one study provided evidence above Level IV, a Cochrane systematic review examining the effects of physical restraint (and seclusion) of people with serious mental illness (Sailas and Fenton, 2000). This study provided Level I evidence (see **Table 1, page 6**).

Eight of the studies graded as Level IV evidence were descriptive case series reviews, mostly examining deaths in police custody following the use of physical restraint. Seven of these were retrospective reviews and one study was a prospective review (see **Table 3, pages 11 - 18**).

The other four Level IV studies were quasi-experimental designs evaluating the physiological aspects of post-exercise recovery while under physical restraint in laboratory conditions. Although prospective and some used subject crossover designs none of these studies used concurrent controls, parallel or historical controls or comparison groups (see **Table 1, page 6**). Hence, these studies were all graded as Level IV as they were considered to be prospective case series with a pretest and post-test experimental design.

All of the appraised studies were found in the peer-reviewed literature. The studies were mostly set in the USA (10 studies) but also included the United Kingdom (one study), Canada (one study) and Finland (one study). Physical restraint use by police was examined in seven studies and medical staff in two studies, the other four studies examined restraint use in experimental laboratory conditions.

Overall assessment of evidence regarding the safety of physical restraint use

One Cochrane systematic review (Sailas and Fenton, 2000) examined evidence related to the effects of physical restraint use within inpatient settings for seriously mentally ill people (see **Table 1, page 6**). This found no Randomised Controlled Trials (RCTs), with most studies focusing on restraint for the elderly to prevent falls and wandering, and that further research with well-designed trials was needed. Incidents of serious adverse effects related to physical restraint were reported in qualitative reviews and case series.

Four quasi-experimental studies (see **Table 2, pages 7 - 10**) examined post-exercise ventilation and/or pulmonary functioning and did not clearly demonstrate that body position (prone or supine) in physical restraint situations (mostly using “hog-tie” methods) impacted upon exercise recovery times in a clinically significant way. It was not possible to infer from these studies that these results translate into increased risk of positional asphyxiation in real physical restraint situations. This was due to limitations in the study methodology and findings with small or non-significant effects. The study by Reay et al. (1988) became a reference study for much of the later experimental work that set out to test Reay et al.’s hypothesis that the physiological effects of positional restraint are important factors in restraint-related deaths.

Six studies of retrospective case series reviews (see **Table 3, pages 11 - 18**) examined deaths in police custody associated with physical restraint use. The most common physical restraint type was prone positional restraint using “hog-tie” restraint methods and involved pre-restraint struggle and several police officers. These studies relied upon the extensive use of Coroner’s reports, autopsies, medical reports, police reports and eye witness accounts to examine the role of physical restraint use in these cases of in-custody deaths.

Four of these studies' inclusion criteria focused upon cases of sudden death in persons exhibiting an acute behavioural disturbance known as "excited delirium" who had been physically restrained. In all of these studies multiple risk factors were found to have contributed to these deaths. Physical restraint use was associated with other risk factors including drug toxicity, excited delirium, pre-existing heart disease, obesity, police confrontation and struggle and pepper spray use. With multiple confounding factors contributing to these deaths an independent association between physical restraint and sudden death could not be clearly established. These studies do, however, indicate that there is a correlation between excited delirium, physical restraint and sudden death in the presence of other risk factors that may have contributed to these deaths. The other two retrospective case series reviews examined physical restraint related deaths in more general groups of victims. One study examined upper-body control hold restraint and related deaths (Mercy et al. 1990). It was not possible to identify a definitive link between these holds and death during restraint due to the non-specific and problematic nature of autopsy findings. The other study investigated cases of sudden death in individuals who were restrained in a prone position (O'Halloran and Frank, 2000). The certified cause of death was asphyxia in 60% of cases, however, the presence of other risk factors and the reliance upon autopsy findings meant it was problematic establishing the direct cause of death. Refer to the limitations section following for a fuller discussion on the difficulties of determining the cause of death in these case series reviews.

Finally, two other studies looked at non-lethal adverse effects of physical restraint use (see **Table 3, pages 11 - 18**). One study examined client injury rates associated with physical force or mechanical restraint use in a mental health facility (Spreat et al. 1986). The data from this retrospective record review suggests that physical force restraint use in emergency situations had significantly higher injury rates than mechanical restraint and planned restraint use. The other study looking at handcuff related nerve injuries of the wrist (Grant and Cook, 2000) found evidence of handcuff induced neuropathies, where the degree of resistance to self-tightening cuffs was thought to exacerbate wrist injuries.

Study limitations

The specific limitations of each study are set out in the limitations and conclusions section in the evidence tables. More general limitations of the appraised literature are discussed as follows.

The appraised case series literature had limited generalisability to physical restraint use by police and mental health services in New Zealand. Almost all of the included studies were set in North America, where restraint use and methods may not necessarily reflect those used here in New Zealand. No relevant New Zealand literature was included and only two related documents were identified. One was the ministerial inquiry into the death of Matthew Innes (Mason, 1994) and the other, an excluded study, a survey of restraint practices in Australasian emergency departments (Cannon et al. 2001). Material available from the New Zealand Police on physical restraint was identified but was not suitable research material for inclusion in this Tech Brief. The quasi-experimental studies also had limited generalisability to real physical restraint situations because they were conducted under laboratory conditions, focused upon post-exercise recovery while under restraint, and involved healthy non-behaviourally disturbed subjects.

In the retrospective case series reviews examining deaths following the use of physical restraint there was a lack of objective pathological criteria by which "restraint asphyxia" or "positional asphyxia" and death can be attributed to restraint use. In forensic pathology, these types of deaths are linked to a series of historical events in which intoxicated and traumatised victims cannot escape from a restraint hold or position that inhibits breathing, and other causes of death have been excluded from the autopsy findings (O'Halloran and Frank, 2000). The reliance upon autopsy and also potentially biased police reports and witness accounts, makes the inference of a casual link between physical restraint use and death problematic. It is acknowledged that the litigative and controversial nature of the material may promote reporting bias where the police use and methods of physical restraint resulted in a victim's death and litigation has ensued.

In the case series literature, the evidence for deaths following the use of restraint is largely circumstantial and involves a series of interrelated historical events leading to death (Mohr and Mohr, 2000). Many risk factors are present in these cases and contribute to these deaths. Possible confounding risk factors in the restraint-death relationship include drug and alcohol intoxication,

underlying respiratory and cardiovascular conditions, obesity, severe mental illness, prolonged struggle, and exposure to pepper spray (Paterson et al. 1998). Many contributing factors cause death and often the cause of death is described as “unascertained” or cardiorespiratory failure associated with struggle, restraint and drug use (Morrison and Sadler, 2001). Cocaine or other drug induced excited delirium as well as the potential lethality of cocaine use has been documented in the literature. Excited delirium deaths, particularly in police custody have also been documented (Ross 1998). The casual inference that physical restraint position or certain types of holds are an independent predictor of death during physical restraint cannot be made definitively.

The analytical methods used in the case series review literature were descriptive. There was no controlling for confounding factors – i.e., other risk factors contributing to death or injury while under restraint. There was no control group or comparison group to compare the relative safety of physical restraint methods and use versus non-use, or fatal with non-fatal incidents. The qualitative nature of the data analysis could be more susceptible to investigator bias.

The quasi-experimental studies main limitations include the use of small convenience samples of healthy volunteers, controlled conditions and potential measurement error from physiological testing instruments and methods. There is an issue related to the validity of pulmonary and ventilatory function testing to adequately measure phenomena relevant to adverse outcomes associated with actual physical restraint situations. A lack of validity can result in important phenomena being excluded and the over or underestimation of physiological effects in the outcomes of interest.

The actual level of physical restraint use by method is unknown therefore it is impossible to determine the actual incidence rates of morbidity and mortality associated with its use. Variability in restraint use and methods across police jurisdictions and mental health service providers and variable reporting requirements means that the extent of real risk is unknown. Most studies focused on case studies of deaths associated with physical restraint use. There was a lack of information regarding non-fatal injury incidence following restraint use. Within the New Zealand context a lack of audit of restraint practices is seen as a major reason for a lack of data, particularly in emergency departments (Cannon et al. 2001); but this could also be reflective of other health settings.

Gaps in knowledge

Significant gaps exist in the literature regarding evidence for the safety of physical restraint use on acutely behaviourally disturbed individuals in crisis situations. There is a lack of consensus concerning the causes of death proximal to physical restraint use in these situations. The lack of objective pathological criteria by which to determine the cause of death means that the usual sources of information for determining restraint asphyxia are the historical events of struggle and restraint leading to death. Forensic literature has documented deaths of adults from positional asphyxia where individuals are placed in prone positions which compromise their breathing and are unable to escape (Mohr and Mohr, 2000).

Other related complications include death by aspiration from vomiting or regurgitation in prone or supine body positions, asphyxia related to neck-holds used by law enforcement personnel, myocardial concussion due to chest wall trauma, sudden rush of adrenal catecholamines and ventricular arrhythmias resulting from intense struggle or psychic stress, and rhabdomyolysis resulting from things such as extreme exertion, intoxication, infection and trauma (Mohr and Mohr, 2000). There is a lack of specific evidence in the literature regarding these complications proximal to restraint use. Further robust research conducted with appropriately designed studies to capture relatively rare events is needed.

Conclusions

The reviewed literature documents serious complications, particularly sudden death, as being associated with physical restraint use on acutely behaviourally disturbed individuals. The exact casual mechanisms that lead to these complications are complex as many risk factors are seen as being contributory to death and remain a challenge to medical examiners in determining the cause of death (Ross, 1998). From the evidence reviewed it was difficult to assign an independent association of

physical restraint use and method to these deaths. Restraint methods involving the prone position with “hog-tie” restraint appear to be a risk factor contributing to these deaths. The descriptions of these deaths in the literature have identified the cause of death as “restraint” or “positional” asphyxia. Despite the highly controversial and newsworthy profile of these deaths they remain a rare event compared with the overall prevalence of restraint use in health settings or in law enforcement. The experimental literature reviewed did not adequately establish a direct relationship between prone restraint and compromised cardio-pulmonary or ventilatory functioning.

The quality of the evidence that is presented here was relatively low with only one systematic review graded above Level IV according to the NHMRC hierarchy of evidence. The lack of relevant published literature from New Zealand health and law enforcement settings was a major limitation of this Tech Brief. The focus of the published literature was on deaths associated with the physical restraint of behaviourally disturbed individuals. There was a lack of material examining non-fatal adverse effects and also the benefits of physical restraint use.

The overall evidence for the safety of physical restraint use indicates that its use may be contributory to serious adverse effects in behaviourally disturbed individuals. Formal staff training in restraint use, alternatives to physical restraint and evidence-based protocols may help minimise the risk of harm. More appropriate empirical research on the safety as well as the efficacy of physical restraint is required.

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APPENDIX 1: LEVELS OF EVIDENCE

- Level I Evidence obtained from a systematic review (or meta-analysis) of relevant randomised controlled trials.
- Level II Evidence obtained from at least one randomised controlled trial.
- Level III. 1 Evidence obtained from pseudorandomised controlled trials (alternate allocation or some other method).
- 2 Evidence obtained from comparative studies (including a systematic reviews of such studies) with concurrent controls and allocation not randomised, cohort studies, case control studies or interrupted time series with a control group).
- 3 Evidence obtained from comparative studies with historical control, two or more single-arm studies or interrupted time series without a parallel control group.
- Level IV Evidence obtained from case series, either post-test or pretest/post-test.

NHMRC (1999)

APPENDIX 2: SEARCH STRATEGY

Medline

- 1 restraint/ (5634)
- 2 exp mental disorders/ (470934)
- 3 1 and 2 (533)
- 4 limit 3 to human (478)
- 5 3 not 4 (55)
- 6 restraint/ae (449)
- 7 limit 6 to human (272)
- 8 7 not 4 (207)
- 9 violence/ (11626)
- 10 Aggression/ (15183)
- 11 Self-Injurious Behavior/ (1221)
- 12 agitat\$.tw. (4660)
- 13 POLICE/ (955)
- 14 Emergency Service, Hospital/ or Emergency Medical Services/ (30236)
- 15 Emergency Services, Psychiatric/ (1198)
- 16 ASPHYXIA/ (2724)
- 17 positional asphyxia.mp. (19)
- 18 or/9-17 (65062)
- 19 1 and 18 (428)
- 20 4 or 8 (685)
- 21 19 or 20 (895)
- 22 from 21 keep (selected references)

Embase

- 1 IMMOBILIZATION/ (6100)
- 2 safety/ (16493)
- 3 police/ (1499)
- 4 aggression/ or agitation/ or violence/ (14945)
- 5 emergency/ or emergency health service/ or emergency ward/ or emergency medicine/ or emergency treatment/ or psychiatric treatment/ (21896)
- 6 asphyxia/ or positional asphyxia.tw. (1537)
- 7 exp mental disease/ (323922)
- 8 or/2-7 (364101)
- 9 1 and 8 (551)
- 10 (mouse or mice or rat or rats or monkey\$.mp. (809452)
- 11 9 not 10 (363)
- 12 from 11 keep (selected references)(5)
- 13 restraint\$.mp. (5232)
- 14 Sudden Death/ (7123)
- 15 (1 or 13) and 14 (27)
- 16 13 and (2 or 6) (93)
- 17 15 or 16 (112)
- 18 17 not 11 (92)
- 19 from 18 keep (selected references)

Current Contents

- 1 positional asphyxia.mp. (34)
- 2 asphyxia.mp. (1897)
- 3 restraint.mp. (4648)
- 4 2 and 3 (24)
- 5 1 or 4 (43)
- 6 police.mp. (4378)
- 7 (violence or agitation or aggression).mp. (24536)
- 8 safety.mp. (61052)
- 9 emergenc\$.mp. (52551)
- 10 or/6-9 (138722)
- 11 3 and 10 (373)
- 12 physical restrain.mp. (0)
- 13 physical restraint.mp. (219)
- 14 5 or 11 (409)
- 15 (seatbelt or seat belt).mp. (460)
- 16 14 not 15 (378)
- 17 from 16 keep (selected references)

Cinahl

- 1 RESTRAINT, PHYSICAL/ae (Adverse Effects) (77)
- 2 restraint, physical/ (1135)
- 3 exp Mental Disorders/ (37295)
- 4 2 and 3 (91)
- 5 ASPHYXIA/ (109)
- 6 positional asphyxia.mp. (3)
- 7 POLICE/ (347)
- 8 VIOLENCE/ (2398)
- 9 AGITATION/ (306)
- 10 Emergency Medical Services/ (4362)
- 11 emergencies/ or emergency care/ or emergency service/ or emergency medicine/ or emergency nursing/ or psychiatric emergencies/ (12080)
- 12 Self-Injurious Behavior/ (52)
- 13 AGGRESSION/ (719)
- 14 or/5-13 (19402)
- 15 SAFETY/ (1854)
- 16 2 and 14 (168)
- 17 2 and 15 (17)
- 18 1 or 4 or 16 or 17 (299)
- 19 from 18 keep (selected references)

Psychinfo

- 1 positional asphyxia.mp. (1)
- 2 asphyxia.mp. (198)
- 3 restraint.mp. (3651)
- 4 2 and 3 (2)
- 5 exp PHYSICAL RESTRAINT/ (1013)
- 6 emergency services/ or crisis intervention services/ (2337)
- 7 emergenc\$.mp. (12583)
- 8 violence/ or patient violence/ or dangerousness/ (8946)
- 9 anoxia/ (570)
- 10 agitation/ (431)
- 11 aggress\$.mp. (32847)
- 12 police.mp. (5801)
- 13 exp SAFETY/ (3651)

- 14 (vehicle or safety belt or seat belt or seatbelt or safety seat or crash or traffic).mp. (9636)
- 15 (rat or rats or mouse or mice).mp. (78705)
- 16 dietary.mp. (3869)
- 17 or/6-13 (61691)
- 18 5 and 17 (136)
- 19 1 or 4 or 18 (137)
- 20 3 and 17 (402)
- 21 or/14-16 (89157)
- 22 20 not 21 (333)
- 23 18 or 22 (347)
- 24 from 23 keep (selected references)

Other databases

Combinations of the keywords in the strategies above were used in free text searching of smaller databases and sources without formal index terms.

APPENDIX 3: EXCLUDED RETRIEVED PAPERS

American Civil Liberties Union of Southern California (1995). Pepper spray update: more fatalities, more questions. Los Angeles, CA: ACLU.

A case review by the ACLU on 26 in-custody deaths. The aim of this study was to look at the role of pepper spray as a potential cause of death in these cases; therefore, it was excluded. Data were reviewed from autopsy and medical examiner investigation reports, interviews with police officers and friends and family of victims. It was concluded that there is a strong association with the use of pepper spray and physical restraint techniques – e.g., hog-tying and death. Secondary findings of this report were that in 50% of cases, police restraint techniques were identified as being contributory or the primary cause of death. Refer to the critical appraisal of this study in the NZHTA Tech Brief on Pepper Spray by Marita Broadstock, September 2002.

Annas, G. J. (1999). The last resort - the use of physical restraints in medical emergencies. *New England Journal of Medicine*, 341, 1408-1412.

Expert opinion narrative article looking at medico-legal issues in the use of physical restraint in medical emergencies. Discusses informed patient consent requirements before undertaking treatment including restraint, and that patient competency is blurred in emergency situations when protecting the patient from harming self or others. Advocates physical restraint use only as a last resort. Outlines new US Federal regulations which enforce patient rights.

Aschen, S. R. (1995). Restraints: does position make a difference? *Issues in Mental Health Nursing*, 16, 87-92.

Retrospective case review of 20 patients in a psychiatric hospital setting in the USA investigating how quickly patients were brought under control using supine or prone position restraint. Supine took longer but difference (3.2 hours) was not statistically significant from prone restraint position. This study examines effectiveness and presents no data on safety outcomes.

Bell, M. D., Rao, V. J., Wetli, C. V., & Rodriguez, R. N. (1992). Positional asphyxiation in adults - a series of 30 cases from the Dade and Broward County Florida Medical Examiner Offices from 1982 to 1990. *American Journal of Forensic Medicine & Pathology*, 13, 101-107.

A retrospective chart review of 30 cases of death attributed to positional asphyxia from US county Medical Examiner Offices. Only accidental asphyxial death cases were selected, deaths were not related to physical restraint use. The criteria for inclusion were that the decedent must have been found in a position which compromised pulmonary gas exchange, the ability of a person to escape was explainable and other causes of death were excluded through autopsy. Over 50% of cases were found in either a bedroom or automobile. The most significant risk factor was alcoholism. Body position commonly included a restrictive position with hyperflexed neck, obstruction and face down with nose and mouth obstruction.

Binder, R. L., & McNiel, D. E. (1999). Emergency psychiatry: contemporary practices in managing acutely violent patients in 20 psychiatric emergency rooms. *Psychiatric Services*, 50, 1553-1554.

A qualitative survey of management practices of acutely violent patients in 20 US psychiatric emergency rooms. Results suggest clinicians prioritise the prevention of staff and patient injury by rapid reduction in violent behaviour through the use of both physical restraint and intramuscular chemical restraint.

Busch, A. B., & Shore, M. F. (2000). Seclusion and restraint: a review of recent literature. *Harvard Review of Psychiatry*, 8, 261-270.

Narrative review looking at changes in the literature regarding the understanding of involuntary seclusion and restraint use since the review by Fisher (1994), see below, use of emergency medications and the role of quality assessment in seclusion, restraint and emergency medication use.

Findings on restraint use include variation in their use independent of patient case mix or other demographics. Inconsistent staff decision-making on restraint use which is often influenced by staff gender, education and clinical experience. Benefits are derived from service reorganisation, staff training and implementation of protocols in reducing restraint use and staff/patient injury.

Cannon, M. E., Sprivulis, P., & McCarthy, J. (2001). Restraint practices in Australasian emergency departments. *Australian & New Zealand Journal of Psychiatry*, 35, 464-467.

A survey of restraint techniques used in 116 Australasian emergency departments. Restraint is a commonly used procedure but there is a lack of documentation, audit or formal training in its use. No data on safety or adverse effects.

Chan, T. C., Vilke, G. M., & Neuman, T. (1998). Reexamination of custody restraint position and positional asphyxia. *American Journal of Forensic Medicine & Pathology*, 19, 201-205.

A narrative review looking at factors contributing to sudden and unexpected deaths in custody of detainees in the "hog-tie" restraint position. The authors conclude that other factors apart from body positioning appear to be more important determinants of these types of deaths. These factors include things such as illicit drugs, physiologic stress, hyperactivity, hyperthermia and struggle trauma etc. Evidence suggests that even though restraint increases physiologic stress it does not suggest body position alone causes respiratory complications in the "hog-tie" position.

Connick, C., Palat, M., & Pugliese, S. (2000). The appropriate use of physical restraint: considerations. *Journal of Dentistry for Children*, 67, 256-262, 231.

Expert opinion narrative discussing the appropriate use of physical restraint in clinical and preventative dental care of severely mentally retarded people. Outlines guidelines which recommend adequate assessment of patients for those requiring some form of restraint, patient (or guardian) consent to restraint use and explanation why restraint is to be used and proper documentation of process. Argues that despite US federal and state guidelines the appropriate use of restraints in these contexts is still not clear.

Currier, G. W., & Allen, M. H. (2000). Emergency psychiatry: physical and chemical restraint in the psychiatric emergency service. *Psychiatric Services*, 51, 717-719.

Expert opinion narrative outlining the need for evidence-based guidelines on the management of behavioral emergencies. Regulatory attention was seen as bringing impetus for clarifying the status of psychiatric emergency services and the technical difficulties in caring for the behaviourally disturbed patient.

DeToledo, J. C., Lowe, M. R., & Ramsay, R. E. (1999). Restraining patients and shoulder dislocations during seizures. *Journal of Shoulder & Elbow Surgery*, 8, 300-302.

A retrospective analysis of three cases from 1,432 patients from a US epilepsy clinic over an 18-month period where epileptic patients dislocated shoulders when the arm was restrained during seizure. Recommends controlling seizures as well as possible but manifestations of seizures are varied and some postures may facilitate dislocations more than other.

Dorfman, D. H. (2000). The use of physical and chemical restraints in the pediatric emergency department. *Pediatric Emergency Care*, 16, 355-360.

Narrative review looking at the use of physical and chemical restraints on paediatric patients in emergency settings. The author argues that the use of restraints is potentially dangerous and should be viewed as a last resort. Staff training and proper protocols are needed to minimize the risk of harm to patients and staff. Further studies are needed to evaluate safety and efficacy.

Emson, H. E. (1994). Death in a restraint jacket from mechanical asphyxia. *Canadian Medical Association Journal*, 151, 985-987.

A case report of the death of woman admitted to a Canadian hospital with delirium tremens due to chronic alcoholism who was restrained in a chair with a Posey strait jacket. After a review of the hospital record autopsy report and court transcripts the author concludes that the most likely cause of death was postural or positional asphyxia.

Evans, D., Wood, J., Lambert, L., & Fitzgerald, M. (2002). Physical restraint in acute and residential care. *Systematic Review No. 22*. Adelaide: Joanna Briggs Institute.

A systematic review on the use of physical restraint in acute and residential care facilities. This review covered the prevalence and types of restraint used in these settings, the reasons for restraint use, injury associated with restraint, the experiences of residents and patients of being restrained and restraint minimisation programs. With regards to restraint injury, the literature here mostly involved restraint injury of the elderly in hospital and residential care settings and therefore was excluded from this Tech Brief. The review highlighted the lack of information on the prevalence of injuries and under-reporting, that deaths were the most common injury reported in the literature and that there was little literature concerning minor injuries. Recommendations included risk minimisation, restraint use only as a last resort and then only at a minimal level to ensure safety and the regular review on the need for restraint.

Fisher, W. A. (1994). Restraint and seclusion: a review of the literature. *American Journal of Psychiatry*, 151, 1584-1591.

Narrative literature review on restraint and seclusion. Concludes that restraint and seclusion have substantial negative physical and often psychological effects on patients and staff, which is particularly evident from psychiatric consumer/survivor reports. The author suggests that restraint and seclusion is basically efficacious and that it is almost always required in work with severely symptomatic individuals and that use is governed more by cultural biases, staff perceptions, and hospital attitudes rather than demographic and clinical factors.

Frank, C., Hodgetts, G., & Puxty, J. (1996). Safety and efficacy of physical restraints for the elderly. Review of the evidence. *Canadian Family Physician*, 42, 2402-2409.

Systematic review of evidence related to the safety and efficacy of physical restraint of the elderly and the provision of guidelines on the reasonable use of restraints for family physicians. No RCTs were identified, a variety of other studies including cohort studies, retrospective chart reviews and case series showed little evidence that restraint-reduction programs reduced injury rates, or restraints prevent injury. A number of case series document injuries and deaths related to restraint use or misuse.

Granfield, J., Onnen, J., & Petty, C. S. (1994). Pepper spray and in-custody deaths. *RCMP Gazette*, 56, 12-17.

Retrospective case series review investigating 30 US cases where death of a subject occurred following the use of pepper spray (OC). The cases reviewed were selected because of pepper spray use and therefore the study was excluded. Incident reports, investigative, coroner/medical records including autopsy and toxicologic reports were analysed to determine cause of death. Data were examined to determine consistent factors that were present in these confrontations. In the 22 cases where information was available, OC was not a contributing factor to these deaths. Positional asphyxia it was concluded was the cause of death in 18 cases with drugs and/or disease being contributing risk factors. Refer to the critical appraisal of this study in the NZHTA Tech Brief on Pepper Spray by Marita Broadstock, September 2002.

Harris, J. (1996). Physical restraint procedures for managing challenging behaviours presented by mentally retarded adults and children. *Research in Developmental Disabilities*, 17, 99-134.

Narrative review examining the use of physical restraint with mentally retarded adults. The numerous processes that contribute to the various restraint outcomes are not well understood. Continuous and short-term restraint have different processes and outcomes. There is a real risk of injury to both staff and patients in unplanned and emergency restraint situations.

Hem, E., Steen, O., & Opjordsmoen, S. (2001). Thrombosis associated with physical restraints. *Acta Psychiatrica Scandinavica*, 103, 73-75; discussion 75-76.

Report on two cases, one resulting in death describing thromboembolic indications associated with physical restraint in Norwegian hospital setting. It was concluded that leg immobilisation and trauma while in restraint explained the occurrence of thrombosis. Authors conducted a literature search identifying no papers on thrombosis in physical restraint and concluded that further research is needed.

Hick, J. L., Smith, S. W., & Lynch, M. T. (1999). Metabolic acidosis in restraint-associated cardiac arrest: A case series. *Academic Emergency Medicine*, 6, 239-243.

A case series of five emergency department patients in the US with restraint related cardiac arrest and significant metabolic acidosis. All patients were struggling despite the application of maximal restraint. Four patients died despite aggressive resuscitation attempts. At least three cases had used cocaine around the time of precipitating event. Serum toxicology screens were not available for two cases.

Jacobs, D. (1983). Evaluation and management of the violent patient in emergency settings. *Psychiatric Clinics of North America*, 6, 259-269.

Expert opinion narrative focusing on the assessment and management of the violent patient in emergency department settings. Author concludes that such management is a difficult undertaking, with many etiological factors such as biologic, psychologic and social factors and that there must be familiarity by staff with both chemical and physical restraint uses.

Karch, S. B., & Stephens, B. G. (1999). Drug abusers who die during arrest or in custody. *Journal of the Royal Society of Medicine*, 92, 110-113.

Expert opinion narrative article examining deaths in custody or during arrest of drug abusers. The author argues that careful documentation of pathological information at scene of death and of necropsy findings will make the determination of cause of death and any mistreatment more likely.

Kennedy, S. S., & Mohr, W. K. (2001). A prolegomenon on restraint of children: implicating constitutional rights. *American Journal of Orthopsychiatry*, 71, 26-37.

Narrative review examining the use of physical restraint on children in institutions arguing that such use is unethical and may be a breach of US constitutional rights. Authors suggest that providers risk legal liability where decisions for restraint use are a major departure from accepted protocol. With the limited nature of the efficacy evidence and contradictions in the use of restraints on children the development of evidence-based standards that can also be justified under ethical and legal requirements are required.

Koiwai, E. K. (1987). Deaths allegedly caused by the use of "choke holds" (shime-waza). *Journal of Forensic Sciences*, 32, 419-432.

Case review and narrative based on pathological findings from autopsies to illustrate incorrect methods of choke-hold (or Shime-Waza, as it is known in judo) application. Fourteen cases are described of deaths attributed to incorrect choke-holds by law enforcement officers. The study has little information on its methodology with no clearly focused research question and objectives, no description of study methodology, data sources, case selection, inclusion/exclusion criteria and outcome measures. Concludes that if police use choke-holds they should be properly trained by certified judo instructors and that police training manuals should be revised.

Langslow, A. (1999). Safety and physical restraint. *Australian Nursing Journal*, 7, 34-35.

Single case report on death of a patient in restraint in an Australian hospital. The coroner concluded that this case did not infer the limiting of the use of restraint devices but provided assistance with recognising the level of risk and steps to reduce that risk and that staff should be aware of legislative requirements, risks, guidelines, device instructions when using restraints.

Levin, R. A., & Felsenthal, G. (1984). Handcuff neuropathy: two unusual cases. *Archives of Physical Medicine & Rehabilitation*, 65, 41-43.

A report on two cases in the US of handcuff neuropathy, where handcuff compression of peripheral nerves at the wrist resulted in weakness and significant sensory impairment.

Madea, B. (1993). Death in a head-down position. *Forensic Science International*, 61, 119-132.

A study examining two cases of persons dying in a head-down position but with no clear morphological cause of death. Such positions where a person is suspended upside down by their ankles have been inflicted on torture victims, suicides or seen in autoerotic accidents. Concludes that postural changes of circulation must be considered but that deaths in unusual body positions often have no obvious anatomical cause of death and that death, especially in healthy persons can take a number of hours.

Masters, K. J., Bellonci, C., Bernet, W., Arnold, V., Beitchman, J., Benson, R. S., Bukstein, O., et al. American Academy of Child & Adolescent Psychiatry (2002). Practice parameter for the prevention and management of aggressive behavior in child and adolescent psychiatric institutions, with special reference to seclusion and restraint. *Journal of the American Academy of Child & Adolescent Psychiatry*, 41, 4S-25S.

Practice parameter from the American Academy of Child and Adolescent Psychiatry (AACAP) reviewing the prevention and management of violent and aggressive behaviour of children and adolescents in psychiatric settings. Guidelines are presented which account more for personal safety and patient rights as a response to wide spread concern about the use of restrictive interventions. Issues related to indications, safety and effectiveness of seclusion and restraint are considered. The aim of the interventions presented is to provide opportunity for greater patient independence and satisfaction with care and reduce the use of restrictive procedures.

McCarron, M. M., & Challoner, K. R. (1999). Emergency department treatment of patients in police custody. *Topics in Emergency Medicine*, 21, 39-48.

Expert opinion narrative article discussing forensic issues related to the treatment of patients in police custody. Many suspects brought into emergency departments present with drug overdose, withdrawal, contraband body smuggling and trauma and that physical restraint may increase the risk of morbidity and death. The authors conclude that whenever forensic evidence is required by the police staff should equally protect patient rights and respond to these requests. Also, staff should ensure that medical records are accurate and impartial and suitable for presentation as evidence in court.

McMahon, B., & Enders, M. (1999). *Police force: humane restraint and use of force by police. PDC (Policing) Research Report No. 1.* Goulburn, NSW: Charles Sturt University.

A research report examining the use of force in policing work within an Australian context. Report includes a narrative literature review of the use of force and restraint of persons in custody. It identifies measures that can be used to reduce injuries and health risks to police officers. The authors advocate abandoning the use of excessive force by changing the way police make decisions on the use of force and advocates non-lethal force alternatives, building on the baton and handcuffs and the design of simple, effective and safe restraint methods for people who want to self-harm.

Mercieca, J., & Brown, E. A. (1984). Acute renal failure due to rhabdomyolysis associated with use of a straitjacket in lysergide intoxication. *British Medical Journal*, 288, 1949-1950.

A report on two cases in the UK, one subsequently dying, of acute renal failure secondary to rhabdomyolysis induced by strait jacket restraint to control violent behaviour after taking LSD. Rhabdomyolysis resulted from the combination of restraint and violent movements induced by the LSD.

Miles, S. H., & Irvine, P. (1992). Deaths caused by physical restraints. *Gerontologist*, 32, 762-766.

Retrospective chart review of 122 nursing home and hospital deaths in elderly patients caused by vest and strap restraints. The authors conclude that restraint related deaths are avoidable and often go unrecognised and underreported. They are estimated to be the cause of at least one in every 1,000 nursing home deaths.

Mirchandani, H. G., Rorke, L. B., Sekula-Perlman, A., & Hood, I. C. (1994). Cocaine-induced agitated delirium, forceful struggle, and minor head injury. A further definition of sudden death during restraint. *American Journal of Forensic Medicine & Pathology*, 15, 95-99.

A report on four cases of sudden death of persons with cocaine-induced agitated delirium accompanied by violent struggle and minor head injury during restraint. The cause of death reported in each case was cocaine-induced coupled with the stress of violent struggle during apprehension and restraint. Head injury alone was not considered to be a cause of death. Concludes that the importance of the pathophysiologic effects of drug use should be considered in cases of sudden death.

Mohr, W. K., & Mohr, B. D. (2000). Mechanisms of injury and death proximal to restraint use. *Archives of Psychiatric Nursing*, 14, 285-295.

Narrative review describing both established and hypothesised mechanisms behind death and adverse effects of restraint use. Concludes that there is little consensus in literature concerning the causes of death proximal to restraint use.

Morrison, A., & Sadler, D. (2001). Death of a psychiatric patient during physical restraint. Excited delirium - a case report. *Medicine, Science & the Law*, 41, 46-50.

Single case review and commentary of young male schizophrenic patient with multiple drug use who died under restraint in a Scottish hospital. Cause of death given as 'positional and restraint asphyxiation in acute psychotic delirium'.

Oberleitner, L. L. (2000). Aversiveness of traditional psychiatric patient restriction. *Archives of Psychiatric Nursing*, 14, 93-97.

Narrative review critiquing traditional restraint methods on psychiatric patients that have been shown to have injurious effects. Examines the use of alternative restraint methods such as environmental factors, unit policies, staff education, effective pharmacological medications and psychological techniques.

Paterson, B., Leadbetter, D., & McComish, A. (1998). Restraint and sudden death from asphyxia. *Nursing Times*, 94, 62-64.

Narrative review examining evidence regarding restraint sudden death due to positional asphyxia. Concludes that such deaths are rare, that there is debate about the link between restraint position and increase risk of sudden death, that only careful and last-resort use of prone restraint is warranted, and that adequate staff training on risks and use is required.

Reay, D. T., Fligner, C. L., Stilwell, A. D., & Arnold, J. (1992). Positional asphyxia during law enforcement transport. *American Journal of Forensic Medicine & Pathology*, 13, 90-97.

An article describing three US cases of death due to positional asphyxia in persons restrained ("hog-tied") after violence or agitation in prone positions on the floor in the back of police vehicles. Autopsies revealed no anatomic cause of death. Sub-therapeutic levels of substances such as LSD and alcohol were evident in two cases, explaining erratic behaviour but not death. After detailed investigation of autopsies, history and reconstruction of events the authors reason that the use of "hog-tie" restraint and positioning in confined space led to respiratory inhibition (positional asphyxia) that caused these deaths. Authors conclude that difficulties remain in determining cause of death in these situations.

Roeggla, M., Wagner, A., Muellner, M., Bur, A., Roeggla, H., Hirschl, M. M., Laggner, A. N., et al. (1997). Cardiorespiratory consequences to hobble restraint. *Wiener Klinische Wochenschrift*, 109, 359-361.

An experimental randomised cross-over trial on six healthy male volunteers testing cardiopulmonary response to prone or upright hobble restraint for three minutes. No significant changes in cardiopulmonary indicators were observed after hobble restraint in the upright position. Significant decreases (all $p < 0.01$) were recorded in cardiopulmonary indicators for prone hobble restraint. The effect of any treatment carry-over and test order was found to have no significant effects on cardiopulmonary indicators. Conclusion of study is that hobble restraint in prone position leads to significant compromise of hemo-dynamics and respiration.

Rubin, B. S., Dube, A. H., & Mitchell, E. K. (1993). Asphyxial deaths due to physical restraint. A case series. *Archives of Family Medicine*, 2, 405-408.

A retrospective case series analysis of 63 deaths due to asphyxiation associated with physical restraint from 37 coroner jurisdictions in the US. Questionnaires were sent to chief death investigators of each jurisdiction. Study excluded as sample mostly geriatric population and not acutely behaviourally disturbed.

A wide range of restraint types was used including medical, adaptive and protective devices. Authors conclude that these deaths are underrepresented and occur most often when restraints are incorrectly applied and that the safety and efficacy of physical restraint requires further research.

Siebert, C. F., Jr., & Thogmartin, J. R. (2000). Restraint-related fatalities in mental health facilities: report of two cases. *American Journal of Forensic Medicine & Pathology*, 21, 210-212.

A case report describing two deaths associated with physical restraint at US mental health institutions. Both patients were restrained by staff using neck or arm "basket holds" on patients in a prone position. Also, both patients received upper body chest compression for greater than four minutes and presented with petechial hemorrhages, which could have resulted in severe cerebral hypoxia. There was no other natural disease likely to cause sudden death. Legal proceedings did not convict the staff involved.

Stratton, S. J., Rogers, C., & Green, K. (1995). Sudden death in individuals in hobble restraints during paramedic transport. *Annals of Emergency Medicine*, 25, 710-712.

Report of two male cases of sudden death during ambulance transport in a US city. Both patients were placed by police in a hobble restraint position, described as face down on their abdomens on the ambulance floor. Toxicology results obtained at autopsy revealed that both patients had non-lethal levels of amphetamines. Also, rapid asystolic arrest suggested death resulting from asphyxia. Cause of death was determined to be positional asphyxiation during excited delirium.

Telintelo, S., Kuhlman, T. L., & Winget, C. (1983). A study of the use of restraint in a psychiatric emergency room. *Hospital & Community Psychiatry*, 34, 164-165.

A cross-sectional study examining the use of mechanical restraint in a US general hospital psychiatric room. Data were collected over one month involving 165 patients. No data on safety or adverse outcomes were presented, therefore the study was excluded. Over this period 24% of the sample were restrained, of these patients 60% had to be immediately restrained before any intervention. Data indicated a predominance of males in the restrained group and over representation of blacks. Freedom of choice was granted to 50% of restrained patients for termination of restraint. Need for more investigation into restraint as a measure to facilitate clinical interventions in emergency room situations.

Wendkos, M. (1980). Psychiatric patients and sudden death. *American Journal of Psychiatry*, 137, 1627-1628.

Letter to the editor expressing opinion that physical restraint alone is a meaningful risk factor in sudden unexplained deaths regardless of prior psychotropic drug administration.

Wright, S. (1999). Physical restraint in the management of violence and aggression in in-patient settings: a review of issues. *Journal of Mental Health*, 8, 459-472.

Narrative review of issues related to physical restraint of inpatients in mental health settings. The author suggests that physical restraint is only one aspect of overall psychiatric care and the management of violent or aggressive behaviour. Also, that it is recognised that in some situations there are no other reasonable alternatives but focus should be de-escalation and prevention. That training in disengagement from assault and of appropriate, safe and effective restraint is required. Concludes that more research is needed into effectiveness and appropriateness of current systems in health care settings.

APPENDIX 4: APPRAISED RETRIEVED PAPERS

Chan, T. C., Vilke, G. M., Neuman, T., & Clausen, J. L. (1997). Restraint position and positional asphyxia. *Annals of Emergency Medicine*, 30, 578-586.

Grant, A. C., & Cook, A. A. (2000). A prospective study of handcuff neuropathies. *Muscle & Nerve*, 23, 933-938.

Mercy, J. A., Heath, C. W., Jr., & Rosenberg, M. L. (1990). Mortality associated with the use of upper-body control holds by police. *Violence & Victims*, 5, 215-222.

O'Halloran, R. L., & Frank, J. G. (2000). Asphyxial death during prone restraint revisited - A report of 21 cases. *American Journal of Forensic Medicine & Pathology*, 21, 39-52.

O'Halloran, R. L., & Lewman, L. V. (1993). Restraint asphyxiation in excited delirium. *American Journal of Forensic Medicine & Pathology*, 14, 289-295.

Parkes, J. (2000). Sudden death during restraint: a study to measure the effect of restraint positions on the rate of recovery from exercise. *Medicine, Science & the Law*, 40, 39-44.

Pollanen, M. S., Chiasson, D. A., Cairns, J. T., & Young, J. G. (1998). Unexpected death related to restraint for excited delirium: a retrospective study of deaths in police custody and in the community. *CMAJ*, 158, 1603-1607.

Reay, D. T., Howard, J. D., Fligner, C. L., & Ward, R. J. (1988). Effects of positional restraint on oxygen saturation and heart rate following exercise. *American Journal of Forensic Medicine & Pathology*, 9, 16-18.

Ross, D. L. (1998). Factors associated with excited delirium deaths in police custody. *Modern Pathology*, 11, 1127-1137.

Sailas, E., & Fenton, M. (2000). Seclusion and restraint for people with serious mental illnesses. *Cochrane Database of Systematic Reviews*, Issue 2, CD001163.

Schmidt, P., & Snowden, T. (1999). The effects of positional restraint on heart rate and oxygen saturation. *Journal of Emergency Medicine*, 17, 777-782.

Spreat, S., Lipinski, D., Hill, J., & Halpin, M. E. (1986). Safety indices associated with the use of contingent restraint procedures. *Applied Research in Mental Retardation*, 7, 475-481.

Stratton, S. J., Rogers, C., Brickett, K., & Gruzinski, G. (2001). Factors associated with sudden death of individuals requiring restraint for excited delirium. *American Journal of Emergency Medicine*, 19, 187-191.