The benefits of upright movement for children with motor impairment: a literature review

Foreword

Upright movement is instinctive – it's what humans are designed to do as soon as they are able. As in all development, each stage plays a part in the building blocks of the next stage, therefore upright movement (pulling to stand, cruising) starts months before walking is achieved. But when children have a motor impairment, it seems logical that the need to move in a safe and beneficial way is every bit as important, even if it is more difficult. The Upsee has been designed to fill this gap, by enabling infants and small children with motor impairment to stand, and achieve repetitive walking training, with the assistance of an adult.

Formal research data about the Upsee has not been possible to collect thus far – we are never able to do this *before* a product launch due to time constraints, hampered further by the ethical barriers of using a prototype product in research. We wanted to get a safe and effective product to you as quickly as possible, so we have used our clinical, design, and technical expertise, along with product evaluations, clinical observations and secondary evidence (research already reported by others) to show that the Upsee has the potential to be an effective tool for enhancing family participation as well as providing standing and movement experience.

This is what is presented to you here. The literature review has been carried out and written on a part-time consultancy basis by Sheila McNeill, an extremely experienced paediatric physiotherapist. Sheila continues to maintain a caseload of neurologically impaired children and young people, and her clinical expertise into the Upsee development has been both insightful and invaluable.

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Background to the literature review and ongoing research

In order to investigate the potential benefits of the Upsee, a literature search was carried out to examine the evidence for the general benefits of upright movement for children with motor impairment. While it is recognised that the benefits of the Upsee are subsequently inferred (the assumption that benefits of upright movement in other situations can be replicated by using the Upsee), this is the best available evidence to date. It is the intention that specific Upsee research will follow in due course.

The following key words were used to search the published literature: ICF-CY, cerebral palsy, child development, mobility, weight bearing, postural management, standing, bone mineral density, joint development, strengthening, balance, participation, gait, treadmill training, therapy, play, parents, environmental factors, assistive devices.

The following sources were used to carry out this search:
Pubmed, CINHAL, Medline and Google Scholar.

In addition, grey literature, seminal works, and books were searched from 1973 to the present time (March 2014). In total, 40 resources were located and are referenced at the end of this document.

Introduction to Upsee

The system consists of a waistcoat for the child, with a pelvic belt, groin supports and adjustable straps to link the child from his/her shoulders to the adult's pelvic belt. The child and adult also share sandals which accommodate the child and adult's feet in each sandal. The child stands with support as required from the adult. Child and adult step simultaneously with the child's arms free for play (see figure 1).

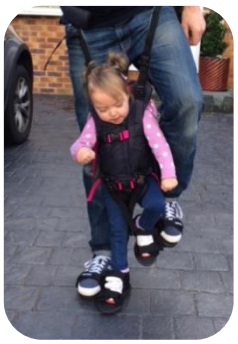

Figure 1

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The Upsee can be used in the home or school giving the potential to enhance participation, and widen the experiences of the child. At home, parents can set playful tasks to achieve participation in activities with siblings or peers. The child is best placed in a stimulating environment, where toys or objects of interest are available within their reach, in a direction which promotes an active upright posture, upper limb function and walking. Examples include dancing, throw/catch, football, push-along toys, action songs, table top play and walking to fetch objects or toys.

Of relevance to the Upsee is research into the effectiveness of interventions for young children with cerebral palsy. Evidence relating to Early Intervention and Home Programmes supports general stimulation, developmental approaches and parent coaching programmes.[1] [2] The therapeutic practice of goal-based tasks by the child, led by the parent and supported by the therapist, in the home environment showed improved performance of functional activities and improved participation. [3] [4]

Colver[5], promotes the idea that children are 'human beings' rather than 'human becomings' for whom participation and quality of life are immediately important and not just an aspiration for the future. The Upsee has the potential to enhance the experience of early childhood by enabling new experience of movement and participation for the child with motor impairment.

The International Classification of Functioning, Disability and Health Framework (ICF)

In this report, benefits of upright movement are investigated and reported using the International Classification of Functioning, Disability and Health Framework for Children and Youth (ICF-CY). This delivers a common language to describe any condition (in this case childhood impaired mobility) in relation to body structures and functions, activities and participation. (Figure 2).

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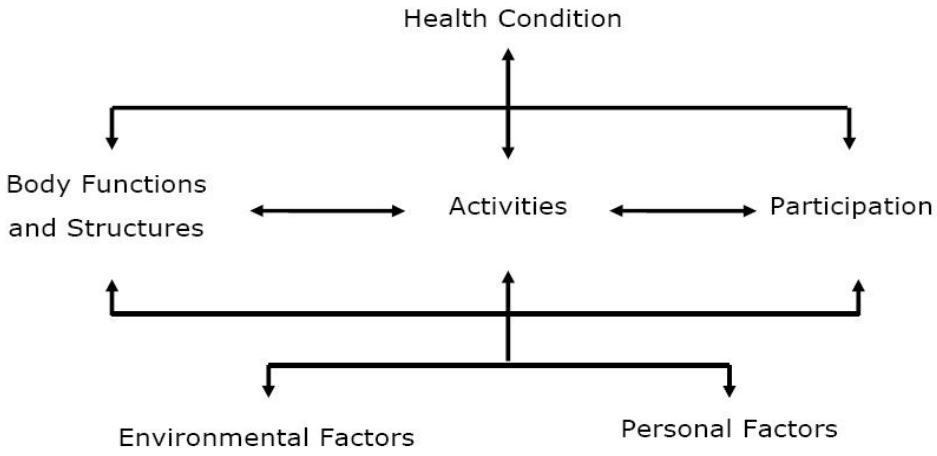

Figure 2. International Classification of Functioning, Disability and Health Framework
(World health Organisation 2007)[6]

Body structures and functions relate to the basic **impairment**. What is wrong with the body? In childhood disability this may include tonal abnormality, muscle shortening, joint deformity and discomfort.

These impairments impact on the child's **activity**. Can the child get up from the floor? Can he sit on a bench? Can he rise to stand and walk? What is the child capable of doing?

Activity impacts on the child's level of **participation** in everyday activities such as playing, eating, dressing, cycling, going to the shops, involvement in sports etc.

Alongside these levels is the impact of the child's **environmental factors** and **personal factors**. Parents, siblings, motivation, cognitive ability, housing, infrastructure of local health and education services and access to sports and leisure facilities are a few of the environmental and personal factors that may impact on a child's impairment, activity and participation.

Research suggests that services that are comprehensive in nature and target multiple levels of functioning and outcomes, appear to be more beneficial than a single treatment approach. Consequently, interventions should target all three components of health (body functions and

structures, activities and participation) as well as contextual factors (environmental and personal) of the ICF.[7]

The Upsee has the potential to address factors relating to impairment, activity and participation and consider environmental and personal factors relating to children with motor impairment.

1. Body Structure and Functions (Impairment)

1.1 Abnormal bone and joint development

In the typically developing child, the growing skeleton remodels in response to characteristic stresses associated with the motor milestones, which when delayed or absent, result in retention of infantile body structure and development of secondary bony deformities and joint instability.[8]

Combining weight-bearing activities with movement should create more desirable forces for joint formation. Modelling of the bone and associated joints takes place most readily during the first few years of life with the acetabular shape fairly well defined by the age of three years in a typically developing child.[9]

In a study by Beals[10] 40 children with CP were monitored and compared to typically developing children.
The acetabulae of the children with CP had appeared normal after birth, but they did not increase in depth as expected by the age of two years. Nevertheless, acetabular depth was comparable with that of the typically developing population when the children were 8 years old. All but one of the 40 children included in this study were walking by this age, suggesting that the dynamic compressive forces of walking contributed to increased depth of the acetabulum. This relationship between hip stability and ambulation has been further supported in the literature by other studies.[11] [12]

Soo et al[13] proposed that risk of dislocation is independent of motor type of CP, and that lack of functional weight bearing is more important than spasticity in the aetiology of subluxation and dislocation.

Potential impact of Upsee on bone and joint development

The Upsee may enable the child to achieve an upright position and mobile weight bearing through their lower limbs. The degree of weight bearing through the lower limbs is increased or decreased as the parent adjusts the

supporting straps in response to the child's own ability to take weight through their legs. The intensity of weight bearing required to match that of a typically developing child is unlikely to be achieved. However there is evidence to support the notion that activities which achieve active weight bearing in young children with physical impairment may have a substantial influence on the shape and function of the joint.[14]

1.2 Muscle weakness

Muscle weakness has been reported to be a common symptom in children with cerebral palsy affecting anti-gravity muscles including ankle dorsiflexors and plantarflexors, and knee and hip extensors.[15] [16] Evidence relating to strength training advocates functional training within functional tasks.[17]

Strength, motor control, balance, and endurance are all required for good postural control and independent gait.

Use of supportive walkers to address these impairments as a pre-gait activity for children with disabilities is supported by recent studies focussing on increased strength as an intervention to improve gait and postural control as well as using the motor activity around a purposeful task to improve selective motor control.[18]

Potential impact of Upsee on muscle weakness

The Upsee has the potential to progressively lower the amount of support given, so that the child uses their optimum lower limb strength to maintain an upright posture. Provision of the minimum level of support by the adult presents the child with the opportunity to gain lower limb strength should sufficient frequency of use be achieved.

1.3 Decreased bone density

Active standing and other forms of weight bearing activity have been advocated to decrease skeletal fragility and susceptibility to fracture in children with limited mobility.[19] This recommendation is based on several studies which suggest that weight bearing has a positive effect on bone strength.

- Chad et al[20] reported an increase in femoral neck bone mineral content, volumetric bone mineral density and total proximal femur in an intervention group of children with CP after an 8 month physical intervention programme, compared with control subjects.

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- Caulton et al[21] showed a large and significant increase in bone mineral density on the lumbar spine when increasing static standing time.

- In a systematic review, weight-bearing was been identified as an intervention to improve bone mineral density which demonstrated the most promising results, with the need for further research.[22]

Potential impact of Upsee on bone density

The Upsee may provide a contribution to the total weight bearing required to maintain or improve bone density.

1.4 Cognitive impairment

In a study to explore facilitators and barriers to participation in physical activity in children with cerebral palsy, Vershuren et al[23] identified the presence of a cognitive impairment as one of many factors which compromise the potential to participate in physical activity.

With regard to cognitive development, studies confirm that motor behaviour is an integral part of both cognitive and social development. Port and Van Gelder[24] described the trinity of brain, body and environment leading to cognitive development. They claimed that to understand cognition is to understand the interplay of all three.

Similar work by Warren[25] described this relationship between action and cognition as 'enactive knowledge' while Sugden and Wade[26] referred to this as 'behavioural flexibility' and stated that physical exploration is critical in an infant's ability to acquire knowledge about the wider environment and his/her relationship to the things that make up their world.

Potential impact of Upsee on cognitive development

It would follow that interventions designed to enhance physical development within the right environment may have a role in promoting optimum cognitive development.
Children with learning disability may have reduced motivation to play and explore. Locomotor experience using the Upsee, may provide the opportunities for children to play in a different way within a variety of environments. Forward planning of activities to ensure optimum activity using familiar toys or toys with features such as bright colour, sounds, music and vibration may be useful.

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2 Activities

2.1 Developmental sequence

Infants usually stand with assistance at around 7.6 months.[27] While in standing they will begin to shift weight. This weight shift is not only the start of upright balancing but also the start of upright mobility, because infants will soon learn to cruise along a supporting surface. Cruising along an object such as a sofa is an important developmental skill because of the unilateral weight-bearing, weight shifting, balance, and synergistic hip abduction/adduction required for movement.[28]

Potential impact of Upsee on developmental sequence

The Upsee has the potential to enable the child to experience the upright stages of normal development in a timely manner. Also, use of the Upsee has the potential to enable the child who normally experiences stereotyped activity, to move through a variety of sensori-motor experiences in standing and walking. This has been advocated as an approach to therapy in the Neuronal Group Selection Theory.[29]

2.2 Active stepping and weight bearing

Active participation with any physical intervention is required to ensure optimum progress. This involves practise of tasks at a sufficiently challenging level.[30] Body Weight Supported Treadmill Training studies (BWSTT) have included gradual increase of weight bearing, similar to use of the UpSee harness. Willoughby et al[31] suggested that when using BWSTT, the amount of body weight support should be reduced as quickly as possible in order to optimise functional carry over.

Potential impact of Upsee on active stepping and weight bearing

This is what the Upsee is designed to facilitate. In order to gain optimum benefit from using the Upsee, the child should be encouraged to be actively involved. Time should be given for the child to initiate and take steps, with assistance from the adult as required.

Also, the child should take as much weight through their legs as possible. This can be achieved by adjusting the straps adjoining the adult and child.

Progressively decreasing body weight support in a non-ambulatory person can be an effective way to increase lower limb strength. This has the

additional benefit of being accomplished in a task specific manner, such as standing to play, which should translate more readily into functional gains.

2.3 Balance

The relationship between impaired balance and functional limitations has meant that a major focus of many intervention programmes in children with cerebral palsy is to improve postural control. A study examined the effect of balance training on the recovery of stability in children with spastic cerebral palsy and concluded that therapeutic equipment to challenge different degrees of balance perturbation may be helpful.[32]

Potential impact of Upsee on balance

The Upsee may enable a child to practise balance activities where there is potential for these skills to be developed. Maximum support involves adjusting the straps so that the child does not require any degree of balance in order to maintain an upright position. The supportive straps may be loosened and allow the child the opportunity to use balance to maintain an upright trunk over actively extended legs.

2.4 Experience of Movement

Children with motor impairment lack experience of movement both in terms of variety and repetition of movement. Adolph et al[33] identified the importance of practice in normal development when infants engage in a great deal of supported walking which improves leg and trunk strength.

Potential impact of Upsee on movement experience

Regular use of the Upsee may provide a child with sufficient experience of movement to enable progress with development of standing and cruising along furniture.

3. Participation

Participation is defined as involvement in life situations, reflecting the interaction of the person, activity and environment.[34] Participation of children with motor impairment is influenced by multiple factors including child functional ability, family participation in social and recreational activities and child preferences.[35]

Palisano[36] described principles of participation-based therapy services for children with motor impairment. These include:

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- Goal-oriented: Child and family identify goals for home and community participation that they are interested in and ready to focus on. Goals are feasible and attainable in 4 months.
- Family-centred: The family is recognised as the expert on their child. Interventions are guided by respect for parents' understandings of their child's needs and appreciation of family and child world views, values and preferences.
- Collaborative: The therapist collaborates with the child, family and community providers (eg teachers), agencies and organisations.
- Strength-based: Interventions are designed to build on the strengths and resources of the child, family and community.
- Ecological: Interventions are provided in natural environments and emphasise real-world experiences.
- Self-determined: The child is engaged in activities that are fulfilling and promote a sense of belonging and self-accomplishment. The therapist shares information, educates and instructs in ways that enable the child and family to solve problems, and discover solutions to participation.

Potential impact of Upsee on participation

In applying these principles to use of the Upsee, parental choice with regard to assisted mobility for their child should be respected. Parental motivation to see their child in an upright position, achieving stepping with hands free to play is an understandable aspiration. Of importance in the principles outlined above is consideration of the ability and interests of the child to ensure optimum enjoyment, engagement and achievement in activities.

One of the key elements in the successful use of the Upsee is participation through play. Play as the primary productive activity for children, should be intrinsically motivating and pleasurable.[37] The 'hands-free element of the Upsee sets the scene for optimum opportunity for the child to engage with different types of play in a standing position within their home environment. It is doing rather than a superior level of accomplishment that is most meaningful to most children.[38]

The Upsee may have an impact on the following issues relating to participation:

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- Mobility within the home
- Mobility on various terrains
- Inclusion in leisure activities – football/push along toys/actions songs/table top play/group play.

4. Environmental and Personal Factors

Environmental factors identified by Sugden and Wade[39], which may impact on the development of a child with motor impairment include:

- Support from health and educational agencies
- Support at home
- Peer perception and support
- Socio-economic status and culture
- Community opportunities
- Assistive devices
- Expectations of parents

Potential impact of Upsee on environmental and personal factors

The interplay between these factors defines the environmental context in which the learning of movement takes place. The role of the Upsee within this context is dependent on a supportive environment with parental commitment crucial to achieve optimum benefit from the device.

Compared with typically developing children who usually play with other children, the children with motor impairment almost always have an adult with them when they play.
These adults are almost a necessity for the child in order to be able to get to places where the activities take place, and as well, many of the games demand the participation of the adult for the sake of the disabled child, although there are other children playing.[40]

Personal factors relating to the Upsee include:

- Relationships with parents and siblings; social engagement[41] [42]
- Fear[43]
- Desire to be active psychosocial benefits[44]

The Upsee should be used in a social, safe and supportive environment to ensure optimum benefits are achieved from using the device.

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5. Quality of Life and the Upsee

Verschuren et al[45] identifies the experience of enjoyment as a facilitator to participation in physical activity. The importance of this should not be overlooked as part of the Upsee experience, utilising play, music and social engagement to enhance enjoyment of this device.

Conclusion

The Upsee is an assistive device designed to address upright developmental needs of certain infants and small children with motor impairment. Efficient use of assistive devices for such children may enable them to access and participate in a variety of activities and settings.[46] The evidence presented relating to use of the Upsee provides some indicators that appropriate use may enhance activity and participation with immediate effect for a child, or with use over time it may contribute as an adjunct to treatment, to achieve improvement in the child's ability in standing and stepping.

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upsee

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