Postural Management: Components of Specialised Seating Equipment

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CONTENTS

Terms of Reference .......................... 4

Introduction ................................ 5

Method ..................................... 5

Postural Management using Specialised Seating Equipment
with the Paediatric Population ............. 6

Aims of Specialised Seating Equipment ......... 6

Evidence Regarding the Effectiveness of Postural Management
using Seating Equipment with the Paediatric Population........ 7

Components of Seating Systems ................. 9

Seat and Backrest Inclinations .................. 9

Straddle Seating ............................ 13

Seating Surfaces ............................. 14

Pelvic Stabilisation Devices ................... 15

Ramped Cushions ............................ 16

Sacral Pads and Kneeblocks ................. 16

Pelvic Straps ............................... 17
Contents

Rigid Pelvic Stabilisers 18
Dynamic Pelvic Stabilisation Devices 20
Trunk Supports 20
Anterior Trunk Supports 20
Lateral Pads 21
The Future of Specialised Seating Equipment 22
Summary 22
References 23
Appendix I, Table of Results 30
TERMS OF REFERENCE

This is the second part of a three part literature review.

Part one is entitled ‘Fundamental Principles of Seating and Positioning in Children and Young People with Physical Disabilities’ by Laura Neville.

Part three is entitled ‘Early Intervention and Adaptive Seating for Function’ by Glenda Alexander.

This was commissioned by James Leckey Design Ltd during June to August 2005.

A steering group was formed comprising:-
Mr J Leckey, MD
Mr Noel McQuaid, Technical Director
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There were two academic supervisors:-
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The three members of the steering group devised the terms of reference for the project and together with the academic supervisors steered the project as the steering group.

The project was supervised on a weekly basis by the academic supervisors.
Postural Management: Components of Specialised Seating Equipment

Introduction
Postural management may be defined as, "the use of any technique to minimize postural abnormality and enhance function" (Farley et al 2003). For children with neuromotor dysfunction, positioning techniques can be used as a therapeutic modality to enhance functional ability and should therefore be implemented as early as possible in order to promote development (Wandel 2000).

Advances in technology have led to the manufacture of specifically designed positioning equipment which provides a stable posture for children with severe physical disabilities. Stability enhances postural control which is fundamental to the performance of most functional tasks. Pountney et al (2000) advocate the use of postural management equipment in conjunction with therapy as it enables positioning to become part of a twenty-four hour programme during lying, sitting and standing. According to Trefler and Taylor (1991) positioning equipment and, in particular seating systems, can help the individual with disability to participate more fully in activities at home, school, work and in the community.

The purpose of this review is to examine the literature regarding the effectiveness of postural management using specialised seating equipment with the paediatric population. In addition, the individual components of seating systems will be explored together with a review of the evidence regarding their efficacy.

Method
A literature search of articles published between 1990 and June 2005 was performed. Databases used were OTDBase, CINAHL, AMED, BNI, EMBASE, MEDLINE, PsychInfo, BIDS, Proquest, ASSIA, ISI Web of Science, Zetoc and Pubmed. Relevant literature was identified using the keywords postural management, seating, tone, trunk, hip dislocation, knee blocks, lateral supports, postural prompts, physical prompts, contoured seating, ramp cushions, pommels, lap straps, groin straps, waistcoats, vests and bolster.
Other sources of information included text books, papers presented at the International Seating Symposium and hand searching of relevant journals. The search was confined to English language publications. A number of relevant studies prior to 1990 identified during ancestral searching were also included. (See Appendix I for tabulated results.)

**Postural Management using Specialised Seating Equipment with the Paediatric Population**

As a form of assistive technology, seating has undergone dramatic changes in the last 20 years (Cook and Hussey 2002). Consequently, seating and postural control can now be integrated into one system referred to as a postural support system which incorporates the seating surface with the stationary or mobile system to which it is attached (Healy et al 1997). Seating systems designed for children provide an opportunity for greater functional independence in activities of daily living, school and leisure activities (Santangelo and O’Reilly 1999).

**Aims of Specialised Seating Equipment**

- To provide postural stabilisation which is vital to the establishment of a functional sitting posture (Green and Nelham 1991). Stabilising the pelvis and trunk enables freedom of the upper limbs for movement which is crucial in the development of fine motor skills. This has important implications for the child’s education and their ability to use computers and switch technology.

- To reduce the influence of abnormal muscle tone and reflexes on the body, thereby increasing the possibility of normal movement (Cook and Hussey 2002). When used for corrective purposes, the seating system may be viewed as an orthotic device which can assist in treatment of the client (Herman and Lange 1999).

- Prevention, delay or accommodation of deformity or muscle contractures (Trefler and Trefler 1991). According to Cogher et al (1992) deformities such as compensatory scoliosis or kyphosis can be limited, if not avoided altogether with good postural seating used in conjunction with appropriate surgical intervention.
• To distribute pressure across the weight-bearing surface in order to reduce the likelihood of tissue trauma (Cook and Hussey 2002).

• To enable safe, comfortable positioning and reduce fatigue (Healy et al 1997).

• To improve head control. This is essential for orientation, socialisation and for the child to develop cognitive and communication skills (Farley et al 2003).

• To provide an optimum position for feeding, respiratory and digestive function (Cook and Hussey 2002).

• To enable access to the environment.

**Evidence Regarding the Effectiveness of Postural Management using Seating Equipment with the Paediatric Population**

Farley et al (2003) performed an extensive review of 150 articles to examine the evidence for postural management in some common clinical conditions. During their evaluation of 18 articles which pertained to cerebral palsy, they found that evidence to support the use of special seating systems was based on retrospective qualitative or descriptive studies with few studies being randomised with controls. As this review was recent and of high quality, it was decided not to repeat it but to summarise it and incorporate subsequent findings which relate specifically to seating and children.

During their study of 19 disabled children using structured observation and a parent questionnaire, Hulme et al (1987a) found that adaptive seating improved sitting posture, control and grasp. Clark et al (2004) also found a significant improvement in sitting posture in an adapted wheelchair when compared to a standard wheelchair. Meidaner (1990) produced statistically significant results to show that active trunk extension is improved in adaptive seating which comprised an anterior inclined seat and kneeblocks.

Regarding functional activities, Hulme et al (1987b) found that adaptive seating improved some components of eating and drinking behaviour such as food retention.
Whilst these findings may have been influenced by maturational changes due to the longitudinal nature of this study, the authors highlight the lack of change during the period before the seating device was used. Meanwhile, Miedaner and Finuf (1993) used the mental scale of the Bayley Scales of Infant Development to compare test performance in a sample of 12 children with cerebral palsy sitting unsupported and whilst using an adaptive seating system. Results were statistically and clinically significant, indicating that young children with cerebral palsy appeared to have increased mental performance whilst using an adaptive seating system. Clarke and Redden (1992) reported that a controlled seating posture enabled better interaction with surroundings.

Nwaobi and Smith (1986) found statistically significant results demonstrating that adaptive seating improved pulmonary function of children with cerebral palsy when compared to seating in a regular wheelchair. This is in comparison to findings by Clark et al (2004) who found no significant difference in the respiratory function of 19 young people in adaptive seating when compared to the standard wheelchair. However subject population of this study differed from Nwaobi’s in that they had a diagnosis of Duchenne muscular dystrophy or Friedreich’s ataxia. Furthermore, the authors report that these results may have been affected by factors such as subject exhaustion during testing in the adapted wheelchair. This study also failed to show an instantaneous overall improvement in upper limb function on comparing the adaptive seating to the standard wheelchair.

Adaptive seating was reported to be effective in increasing vocalisations in children with cerebral palsy by Hulme et al (1989). Due to the longitudinal nature of this study, findings may have been affected by maturational changes.

Scrutton (1991) and Clarke and Redden (1992) emphasise the importance of positioning during seating in order to prevent fixed and structural deformity of the hips and to minimise pain.

It would appear that whilst the need for further research studies is indicated, evidence to date suggests that adaptive seating systems can play a major role in the positioning and support of children with disabilities such as cerebral palsy. Potential benefits
include improved posture, pulmonary and cognitive function, communication skills and functional performance.

COMPONENTS OF SEATING SYSTEMS
Individual assessment is crucial in the provision of an appropriate seating system. The literature would suggest there is generally one approach for those with low muscle tone such as spinal cord injury who may require increased support for stability and another for those with high muscle tone such as cerebral palsy when the aim of support is to encourage the muscles to relax (Pain et al 2003). Assistive seating devices can include a range of components and it is essential that prescribing therapists understand their purpose and when they should be recommended.

Seat and Backrest Inclinations
Despite a review of 18 studies which involved the impact of seat and backrest angles, the evidence remains controversial regarding the optimum seating position for disabled children.

Using EMG studies, Nwaobi et al (1983) and Nwaobi (1986) investigated the impact of different seating positions on tonic muscle activity of children with cerebral palsy and found an increase in tone when the seat was reclined, thus promoting extensor thrust. It was subsequently proposed that function could be maximised in the upright position with more normal tone. Myhr and von Wendt (1993) examined the influence of different sitting positions and abduction orthoses on leg muscle activity during their study comprising 8 children with cerebral palsy and 6 healthy children as controls. They found that the use of an abduction orthosis combined with either horizontal or forward-leaning seats decreased leg muscle activity. Leg muscle activity was highest in the reclined and horizontal positions without the orthosis during performance of an upper extremity task. The authors advised against the use of reclined seating when adapting chairs for function. However it was felt that much of the statistically significant evidence (p<0.05) from this study appeared to support the use of an abduction orthosis during seating as this appeared to reduce EMG activity in leg muscles in all positions. Burgman (1994) highlights evidence that whilst levels of muscular activity have been shown to increase with increasing backrest inclination in
children and adults with neurological disability, the opposite has been demonstrated in non-disabled adults.

A number of studies examined the effects of seating position and function. Seegar et al (1984) investigated the effect of variations in seat angle (with a vertical backrest) on hand function of 9 children and young adults with cerebral palsy. Their study found that increasing the seat angle above horizontal to increase hip-flexion failed to improve hand function. This was consistent with findings by McPherson et al (1991) who found that sitting positions did not consistently alter the quality of reaching movements in 12 adults with and without cerebral palsy. This study evaluated function whilst the hip was tilted 15° posteriorly and anteriorly with a vertical backrest.

Contrary to these findings however a number of authors have found that seating position can affect function. Nwaobi (1987) measured upper extremity movement time of 13 children with cerebral palsy when the hip was positioned at 0° in the vertical plane, 15 and 30° posterior to the vertical plane and 15° anterior to the vertical plane. The hip joint angle was maintained at 90° during each position by adjusting the seat surface inclination independently. The highest levels of upper extremity performance were demonstrated in the 0° orientation position (upright position). Pountney et al (2000) also advocate the use of the upright sitting position as opposed to a reclined position. They list the advantages as being less induced extensor tone, improved positioning of the upper extremities for function, postural security, the opportunity to develop sitting ability, a better line of vision, facilitation of a normal swallowing pattern and an increased ability to achieve cognitive tasks such as schoolwork. The authors acknowledge that in certain circumstances there is a need to recline the seat if the child should suffer from severe epilepsy or hypotonia, but recommend an upright position if possible for practical activities.

Other studies have produced evidence to support the use of a forward inclined seat base. Myhr and von Wendt (1990 and 1991) initially carried out a pilot study followed by a larger study involving 23 children with cerebral palsy in order to find a functional sitting position (FSP). They found that pathological movements were minimised and postural control, arm and hand function was at its best when the child
was sitting in an anterior-tipped seat, with a firm backrest supporting the pelvis, arms supported on a table and feet permitted to move backwards. The results produced statistically significant data (p<0.001) for improvement of postural control, arm and hand function. The backward positioning of the feet was supported by Myhr’s (1994) study of 10 non-disabled children which found that they all spontaneously held their feet posterior to the knee joints during task performance regardless of whether the seat inclination was horizontal, forward or backward with the backrest vertical. Myhr et al (1995) went on to re-assess 10 children who had been introduced to their FSP after 5 years in order to determine the long-term effects. The 8 children who had been seated according to their guidelines throughout this time showed slight but significant improvement in postural control, arm and hand function. The remaining 2 children had not been sitting in the FSP but with a backward-tilted pelvis and had deteriorated on all items assessed. However it is difficult in a longitudinal study of this nature to be certain that changes are not influenced by maturational or extraneous factors.

Miedaner (1990) found that when children were positioned in an anterior sitting posture, trunk extension increased over time and it appeared to improve their ability to sit up straighter without compromising upper extremity function. This finding was supported by Myhr (1994) who observed that non-disabled children sat with a straight back when the seat was inclined forward whereas backward inclination of the seat resulted in the children tilting their pelvis backward and bending their back during task performance. The backward tilting of the pelvis was reinforced further when the backrest was also reclined.

Reid et al (1991) compared the effects of a flat and forward inclined seat base on postural sway with 8 children with cerebral palsy. Individual data analysis revealed that an anterior inclined seat reduced sway for 50% of the children and increased sway for the other 50%. The authors noted that all the children who exhibited reduced sway were reported as being spastic with tight hamstring muscles. Clinical observations however revealed a more upright sitting posture for all children on the inclined seat and hence the authors highlight that reduced sway may not necessarily result in improved sitting posture for all children with cerebral palsy.
Evidence to support anterior inclination was also provided by van der Heide et al (2003) when, contrary to their expectations, a 15° forward tilted sitting position was found to be more efficient in terms of postural control and activity than the horizontal or backward tilted positions. However whilst the sample size in this study was relatively large involving 29 children of typical development and 10 adults, the findings may not necessarily be generalised to children with neurological impairment.

In response to research demonstrating the possible advantages of anterior-tipped seating, Reid and Sochaniwskyj (1991) investigated the effects of seat base position on respiratory function. Their study found that a forward inclined seat caused an increase in respiration rate, tidal volume and minute ventilation in children with cerebral palsy but that differences were not significant. They suggested that altering the seat base angle affects individuals in different ways and further research was warranted.

A number of other studies produced evidence against seating with forward inclination. McClenaghan et al (1992) found that a 5° anterior tilt of the seating surface generally decreased postural stability during quiet sitting and had little effect on upper extremity performance in children with cerebral palsy. The authors used only a 5° tilt during this study, reporting that previous work conducted in their laboratory suggested that a tilt of greater than 5° was difficult to tolerate for an extended period. However the authors acknowledge that results were variable and that several children’s postures actually improved in the anterior position. Hadders-Algra et al (1999) performed a longitudinal study of postural adjustments during reaching involving 7 infants with cerebral palsy and proposed that a backward-tilted seat surface may be useful as it offers biomechanical compensation for the forward sway induced by reaching movements. During a single-subject design, Angelo (1993) investigated the effect of tilt-in-space on head control for a child with cerebral palsy. Results found that head control was most consistent during a 15° tilt with the least amount of head control displayed at 0°. Whilst this study involved only one subject, it highlights the role that head control may have on the child’s ability to interact and attend to activities.

Sprigle et al (2003) found that sitting in a wheelchair with increased posterior pelvic tilt enhanced stability and enabled greater functional reach. However the subjects of
this study were adults with spinal cord injury and therefore results may not necessarily generalise to other groups. The authors advise that pressure sore development and induced kyphotic posture are risks associated with sitting with a posterior pelvic tilt.

The studies reviewed would appear to produce conflicting evidence regarding seating angles with little conclusive evidence to date. Due to the variability among children with cerebral palsy some authors acknowledge that a universal seating position is not practical and recommend individual assessment (Nwaobi 1983, McClenaghan et al 1992, Pountney et al 2000). Orthopaedic deformities such as scoliosis may also dictate backrest angles as seating may need to accommodate the more severe deformities (Trefler and Taylor 1991). Furthermore, Angelo (1993) points out that results from studies cannot usually be generalised to individual clients and advocates the use of a single-subject research design with clients to identify optimum positioning needs. Whilst this may be a time-consuming process, it may be a useful method for the more complex client and also provides supporting evidence for the therapist’s recommendations. The importance of alternating tilt position throughout the day depending on the client’s energy and motivation levels is also highlighted. The task itself and the environment can have implications for spontaneous body positions and as such play an integral role in functional seating (Myhr 1994). Generally the consensus from the literature appears to be that the pelvis should be positioned in a neutral to slight anterior tilt if feasible for the client.

**Straddle Seating**

Straddle (or saddle) seating aims to replicate the advantages noted from people sitting on horseback whereby the pelvis is upright, the legs apart to promote hip stability and the hips are less flexed than in conventional seating (Pain et al 2003). Some of the seats using this principle are designed in the form of a bolster whilst others are shaped similar to an exaggerated bicycle saddle.

Stewart and McQuilton (1987) trialled a straddle seat which incorporated pelvic fixation with 10 children and found positive results in terms of hand, arm and head function although these appeared to be based on subjective qualitative findings. Whilst using the straddle seat, it was observed that the tendency to flex the lumbar
spine was less marked in the hypotonic children and that the asymmetric tonic neck reflex was less evident with the hypertonic children. It was noted however that the straddle position produced difficulties for those with very poor or no head control.

Pope et al (1994) performed a 3 year study involving 9 children with cerebral palsy which evaluated the use of a seating system which incorporated a saddle, anterior-inclined seat. As acknowledged by the authors, the results of this study were affected by it longitudinal nature as improvements may have been due to maturational changes and other extraneous factors. However qualitative improvements were noted from photographs of most of the children in terms of symmetry and trunk extension whilst positive feedback was obtained from parents and teachers that the system appeared to be of benefit physically and socially.

Reid (1996) carried out a small study involving 6 children with mild to moderate spastic cerebral palsy to evaluate the effects of a flat bench in comparison to saddle bench seating. A significant improvement in upright sitting and postural control was noted on the saddle seat. Over half of the subjects demonstrated faster and more accurate reaching movements but these results were not statistically significant and warrant further research.

Myhr and von Wendt (1991) found that extensor spasms increased for 3 children whilst sitting on a saddle type seat but suspected that these movement patterns were probably caused by the type of fixation devices used.

A wheelchair incorporating a barrel-shaped cylindrical seat has also been used with selected cerebral palsy children in order to control hip displacement by keeping the joints in an abducted position (Clarke and Redden 1992). Pelvic radiographs of one subject demonstrated reduced hip migration than when the subject was seated in a conventional wheelchair.

**Seating Surfaces**

Seating surfaces may be planar, contoured or custom moulded (Wright-Ott and Egilson 2001). A planar surface is flat and more appropriate for those requiring only minimal support. Contoured seating conforms to the shape of the spine, buttocks and
thighs, allowing the body to have more contact with the seating surface and providing increased support and control. Custom moulded seating is specifically designed for the more severely affected individual to accommodate fixed deformities and provide comfort. The seat base, backrest or both can be moulded.

Whilst literature was identified which discussed the fabrication and use of contoured seating, only one study was identified investigating its efficacy. In this study Washington et al (2001) evaluated the effects of a contoured foam seat on children with neurological impairment. Results showed a sustained improvement in postural alignment for all subjects whilst seated on the contoured foam seat. Effects on increasing bilateral play were not demonstrated but qualitative data obtained from parents described perceived benefits of increased independence in functional skills and improved social interaction. However a major limitation of this study as acknowledged by the authors was the small sample size of only 4 infants.

Nevertheless, a number of disadvantages of moulded seating have been identified. Mulcahy et al (1988) discuss how the trunk weight can cause the pelvis to slide round the contours of the base leading to sacral sitting and the risk of tissue trauma. Cook and Hussey (2002) list disadvantages of custom contouring as being its limited ability to allow for growth of the individual, difficulty with transfers and its lack of dynamic properties as the individual is held in a fixed posture. However it continues to be useful for children with severe fixed deformities (Cogher et al 1992).

Seating systems are continually developing and at the 21st International Seating Symposium Freney-Bailey (2005) presented a system incorporating a dynamic adjustable contoured back. It was suggested that this would be appropriate for children with growth considerations or clients who have changes in their orthopaedic status. Positive feedback was obtained after using the system with a variety of clients but further research would be beneficial.

**Pelvic Stabilisation Devices**

Pelvic stabilisation is regarded as crucial for the individual to obtain optimal postural support, control and ultimately function. Often disabled children are unable to
achieve pelvic and trunk stability independently and hence various external stabilisation devices are used.

**Ramped Cushions (Anti-Thrust Cushion)**
The ramped cushion has a flat surface from the seat back to the gluteal fold and generally a 15º ramp starting anterior to the gluteal crease. According to Mulcahy and Pountney (1987), its aims are to maintain the femur in a horizontal position, to provide a flat surface for the ischial tuberosities, to allow even weight distribution and to facilitate maintenance of the hips and knees at 90º thereby decreasing the tendency to sacral sit.

The ramped cushion was reported to have achieved these goals following anthropometric measurements and clinical observations of children placed in a sitting position (Shumway 1986). In their study involving 15 children with neuromuscular disorder, Shoham et al (2004) evaluated the effect of a 10º wedge insertion under the pelvis and found that it had no significant effect on distribution of body-seat interface pressure. However this finding may not be particularly relevant in the use of ramped cushions as their main role is to facilitate pelvic stabilization which was not measured in this study.

Generally it is recommended that the ramped cushion is used in combination with a sacral pad and pelvic belt. Green and Nelham (1991) go further and state that the feet must also be supported at the correct height to maintain the knees at 90º to facilitate support and control of the pelvis and thighs.

**Sacral Pads and Kneeblocks**
A sacral pad and kneeblocks are used in conjunction to stabilise the pelvis in most seating systems. They apply biomechanical principles designed to maintain the pelvis in an anterior/neutral tilt to enable upright sitting and to control pelvic rotation (Green and Nelham 1991). It has also been suggested that this intervention can be used to prevent or control windswept hip deformities by applying the kneeblock forces in such a way as to bring both hips into a neutral position (Mulcahy et al 1988, Cogher et al 1992, Pountney et al 2000).
The sacral pad is positioned at the base of the child's backrest at a 90° angle to the seat base, extends the full width of the pelvis and no higher than the L5/S1 joint. The kneeblocks are positioned at the front and medial sides of the knees. These devices apply force via the femurs to the hip joints and control abduction and adduction of the hips via the medial force which is counterbalanced by pads positioned on the lateral side of both hips. The sacral pad and kneeblock apply force equally and in opposite directions to maintain the pelvis in an upright position (Pountney et al 2000).

Clinically however there is discussion regarding the exact placement of the kneeblocks and whether they should be positioned directly on the patella or below it. There are also concerns that incorrect application may adversely affect the hip and knee joint and patellar ligaments and whether they produce secondary effects on trunk control and alignment (McDonald et al 2003).

The majority of evidence to support these devices appears to be based on clinical observations as opposed to research studies. However in their study involving 23 children with cerebral palsy Myhr and von Wendt (1991) supported the use of a sacral pad, stating that it helped maintain the pelvis in an anterior/neutral tilt and allowed the child to develop upright sitting.

A body of unpublished material is currently in preparation by McDonald and colleagues who have investigated the use of the sacral pad and kneeblock arrangement to control the pelvis. In their study involving 23 children with cerebral palsy, they found no statistically significant effect upon hip, pelvic, trunk and head alignment immediately after removal or replacement of the kneeblocks. Furthermore, this confirmed findings in their earlier report that removal of the kneeblocks for a one month period also had no significant effect. Clearly this indicates a need for further research regarding the efficacy of these devices.

Pelvic Straps
The pelvic strap is designed to provide additional pelvic stabilisation, to support the pelvis in a neutral or anterior tilted position and prevent forward sliding in the seat. Additionally, it can prevent the child from standing or extending out of the seat and for safety purposes (Green and Nelham 1991). However controversy remains
regarding the ideal angle at which these devices should be attached to the seating system.

In their descriptive articles, Mulcahy et al (1988), Green and Nelham (1991) and Healy et al (1997) advocate the use of a pelvic strap which should pull down and back at 45° to apply an opposing force to the sacral pad. This was supported in research studies performed by Myhr and von Wendt (1990, 1991) in their investigation to find a functional sitting position for children with cerebral palsy. They found that a hip belt positioned at a 45° angle and anchored under the seat provided good symmetrical pelvic positioning, helped prevent the child from sliding but allowed forward movements of the upper body. It is important to note however that these studies did not investigate the efficacy of the hip belt as a single component but rather as part of the functional sitting position as a whole.

Conflicting evidence is provided during a study by Axelson and Chesney (1995) which used computer simulation of various belt configurations. They found no support for the 45° angle but found that a pelvic belt angle of 60 to 90° combined with an attachment point close to the seat surface decreased the likelihood of the pelvis sliding forward and under the belt. Pountney et al (2000) also advocate a pelvic strap angled at approximately 60°.

Other authors describe the use of a pelvic belt mounted at 45° for most clients but indicate that an 80 to 90° angle may be more effective for clients with fixed posterior pelvic rotation or excessive hip extension (Trefler and Taylor 1991, Cook and Hussey 2002).

In light of the inconclusive evidence to date and the variation in this client group, it may be advisable to approach pelvic belt angle on an individual client basis.

Rigid Pelvic Stabilisers (subASIS bar)
The rigid pelvic stabiliser (RPS) is a padded metal bar positioned across the front of the pelvis over the thighs. It applies a posteriorly directed force inferior to the individual\'s anterior superior iliac spines (ASIS). According to Reid and Rigby (1996b), its purpose is to stabilise the pelvis in a neutral/anterior tilt, to control pelvic
rotation, control extensor thrusting at the hips and prevent the pelvis from sliding forward in the seat. It is designed for use with a complete back and seat system for individuals who require greater control (Cook and Hussey 2002).

During their analytical review, Reid and Rigby (1996a) identified the need for further research regarding the use of this device as previous evidence had consisted of case studies reported at seating conferences. Subsequently, Reid et al (1999) carried out a within-subject ABA design study to assess the functional impact of a wheelchair mounted rigid pelvic stabiliser in comparison to a lap belt on 6 children with cerebral palsy. Single-subject data analysis revealed clinically significant changes in task performance during the treatment phase when the RPS was worn as compared to the lap belt for all subjects. Whilst performance levels decreased during the second baseline phase when the RPS was removed, they did not return to original baseline levels. From this result the authors suggest that the RPS has a facilitating effect for increasing physical functioning. The measures used in this study were the Canadian Occupational Performance Measure (COPM) which scores the client’s self-perceived performance and a structured interview to gain caregiver views. Correlation was discovered between caregivers’ perception of functional change and subjects self-rated performance on specific tasks. Due to the subjective nature of these measures and the small sample size, the authors acknowledge the need for further research using a valid and reliable functional rating scale.

During further analysis of the same study, Rigby et al (2001) found that during the phase when the RPS was used, caregiver assistance was reduced for 30% of the tasks evaluated. Five of the 6 children also required less repositioning during this phase as recorded in log books kept by parents.

Whilst these findings appear promising, it has been reported that some wheelchair users cannot tolerate this rigid bar due to discomfort or lower abdominal compression. This has resulted in the recent manufacture of a sub-ASIS belt (Beneficial Designs, Inc., Minden, Nevada USA). This product aims to provide a similar degree of control as the sub-ASIS bar but with a decreased degree of abdominal compression (Siekman and Noon 2004).
**Dynamic Pelvic Stabilisation Devices**

Recent seating developments have led to the fabrication of a dynamic pelvic stabilisation system called the HipGrip (Beneficial Designs, Inc., Minden, Nevada USA). It consists of a padded rear shell, a padded front belt, a pivot mechanism and wheelchair attachment hardware. The purpose of this device is to assist the wheelchair user to maintain pelvic stability whilst allowing functional pelvic movements. It is claimed that the HipGrip allows the pelvis to pivot forward about the hip joint whilst providing variable resistance to bring the pelvis back into a neutral position (Siekman et al 2003). During a 3 to 6 month home trial involving 25 subjects using the HipGrip, measurements indicated an increase in functional movement, improved postural alignment, and a decrease in unwanted postural movement (Siekman 2005). The device is contraindicated for individuals with spina bifida or pressure sores. Whilst preliminary results appear promising, further research would be beneficial in view of the fact that the product has only recently been released.

**Trunk Supports**

Ideally the trunk should be in an upright symmetrical position although this may not be possible for children with fixed deformities. Trunk support can be provided from behind, the side or in front and the amount required depends on the individual (Cook and Hussey 2002). Back support is increased with a higher backrest or contouring. Lumbar supports can be used for individuals with lordosis whilst the appropriate positioning of lateral thoracic and pelvic supports can support the scoliosed spine. Anterior supports such as straps, chest panels, vests, harnesses and shoulder supports can be used to help prevent forward trunk flexion for those unable to maintain an upright position.

**Anterior Trunk Supports**

Trefler and Angelo (1997) performed a comparison of four anterior trunk supports when used by children with cerebral palsy during a functional activity. The devices tested were an anterior chest panel, a one inch wide single horizontal strap, an anterior shoulder support and a tray with moulded chest support. Their study involved 17 children with cerebral palsy and revealed no statistically significant differences between the four. The activity measured was the pressing of a single switch to activate a computer programme and the authors queried whether this may not have
been physically challenging enough to demonstrate significant results. Following these findings, the authors recommend that choice of trunk support for this client group be based on client preferences, ease of caregiver use, cost and aesthetics.

However Myhr (1994) suggested that the use of devices such as belts or shells across the trunk whilst reclining the child with cerebral palsy may encourage extensor spasticity as they attempt to fight against gravity to lean forward to perform a task. Kangas (2001, 2005) also found that chest supports are not effective for individuals with high tone, observing that these clients tend to push forward or hang onto them whilst thrusting out at the pelvis. Instead she proposes the use of a lightweight, plastazote vest which is firm but not as hard as the standard orthotic vest used to prevent or control scoliosis. Instead the lightweight vest is designed to assist the child to maintain an upright posture during an activity and prevent their trunk from collapsing. Research evidence to support the use of this device is not yet available.

Lateral Pads
Holmes et al (2003) carried out a biomechanical study to investigate the effects of special seating on lateral spinal curvature in a non-ambulant cerebral palsy population with scoliosis. They compared 3 arrangements where the lateral pads were placed in different positions. The first arrangement involved placement of the lateral pads only at pelvis level, the second arrangement added a further pair of lateral pads on either side of the upper trunk under the axillae and the third arrangement again positioned the pelvic pads but added the further lateral pads at different heights. One was positioned at the level of the apex of the scoliosis and the other just under the axilla on the opposite concave side in an arrangement referred to as the 3-point force system. Their results showed that positioning of the lateral pads to produce a 3-point force significantly improved correction in spinal curvature in comparison to the other arrangements. The authors of this study acknowledge limitations including the sensitivity of results to the exact positioning of the pads and whether the forces exerted on the subjects would be tolerated on a long term basis. They recommend that care be taken in the manufacture of these devices to ensure that they are sufficiently adjustable to spread the load of applied forces and that they provide pressure relief.
The Future of Specialised Seating Equipment

One of the current trends for seating devices is the development of dynamic seating components. It has been recognised that individuals suffering from extensor thrusts are at risk of injury and may damage their seating systems. In view of this, the first objective of dynamic seating is to enable movement during an extensor thrust event whilst still supporting the client (Brown et al 2001).

A second objective of dynamic seating is to allow controlled postural movement which facilitates function whilst maintaining comfort and stability (Siekman 2005). Consequently a variety of seating components which have traditionally been static and restrictive are now being developed to allow movement within a predetermined range (Magnuson and Dilabio 2003). The most common components which have been fabricated with dynamic properties include seat backs, chest straps, headrests, footrests and the HipGrip.

Summary

Much of the literature regarding seating systems and their components has been conflicting or appeared to be a matter of clinical opinion as opposed to evidence based. Some of the literature even shows evidence of trends of use over time. It is therefore important that future research is conducted in order to provide evidence to support or refute current positioning techniques and approaches. Furthermore, with the rapid development of products such as dynamic seating components, it is essential that evidence to support the use of these devices is provided. Nevertheless it is hoped that the current technological advances can lead to continued improvement in function and quality of life for those children using specialised seating systems.
REFERENCES


### APPENDIX I TABLE OF RESULTS

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Title</th>
<th>Methodology</th>
<th>Key Findings</th>
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<tbody>
<tr>
<td>Angelo J 1993</td>
<td>Using single-subject design in clinical decision making: the effects of tilt-in-space on head control for a child with cerebral palsy.</td>
<td>Single-subject design. N=1, a child with CP.</td>
<td>The subject displayed greater head control when the tilt-in-space facility of the wheelchair was placed at 15° or 30° tilt rather than 0°. The author recommends therapists use a single-subject design with clients to provide supporting evidence for their recommendations and document the effects of treatment.</td>
</tr>
<tr>
<td>Brown D, Zeltwanger AP, Bertocci G 2001</td>
<td>Quantification of forces associated with full body extensor thrust in children.</td>
<td>Single-subject design. N=18, the majority with CP.</td>
<td>The study focused on examining the force response of extensor thrust in a select population. The study illustrated the effectiveness of computer simulation as a tool to model the human–assistive technology interface.</td>
</tr>
<tr>
<td>Burgman I 1994</td>
<td>The trunk/spine complex and wheelchair seating for children: a literature review.</td>
<td>Review of quantitative literature.</td>
<td>The effects of positioning the trunk/spine complex has been quantitatively investigated in relation to non-disabled adults, but little literature is available in relation to children. Individual assessment and awareness of potential physical stress areas enables informed practice by therapists when prescribing wheelchair seating for children.</td>
</tr>
<tr>
<td>Clark J, Michael S, Morrow M 2004</td>
<td>Wheelchair postural support for young people with progressive neuromuscular disorders.</td>
<td>Prospective two-period randomised crossover study. N=19, children and young adults diagnosed with Duchenne muscular dystrophy or Friedreich's ataxia.</td>
<td>Adaptive seating within the wheelchair can instantaneously improve sitting posture for this client group in comparison to a standard wheelchair. There is potential for over-correction of the person's position with inappropriately configured seating. There was no instantaneous improvement in respiratory function in adaptive seating compared to a standard wheelchair. There was no overall improvement in upper limb function in adaptive seating compared to standard wheelchair.</td>
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<tr>
<td>Clarke AM, Redden JF 1992</td>
<td>Management of hip posture in cerebral palsy.</td>
<td>Description of the use of the Sandall Wood wheelchair with selected patients with CP.</td>
<td>Hips kept in an abducted position improves femoral head location, minimises pain and allows better interaction with the surroundings.</td>
</tr>
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<td>Farley R, Clark J, Davidson C, Evans G, MacLennan K, Michael S, Morrow M, Thorpe S. 2003</td>
<td>What is the evidence for the effectiveness of postural management?</td>
<td>Literature review of 150 articles relating to the evidence for postural management in some common clinical conditions. Included review of 18 articles regarding CP.</td>
<td>The majority of evidence to support the use of special seating systems for children and adults with CP was based on retrospective qualitative or descriptive studies or texts. Few studies were randomised and with controls. In paediatrics, there was a clear role for postural management in promoting musculoskeletal development. Potential benefits from postural interventions include enhanced cognitive function, dexterity and communication skills with adaptive seating playing an important role.</td>
</tr>
<tr>
<td>Freney-Bailey D 2005</td>
<td>Custom contoured seating: a pediatric lightweight system and an adjustable contoured back.</td>
<td>Descriptive presentation paper.</td>
<td>The author outlines the design and goals of a paediatric lightweight seating system and an adjustable contoured back.</td>
</tr>
<tr>
<td>Green EM, Nelham RL. 1991</td>
<td>Development of sitting ability, assessment of children with a motor handicap and prescription of appropriate seating systems.</td>
<td>Summary of work undertaken by Chailey Heritage.</td>
<td>Seating is part of postural management and postural management must be considered as part of the child’s overall management programme.</td>
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<tr>
<td>Hadders-Algra M, van der Fits IBM, Str Emmelaar EF, Touwen BCL</td>
<td>Development of postural adjustments during reaching in infants with CP.</td>
<td>Longitudinal study using EMG to record muscle activity during reaching in various positions. N=7, young infants with CP.</td>
<td>Children with spastic CP demonstrated a reduced capacity to modulate postural output in relation to task-specific conditions. For these children, a backward-tilted seat surface could offer biomechanical compensation for the forward sway induced by reaching movements. The child with spastic-dyskinetic CP showed distinct abnormalities in the basic organisation of postural adjustments.</td>
</tr>
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<td>Healy A, Ramsey C, Sexsmith E. 1997</td>
<td>Postural support systems: their fabrication and functional use.</td>
<td>Descriptive piece/ account of current practice.</td>
<td>The authors emphasise the importance of individual client assessment and involvement when generating a postural support system. The design, fabrication and fitting of the system should be based on client needs. The system should be evaluated to determine its impact on the patient’s functional life.</td>
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<td>Herman JH, Lange ML. 1999</td>
<td>Seating and positioning to manage spasticity after brain injury.</td>
<td>Descriptive piece/ account of current practice.</td>
<td>Therapeutic seating and positioning can be effective in both inhibiting spasticity and in accommodating its sequelae and should therefore be part of the standard rehabilitation programme for persons experiencing spasticity after a head injury.</td>
</tr>
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<td>Holmes KJ, Michael SM, Thorpe SL, Solomonidis SE. 2003</td>
<td>Management of scoliosis with special seating for the non-ambulant spastic cerebral palsy population ñ a biomechanical study.</td>
<td>Prospective study with matched pairs (same subject pre and post intervention). N=16, children and young adults with CP</td>
<td>Significant static correction of the scoliotic spine can be achieved with an arrangement of lateral pads on a seating system that applies a 3-point force system to the sides of the body. The authors recommend that lateral pads are designed to be extremely adjustable in order to adequately spread the load of applied forces and that they provide adequate pressure relief.</td>
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<td>Hulme JB, Gallacher K, Walsh J, Niesen S, Waldron D. 1987a</td>
<td>Behavioral and postural changes observed with use of adaptive seating by clients with multiple handicaps.</td>
<td>Longitudinal prospective study - direct observation and parent/guardian questionnaire. N=19, children with multiple handicaps and developmental disabilities.</td>
<td>The use of adaptive seating devices improved sitting posture, head stability and grasp but not visual tracking or reach. Caregivers reported that they could feed, play and travel with the child more easily with the use of the adaptive seating device.</td>
</tr>
<tr>
<td>Kangas K 2001</td>
<td>Chest supports: why they are not working!</td>
<td>Clinical opinion.</td>
<td>The author has observed that individuals with hypertonicity or combined hyper and hypotonicity tend to hang onto their chest support whilst thrusting out at the pelvis. The author suggests that support is alternatively provided for such children by a plastazote vest.</td>
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<td>Kangas KM 2005</td>
<td>Hyperextension, obligatory reflexes, or the opisthotonic reaction?</td>
<td>Clinical opinion.</td>
<td>Seating system design may be exacerbating the opisthotonic reaction displayed by individuals with CP or brain injury. From clinical experience, the author describes the design and benefits of using a plastazote vest to provide trunk support for young children.</td>
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<td></td>
<td>Facing the seating challenges of children whose seating systems do not recognize this body posture.</td>
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<tr>
<td>Magnuson S, Dilabio M 2003</td>
<td>Dynamic seating components: the best evidence and clinical experience.</td>
<td>Descriptive presentation paper.</td>
<td>Dynamic seating components allow movement within a predetermined range. The most commonly made dynamic components are chest straps, seat backs, headrests and footrests. There is a growing interest in dynamic seating, although clinical experience to support it is currently limited.</td>
</tr>
<tr>
<td>McClenaghan BA, Thombs L, Milner M. 1992</td>
<td>Effects of seat-surface inclination on postural stability and function of the upper extremities of children with cerebral palsy.</td>
<td>Single subject, multiple baseline design. N=20, 10 children with CP and 10 non-impaired children</td>
<td>A 5° anterior or posterior inclination in seating surface had little effect on functional ability of the upper extremities of children with CP. Anteriorly tilting the seats of children with cerebral palsy may disturb postural stability. Due to the variability among such children, identification of a universal seating position is not practical.</td>
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<td>McDonald R, Surtees R, Wirz S. 2003</td>
<td>The relationship between pelvic and trunk alignment and force measured through a kneeblock in children with cerebral palsy.</td>
<td>Mixed method, case-controlled trial. (Preliminary results) N=25, children with CP.</td>
<td>No relationship was seen between the force measured at the kneeblock and pressure measured at the sacral pad. There was no significant effect following removal of kneeblocks for one month on the posture of the children. The sacral pad and kneeblock system may have a positive effect on reducing hip rotation, however no change in pelvic tilt or pelvic rotation was seen. Kneeblocks may act as a support, rather than an active intervention.</td>
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<tr>
<td>Miedaner JA 1990</td>
<td>The effects of sitting positions on trunk extension for children with motor impairment.</td>
<td>Prospective repeated treatments. N=15, children with developmental delay and/or CP.</td>
<td>Trunk extension is increased when the child is positioned in an anterior sitting posture. Observations also suggest that upper extremity function is not compromised in this position.</td>
</tr>
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<td>Mulcahy CM, Pountney TE. 1987</td>
<td>Equipment Review. Ramped Cushion.</td>
<td>Descriptive article.</td>
<td>Description of the design and clinical aims of the ramped cushion.</td>
</tr>
<tr>
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Definition of seven levels of sitting ability. 
Description of assessment procedure and prescription criteria for the provision of adaptive seating. 
The authors state that seating should encourage a child’s postural development and should be considered as part of the overall management programme. |
N=10, non-disabled children. | In positions with a vertical backrest and the use of a hipbelt, all children held their feet posterior to the knee joint axis regardless of whether seat inclination was flat, forward or backward. 
When seated in a reclined position and fastened across their trunks, the children more frequently held their feet anterior to the knee joint axis, suggesting counteraction against gravity in order to move forward to perform a task. |
N=2, children with cerebral palsy. | The greatest reduction of spasticity was gained and postural control was markedly superior when three factors were combined: the symmetrical fixation of the child by a belt anchored under the seat, the use of an abduction orthosis and positioning of the line of gravity of the upper body anterior to the axis of rotation at the ischial tuberosities. 
This can only be achieved if the seat slopes forward or is horizontal. |
N=23, children with CP. | Pathological movements were minimised and postural control and arm and hand function best when the child was sitting in a forward-tipped seat, with a firm backrest supporting the pelvis, arms supported on a table and feet permitted to move backwards. |
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<th>Author/Year</th>
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<tr>
<td>Myhr U, von Wendt L. 1993</td>
<td>Influence of different sitting positions and abduction orthoses on leg muscle activity in children with cerebral palsy.</td>
<td>Single case design. N=14, 8 children with CP and 6 healthy children as controls.</td>
<td>EMG responses indicate that the use of an abduction orthosis and horizontal and forward-learning seats decrease lower-extremity muscle activity, and so may possibly also improve upper-extremity function.</td>
</tr>
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<td>Five-year follow up of functional sitting position in children with cerebral palsy.</td>
<td>Five-year longitudinal study. N=10, children with CP.</td>
<td>The 8 children who had been using the functional seating position (as recommended by the authors) showed slight but significant improvement in postural control, arm and hand function. The 2 children who had not been using the functional sitting position but had been sitting with a backward-tilted pelvis deteriorated in all items assessed.</td>
</tr>
<tr>
<td>Nwaobi OM 1986</td>
<td>Effects of body orientation in space on tonic muscle activity of patients with cerebral palsy.</td>
<td>Single case design. N=12, children and young adults with CP.</td>
<td>Muscle activity measured by EMG responses changed in response to body orientation. EMG activity increased when the body was reclined at 30º relative to the vertical, and was less when the body was positioned at 0º (upright) relative to the vertical.</td>
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<tr>
<td>Nwaobi OM 1987</td>
<td>Seating orientations and upper extremity function in children with cerebral palsy.</td>
<td>Randomised concurrent cohort. N=13, children and adolescents with CP.</td>
<td>Orientation of the body in space affects upper extremity function. The level of performance was highest in the upright seating orientation ie. 0º relative to the vertical plane with the hip joint at 90º.</td>
</tr>
<tr>
<td>Nwaobi OM, Smith PD. 1986</td>
<td>Effect of adaptive seating on pulmonary function of children with cerebral palsy.</td>
<td>Prospective two-period crossover. N=8, children with CP.</td>
<td>Statistically significant improvement of pulmonary function was measured whilst seated in an adaptive seating system, in comparison to whilst seated in a regular sling-type wheelchair.</td>
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<td>Nwaobi OM, Brubaker CE, Cusick B, Sussman MD. 1983</td>
<td>Electromyographic investigation of extensor activity in cerebral-palsied children in different seating positions.</td>
<td>Single case design. N=11, children with CP.</td>
<td>The activity of lumbar spine extensor muscles varied in different seating positions. The average trend was that electrical activity was least at 90° and highest at 75° and 120° backrest inclination. Electrical activity was lower when the seat surface was at 0° than when elevated at 15°</td>
</tr>
<tr>
<td>Pope PM, Bowes CE, Booth E. 1994</td>
<td>Postural control in sitting. The SAM system: evaluation of use over three years.</td>
<td>Longitudinal monitoring programme. N=9, children with CP.</td>
<td>Qualitative improvement evident from photographs in terms of symmetry and trunk extension after using the SAM system. Positive feedback from parents and teachers that the system appeared to be of benefit physically, functionally and socially.</td>
</tr>
<tr>
<td>Reid DT 1996</td>
<td>The effects of the saddle seat on seated postural control and upper-extremity movement in children with cerebral palsy.</td>
<td>Repeated-measures experimental crossover study. N=6, children with CP.</td>
<td>Seating on the saddle bench showed statistically significant improvements in seated postural control compared to the flat bench. No statistically significant differences were found for the reaching variables.</td>
</tr>
<tr>
<td>Reid DT, Rigby P. 1996a</td>
<td>Towards improved anterior pelvic stabilization devices for paediatric wheelchair users with cerebral palsy.</td>
<td>Descriptive article, includes analytical review of anterior pelvic stabilization devices.</td>
<td>Provides a review of key principles and practices related to the provision of seated pelvic stabilization for paediatric wheelchair users who have cerebral palsy. The review found that the most effective technique for enhancing seated pelvic stabilization was more a matter of clinical opinion than the result of research.</td>
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<tr>
<td>Reid DT, Rigby P. 1996b</td>
<td>Development of improved anterior pelvic stabilization devices for children with cerebral palsy.</td>
<td>Descriptive article.</td>
<td>Descriptive article providing background information and rationale for research in progress.</td>
</tr>
<tr>
<td>Reid DT, Sochaniwskij A, Milner M. 1991</td>
<td>An investigation of postural sway in sitting of normal children and children with neurological disorders.</td>
<td>Study comprising 3 groups of subjects. N=61, 46 normal children, 8 children with cerebral palsy, 7 children with acquired brain injury.</td>
<td>Individual data analysis revealed that an anteriorly inclined seat reduced sway for 50% of the children with cerebral palsy and increased sway for the other 50%. A reduction in sway may not necessarily result in an improvement of sitting posture.</td>
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<tr>
<td>Reid D, Rigby P, Ryan S. 1999</td>
<td>Functional impact of a rigid pelvic stabilizer on children with cerebral palsy who use wheelchairs: users' and caregivers' perceptions.</td>
<td>Within-subject ABA design. N=6, children with CP.</td>
<td>Clinically significant changes in task performance and satisfaction with performance were shown when the rigid pelvic stabilizer was worn as compared to the lap belt for all subjects.</td>
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<td>Rigby P, Reid D, Schoger S, Ryan S. 2001</td>
<td>Effects of a wheelchair-mounted rigid pelvic stabilizer on caregiver assistance for children with cerebral palsy.</td>
<td>Within-subject ABA design. N=6, children with CP.</td>
<td>On comparison with a traditional lap belt, the use of a rigid pelvic stabilizer appeared to impact directly on reducing caregiver assistance for 30% of the tasks. 5 of the children required repositioning less often whilst using the rigid pelvic stabilizer.</td>
</tr>
<tr>
<td>Roxborough L 1995</td>
<td>Review of the efficacy and effectiveness of adaptive seating for children with cerebral palsy.</td>
<td>Literature review of 8 studies which met the selection criteria.</td>
<td>Adaptive seating achieved short-term improvement in pulmonary function, active trunk extension and mental test performance. Studies of a weaker design found that adaptive seating used over a longer period may be effective in improving sitting posture, vocalization and oral motor eating skills. Some forms of seating have been found to have no effect on reach.</td>
</tr>
<tr>
<td>Santangelo MA, O'Reilly KP. 1999</td>
<td>Long term rehab. Increasing independence. Advances in pediatric seating and positioning with power mobility.</td>
<td>Descriptive article including a case study.</td>
<td>Outlines the development and fabrication of wheelchairs and seating systems. Includes discussion of current trends and technological advances.</td>
</tr>
<tr>
<td>Scrutton D 1991</td>
<td>The causes of developmental deformity and their implication for seating.</td>
<td>Descriptive article.</td>
<td>The position in which children with cerebral palsy are placed and the time these postures are maintained are important in preventing fixed and structural deformity.</td>
</tr>
<tr>
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<td>Hand function in cerebral palsy: the effect of hip-flexion angle.</td>
<td>N=9, children and young adults with CP.</td>
<td>Results show that increasing the hip-flexion angle in seating for a child with cerebral palsy and extensor spasticity appears to have no effect on hand function.</td>
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<tr>
<td>Siekman A 2005</td>
<td>Stable, not static: dynamic seating to improve movement and function.</td>
<td>Results of home trial of the HipGrip, a dynamic pelvic stabilization device N=25, wheelchair users.</td>
<td>Results show that the HipGrip device increased functional movement, improved overall postural alignment and decreased unwanted postural movement. Dynamic seating should include the design of equipment that allows controlled functional movement whilst improving postural stability.</td>
</tr>
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<td>The Sub-ASIS belt: a new concept in pelvis control.</td>
<td>Descriptive presentation paper.</td>
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<td>Description of the design and application of the HipGrip, a dynamic pelvic stabilization device. An ongoing trial involving 25 subjects is described together with preliminary results from 3 case studies which suggest that the device can increase functional movement.</td>
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<td>Sprigle S, Wootten M, Sawacha Z, Theilman G. 2003</td>
<td>Relationships among cushion type, backrest height, seated posture, and reach of wheelchair users with spinal cord injury.</td>
<td>Randomised 2 x 3 repeated measures factorial design. N=22, adults with spinal cord injury.</td>
<td>The posture adopted by wheelchair users is a more important influence on upper-extremity reach than are the cushion or backrest height. Sitting with increased posterior pelvic tilt enhanced stability and permitted greater reach.</td>
</tr>
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<td>Straddle seating for the cerebral palsied child.</td>
<td>Clinical observations. N=10, children with cerebral palsy.</td>
<td>Observations found positive results in terms of hand, arm and head function in straddle seat compared to conventional seating. In the hypotonic child, the tendency to flex the lumbar spine was less marked in the straddle seat. With the hypertonic child, the asymmetric tonic neck reflex was less evident in the straddle seat. The straddle position produced difficulties for those with very poor or no head control.</td>
</tr>
<tr>
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<td>Comparison of anterior trunk supports for children with cerebral palsy.</td>
<td>Single case design. N=17, children with CP.</td>
<td>No statistically significant differences were found on comparison of 4 anterior trunk supports when used by children with cerebral palsy during a functional activity.</td>
</tr>
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<td>Prescription and positioning: evaluating the physically disabled individual for wheelchair seating.</td>
<td>Descriptive article.</td>
<td>Describes the client evaluation process for the prescription of wheelchair seating and provides principles of positioning.</td>
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<td>van der Heide JC, Otten B, van Eykern LA, Hadders-Algra M. 2003</td>
<td>Development of postural adjustments during reaching in sitting children.</td>
<td>Study using multiple surface EMGs and kinematics. N=39, 29 typically developing children and 10 adults.</td>
<td>Anticipatory postural muscle activity was consistently present in adults but virtually absent between 2 and 11 years of age. A 15º forward tilted sitting position was, in terms of postural efficiency, more efficient than the horizontal or the 15º backward tilted sitting position.</td>
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<td>The effects of a contoured foam seat on postural alignment and upper-extremity function in infants with neuromotor impairments.</td>
<td>Time series, alternating treatments design. N=4, infants unable to sit independently.</td>
<td>Results showed a sustained effect of the contoured foam seat on improving postural alignment for all subjects. Effects of the contoured foam seat on increasing bilateral play were not demonstrated for any subjects.</td>
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