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Snoezelen: A controlled multi-sensory stimulation therapy for children recovering from severe brain injury

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Abstract
Objective: To investigate the effects of Snoezelen therapy on physiological, cognitive and behavioural changes in children recovering from severe traumatic brain injury (TBI).
Methods: An observational study was conducted to assess the physiological, cognitive and behavioural changes of children recovering from severe TBI while receiving Snoezelen therapy. Fifteen subjects completed the pre- and post-Snoezelen treatment measurements computed over 10 consecutive sessions. Physiological, cognitive and behavioural measures were administered. Data was collected prospectively on each session in the Snoezelen room and were analysed by calculating the difference between pre- and post-treatment measurements for each Snoezelen session.
Results: Results revealed significant changes on physiological measures. Heart rates decreased for each subject in each treatment session and were found to be significant ($p = 0.032$). Muscle tone was decreased in all the affected extremities (right upper extremity $p = 0.009$, left upper extremity $p = 0.020$, right lower extremity $p = 0.036$ and left lower extremity $p = 0.018$). Agitation levels decreased over time and the overall cognitive outcome measures showed significant improvement when comparing the beginning of treatment with the end.
Conclusion: This study revealed a beneficial use of Snoezelen therapy with children recovering from severe brain injury. However, there continues to be a critical need for evidenced-based research for this patient population and others in this multi-sensory environment.

Keywords: *Behavioural, children, multi-sensory, Snoezelen, therapy*

Introduction

Trauma is the leading worldwide cause of death and a major cause of disability in children. Traumatic brain injuries (TBI) occur in 85% of traumatized children and account for more than 50% of the deaths in the paediatric population. Each year, more than 1 million children in the US sustain TBI, with ~250 000 admitted to hospitals for treatment. As many as 7000 die and 30 000 are permanently disabled [1–5].

Motor vehicle accidents involving pedestrians is the second leading cause of unintentional injury among children under the age of 15 in motorized countries [6]. Miami-Dade County has the highest incidence of paediatric pedestrian injuries and fatalities in the state of Florida [7]. The Ryder Trauma Center (RTC) at University of Miami/Jackson Memorial Medical Center at (UM/JMMC) provides care to trauma victims in South Florida. The RTC sees about 500 children and adolescents <18 years

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of age per year. Of these, ~50 children with moderate and severe TBI are admitted per year to the Paediatric Rehabilitation Unit of this hospital.

Recovery from paediatric brain injury entails a complex interplay among diverse factors, such as the pathophysiology of the brain injury, the developmental stage at the time of injury, cerebral plasticity, the amount of time after the injury and the child's reserve of psychosocial resources. Dennis [8] found that some impairments in young children actually increase in severity over time after injury. They hypothesized that early insults may limit the brain's capacity to develop normally or may interfere with the timing of neural development and that new deficits may emerge at later stages after injury.

Other experts argue that the concept of cerebral plasticity of the developing brain still seems to lead to more favourable outcomes after TBI for younger age groups [9, 10]. Enhancement of plasticity is known to occur through both endogenous factors, such as the release of nerve growth factor [11, 12] and exogenous factors such as environmental stimulation [8]. There is evidence that suggests that the myelinization process as well as the synaptic plasticity is influenced by functional interaction with the environment [13, 14]. Based on previous evidence, the influence of environment stimulation can be used as an intervention to improve motor skills and cognitive function.

Current treatments for children with severe TBI in the acute stages include coma stimulation or sensory regulation programmes. These programmes try to achieve an awakening or increasing arousal level of the patient. Stimulation programmes have been advocated for these persons; however, reliable evidence as to their effectiveness and their conceptual basis has been poorly understood. Early experimental evidence indicates that normal animals reared in enriched environments demonstrate significantly greater learning and memory skills than those reared in less stimulating or impoverished environments [15]. Studies of animals with brain lesions suggest that those cared for in environments permitting greater perceptual and motor stimulation performed significantly better on general learning tasks than those cared for in non-enriched environments [16]. A more recent study by Giza et al. [17], studied baby rats following a fluid percussion injury reared in either a standard or enriched environment. The findings confirm that early TBI has effects on experience-dependent plasticity resulting in long-term neurobehavioural deficits and beneficial effects from environmental stimulation following TBI are dependent upon time after injury.

The multi-stimulation approach such as the Coma Recovery Programme or Coma Arousal Therapy [18–20] is based on behaviourism. Basically, it is any application of a treatment that is tailored in intensity and frequency of stimulation to an individual's threshold (consisting of auditory, visual, tactile, gustatory, olfactory and kinetic modes) in an attempt to increase arousal and awareness and elicit meaningful, behavioural response. The rationale is that exposure to frequent and various sensory stimulations will facilitate both dendritic growth and improve synaptic connectivity in those with damaged nervous systems [18, 19]. Most sensory stimulation programmes are designed to prevent sensory deprivation and to provide structured input in order to maximize a patient's ability to process and respond to stimuli [21]. The ultimate goal of enriched environments is to facilitate recovery of the nervous system so that patients are able to process information of increasing variety and complexity.

In contrast, the sensory regulation approach is based on information processing and mediation of reaction to sensory information with emphasis on enhancing selective attention by regulating the environment rather than providing high degrees of stimulation. What both approaches have in common is that those in minimally conscious states at some level are able to perceive and begin to process information and that external stimulation may enhance that process [22]. Therefore, to observe any recovery in patients with severe brain injury, increasing the level of arousal and attention is the first step on the road to recovery.

Snoezelen, or controlled multi-sensory stimulation therapy, comprises the components of a novel sensory stimulation approach. Snoezelen as an alternative treatment modality is gaining attention worldwide. Hulsegge and Verheul from the Netherlands derived this term in 1975 by blending two Dutch words, 'sniffing' and 'dozing' together, to describe a process of controlled sensory stimulation in a non-threatening secure environment involving all sensory systems [23, 24]. These multi-sensory rooms contain visual, olfactory, auditory, vestibular and proprioceptive equipment (e.g. mirror light balls, bubble tubes, fibre-optic cables, ball pools, aromatherapy, calming music, etc.). Once inside this environment, there are opportunities for stimulation of all senses. Currently, Snoezelen has been most commonly utilized for individuals with severe sensory impairments, autism, severe developmental and/or learning disabilities, severe and profound mental retardation, dementia, chronic pain and burns [25–28]. In 1992 in the US, 'Snoezelen' became a registered trademark of FLAGHOUSE, Inc.

Snoezelen is similar to the notion of sensory stimulation or sensory buffet which has been studied by many investigators [25, 29]. Snoezelen environments are thought to facilitate relaxation, provide enjoyment experience and inhibit behavioural changes [30, 31]. The stimulation is believed to promote a sense of enjoyment and a relief from tension and pressure, with consequent improvement in general behaviour. Kwok et al. [32] reported nine functions that can be promoted in a Snoezelen room, including: (1) Relaxation; (2) Development of self-confidence; (3) Achieve sense of self control; (4) Encourage exploration and creative activities; (5) Establish rapport with care takers; (6) Provide leisure and enjoyment; (7) Promote choice; (8) Improve attention span, and (9) Reduce challenging behaviours.

Although Snoezelen is a relatively old concept overall, there exists a limited amount of research on the beneficial impact of Snoezelen on patients' social and emotional behaviour as well as adaptive and performance skills. The outcomes of the Snoezelen research obtained from people with developmental disabilities and dementia suggest caution. In some studies, the positive results were based largely on qualitative data, such as post-session ratings, diary cards completed retrospectively and staff interviews [30, 33]. Although the majority of studies have reported within-session positive effects of Snoezelen, methodological issues have considerably reduced the overall strength, impact and generality of the findings. Both Hogg et al. [34] and Lancioni et al. [25] in their review articles have reported on the dearth of well-controlled studies, a fact that necessitates further research into the effects of Snoezelen on the behaviour of individuals with a wide range of disabilities.

The growing interest and acceptance of Snoezelen rooms has been accompanied by limited research efforts to formally assess the effects of this treatment modality and its environment. Most of the recent reported studies have been conducted in adults, except for the work done by Shapiro et al. [35] in Israel. In two recent literature reviews, 14 studies were identified that assessed the effects of Snoezelen on the behaviour of individuals with developmental disabilities [25, 29]. A number of these studies reported positive effects on socially adaptive and maladaptive behaviour of the participants while they were in the Snoezelen room [35–38]; however, the carryover of these positive effects to other settings was limited and they report no long-term effects [25, 38–40].

There have been no studies looking at Snoezelen with brain injury. Due to some of the common sensory and behavioural changes seen in children recovering from severe brain injury, it was thought that the Snoezelen environment could be beneficial to assist the child during the early recovery period as they emerge from minimally conscious states to higher levels of functioning. The main reasons to support the idea include: (1) A limited number of alternative modalities in addition to traditional rehabilitation therapies available for care takers and family members to work purposefully and effectively with children recovering from severe TBI; and (2) the widely held notion that Snoezelen is a pleasurable, friendly and highly humane approach. The purpose of this study was to investigate the effects of Snoezelen therapy on physiological, cognitive and behavioural changes in children recovering from severe brain injury.

Methods

Subjects

Fifteen children were involved in the study, 11 (73%) boys and four (26%) girls, with a mean age of 9.87 (range = 1.2–16.9). Fourteen of the subjects sustained a severe TBI and one an anoxic event, with a mean Injury Severity Score (ISS) [41] of 31.29 (range = 13–50) and an Abbreviated Injury Score (AIS) [41] of 4.71 (range = 3–5). The mechanisms of injury included: eight pedestrians hit by a car, five motor vehicle crashes, one near drowning and one motorcycle accident. Each subject received a different number of Snoezelen treatment sessions depending on their length of stay; however, data was computed over the first 10 consecutive treatment sessions. The mean number of treatment sessions was 6.7 (range = 3–10).

The inclusion criteria included: (1) age at time of injury: 1 year 0 months to 17 years 11 months; (2) documented lowest post-resuscitation Glasgow Coma Scale (GCS) score [42] at admission of <8 (severe); (3) mass lesion or evidence of pathologic condition on CT/MRI scans; (4) Rancho Los Amigos Scale Score [21] at admission to PRU of II (generalized) to V (confused, inappropriate); and (5) ability to participate in the inpatient rehabilitation programme for at least 3 consecutive weeks.

Exclusion criteria included: (1) penetrating head injury; (2) TBI as result of child abuse; (3) previous TBI; and (4) pre-existing physical, neurological, psychiatric or developmental disorder. All subjects were medically and surgically stable. The mean number of days post-injury was 63 days (range = 11–282). Each subject required parental consent to participate in this IRB- approved protocol prior to the initiation of snoezelen Therapy. See Table I for details regarding subject characteristics.

Measures

The outcome measures selected were based upon two factors: consideration of the multi-factorial nature of TBI and the fact that the clinic staff were already using the assessment tools. Glasgow Coma

Table I. Demographic characteristics and injury severity.

Demographic characteristics	$n = 15$
Age	
Mean	9.87 (1.2–16.9)
Gender	
Male	11
Female	4
Ethnicity	
African–American	8
Caucasian	4
Hispanic	3
ISS	
Mean	31.3 (13–50)
AIS	
Mean	4.7 (3–5)
GCS at scene	
Mean	4.8 (3–8)
Days post-injury	
Mean	62.93 (11–282)
Mechanism of injury	
PHBC/BHC	8
MVC	5
MCA	1
Near drowning	1

Scale (GCS) was used to document the level of consciousness in relation to responses in the areas of eye opening, verbal response and motor response. A score of 8 or less indicates severe, 9–12 moderate and 13–15 mild head injuries with a maximum of 15 points [42].

Physiological measures. The physiological measures used pre- and post-treatment consisted of the following: heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), oxygen saturation (02 SAT) and muscle tone (Modified Ashworth Scale). The systolic, diastolic and mean arterial pressure was determined using a mechanical blood pressure monitor (DINAMAP^{TM} XL Vital signs Monitor). The oxygen saturation and the pulse rate were taken using a portable pulse oximeter monitor system, which includes a monitor and an oximetry finger sensor. All the machines used to calculate the physiological measures were routinely used by nursing staff on a daily basis. The Modified Ashworth Scale (MAS) was used to test the measurement of muscle spasticity. The scale measures the degree of muscle resistance to passive movements and impairment on a five-point scale, ranging from 0–4 (0, normal muscle tone; 4, fixed muscle contracture). This scale was used to evaluate a target muscle group in either upper or lower extremity or both according to the injury level at pre- and post-Snoezelen treatment sessions [43].

The cognitive and behavioural measures included:

(1) Ranchos Los Amigos Scale (RLAS) is an 8-level descriptive scale of cognitive and behavioural responses at specific levels of functioning that range from I–no response to VIII–purposeful/appropriate. The scale represents the progression of recovery of cognitive skills as demonstrated through behavioural change [21].
(2) Agitated Behaviour Scale (ABS) assesses the nature and extent of agitation during the acute phase of recovery from acquired brain injury and consists of 14 items that can be given a score ranging from 1–behaviour absent to 4–extremely present. This scale was developed to assess the nature and extent of agitation during the acute phase of recovery from acquired brain injury. Its primary purpose is to allow serial assessment of agitation by treatment professionals who require objective feedback about the course of a patient's agitation. Some of the descriptive behaviours items evaluated include: #2–Impulsive, impatient low tolerance for pain of frustration, #5–explosive unpredictable anger, #10–repetitive motor or verbal behaviours. The highest possible total score is 56 and the lowest possible score is 14. Ratings were based on a 10-minute observation period per patient at pre- and post -Snoezelen sessions [44].
(3) Functional Independent Measure (FIM) assesses level of independence ranging from 1–total assistance to 7–completely independent [45]. The FIM measures independent performance in self-care, sphincter control, transfers, locomotion, communication and social cognition. By adding the points for each item, the possible total score ranges from 18 (lowest) to 126 (highest) level of independence.

The ABS and the GCS were administered before and after each Snoezelen treatment and the RLAS and the FIM were administered on admission and discharge from the Snoezelen study.

Procedures. The study was conducted in the Snoezelen room in the Paediatric Rehabilitation Unit located at UM/JMMC. Experts from Beit Issie Shapiro Centre for Children with Disabilities assisted in setting up the room and training the staff prior to the start of the study. Beit Issie Shapiro is a non-profit treatment centre in Ra'anana, Israel, that provides a variety of services to children with developmental disabilities and their families. Since 1999, the Centre has provided a training programme in Israel for Snoezelen, or Controlled Multi-sensory Stimulation using Snoezelen, and guided the setting up of Snoezelen facilities all over Israel. Recently, they have established a professional training in the US with the collaboration between Trump International Institute of Continuing Education in Developmental Disabilities and UM/JMMC.

Snoezelen training was available for physical, occupational, speech and recreational therapists, nurses and research assistants of the PRU at UM/JMMC. All enrolled practitioners were required to attend a 20-hour course which included: background information and principles, philosophy, therapeutic techniques, applications, maintenance, support services and demonstrations in the room. A certificate was provided on completion of the course.

The Snoezelen room

The dimensions of the room are 20×20 ft and composed of various spatial configurations and an array of multi-sensory equipment that provide stimulation in different modes to each participant (see Figure 1). The room is considered a white Snoezelen room with the walls covered in white padding, ceiling in white fabric and windows with white blackout curtains. The stimuli include: olfactory (e.g. aromatherapy diffuser with a lavender scent); vibratory and tactile (e.g. tactile panels, vibrating pillow, cushioned bubble tube platform, interactive bubble tube and fibre-optic bundles); auditory (e.g. stereo system to play soft new age music, interactive light and sound wall); visual (e.g. stationary mirror ball, interactive light and sound wall, liquid effect wheels, shimmering light curtain, fibre-optic bundles, acrylic mirror panels, glowing in the dark stars and interactive bubble tube); and vestibular–proprioceptive (e.g. bean bag bed, leaf chair, glowing ball pool with clear balls). In addition, the room is fully ventilated, the floor is partially covered with white mats, and the walls are painted in white to allow light reflection. Music is part of the environment, and repetitive instrumental music is continuously played softly in the background.

Information describing the study was provided to families of children with TBI during their child's admission to PRU. Children who met inclusion criteria and their parents or legal guardians who signed consent forms were recruited. The subjects were then scheduled for Snoezelen therapy three times a week, along with their comprehensive neurorehabilitation programme, consisting of physical therapy (PT), occupational therapy (OT), speech therapy (ST) and neuropsychology one or two times per day, six times a week. Depending on subject's ability to participate sessions lasted ~30–40 minutes.

A Snoezelen therapist, who was a physical therapist with sensory integration experience had taken the Snoezelen training course, along with the research assistant (RA). They administered one-to-one 30 minute treatment sessions, using one-to-three pieces of equipment in a sequential order three times a week until the patient was discharged from PRU. Both the therapist and RA were involved with the subject's exposure to the Snoezelen environment by facilitating physical contact and interaction, but not interfering with the subject's choice or pace. They functioned as enablers, rather than conventional rehabilitation therapists who guide the person toward present performance or engagement activities. The subject was the centre of the Snoezelen experience and the stimuli and staff were there to promote and guide the experience and any related effects. For those subjects that were dependent for ambulation and sitting, the therapist moved their wheelchairs near the equipment or the subject was carried to the piece of equipment being used.

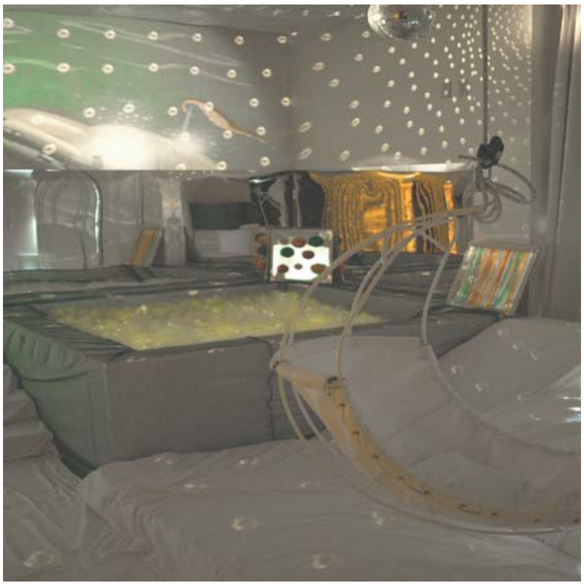

Figure 1. Snoezelen room.

The Snoezelen treatment sessions involved the following phases: (1) introduction to the room, (2) carrying out of the session through equipment use and (3) winding the session down. The frequency and length of each session was the same for each participant. There was one treating therapist with a subject in the room during each session.

The following protocol was used in the Snoezelen room:

(1) Prior to entering the Snoezelen room, the regular fluorescent room lights were turned off, the aroma therapy diffuser with lavender was turned on and new age soft music playing, the projection of the mirror ball was turned on.

(2) The subject was brought into the transitional area (hallway) of the room. This is a small area located close to the entrance of the room and has stars that glow in the dark with the effect of an ultraviolet black light. The purpose of using this is to allow the participant to become accustomed to a darker room.
(3) Light and sound wall was turned on with new age music played softly. The volume was the same for each session.
(4) After 2–3 minutes, the bubble tube was turned on and the therapist waited for any kind of response.
(5) After another few minutes, the projector wheel with a different scene or liquid effects wheel was turned on.
(6) The equipment used in a Snoezelen session depended on the individual's level of arousal or relaxation. After use of the standard pieces of equipment, the treating therapist decided whether to use other pieces of equipment in the room (for example, the ball pit was used for children with increased tone and spasticity).
(7) After ~25 minutes, a reverse ordering of turning the equipment off was done. When leaving to go through the transition area all post-session measures were administered prior to leaving the Snoezelen room.

The pre- and post-physiological, cognitive and behavioural measures were taken before and after each Snoezelen treatment session by the RA. Data was collected prospectively for the each consecutive Snoezelen treatment session. Total testing time for these were ~10 minutes for each session. In addition, weekly progress notes were written by the treating Snoezelen therapist based on clinical observations documenting baseline interactions and weekly changes during patient interaction with equipment and therapist. Videotaping of many of the sessions assisted with tracking some of the behavioural changes. The Research team met weekly to review the cases and discuss their progress while receiving the Snoezelen therapy.

Statistical analysis

This observational study was developed using a case series study design. The patient data were collected prospectively three times a week at pre- and post-treatment conditions. The RA was responsible for entering patient data into an Excel database. Sessions were scheduled consecutively for each subject. If a subject did not attend a scheduled session or if data were not obtained, the data for that session were coded as missing. Pre-exposure and post-exposure means were calculated for each subject over all sessions completed. Summary statistics are presented as the mean ± standard error weighted by the number of sessions per subject. The pre-exposure and post-exposure means were compared using a paired *t*-test weighted by the number of sessions per subject. The linear regressions analysis of changes in HR over sessions was computed by calculating the standard error for each pre- and post-session and weighting each observation inversely to the standard error for that session. Since the direction of improvement is known for all measures, a one-tailed α of 0.05 was used for all statistical tests.

Results

Physiological measures

The evaluation of the patients HR and MAP was done by comparing the individual changes from the pre-treatment setting to the post-treatment phase in the Snoezelen room. The HR decreased from pre- to post-treatment sessions and was found to be significant ($p = 0.032$). With regards to these changes in HR, the changes over accumulated sessions, as shown in Figure 2, indicates a constant intra-session decrease in HR with average HR decreasing over sessions. The average pre- and post-HR were correlated within subjects at $r = 0.92$, $p < 0.001$). There was no significant difference found between the pre- and post-sessions in terms of changes over time in mean arterial blood pressure (MAP) ($p = 0.318$). It was also noted that in most of those children with spasticity, the muscle tone measured using the Modified Ashworth Scale (MAS) [43] decreased in all the affected extremities, see Table II. The average changes (±SE) of physiological measures over 10 sessions with four or more observations were recorded.

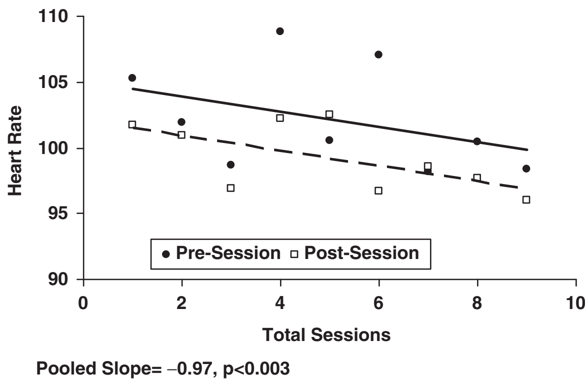

Figure 2. Heart rate changes of the group by session.

Table II. Average of the physiological measures from pre- to post-treatment sessions.

Measure	Pre-session	Post-session	Change	p-value
HR	101.9 ± 3.7	99.0 ± 3.5	2.9 ± 1.4	0.032
MAP	80.6 ± 2.8	79.6 ± 1.8	1.1 ± 2.2	0.318
MAS: Muscle tone				
Right upper	0.86 ± 0.37	0.62 ± 0.27	-0.24 ± 0.10	0.009
Left upper	0.72 ± 0.31	0.62 ± 0.27	-0.10 ± 0.05	0.020
Right lower	1.69 ± 0.54	1.47 ± 0.46	-0.21 ± 0.12	0.036
Left lower	1.63 ± 0.47	1.47 ± 0.45	-0.16 ± 0.07	0.018

HR = Heart rate, MAP = Mean arterial pressure, MAS = Modified Ashworth scale.

Cognitive and behavioural measures

In reference to the Agitation Behaviour Scale (ABS) [44] which measures agitation level, these scores decreased over time from pre- to post-treatment, but did not reach significance ($p = 0.072$). However, Snoezelen appears to have some beneficial effect on decreasing the level of agitation, with considerable variation between individual subjects. A comparison of the cognitive and functional outcome measures Rancho Los Amigos Scale [21] and the Functional Independent Measure (FIM) [45] of the study group from admission to discharge showed a significant improvement ($p = 0.002$ and 0.002, respectively). Table III shows average changes (±SE) of cognitive and behavioural measures.

Table III. Average of behavioural measures.

Measure	Pre-session	Post-session	Change	p-value
ABS	20.8 ± 1.8	18.9 ± 1.3	1.9 ± 1.2	0.072
RLAS	3.6 ± 0.3	4.1 ± 0.5	0.9 ± 1.3	0.002
FIM	23.8 ± 2.09	65.8 ± 8.20	38.5 ± 7.86	0.0005

RLAS = Rancho Los Amigos Scale, FIM = Functional Independent Measure.

Discussion

This study utilized physiological, cognitive and behavioural measures to assess the effect of Snoezelen therapy in a group of 15 children recovering from severe brain injury. The demographic data from this study is comparable with other reviews of severe brain injury. It was also able to replicate other studies that have exhibited positive effects of Snoezelen from the pre-treatment to the immediate post-treatment phase using other patient populations. The subjects in this study were also receiving a daily comprehensive neurorehabilitation programme on a paediatric inpatient rehabilitation unit. The subjects level of participation depended on age, injury severity and attention and fatigue levels.

The results of this study showed a significant decrease in HR which occurred during each treatment session for each subject. No statistically significant change on the level of agitation was seen within sessions; however, an improvement in a positive direction on the behaviour and agitation level of the subjects was noted. Snoezelen therapy was expected to decrease the level of agitation and heart rate due to the relaxation effect. This may indicate that the Snoezelen treatment does not only evoke a relaxation response; in addition, it seems to have a regulatory effect on the children's heart rate and on their behaviour in this study group. In analysing the changes in muscle tone in true spastic children, it was noted that in all of the children the muscle tone decreased in the affected extremity from pre- to post-treatment settings. Unlike other relaxation methods, it appears that the Snoezelen environment brings about the relaxation process without any conscious effort by the individual and facilitates muscle stretching and range of motion exercises. Whether these changes over time are simply due to natural recovery post-injury or are due in some measure to the Snoezelen environment cannot be determined with the current data.

Changes in functional outcome measure (RLAS, FIM) of the study group were achieved with the incorporation of Snoezelen treatment in the comprehensive neurorehabilitation programme. Therefore, the neurological recovery of the severe TBI subjects in this study may have also been affected by intensive multi-disciplinary therapies, neuropharmalogical medication and spontaneous recovery. In children recovering from brain injury, plasticity must be considered. Impaired plasticity refers to situations in which genetic or acquired disorders disrupt molecular plasticity pathways, for example in genetic and acquired disorders such as TBI that cause cognitive impairment [46]. The Snoezelen environment may be an enriched environment that is beneficial for children with disruption in the signalling cascades that have been shown to mediate learning, memory and other forms of neuronal plasticity in animal models [47, 48].

It has been reported that children who have severe or moderate mental retardation may find their immediate environment chaotic, frightening, confusing and unstimulating [46]. These are similar behaviours of agitation and confusion that children recovering from severe brain injury experience as recovery occurs. In these cases the children may respond to this situation with behavioural disturbances, which could be due to either sensory restriction or sensory overload. In recent years a growing body of knowledge has demonstrated that certain children with learning disabilities and children with severe mental retardation can benefit from sensory input [26, 49, 50].

Shapiro et al. [35] conducted a Snoezelen study using children. This unique study explored physiological variables such as ambulatory heart rate. This study compared Snoezelen with playroom sessions in 20 children between 5–10 years of age. The children, who had moderate or severe mental retardation and stereotypical behaviour, were exposed to both types of sessions using a cross-over design. One half of the subjects started with the Snoezelen sessions, which were then followed by the playroom sessions after 7 days rest. The other half had the opposite sequence. Measures that were used during the session included adaptive and maladaptive behaviours, as well as pre-, within and post-session heart rates. The results indicated that the number and duration of adaptive behaviours were significantly higher, while the number and duration of maladaptive behaviours were lower in the Snoezelen sessions compared to the playroom sessions. Heart rates also showed more observable changes during and after the Snoezelen sessions, suggesting that the Snoezelen sessions had greater impact than the playroom sessions. These are preliminary findings that need to be further explored.

Over the last few years these rooms have been increasingly used worldwide in hospitals, rehabilitation centres, group homes, residential homes, schools, nursing homes, maternity hospitals, pain centres as well as burn units. A recent study from Hong Kong [32] that studied a group with learning disabilities reported nine functions that were promoted in a Snoezelen room including; relaxation; development of self-confidence; sense of self-control; encourage exploration and creative activities; establish rapport with care takers; provide leisure and enjoyment; promote choice; improve attention span and reduce challenging behaviours. The Snoezelen experience seems to 'lower the stress chemistry and increases the relaxation chemistry'. This balance is achieved through the chemical interaction that allows self-regulation, motivation, organization and integration to take place for the individual [51]. A significant key finding may be the appropriate combination of sensory input that allows the individual to take control once a balance has been achieved.

There were specific limitations in the present study. First was the lack of blinding of treating therapists, the data collectors who were also the treating therapists potentially created a bias. Secondly, the age range was 1.2–16.9 years, due to developmental levels age should have been subgrouped (infants, toddlers, etc.). Thirdly, it was difficult to find an objective standardized assessment tool that measured behavioural changes of these severely neurologically impaired children in this multi-sensory environment. Lastly, the treatment duration was dependent on the length of stay in the PRU and the treatment frequency was dependent on interference by medical procedures, such as CTs, MRIs, X-rays, surgeries and other therapies. The present findings support the hypothesis that Snoezelen therapy has a positive effect on physiological, behavioural and cognitive functioning in children recovering from severe brain injury in children; however, this study is the first step to designing more rigorous studies to investigate the beneficial effects of this multi-sensory environment.

Conclusion

This study investigated the effects of Snoezelen therapy on physiological, cognitive and behavioural changes in children recovering from severe brain injury. Although this study revealed an overall beneficial use of Snoezelen therapy with children recovering from severe brain injury, there continues to be a critical need for evidenced-based research for this patient population in this unique multi-sensory environment. Future studies in Snoezelen therapy with this patient population and others should consider utilizing a well developed methodological design in order to assess the main effect of the treatment and of this multi-sensory environment. It is also important to evaluate if the changes are due to the effect of the treatment alone and what is the extent if any of any carry-over effect. In addition, a comparison of the effects found in Snoezelen treatment to other therapeutic environments is essential in order to really measure the effects of Snoezelen therapy.

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