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# Systematic review of restraint interventions for challenging behaviour among persons with intellectual disabilities: Focus on effectiveness in single-case experiments

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**Abstract**

Background: This article is the first in a two-part series: we focus on the effectiveness of restraint interventions (RIs) for reducing challenging behaviour (CB) among persons with intellectual disabilities (ID) in this first article. In the second article we focus on experiences with RIs for CB among people with ID.

Methods: A mixed methods research synthesis involving statistical meta-analysis and qualitative meta-synthesis techniques was applied to synthesize 76 retrieved articles. This first article reports on the meta-analysis of 59 single-case experiments (SCEs) on effectiveness of RIs for CB among people with ID.

Results and Conclusions: The RIs reported on in the SCEs were on average highly effective in reducing CB for people with ID, and this reduction in CB was statistically significant. However, the effects vary significantly over the included participants, and the published data and reported outcomes are rather unrepresentative of the everyday use of RIs among persons with ID.

Keywords: Single-case studies, Meta-analysis, Hierarchical linear model, Restraint, Challenging behaviour, Problem behaviour

Systematic review of restraint interventions for challenging behaviour among persons with intellectual disabilities: Focus on effectiveness

## Introduction

Challenging behaviours (CBs) are prevalent among people with intellectual disabilities (ID) (Emerson *et al.* 2001, Holden & Gitlesen 2006, Lowe *et al.* 2007). Since CB is associated with negative outcomes for the persons with ID and their direct environment (e.g., increased risks of physical harm, of social exclusion, of reduced quality of life, of stress, and of costly care), divergent proactive and reactive interventions are applied to reduce CB. Restraint interventions (RIs) such as physical restraint, mechanical restraint, and environmental restraint are often used as reactive behaviour management strategies to warrant a safe and efficient management of CB among persons with ID (Adams & Allen 2001, Allen *et al.* 2009, Harris 1996, Jones *et al.* 2007, Luiselli 2009, Sturmey 2009). Due to several ethical issues (RIs conflict with certain values and ethical standards), lawfulness issues (RIs are only rendered lawful under specific conditions), and effectiveness issues (RIs can provoke additional CB, RIs can maintain CB when they function as reinforcement) issues, their use is controversial (Harris 1996, Luiselli 2009). Consequently, several recent papers call for safely reducing RIs among persons with ID (e.g., Deveau & McDonnell 2009, Luiselli 2009, Sturmey 2009, Williams 2010, Williams & Grossett 2011). However, since these interventions are still often used in the management of CB among persons with ID (e.g., Adams & Allen 2001, Allen *et al.* 2006, Baker & Bissmire 2000, Deveau & McGill 2009, Emerson *et al.* 2000, Jones *et al.* 2007, McGill *et al.* 2009, Sturmey 1999), and since they might be appropriate under certain circumstances (Department of Health 2002), it is of major importance to systematically summarize the existing research on the topic in order to accurately inform policy and caregivers.

Within the present evidence-based practice movement, researchers and practitioners increasingly rely on statistical meta-analyses and qualitative meta-syntheses to render guidelines for best practice (Beretvas & Chung 2008, Finfgeld 2003, Shadish & Rindskopf 2007). Benefits of qualitative meta-syntheses over single primary studies include containing and managing the

information explosion on a certain research topic, addressing the problem of knowledge fragmentation, identifying knowledge gaps and omissions, advancing theory development, and stimulating evidence-based practice and policy (Estabrooks *et al.* 1994, Finfgeld 2003, Jensen & Allen 1996, Major & Savin-Baden 2010, Sandelowski *et al.* 1997, Walsh & Downe 2005). The advantages of statistical meta-analytic research over single primary studies have also been widely documented and include: a higher statistical power to detect effects, more accurate effect size estimations, the ability to make more convincing generalizations to a larger population, and the ability to identify sources of heterogeneity and to test moderators to explain detected between-study variation (Borenstein *et al.* 2009, Cooper 2010, Cooper *et al.* 2009, Ellis 2010, Hartung *et al.* 2008, Kulinskaya *et al.* 2008, Lapan & Quartaroli 2009, Lipsey & Wilson 2001).

Although recently some primary studies on the *views*, *emotions*, *acceptability*, and/or *perspectives* of carers and/or persons with ID concerning RIs for CB were published (e.g., Cunningham *et al.* 2003, Dagnan & Weston 2006, Elford *et al.* 2010, Fish & Culshaw 2005, Foxx *et al.* 1996, Hawkins *et al.* 2005, Jones & Kroese 2007 2008, MacDonald *et al.* 2011, McDonnell & Sturmey 2000, Ravoux *et al.* 2012, Sequeira & Halstead 2001), so far no review systematically summarized their findings. Furthermore, even though there exists a large amount of recent single-case experimental research that evaluates the effectiveness of RIs for CB among persons with ID (e.g., see publications in Journal of Applied Behavior Analysis and Behavioral Interventions), only one older effectiveness review has been written on the topic (Harris 1996). However, this review was not a systematic review (see Higgins & Green 2008) nor did it apply statistical meta-analytic techniques to summarize the existing research on the effectiveness of these interventions. We did not find any group-comparison studies that evaluate the effectiveness of RIs for CB among persons with ID.

In order to fill these knowledge gaps, we will conduct a systematic review of experiences- and effectiveness-studies on RIs for CB among persons with ID. Retrieved 'qualitative' and 'quantitative' studies will be systematically summarized within a mixed methods research synthesis framework (Harden & Thomas 2010, Heyvaert *et al.* 2011 2013a 2013b, Sandelowski *et al.* 2006), involving systematic review techniques, statistical meta-analysis techniques, and qualitative meta-synthesis

techniques. Although it is sometimes possible to present mixed methods findings in a *single* paper, presenting the findings in *separate* papers is considered a very beneficial approach (Creswell & Tashakkori 2007, Stange *et al.* 2006). If the findings are reported in separate papers a more focused presentation and discussion of the methods and results can be provided. However, it is recommended that in the discussion the findings of one article are interpreted in light of the other article (Stange *et al.* 2006).

This article is the first in a two-part series. We focus on the effectiveness of RIs for reducing CB in this first article. We include single-case experiments (SCEs) reporting on effectiveness of RIs for CB among people with ID. In an SCE usually one person is studied: there is a manipulation of the independent variable(s) (i.e., experimental control) and the dependent variable is repeatedly measured under different levels of the independent variable for that person (cf. Onghena 2005). In comparison to the group-comparison design, some advantages of the SCE design are its focus on the individual aiming at in-depth insight into the behaviour of a single case, the study of behaviour evolution through a large number of repeated observations, and its cost-effective approach (Heyvaert *et al.* 2012, Horner *et al.* 2005, Van den Noortgate & Onghena 2007). We use statistical meta-analytic techniques to summarize the SCEs. By providing information about the overall effect and about the effects for the individual participants, a meta-analysis of SCEs combines the strengths of group-comparison studies and SCEs (cf. Van den Noortgate & Onghena 2003).

In the second article (Heyvaert *et al.* 2014) we focus on experiences with RIs for CB among people with ID. It is our intent that both papers are considered together. The overall systematic search process that is described below was aimed at retrieving effectiveness - as well as experiences-articles. Afterwards, these effectiveness- and experiences-articles were separately analysed. At the end of this first article we discuss the findings relating to the effectiveness of RIs for reducing CB. In the discussion of the second article (Heyvaert *et al.* 2014) we confront and integrate the findings of both articles.

## Materials and Methods

### Data collection

**Systematic search process.** Studies were retrieved by systematically searching electronic databases, relevant journals, bibliographies of relevant articles, and citation indexes. We searched for studies published between January 1990 and September 2011, covering more than two decades of research. First, we searched eight relevant electronic databases: Academic Search Premier, Cumulative Index to Nursing and Allied Health Literature, Embase, Education Resources Information Center, Medline, PsycINFO, PubMed, and Web of Science. We used ID-related keywords (intellectual disabilit* OR developmental disabilit* OR learning disabilit* OR learning difficult* OR mental* retard*) in combination with restraint-related keywords (restraint intervention OR restraint OR immobilisation OR immobilization OR protective equipment OR protective device OR movement restriction OR movement suppression OR protective holding). Second, we conducted a hand search of 32 relevant journals: American Journal on Intellectual and Developmental Disabilities (American Journal on Mental Retardation); Behavior Modification; Behaviour Research and Therapy; Behavior Therapy; Behavioral Disorders; Behavioral Interventions; Brain and Development; British Journal of Clinical Psychology; British Journal of Learning Disabilities; Child and Family Behavior Therapy; Clinical Case Studies; Cognitive and Behavioral Practice; Disability & Rehabilitation; Exceptional Children; Intellectual and Developmental Disabilities (Mental Retardation); International Journal of Disability, Development and Education; International Journal of Rehabilitation Research; Journal of Abnormal Child Psychology; Journal of Applied Behavior Analysis; Journal of Applied Research in Intellectual Disabilities; Journal of Autism and Developmental Disorders; Journal of Behavior Therapy and Experimental Psychiatry; Journal of Clinical Child & Adolescent Psychology; Journal of Consulting and Clinical Psychology; Journal of Developmental and Physical Disabilities; Journal of Experimental Child Psychology; Journal of Intellectual and Developmental Disability; Journal of Intellectual Disabilities; Journal of Intellectual Disability Research; Journal of Positive Behavior Interventions; Journal of Special Education; and Research in Developmental Disabilities. Third, we examined the bibliographies of all the articles that were identified as relevant in the first and second

search step. Fourth, we searched for more recent studies referring to the papers identified as relevant in the three previous search steps, by consulting three citation indexes: the Arts & Humanities Citation Index, the Science Citation Index Expanded, and the Social Sciences Citation Index - all three accessed through Web of Science.

**Inclusion and exclusion criteria.** We aimed at retrieving studies reporting on experiences of RIs for CB among persons with ID, as well as studies reporting on effectiveness of RIs for this population. Intending to conduct a systematic review of recent literature over the last two decades, the articles had to be published between January 1990 and September 2011. Articles that were published online in that period, but not yet published in a printed format, were also included if these articles could be retrieved in full text format.

For this first article, we focus on SCEs reporting on effectiveness of RIs for CB among people with ID. An article was included when: (a) it was an SCE article describing for each participant individual characteristics and raw data points representing the level of CB under no-restraint (i.e., baseline) and restraint conditions (i.e., intervention), by intentional manipulation of the independent variable; (b) with the raw data points reported in a table or clearly pictured in a graph; and (c) with no-restraint as well as restraint conditions containing at least five data points for each participant (cf. Horner *et al.* 2005, Kratochwill *et al.* 2010, Romeiser-Logan *et al.* 2008). As a consequence of (a), articles only reporting percentages of reduction of CB, as well as articles only reporting aggregated data for multiple participants, were excluded from the meta-analysis.

We follow the widely accepted definition of Emerson (1995) when delineating *challenging behaviour*: it is culturally abnormal behaviour of such an intensity, frequency or duration that the physical safety of the person or others is likely to be placed in serious jeopardy, or it is behaviour which is likely to seriously limit use of, or results in the person being denied access to, ordinary community facilities. Restraint interventions are defined as interventions responding to CB which involve the limitation or restriction of movement or mobility. Based on the editorials and review-papers of Harris (1996), Jones *et al.* (2007), Luiselli (2009), and Sturmey (2009), we identified three broad categories of RIs: personal restraint, mechanical restraint, and environmental restraint. Personal

restraint, also called physical restraint or manual restraint, involves direct physical contact (i.e., force or pressure) between a person with CB and at least one other person in order to prevent or restrict the CB. Mechanical restraint concerns using materials or equipment to prevent or decrease CB. Examples are arm splints, belts, harnesses, helmets, masks, mittens, specially adapted clothing, ties, and wrist weights. Environmental restraint involves using material barriers (e.g., locked doors) to restrict CB. We did not include psychotropic medication use that can restrict free movement (i.e., chemical restraint).

We excluded articles reporting on natural therapeutic holding interventions (i.e., non-punitive and non-aversive alternatives to RIs, using touch as a therapeutic medium; Stirling 1998, Stirling & McHugh 1997), since the authors state that these interventions cannot be regarded as RIs. Furthermore, we excluded articles on other interventions than RIs for CB among persons with ID but that describe in their results/discussion sections that the use of RIs decreased through the use of these *other* interventions, and that were on that account retrieved through the electronic databases search. Finally, according to Emerson's (1995) definition of CB as *culturally abnormal* behaviour, we excluded articles on the use of RIs for behaviour that is rather *normal* given specific circumstances (e.g., when visiting a dentist).

**Study retrieval.** The search retrieved 76 unique articles that answered our inclusion criteria: 17 articles on the experiences of RIs for CB among persons with ID, and 59 SCE articles on the effectiveness of RIs. The search of the eight electronic databases retrieved 563 unique articles, from which 20 SCE articles met our inclusion criteria. Additionally, the manual search of the 32 journals pointed us to 38 other SCE articles that met our criteria. Searching the bibliographical lists of all included articles through steps one and two identified no other relevant SCE studies. By consulting the three citation indexes on the articles included through steps one, two, and three, we additionally could include one SCE article. The 59 included SCE articles are marked (*) in the reference list.

**Data analysis**

**Treatment effectiveness.** Information on the effectiveness of the RIs was gathered from the graphs presented in the retrieved SCE articles: the raw data (i.e., XY-coordinates of all data points in

the graphs) were extracted using UnGraph Version 5 (Biosoft, 1997-2011), a software program proven to show highly valid and reliable data extraction results (Shadish *et al.* 2009).

**Statistical analysis.** Since design-specific issues of single-case studies (e.g., potential autocorrelation) make it undesirable to rely on general meta-analytic techniques for studies with large sample sizes, we applied statistical meta-analytic techniques developed specifically to summarize single-case studies. Several meta-analytic procedures have been developed to aggregate the findings of SCEs, including procedures for combining *p* values and procedures for combining effect sizes. We choose to use multilevel models to analyze the SCEs because the retrieved data show a hierarchical three-level structure: we identified 59 SCE articles (between-studies level), that describe 94 unique participants with ID and CB (between-participants level), and for each participant repeated measurements of CB are reported (within-participants level). In order to account for the possible dependency that may result from this three-level nesting, we applied an adaptation of the general hierarchical linear model that can be used for a multilevel meta-analysis of SCEs: this model is described in papers of Van den Noortgate and Onghena (2003 2008). Since the coefficient that indicates the effectiveness of an RI is equal to the difference in condition (i.e., no-restraint vs. restraint) means divided by the within-condition standard deviation in this model, it can be considered as a standardized mean difference (cf. Van den Noortgate & Onghena 2008). We used the SAS software Version 9.3 to conduct the statistical analysis of the SCEs: the SAS PROC MIXED (restricted maximum-likelihood procedure) generated estimates and tests of the overall effect, of the overall intercept, and of the covariance parameters (Littell *et al.* 2006, Van den Noortgate & Onghena 2003 2008).

**Moderator analysis.** Additionally, we studied the possible moderating effects of seven variables: five participant variables and two study variables. The five participant variables are *age* (continuous variable), *gender* (male vs. female), *ID level* (borderline, mild, moderate, severe, profound; if only a range of ID level was reported it was categorized as the lower level), the *CB type* targeted by the RI, and the *type of the RI*. Based on the CB categories used by Didden *et al.* (1997 2006) the *CB type* targeted by the RI was coded as (a) external destructive behaviour (e.g., aggression,

destructive behaviour), (b) internal maladaptive behaviour (e.g., self-injurious behaviour, stereotyped behaviour, pica), (c) socially disruptive behaviour (e.g., disruptive behaviour, inappropriate social behaviour), or (d) a combination of two or three previously mentioned categories. The *type of the RI* was coded as (a) involving personal restraint only, (b) involving mechanical restraint only, (c) involving environmental restraint only, or (d) involving combinations of the previously mentioned RI types. The two study variables are *publication year* and *methodological quality* (both continuous variables). Concerning the latter variable, the methodological quality of each SCE was coded by using the Single-case Experimental Design Scale (SCED Scale; Tate *et al.* 2008). Although there exist several other frameworks and tools for evaluating SCE studies (e.g. Horner *et al.* 2005, Reichow *et al.* 2008, Romeiser-Logan *et al.* 2008), we preferred the SCED Scale because of its good content validity and inter-rater reliability scores (Tate *et al.* 2008). We tested the moderating impact of each variable on the overall treatment effectiveness using the SAS PROC MIXED.

**Reliability.** The first and second author independently coded all included SCE articles ($n$ = 59) for all included participants ($n$ = 94). Intercoder agreement was calculated by dividing the number of agreements by the number of agreements plus disagreements. The intercoder agreement was 96.88%. Disagreements were afterwards resolved by discussion between the first and second author, and the corrected codes were used for the meta-analysis.

## Results

### Description of the participants, studies and effect sizes

Table 1 presents an overview of the coded variables for the 59 included studies and 94 included cases. The mean age of the participants was 24.38 (SD = 14.47; range = 3-58). There were 46 male and 48 female participants. For 82 participants the specific ID level was reported: there were 2 participants with mild, 4 with moderate, 21 with severe, and 55 with profound ID. The most often targeted CB type was internal maladaptive behaviour (for 82 of the 94 participants), and within that category for the majority of the participants only self-injurious behaviour (SIB) was treated. The most often applied RI types were personal restraint only (for 52 participants) and mechanical restraint only

(for 32 participants). For 6 participants environmental restraint only was used, and for 4 participants a combination of RIs was used (3 times a combination of personal and mechanical restraint, and 1 time a combination of personal and environmental restraint). The applied interventions are described in more detail in the last column of Table 1. Using the Single-case Experimental Design Scale, the methodological quality of the 59 articles was on average 7.31 (*SD* = 1.15; range = 4-9).

An effect size was calculated for each included participant. Fig. 1 displays the box and whisker diagram of the standardized random effects. The effect sizes range between 1.27 and -5.78. At the bottom of Fig.1 there is one extreme outlier, participant David described by Atcheson (2006), with an effect size of -5.78. Since this outlying effect size is not based upon incorrect values (that could lead to a distorted view of the population), the participant is not omitted from the analysis. However, as a check of the influence of this outlier on the conclusions, we will perform a sensitivity analysis (see below).

**Statistical analysis**

Looking at the three-level random effects regression model without moderators (i.e., Model 1 in Table 2) for the 59 SCE articles, we can conclude that the RIs are on average highly effective: in comparison to the no-restraint conditions, the level of CB is 3.16 standard deviations lower in the restraint conditions. According to the Wald test, this reduction in CB is statistically significant, $Z = -7.06$, $p < .0001$. However, considering the covariance parameter estimates, the intervention effects show to vary significantly over the participants (estimated variance of 12.21; SD = 2.50; $Z = 4.89$, $p < .0001$). The variance between studies was much smaller than the variance between participants, and was statistically not significant (estimated variance of 3.49; SD = 2.27; $Z = 1.54$, $p = .0616$).

**Moderator analysis**

Aiming to examine which variables can explain the variation of the intervention effectiveness over the participants, we first look at the three-level meta-analysis model including the seven moderators (i.e., Model 2 in Table 2). In Table 2, Model 2 only shows a statistically significant moderating effect for the variable Gender ($Z = -2.37$, $p = .0178$): the RIs on average turn out to be more effective for female than for male participants. No evidence was found for moderating effects of

Age (Z = -0.23, p = .8168), CB type (Z = 0.28, p = .7814), ID level (Z = -1.47, p = .1406), Restraint type (Z = 0.31, p = .7567), Publication year (Z = -0.12, p = .9082), and Study quality (Z = -0.23, p = .8147).

Second, we look at the model containing only *Gender* as moderator variable (i.e., *Model 3* in Table 2): while the expected intervention effect for male participants is -2.20 (i.e., the level of CB is 2.20 standard deviations lower in the restraint conditions in comparison to the no-restraint conditions for males), the expected effect is -4.08 for female participants (i.e., -2.20-1.88; the level of CB is 4.08 standard deviations lower in the restraint conditions in comparison to the no-restraint conditions for female participants).

**Sensitivity analysis**

As discussed above, the dataset includes one extreme outlier (cf. **Fig.1**). In order to study the influence of this outlier on our conclusions, we perform a sensitivity analysis: we compare the conclusions for the full dataset to the dataset without this one outlier.

By removing this outlier the overall effect only changes a little: the overall effect is -3.16 for the complete dataset and -3.18 for the dataset without the outlier. For both datasets, the Wald test shows that on average this reduction in CB is statistically significant, with respectively: $Z = -7.06$, $p < .0001$ for the complete dataset and $Z = -7.07$, $p < .0001$ for the dataset without the outlier. This means that for both datasets the interventions are on average highly effective in reducing CB. After omitting this most extreme scoring participant from the analysis, the intervention effects still vary significantly over the included participants: the estimated variance for the database without the outlier is 12.41 ($SD = 2.54$; $Z = 4.88$, $p < .0001$). Analogous to the complete dataset, the variance between studies for the database without the outlier is much smaller than the variance between participants, and is statistically not significant (estimated variance of 3.41; SD = 2.27; Z = 1.50, p = .0667).

For the moderator analysis too, the results and conclusions for the database without the outlier are analogous to the complete dataset: Model 2 only shows a statistically significant moderating effect for the variable Gender (Z = -2.30, p = .0213), and the RIs on average turn out to be more effective for female than for male participants. No evidence was found for moderating effects of the variables Age

(Z = -0.36, p = .7180), CB type (Z = 0.10, p = .9184), ID level (Z = -0.98, p = .3292), Restraint type (Z = 0.55, p = .5824), Publication year (Z = 0.02, p = .9844), and Study quality (Z = -0.92, p = .3564).

Finally, we look at the model containing only Gender as moderator variable (i.e., Model 3). Again the results and conclusions for the dataset without the outlier are analogous to the complete dataset: while the expected intervention effect for male participants is -2.23 (i.e., the level of CB is 2.23 standard deviations lower in the restraint conditions in comparison to the no-restraint conditions for males), the expected effect is even -4.08 for female participants (i.e., -2.23-1.85; the level of CB is 4.08 standard deviations lower in the restraint conditions in comparison to the no-restraint conditions for female participants).

## Discussion

We used the hierarchical linear model to combine SCEs on the effectiveness of RIs for reducing CB among people with ID. We studied the overall effect, the differences between the included studies and participants, and the moderator effects of five participant characteristics and two study characteristics: Age, Gender, ID level, CB type, RI type, Publication year, and Methodological quality. The analyses of the 59 SCE articles show that RIs were on average highly effective in reducing CB for people with ID and that this reduction in CB was statistically significant. From the seven coded participant and study characteristics, the multilevel model only showed a statistically significant moderating effect for the variable Gender: the RIs on average were more effective for female than for male participants. We conducted a sensitivity analysis in order to study the influence of an outlying case on our results and conclusions: the conclusions regarding the main statistical analysis and the moderator analysis are the same for the full dataset as for the dataset without the one outlier.

Our meta-analysis has several strengths. This meta-analysis is the first to statistically synthesize the large amount of recently published SCE research on RIs among persons with ID. Like we mentioned in the introduction, there are several advantages of statistical meta-analytic research over single primary studies, i.e. a higher statistical power to detect effects, more accurate effect size

estimations, the ability to make more convincing generalizations to a larger population, and the ability to identify sources of heterogeneity and to test moderators to explain detected between-study and between-participant variation (Borenstein *et al.* 2009, Cooper 2010, Cooper *et al.* 2009, Ellis 2010, Hartung *et al.* 2008, Kulinskaya *et al.* 2008, Lapan & Quartaroli 2009, Lipsey & Wilson 2001). Meta-analysis is critical to cumulating research knowledge and informing policy and practice (Cooper *et al.* 2009, Hunter & Schmidt 1996, Rosenthal & DiMatteo 2001). Second, we conducted a thorough systematic search for relevant articles to be included in the meta-analysis: studies were retrieved by systematically searching 8 electronic databases, 32 relevant journals, bibliographies of relevant articles, and 3 citation indexes. Third, our search covered more than two decades of research, and included articles published to September 2011. As such this meta-analysis synthesizes the findings of current research. The publication year was taken into account as a potential moderating variable, but seemed to have no impact on the overall effect. Fourth, study quality is a potentially confounding variable. However, we coded the methodological quality of each SCE by using the SCED Scale (Tate *et al.* 2008). After testing the moderating impact of this variable on the overall treatment effectiveness using the SAS PROC MIXED we can conclude that it does not have an impact on the results.

When interpreting the results two important issues should be discussed. A first important issue is that the sample of published data and the reported outcomes in the published SCE studies seem rather unrepresentative of the everyday use of RIs among persons with ID. This is reflected in the CB type, in the purposes of RIs, and in the kinds of RIs used.

Let us first take a look at the CB type. For the participants in the SCE studies included in the meta-analysis the most often targeted CB type was internal maladaptive behaviour (for 82 of the 94 participants), and within that category for the majority of the participants only SIB was treated (cf. **3.1**). However, McGill *et al.* (2009) collected data on 268 persons with whom RIs were reported to have been used and found that RIs were most likely to be used with physically aggressive behaviour. They report that 74% of the persons displaying physically aggressive behaviour required RI for decreasing that particular CB, while only 41% of the persons displaying SIB required RI for decreasing that particular CB. This discrepancy can be explained by differentiating between

"published treatment effectiveness studies on RIs" and "everyday use of RIs" among persons with ID. For the meta-analysis we retrieved published SCE studies reporting on effectiveness of RIs for reducing CB among persons with ID. In the published literature, when data are gathered on the effectiveness of RIs it is often in the context of "treatment", especially of SIB (cf. Harris 1996, Jones *et al.* 2007, Kahng *et al.* 2002, Luiselli 1992, Matson & LoVullo 2008, Van Houten *et al.* 1992). However, in their "everyday use" RIs are most often used with physically aggressive behaviour (Allen 2000, Allen *et al.* 2009, McGill *et al.* 2009, Tenneij & Koot 2008).

Additionally, we point to the validity issue of using reduction in the frequency of CB as an outcome for RIs. With regards to the RI purposes, it is important to make a distinction between the management and treatment of CB in persons with ID: treatments of CB aim to produce behavioural change that endures over time and generalises across settings, while management approaches focus on safe responding to CB when it occurs (Allen 2000). This meta-analysis includes SCE studies reporting on the effectiveness of RIs as interventions aiming at decreasing CB in persons with ID. Although almost all published SCE studies have reduction in the frequency of CB as the reported treatment outcome for RIs (see also Harris 1996), the "routine" use of RIs - i.e. the management of CB - is not typically evaluated in terms of treatment effectiveness. Accordingly, using reduction in the frequency of CB as an outcome is rather unrepresentative of the everyday management of RIs among persons with ID. RIs are increasingly seen as being designed to bring about safe, secure, and effective management of risk behaviours and are explicitly not given the intention to reduce CB (Allen *et al.* 2009, Lundström *et al.* 2011). The primary aim of using RIs among persons with ID and CB is to prevent them from harming themselves or others through their SIB or physically aggressive behaviour, and not to impact upon future probability of CB occurring (Allen *et al.* 2009). The reduction of CB is not a valid outcome for studying this role increasingly ascribed to RIs concerning safety and effective situational management. Alternative outcomes sensitive to safety and situational management issues are for instance improvement in quality of life.

Next, let us take a closer look at the type of RIs used. Looking at the last column of **Table 1**, it seems that the RIs reported on in the included studies are not just used for a different purpose (i.e.,

treatment rather than safe management; cf. supra) but also are largely of a different kind, when compared to the everyday use of RIs. In the included studies, the most often applied RI types were personal restraint only (for 52 participants) and mechanical restraint only (for 32 participants). For only 6 participants environmental restraint only was used, and for 4 participants a combination of RIs was used (3 times a combination of personal and mechanical restraint, and once a combination of personal and environmental restraint). However, the interventions more routinely found in service provision in reaction to CB are seclusion/isolation/confinement time-out (i.e., environmental restraint) and holding a person with force (i.e., personal restraint), and in a smaller percentage of situations mechanical restraints are used (e.g., Feldman *et al.* 2004, McGill *et al.* 2009, Tenneij & Koot 2008). Furthermore, combining several RI types is part of the everyday use of RIs, while the published studies typically report on only one kind of RI. Summarizing our discussion on this first issue, the published data are rather unrepresentative of the everyday use of RIs among persons with ID, and this is reflected in the studied CB type, in the purposes of RIs, and in the kinds of RIs used.

A second important issue that should be discussed relates to variance: the intervention effects varied significantly over the included participants. Accordingly, although we expect - based on the results of the meta-analysis - that RIs reduce CBs, this might not be true for all participants. We studied whether the variables CB type, ID level, Restraint type, Gender, Age, Publication year, and Study quality could explain this variation of intervention effectiveness over the participants. From these seven coded participant and study characteristics, the multilevel model only showed a statistically significant moderating effect for the variable Gender: the RIs on average were more effective for female than for male participants. The variation between female and male participants is interesting in two ways. First of all, it is interesting that there are more female than male participants. In Table 1 we see that of the 94 included participants, 46 are male and 48 female. For 82 of the 94 included participants information on the ID level was reported: the sample included 2 male participants with mild ID, 1 female and 3 male participants with moderate ID, 11 female and 10 male participants with severe ID, and 26 female and 29 male participants with profound ID. Based on this information, the sample does not seem representative of the population of people with severe and

profound ID presenting CB: we would expect far more males than females (e.g., McClintock *et al.* 2003). A second interesting question is why the female participants apparently respond better than the male participants (i.e., the expected intervention effect is -2.20 for males and -4.08 for females). A possible explanation is reporting bias, i.e. under-reporting of negative studies. The results on male participants who responded poorly might not have been written up.

Finally, there remains some unexplained variance. In Model 1 the intervention effects varied significantly over the participants, with an estimated variance of 12.21 (SD = 2.50; Z = 4.89, $p < .0001$). When Gender, Age, CB type, ID level, Restraint type, Publication year, and Study quality were taken into account in Model 2, the intervention effects still varied significantly over the participants, with the estimated variance reduced to 9.82 (SD = 2.07; Z = 4.73, $p < .0001$). Accordingly, there remain important inter-individual differences that cannot be explained by the seven coded variables. Further research is warranted to study this remaining between-participants variance.

This meta-analysis concerned SCE studies reporting on the effectiveness of RIs as interventions aimed at decreasing CB in persons with ID, i.e. the treatment of CB. In the second article of our two-part series (Heyvaert *et al.* 2014) we will address the views, emotions, and perspectives of carers (e.g., family, staff) and clients concerning RIs used in the management of CB among persons with ID.

**References**


Adams D. & Allen D. (2001) Assessing the need for reactive behaviour management strategies in children with intellectual disability and severe challenging behaviour. *Journal of Intellectual Disability Research* 45, 335-343.

Allen D. (2000) Recent research on physical aggression in persons with intellectual disability: An overview. *Journal of Intellectual and Developmental Disability* 25, 41-57.

Allen D., Hawkins S. & Cooper V. (2006) Parents' use of physical interventions in the management of their children's severe challenging behaviour. *Journal of Applied Research in Intellectual Disabilities* 19, 356-363.

Allen D., Lowe K., Brophy S. & Moore K. (2009) Predictors of restrictive reactive strategy use in people with challenging behaviour. *Journal of Applied Research in Intellectual Disabilities* 22, 159-168.

* Atcheson K. (2006) *Immediate and subsequent effects of response blocking on self-injurious behavior*. Thesis Prepared for the Degree of Master of Science. University of North Texas.

Baker P.A. & Bissmire D. (2000) A pilot study of the use of physical intervention in the crisis management of people with intellectual disabilities who present challenging behaviour. *Journal of Applied Research in Intellectual Disabilities* 13, 38-45.

Beretvas S.N. & Chung H. (2008) A review of meta-analyses of single-subject experimental designs: Methodological issues and practice. *Evidence-Based Communication Assessment and Intervention* 2, 129-141.

Biosoft (1997-2011) *UnGraph Version 5* [Computer software]. Retrieved from http://www.biosoft.com/w/ungraph.htm

Borenstein M., Hedges L.V., Higgins J.P.T. & Rothstein H.R. (2009) *Introduction to meta-analysis.* Wiley, Chichester.

* Borrero J.C., Vollmer T.R., Wright C.S., Lerman D.C. & Kelley M.E. (2002) Further evaluation of the role of protective equipment in the functional analysis of self-injurious behavior. *Journal of Applied Behavior Analysis* 35, 69-72.

* Cameron M.J., Luiselli J.K., Littleton R.F. & Ferrelli L. (1996) Component analysis and stimulus control assessment of a behavior deceleration treatment package. *Research in Developmental Disabilities* 17, 203-215.

* Cannella-Malone H.I., O'Reilly M.F., Sigafoos J. & Chan J.M. (2008) Combined curricular intervention with brief hands down to decrease hand mouthing and the use of arm splints for a young boy with profound disabilities. *Education and Training in Developmental disabilities* 43, 360-366.

* Carr J.E., Dozier C.L., Patel M.R., Adams A.N. & Martin N. (2002) Treatment of automatically reinforced object mouthing with noncontingent reinforcement and response blocking: Experimental analysis and social validation. *Research in Developmental Disabilities* 23, 37-44.

* Chung Y.C. & Cannella-Malone H.I. (2010) The effects of presession manipulations on automatically maintained challenging behavior and task responding. *Behavior Modification* 34, 479-502.

Cooper H., Hedges L.V. & Valentine J.C. (2009) *The handbook of research synthesis and meta-analysis* (2nd ed.). Sage, New York.

Cooper H. (2010) *Research synthesis and meta-analysis: A step-by-step approach* (3rd ed.). Sage, London.

Creswell J.W. & Tashakkori A. (2007) Developing publishable mixed methods papers. *Journal of Mixed Methods Research* 1, 107-111.

Cunningham J., McDonnell A., Eastona S. & Sturmey P. (2003) Social validation data on three methods of physical restraint: Views of consumers, staff and students. *Research in Developmental Disabilities* 24, 307-316.

Dagnan D. & Weston C. (2006) Physical intervention with people with intellectual disabilities: The influence of cognitive and emotional variables. *Journal of Applied Research in Intellectual Disabilities* 19, 219-222.

Department of Health (2002) *Guidance for restrictive physical interventions. How to provide safe services for people with learning disabilities and autism spectrum disorder*. Department of Health, London. Retrieved from http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_4068461.pdf

Deveau R. & McDonnell A. (2009) As the last resort: Reducing the use of restrictive physical interventions using organisational approaches. *British Journal of Learning Disabilities* 37, 172-177.

Deveau R. & McGill P. (2009) Physical interventions for adults with intellectual disabilities: Survey of use, policy, training and monitoring. *Journal of Applied Research in Intellectual Disabilities* 22, 145-151.

Didden R., Duker P.C. & Korzilius H. (1997) Meta-analytic study on treatment effectiveness for problem behaviors with individuals who have mental retardation. *American Journal of Mental Retardation* 101, 387-409.

Didden R., Korzilius H., van Oorsouw W. & Sturmey P. (2006) Behavioural treatment of challenging behaviours in individuals with mild mental retardation: Meta-analysis of single-subject research. *American Journal on Mental Retardation* 111, 290-298.

* Dura J.R. (1991) Controlling extremely dangerous aggressive outbursts when functional analysis fails. *Psychological reports* 69, 451-459.

Elford H., Beail N. & Clarke Z. (2010) 'A very fine line': Parents' experiences of using restraint with their adult son/daughter with intellectual disabilities. *Journal of Applied Research in Intellectual Disabilities* 23, 75-84.

Ellis P.D. (2010) *The essential guide to effect sizes: Statistical power, meta-analysis, and the interpretation of research results.* Cambridge University Press, Cambridge.

Emerson E. (1995) *Challenging behaviour: Analysis and intervention in people with learning disabilities*. Cambridge University Press, Cambridge.

Emerson E., Kiernan C., Alborz A., Reeves D., Mason H., Swarbrick R. et al. (2001) The prevalence of challenging behaviours: A total population study. *Research in Developmental Disabilities* 22, 77-93.

Emerson E., Robertson J., Gregory N., Hatton C., Kessissoglou S., Hallam A. & Hillery J. (2000) Treatment and management of challenging behaviours in residential settings. *Journal of Applied Research in Intellectual Disabilities* 13, 197-215.

Estabrooks C.A., Field P.A. & Morse J.M. (1994) Aggregating qualitative findings: An approach to theory development. *Qualitative Health Research* 4, 503-511.

Feldman M.A., Atkinson L., Foti-Gervais L. & Condillac R. (2004) Formal versus informal interventions for challenging behaviour in persons with intellectual disabilities. *Journal of Intellectual Disability Research* 48, 60-68.

Finfgeld D.L. (2003) Metasynthesis: The state of the art - So far. *Qualitative Health Research* 13, 893-904.

Fish R. & Culshaw E. (2005) The last resort? Staff and client perspectives on physical intervention. *Journal of Intellectual Disabilities* 9, 93-107.

* Fisher W.W., Grace N.C. & Murphy C. (1996) Further analysis of the relationship between self-injury and self-restraint. *Journal of Applied Behavior Analysis* 29, 103-106.

* Fisher W.W., Lindauer S.E., Alterson C.J. & Thompson R.H. (1998) Assessment and treatment of destructive behavior maintained by stereotypic object manipulation. *Journal of Applied Behavior Analysis* 31, 513-527.

* Fisher W.W., Piazza C.C., Bowman L.G., Hanley G.P. & Adelinis J.D. (1997) Direct and collateral effects of restraints and restraint fading. *Journal of Applied Behavior Analysis* 30, 105-120.

* Fox R.A., Holtz C.A. & Barcelona A.L. (2008) Oppositional defiant disorder and aggression in a young man with mental retardation: Long-term treatment in a community-based setting. *Clinical Case Studies* 7, 42-53.

Foxx R.M., McHenry W.C. & Bremer B.A. (1996) The effects of a video vignette on increasing treatment acceptability. *Behavioral Interventions* 11, 131-140.

* Graff R.B., Lineman G.T., Libby M.E. & Ahearn W.H. (1999) Functional analysis and treatment of screaming in a young girl with severe disabilities. *Behavioral Interventions* 14, 233-239.

* Hanley G.P., Iwata B.A., Thompson R.H. & Lindberg J.S. (2000) A component analysis of "stereotypy as reinforcement" for alternative behavior. *Journal of Applied Behavior Analysis* 33, 285-297.

* Hanley G.P., Piazza C.C., Keeney K.M., Blakeley-Smith A.B. & Worsdell A.S. (1998) Effects of wrist weights on self-injurious and adaptive behaviors. *Journal of Applied Behavior Analysis* 31, 307-310.

Harden A. & Thomas J. (2010) Mixed methods and systematic reviews: Examples and emerging issues. In A. Tashakkori & C. Teddlie (Eds.), *Sage handbook of mixed methods in social and behavioral research* (2nd ed., pp. 749-774). Sage, Thousand Oaks.

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

Hartung J., Knapp G. & Sinha B.K. (2008) *Statistical meta-analysis with applications*. Wiley, Hoboken.

Hawkins S., Allen D. & Jenkins R. (2005) The use of physical interventions with people with intellectual disabilities and challenging behaviour - The experience of service users and staff members. *Journal of Applied Research in Intellectual Disabilities* 18, 19-34.

Heyvaert M., Hannes K., Maes B. & Onghena P. (2013a) Critical appraisal of mixed methods studies. *Journal of Mixed Methods Research* 7, 302-327.

Heyvaert M., Maes B. & Onghena P. (2011) Applying mixed methods research at the synthesis level: An overview. *Research in the Schools* 18(1), 12-24.

Heyvaert M., Maes B. & Onghena P. (2013b) Mixed methods research synthesis: Definition, framework, and potential. *Quality & Quantity* 47, 659-676.

Heyvaert M., Maes B., Van den Noortgate W., Kuppens S. & Onghena P. (2012) A multilevel meta-analysis of single-case and small-n research on interventions for reducing challenging behavior in persons with intellectual disabilities. *Research in Developmental Disabilities* 33, 766-780.

Heyvaert M., Saenen L., Maes B. & Onghena P. (2014) Systematic review of restraint interventions for challenging behaviour among persons with intellectual disabilities: Focus on experiences. *Journal of Applied Research in Intellectual Disabilities* (in press).

Higgins J.P.T. & Green S. (2008) *Cochrane handbook for systematic reviews of interventions* [E-book].

Holden B. & Gitlesen J.P. (2006) A total population study of challenging behaviour in the county of Hedmark, Norway: Prevalence and risk markers. *Research in Developmental Disabilities* 27, 456-465.

Horner R.H., Carr E.G., Halle J., McGee G., Odom S. & Wolery M. (2005) The use of single subject research to identify evidence-based practice in special education. *Exceptional Children* 71, 165-179.

Hunter J.E. & Schmidt F.L. (1996) Cumulative research knowledge and social policy formulation: The critical role of meta-analysis. *Psychology, Public Policy, and Law* 2, 324-347.

* Irvin D.S., Thompson T.J., Turner W.D. & Williams D.E. (1998) Utilizing increased response effort to reduce chronic hand mouthing. *Journal of Applied Behavior Analysis* 31, 375-385.

* Jena S.P.K. (1995) Effects of differential reinforcement, physical restraint and verbal reprimand on stereotyped body-rocking. *International Journal of Rehabilitation Research* 18, 70-75.

* Jena S.P.K. (1999) Treatment of self-injurious behaviour by differential reinforcement and physical restraint. *International Journal of Rehabilitation Research* 22, 243-247.

Jensen L.A. & Allen M.N. (1996) Meta-synthesis of qualitative findings. *Qualitative Health Research* 6, 553-560.

Jones E., Allen D., Moore K., Philips B. & Lowe, K. (2007) Restraint and self-injury in people with intellectual disabilities: A review. *Journal of Intellectual Disabilities* 11, 105-118.

Jones P. & Kroese B.S. (2007) Service users' views of physical restraint procedures in secure settings for people with learning disabilities. *British Journal of Learning Disabilities* 35, 50-54.

Jones P. & Kroese B.S. (2008) Service users and staff from secure intellectual disability settings: Views on three physical restraint procedures. *Journal of Intellectual Disabilities* 12, 229-237.

* Kahng S., Abt K.A. & Wilder D.A. (2001) Treatment of self-injury correlated with mechanical restraints. *Behavioral Interventions* 16, 105-110.

Kahng S., Iwata B.A. & Lewin A.B. (2002) Behavioral treatment of self-injury, 1964 to 2000. *American Journal on Mental Retardation* 107, 212-221.

* Kelley M.E., Lerman D.C. & Van Camp C.M. (2002) The effects of competing reinforcement schedules on the acquisition of functional communication. *Journal of Applied Behavior Analysis* 35, 59-63.

* Kerth D.M., Progar P.R. & Morales S. (2009) The effects of non-contingent self-restraint on self-injury. *Journal of Applied Research in Intellectual Disabilities* 22, 187-193.

Kratochwill T.R., Hitchcock J., Horner R.H., Levin J.R., Odom S.L., Rindskopf D.M. & Shadish W.R. (2010) *Single-case designs technical documentation*. Retrieved from http://ies.ed.gov/ncee/wwc/pdf/wwc_scd.pdf.

Kulinskaya E., Morgenthaler S. & Staudte R.G. (2008) *Meta-analysis: A guide to calibrating and combining statistical evidence*. Wiley, Chichester.

* Lalli J.S., Livezey K. & Kates K. (1996) Functional analysis and treatment of eye poking with response blocking. *Journal of Applied Behavior Analysis* 29, 129-132.

Lapan S.D. & Quartaroli M.T. (2009) *Research essentials: An introduction to designs and practices*. Jossey-Bass, San Francisco.

* Le D.D. & Smith R.G. (2002) Functional analysis of self-injury with and without protective equipment. *Journal of developmental and physical disabilities* 14, 277-290.

* LeBlanc L.A., Piazza C.C. & Krug M.A. (1997) Comparing methods for maintaining the safety of a child with pica. *Research in Developmental Disabilities* 18, 215-220.

* Lerman D.C. & Iwata B.A. (1996) A methodology for distinguishing between extinction and punishment effects associated with response blocking. *Journal of Applied Behavior Analysis* 29, 231-234.

* Lerman D.C., Iwata B.A., Shore B.A. & DeLeon I.G. (1997) Effects of intermittent punishment on self-injurious behavior: An evaluation of schedule thinning. *Journal of Applied Behavior Analysis* 30, 187-201.
* Lerman D.C., Kelley M.E., Vorndran C.M. & Van Camp C.M. (2003) Collateral effects of response blocking during the treatment of stereotypic behavior. *Journal of Applied Behavior Analysis* 36, 119-123.
* Lindberg J.S., Iwata B.A. & Kahng S.W. (1999) On the relation between object manipulation and stereotypic self-injurious behavior. *Journal of Applied Behavior Analysis* 32, 51-62.
Lipsey M.W. & Wilson D.B. (2001) *Practical meta-analysis*. Sage, Thousand Oaks.
Littell R.C., Milliken G.A., Stroup W.W., Wolfinger R.D. & Schabenberger O. (2006) *SAS for Mixed Models* (2nd ed.). SAS Institute Inc, Cary, NC.
Lowe K., Allen D., Jones E., Brophy S., Moore K. & James W. (2007) Challenging behaviours: Prevalence and topographies. *Journal of Intellectual Disability Research* 51, 625-636.
* Luiselli J.K. (1991) A non-aversive behavioral-pharmacological intervention for severe self-injury in an adult with dual sensory impairment. *Journal of Behavior Therapy and Experimental Psychiatry* 22, 233-238.
Luiselli J.K. (1992) Protective equipment. In *Self-Injurious Behavior: Analysis, Assessment, and Treatment* (eds J.K. Luiselli, J.L. Matson & N.N. Singh), pp. 235-268. Springer-Verlag, New York.
* Luiselli J.K. (1998) Treatment of self-injurious hand-mouthing in a child with multiple disabilities. *Journal of Developmental and Physical Disabilities* 10, 167-174.
Luiselli J.K. (2009) Physical restraint of people with intellectual disability: A review of implementation reduction and elimination procedures. *Journal of Applied Research in Intellectual Disabilities* 22, 126-134.
Lundström M.O., Antonsson H., Karlsson S. & Graneheim U.H. (2011) Use of physical restraints with people with intellectual disabilities living in Sweden's group homes. *Journal of Policy and Practice in Intellectual Disabilities* 8, 36-41.
MacDonald A., McGill P. & Deveau R. (2011) 'You squeal and squeal but they just hold you down'. Restrictive physical interventions and people with intellectual disabilities: Service user views. *International Journal of Positive Behavioural Support* 1, 45-52.
Major C.H. & Savin-Baden M. (2010) *An introduction to qualitative research synthesis: Managing the information explosion in social science research*. Routledge, London.
* Matson J.L. & Keyes J.B. (1990) A comparison of DRO to movement suppression time-out and DRO with two self-injurious and aggressive mentally retarded adults. *Research in Developmental Disabilities* 11, 111-120.
Matson J.L. & LoVullo S.V. (2008) A review of behavioral treatments for self-injurious behaviors of persons with autism spectrum disorders. *Behavior Modification* 32, 61-76.
* Mazaleski J.L., Iwata B.A., Rodgers T.A., Vollmer T.R. & Zarcone J.R. (1994) Protective equipment as treatment for stereotypic hand mouthing: Sensory extinction or punishment effects? *Journal of Applied Behavior Analysis* 27, 345-355.
McClintock K., Hall S. & Oliver C. (2003) Risk markers associated with challenging behaviours in people with intellectual disabilities: A meta-analytic study. *Journal of Intellectual Disability Research* 47, 405-416.
* McCord B.E., Grosser J.W., Iwata B.A. & Powers L.A. (2005) An analysis of response-blocking parameters in the prevention of pica. *Journal of Applied Behavior Analysis* 38, 391-394.
* McCord B.E., Thomson R.J. & Iwata B.A. (2001) Functional analysis and treatment of self-injury associated with transitions. *Journal of Applied Behavior Analysis* 34, 195-210.

McDonnell A.A. & Sturmey P. (2000) The social validation of three physical restraint procedures: A comparison of young people and professional groups. *Research in Developmental Disabilities* 21, 85-92.

McGill P., Murphy G. & Kelly-Pike A. (2009) Frequency of use and characteristics of people with intellectual disabilities subject to physical interventions. *Journal of Applied Research in Intellectual Disabilities* 22, 152-158.

* McKerchar T.L., Kahng S., Casioppo E. & Wilson D. (2001) Functional analysis of self-injury maintained by automatic reinforcement: Exposing masked social functions. *Behavioral Interventions* 16, 59-63.

* Moore J.W., Fisher W.W. & Pennington A. (2004) Systematic application and removal of protective equipment in the assessment of multiple topographies of self-injury. *Journal of Applied Behavior Analysis* 37, 73-77.

* Mueller M.M. & Kafka C. (2006) Assessment and treatment of object mouthing in a public school classroom. *Behavioral Interventions* 21, 137-154.

* Northup J., Fisher W., Kahang S.W., Harrell R. & Kurtz P. (1997) An assessment of the necessary strength of behavioral treatments for severe behavior problems. *Journal of developmental and physical disabilities* 9, 1-16.

* O'Connor J.T., Sorensen-Burnworth R.J., Rush K.S. & Eidman S.L. (2003) A mand analysis and levels treatment in an outpatient clinic. *Behavioral Interventions* 18, 139-150.

Onghena P. (2005) Single-case designs. In B. Everitt & D. Howell (Eds.), *Encyclopedia of statistics in behavioral science: Vol. 4* (pp. 1850-1854). Wiley, New York.

* Piazza C.C., Fisher W.W., Hanley G.P., LeBlanc L.A., Worsdell A.S., Lindauer S.E. & Keeney K.M. (1998) Treatment of pica through multiple analyses of its reinforcing functions. *Journal of Applied Behavior Analysis* 31, 165-189.

* Rapp J.T. & Miltenberger R.G. (2000) Self-restraint and self-injury: A demonstration of separate functions and response classes. *Behavioral Interventions* 15, 37-51.

* Rapp J.T., Dozier C.L. & Carr J.E. (2001) Functional assessment and treatment of pica: A single-case experiment. *Behavioral Interventions* 16, 111-125.

* Rapp J.T., Miltenberger R.G., Galensky T.L., Ellingson S.A., Stricker J., Garlinghouse M. & Long E.S. (2000) Treatment of hair pulling and hair manipulation maintained by digital-tactile stimulation. *Behavior Therapy* 31, 381-393.

Ravoux P., Baker P. & Brown H. (2012) Thinking on your feet: Understanding the immediate responses of staff to adults who challenge intellectual disability services. *Journal of Applied Research in Intellectual Disabilities* 25, 189-202.

Reichow B., Volkmar F.R. & Cicchetti D.V. (2008) Development of the evaluative method for evaluating and determining evidence-based practices in autism. *Journal of Autism and Developmental Disorders* 38, 1311-1319.

* Reid D.H., Parsons M.B., Phillips J.F. & Green C.W. (1993) Reduction of self-injurious hand mouthing using response blocking. *Journal of Applied Behavior Analysis* 26, 139-140.

* Richman D., Wacker D., Asmus J. & Casey S. (1998) Functional analysis and extinction of different behavior problems exhibited by the same individual. *Journal of Applied Behavior Analysis* 31, 475-478.

* Roane H.S., Piazza C.C., Sgro G.M., Volkert V.M. & Anderson C.M. (2001) Analysis of aberrant behaviour associated with Rett syndrome. *Disability and Rehabilitation* 23, 139-148.

* Rolider A., Williams L., Cummings A. & Van Houten R. (1991) The use of a brief movement restriction procedure to eliminate severe inappropriate behavior. *Journal of Behavior Therapy and Experimental Psychiatry* 22, 23-30.

Romeiser-Logan L., Hickman R.R., Harris S.R. & Heriza C.B. (2008) Single-subject research design: Recommendations for levels of evidence and quality rating. *Developmental Medicine & Child Neurology* 50, 99-103.

* Roscoe E.M., Iwata B.A. & Goh H.L. (1998) A comparison of noncontingent reinforcement and sensory extinction as treatments for self-injurious behavior. *Journal of Applied Behavior Analysis* 31, 635-646.

Rosenthal R. & DiMatteo M.R. (2001) Meta-analysis: Recent developments in quantitative methods for literature reviews. *Annual Review of Psychology* 52, 59-82.

Sandelowski M., Docherty S. & Emden C. (1997) Qualitative metasynthesis: Issues and techniques. *Research in Nursing and Health* 20, 365-371.

Sandelowski M., Voils C.I. & Barroso J. (2006) Defining and designing mixed research synthesis studies. *Research in the Schools* 13, 29-40.

Sequeira H. & Halstead S. (2001) "Is it meant to hurt, is it?" - Management of violence in women with developmental disabilities. *Violence Against Women* 7, 462-476.

Shadish W.R. & Rindskopf D.M. (2007) Methods for evidence-based practice: Quantitative synthesis of single-subject designs. *New Directions for Evaluation* 113, 95-109.

Shadish W.R., Brasil I.C.C., llingworth D.A.I., White K.D., Galindo R., Nagler E.D. & Rindsk D.M. (2009) Using UnGraph to extract data from image files: Verification of reliability and validity. *Behavior Research Methods* 41, 177-183.

* Sisson L.A., Vanhasselt V.B. & Hersen M. (1993) Behavioral interventions to reduce maladaptive responding in youth with dual sensory impairment. An analysis of direct and concurrent effects. *Behavior Modification* 17, 164-188.

* Smith R.G., Iwata B.A., Vollmer T.R. & Pace G.M. (1992) On the relationship between self-injurious behavior and self-restraint. *Journal of Applied Behavior Analysis* 25, 433-445.

* Smith R.G., Lerman D.C. & Iwata B.A. (1996) Self-restraint as positive reinforcement for self-injurious behavior. *Journal of Applied Behavior Analysis* 29, 99-102.

* Smith R.G., Russo L. & Le D.D. (1999) Distinguishing between extinction and punishment effects of response blocking: A replication. *Journal of Applied Behavior Analysis* 32, 367-370.

Stange K.C., Crabtree B.F. & Miller W.L. (2006) Publishing multimethod research. *Annals of Family Medicine* 4, 292-294.

Stirling C. & McHugh A. (1997) Natural therapeutic holding: A non-aversive alternative to the use of control and restraint in the management of violence for people with learning disabilities. *Journal of Advanced Nursing* 26, 304-311.

Stirling C. (1998) The use of natural therapeutic holding as a non-aversive physical intervention in the management of violence. *British Journal of Learning Disabilities* 26, 105-109.

Sturmey P. (1999) Correlates of restraint use in an institutional population. *Research in Developmental Disabilities* 20, 339-346.

Sturmey P. (2009) It is time to reduce and safely eliminate restrictive behavioural practices. *Journal of Applied Research in Intellectual Disabilities* 22, 105-110.

* Tarbox J., Wallace M.D. & Tarbox R.S.F. (2002) Successful generalized parent training and failed schedule thinning of response blocking for automatically maintained object mouthing. *Behavioral Interventions* 17, 169-178.

Tate R.L., McDonald S., Perdices M., Togher L., Schultz R. & Savage S. (2008) Rating the methodological quality of single-subject designs and n-of-1 trials: Introducing the Single-Case Experimental Design (SCED) Scale. *Neuropsychological Rehabilitation* 18, 385-401.

Tenneij N.H. & Koot H.M. (2008) Incidence, types and characteristics of aggressive behaviour in treatment facilities for adults with mild intellectual disability and severe challenging behavior. *Journal of Intellectual Disability Research* 52, 114-124.

* Thompson R.H., Fisher W.W., Piazza C.C. & Kuhn D.E. (1998) The evaluation and treatment of aggression maintained by attention and automatic reinforcement. *Journal of Applied Behavior Analysis* 31, 103-116.

* Thompson R.H., Iwata B.A., Conners J. & Roscoe E.M. (1999) Effects of reinforcement for alternative behavior during punishment of self-injury. *Journal of Applied Behavior Analysis* 32, 317-328.

* Toole L.M., Bowman L.G., Thomason J.L., Hagopian L.P. & Rush K.S. (2003) Observed increases in positive affect during behavioral treatment. *Behavioral Interventions* 18, 35-42.

* Turner W.D., Realon R.E., Irvin D. & Robinson E. (1996) The effects of implementing program consequences with a group of individuals who engaged in sensory maintained hand mouthing. *Research in Developmental Disabilities* 17, 311-330.

Van den Noortgate W. & Onghena P. (2003) Combining single-case experimental data using hierarchical linear models. *School Psychology Quarterly* 18, 325-346.

Van den Noortgate W. & Onghena P. (2007) The aggregation of single-case results using hierarchical linear models. *The Behavior Analyst Today* 8, 196-209.

Van den Noortgate W. & Onghena P. (2008) A multilevel meta-analysis of single-subject experimental design studies. *Evidence-Based Communication Assessment and Intervention* 2, 142-151.

Van Houten R., Rolider A. & Houlihan M. (1992) Treatments of self-injury based on teaching compliance and/or brief physical restraint. In *Self-Injurious Behavior: Analysis, Assessment, and Treatment* (eds J. Liuselli, J.L. Matson & N.N. Singh), pp. 181-199. Springer-Verlag, New York.

* Van Houten R. (1993) The use of wrist weights to reduce self-injury maintained by sensory reinforcement. *Journal of Applied Behavior Analysis* 26, 197-203.

* Vollmer T.R., Marcus B.A. & LeBlanc L. (1994) Treatment of self-injury and hand mouthing following inconclusive functional analyses. *Journal of Applied Behavior Analysis* 27, 331-344.

Walsh D. & Downe S.E. (2005) Meta-synthesis method for qualitative research: A literature review. *Journal of Advanced Nursing* 50, 204-211.

Williams D.E. (2010) Reducing and eliminating restraint of people with developmental disabilities and severe behavior disorders: An overview of recent research. *Research in Developmental Disabilities* 31, 1142-1148.

Williams D.E. & Grossett D.L. (2011) Reduction of restraint of people with intellectual disabilities: An organizational behavior management (OBM) approach. *Research in Developmental Disabilities* 32, 2336-2339.

* Zhou L.M., Goff G.A. & Iwata B.A. (2000) Effects of increased response effort on self-injury and object manipulation as competing responses. *Journal of Applied Behavior Analysis* 33, 29-40.

## Tables

**Table 1**
Characteristics of the 59 included studies and 94 included cases.

| *Study* | **Publi-cation year** | **Study quality**[1] | *Case* | **Age** | **Gender** | **CB cate-gory**[2] | **ID level**[3] | **Restraint type**[4] | **Description of the restraint procedure(s)** |
|---|---|---|---|---|---|---|---|---|---|
| Atcheson 2006 | 2006 | 8 | A | 58 | male | IMB | profound | PR only | Response blocking |
| | | | B | 45 | female | IMB | profound | PR only | Response blocking |
| Borrero *et al.* 2002 | 2002 | 6 | A | 35 | male | IMB | moderate | MR only | Protective equipment: baseball cap and clean gauze |
| | | | B | 8 | male | IMB | profound | MR only | Protective equipment: helmet |
| Cameron *et al.* 1996 | 1996 | 7 | A | 16 | female | SDB | | MR only | Protective equipment: helmet |
| Cannella-Malone *et al.* 2008 | 2008 | 7 | A | 10 | male | IMB | profound | PR only | Hands down procedure |
| Carr *et al.* 2002 | 2002 | 7 | A | 7 | female | IMB | | PR only | Response blocking |
| Chung & Cannella-Malone 2010 | 2010 | 7 | A | 11 | female | IMB | | PR only | Response blocking |
| | | | B | 16 | female | IMB | | PR only | Response blocking |
| Dura 1991 | 1991 | 4 | A | 11 | female | EDB | profound | PR only | Taking the participant down to the floor (mat) |
| Fisher *et al.* 1996 | 1996 | 6 | A | 19 | male | IMB | severe | PR only | Response blocking |
| Fisher *et al.* 1997 | 1997 | 8 | A | 20 | male | IMB | profound | MR only | Protective equipment: arm restraints |
| | | | B | 8 | male | IMB | profound | MR only | Protective equipment: arm restraints |
| | | | C | 7 | male | IMB | profound | MR only | Protective equipment: arm restraints |
| Fisher *et al.* 1998 | 1998 | 8 | A | 7 | male | EDB | moderate | PR only | Response blocking |
| Fox *et al.* 2008 | 2008 | 4 | A | 28 | male | EDB | mild | PR+ER | Holding the participant's arms; Exclusionary time-out |
| Graff *et al.* 1999 | 1999 | 6 | A | 6 | female | SDB | severe | ER only | Time-out area |
| Hanley *et al.* 1998 | 1998 | 7 | A | 6 | male | IMB | profound | MR only | Wrist weights |
| Hanley *et al.* 2000 | 2000 | 8 | A | 36 | female | IMB | profound | PR only | Response blocking |
| | | | B | 33 | male | IMB | profound | PR only | Response blocking |
| | | | C | 46 | male | IMB | profound | PR only | Response blocking |
| Irvin *et al.* 1998 | 1998 | 8 | A | 25 | female | IMB | profound | MR only | Protective equipment: arm restraints |
| | | | B | 41 | female | IMB | profound | MR only | Protective equipment: arm restraints |
| Jena 1995 | 1995 | 7 | A | | male | IMB | severe | PR only | Response blocking |
| Jena 1999 | 1999 | 8 | A | 3 | female | IMB | severe | MR only | Steel bracelet around wrist |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Kahng *et al.* 2001 | 2001 | 6 | A | 16 | female | IMB | severe | MR only | Protective equipment: arm restraints |
| Kelley *et al.* 2002 | 2002 | 7 | A | 10 | female | SDB | severe | PR only | Response blocking |
| Kerth *et al.* 2009 | 2009 | 7 | A | 16 | male | IMB | severe | MR only | Protective equipment: adapted clothing |
| Lalli *et al.* 1996 | 1996 | 7 | A | 4 | female | IMB | severe | PR only | Response blocking |
| Le & Smith 2002 | 2002 | 8 | A | 37 | male | IMB | profound | MR only | Protective equipment: mittens |
| | | | B | 40 | male | IMB | profound | MR only | Protective equipment: gloves |
| | | | C | 35 | male | IMB | profound | MR only | Protective equipment: helmet |
| LeBlanc *et al.* 1997 | 1997 | 6 | A | 4 | female | IMB | severe | PR+MR | Response blocking; Arm restraints; Helmet; Face mask attached to the helmet |
| Lerman & Iwata 1996 | 1996 | 7 | A | 32 | male | IMB | profound | PR only | Response blocking |
| Lerman *et al.* 1997 | 1997 | 8 | A | 31 | female | IMB | profound | PR only | Hold participant's arms to sides contingent on each occurrence of SIB |
| | | | B | 35 | female | IMB | profound | PR+MR | Hold participant's arms to sides contingent on each occurrence of SIB; Collar brace |
| | | | C | 25 | female | IMB | profound | PR only | Hold participant's arms to sides contingent on each occurrence of SIB |
| | | | D | 31 | male | IMB | profound | PR only | Hold participant's arms to sides contingent on each occurrence of SIB |
| Lerman *et al.* 2003 | 2003 | 9 | A | 18 | female | IMB | severe | PR only | Response blocking |
| Lindberg *et al.* 1999 | 1999 | 8 | A | 33 | male | IMB | profound | PR only | Response blocking |
| | | | B | 46 | male | IMB | profound | MR only | Protective equipment: arm restraints |
| Luiselli 1991 | 1991 | 5 | A | 22 | female | IMB | | MR only | Protective equipment: helmet |
| Luiselli 1998 | 1998 | 8 | A | 15 | male | IMB | severe | PR only | Hold participant's hands in his lap contingent on each occurrence of SIB |
| Matson & Keyes 1990 | 1990 | 8 | A | 35 | male | IMB | severe | PR only | Movement suppression: hold participant still with his arms extended out to the sides |
| | | | B | 39 | male | COM | severe | PR only | Movement suppression: hold participant still with his arms extended out to the sides |
| Mazaleski *et al.* 1994 | 1994 | 8 | A | 33 | female | IMB | profound | MR only | Protective equipment: mittens |
| | | | B | 34 | female | IMB | profound | MR only | Protective equipment: mittens |
| McCord *et al.* 2001 | 2001 | 8 | A | 27 | male | IMB | profound | PR only | Response blocking |
| | | | B | 38 | male | IMB | profound | PR only | Response blocking |
| McCord *et al.* 2005 | 2005 | 8 | A | 48 | male | IMB | profound | PR only | Response blocking |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | B | 40 | male | IMB | profound | PR only | Response blocking |
| | | | C | 44 | male | IMB | profound | PR only | Response blocking |
| McKerchar *et al.* 2001 | 2001 | 6 | A | 10 | male | IMB | mild | PR+MR | Response blocking; Protective equipment: soft padded helmet |
| Moore *et al.* 2004 | 2004 | 6 | A | 12 | female | IMB | | MR only | Protective equipment: helmet, rigid arm sleeves, shoulders and legs padded using foam, hands padded using martial arts equipment, boxing gloves, additional padding on hips |
| Mueller & Kafka 2006 | 2006 | 6 | A | 4 | female | IMB | | PR only | Response blocking |
| Northup *et al.* 1997 | 1997 | 8 | A | | male | COM | | ER only | Exclusionary time-out |
| | | | B | 35 | female | IMB | severe | ER only | Exclusionary time-out |
| | | | C | 3 | female | COM | severe | ER only | Exclusionary time-out |
| O'Connor *et al.* 2003 | 2003 | 7 | A | 14 | male | COM | severe | ER only | Exclusionary time-out |
| Piazza *et al.* 1998 | 1998 | 8 | A | 4 | female | IMB | profound | PR only | Response blocking |
| Rapp & Miltenberger 2000 | 2000 | 7 | A | 11 | male | IMB | severe | PR only | Response blocking |
| Rapp *et al.* 2000 | 2000 | 9 | A | 19 | female | IMB | severe | MR only | Hand splint |
| Rapp *et al.* 2001 | 2001 | 8 | A | 6 | female | IMB | | PR only | Response blocking |
| Reid *et al.* 1993 | 1993 | 7 | A | 57 | female | IMB | profound | PR only | Response blocking |
| | | | B | 27 | female | IMB | profound | PR only | Response blocking |
| Richman *et al.* 1998 | 1998 | 6 | A | 27 | female | IMB | profound | PR only | Response blocking |
| Roane *et al.* 2001 | 2001 | 9 | A | 23 | female | IMB | profound | PR only | Hold participant's hands parallel to hips contingent on each occurrence of SIB |
| | | | B | 14 | female | IMB | profound | PR only | Hold participant's hands down contingent on each occurrence of SIB |
| Rolider *et al.* 1991 | 1991 | 7 | A | 24 | male | COM | moderate | PR only | Movement restriction: the mediator placed his/her hand on the participant's upper back and pushed the participant forward down to the knees, so that the participant's chest rested on his own lap; The participant's arms were then placed behind his back |
| Roscoe *et al.* 1998 | 1998 | 8 | A | 29 | male | IMB | profound | MR only | Protective equipment: foam sleeves |
| | | | B | 35 | female | IMB | profound | MR only | Protective equipment: boxing gloves |
| | | | C | 20 | female | IMB | moderate | MR only | Protective equipment: latex gloves |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sisson *et al.* 1993 | 1993 | 9 | A | 18 | male | IMB | profound | PR only | Manual movement suppression |
| | | | B | 10 | male | IMB | profound | PR only | Hold participant's arms to sides contingent on each occurrence of SIB |
| Smith *et al.* 1992 | 1992 | 8 | A | | male | IMB | profound | MR only | Protective equipment: arm tubes |
| | | | B | | male | IMB | profound | MR only | Protective equipment: adapted clothing |
| | | | C | | male | IMB | profound | MR only | Protective equipment: adapted clothing |
| Smith *et al.* 1996 | 1996 | 6 | A | 32 | female | IMB | profound | PR only | Response blocking |
| Smith *et al.* 1999 | 1999 | 7 | A | 41 | female | IMB | | PR only | Response blocking |
| Tarbox *et al.* 2002 | 2002 | 9 | A | 4 | male | IMB | | PR only | Response blocking |
| Thompson *et al.* 1998 | 1998 | 7 | A | 7 | male | IMB | severe | PR only | Response blocking |
| Thompson *et al.* 1999 | 1999 | 8 | A | 34 | male | IMB | profound | PR only | Hold participant's hands in his lap contingent on each occurrence of SIB |
| | | | B | 43 | female | IMB | profound | PR only | Hold participant's hands across chest contingent on each occurrence of SIB |
| | | | C | 44 | female | IMB | profound | PR only | Hold participant's hands across chest contingent on each occurrence of SIB |
| Toole *et al.* 2003 | 2003 | 7 | A | 15 | female | COM | severe | ER only | Exclusionary time-out |
| Turner *et al.* 1996 | 1996 | 9 | A | 40 | female | IMB | profound | PR only | Hold participant's hands in her lap contingent on each occurrence of SIB |
| | | | B | 26 | male | IMB | profound | PR only | Hold participant's hands in his lap contingent on each occurrence of SIB |
| | | | C | 21 | female | IMB | profound | PR only | Hold participant's hands in her lap contingent on each occurrence of SIB |
| Van Houten 1993 | 1993 | 8 | A | 10 | male | IMB | severe | MR only | Wrist weights |
| Vollmer *et al.* 1994 | 1994 | 9 | A | 4 | female | IMB | | PR only | Response blocking |
| Zhou *et al.* 2000 | 2000 | 8 | A | 33 | female | IMB | profound | MR only | Protective equipment: sleeves |
| | | | B | 33 | female | IMB | profound | MR only | Protective equipment: sleeves |
| | | | C | 40 | female | IMB | profound | MR only | Protective equipment: sleeves |
| | | | D | 51 | female | IMB | profound | MR only | Protective equipment: sleeves |

*Notes*: CB = challenging behaviour; ID = intellectual disability

Empty cell: Information missing for this study / for this case

**[1]**: The methodological quality of the articles was coded by using the Single-case Experimental Design Scale (SCED Scale; Tate *et al.* 2008)

[2]: EDB = external destructive behaviour (e.g. aggression, destructive behaviour); IMB = internal maladaptive behaviour (e.g. self-injurious behaviour, stereotyped behaviour, pica); SDB = socially disruptive behaviour (e.g. disruptive behaviour, inappropriate social behaviour); COM = a combinations of two or three previously mentioned categories
[3]: If only a range of intellectual disability level was reported, it was categorized as the lower level
[4]: PR = personal restraint; MR = mechanical restraint; ER = environmental restraint

**Table 2**
Parameter estimates and standard errors for the multilevel meta-analysis of the 59 SCE studies on the effectiveness of restraint interventions for challenging behaviour among persons with intellectual disabilities.

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| Fixed effects | | | |
| Mean treatment effect | -3.16 (0.45) *** | | -2.20 (0.60) *** |
| Moderator effect of | | | |
| Age | | -0.01 (0.03) | |
| Gender | | -1.96 (0.83) * | -1.88 (0.82) * |
| CB type | | 0.22 (0.78) | |
| ID level | | -0.99 (0.67) | |
| Restraint type | | 0.18 (0.58) | |
| Publication year | | -0.01 (0.11) | |
| Study quality | | -0.11 (0.46) | |
| Variance of effect | | | |
| Between studies | 3.49 (2.27) | 2.32 (1.66) | 3.05 (2.19) |
| Between participants | 12.21 (2.50) *** | 9.82 (2.07) *** | 11.88 (2.45) *** |
| Residual variance | 1.00 (0.02) *** | 1.00 (0.02) *** | 1.00 (0.02) *** |

*Notes*: CB = challenging behaviour; ID = intellectual disability
* = statistically significant effect: $p < .05$; ** = $p < .01$; *** = $p < .001$

## Figures

**Figure 1**
Box and whisker diagram of the standardized random effects for the individual participants.