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The effects of sensory integration technique on equilibrium processes in children after prenatal exposure to alcohol

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ABSTRACT

Background: The objective of the study was evaluation of sensory integration therapy effectiveness in children after prenatal exposure to alcohol, on the example of equilibrium processes. **Material and methods:** The study was conducted in 2012 at the Centre of Advanced Physiotherapy in Kielce, and covered a group of 20 children aged 4-5 who had a history of prenatal exposure to alcohol. The children systematically participated in a one-hour SI therapy session, once a week for the period of 6 months. **Results:** While evaluating the equilibrium system, 5 trials with clinical observations were performed according to Ayres: the Schilder test, dynamic and static balance, gravitational uncertainty, and postrotary nystagmus. The high effectiveness of SI therapy was confirmed in children subjected to prenatal alcohol exposure based on the example of the equilibrium system. The positive effects of therapy were proved for all the tests applied: the Schilder test (p<0.001), dynamic balance (p<0.001), static balance (p<0.001), gravitational insecurity (p<0.001), and postrotary nystagmus (p<0.05). **Conclusions:** The sensory integration technique exerts a beneficial effect on the balance functions of children after prenatal exposure to alcohol.

Key words: therapy using SI technique, equilibrium system, prenatal exposure to alcohol

INTRODUCTION

The development of the nervous system requires complicated interaction between biochemical reactions precisely synchronized in time [1]. For this reason, the developing brain is very susceptible to malnutrition, toxic substances and infections which, in later life, may exert a considerably less destructive effect [2]. Dysfunctions of the central nervous system in children after prenatal exposure to alcohol concern mainly disorders in the development of structures, and functions of the basal ganglia, corpus callosum, cerebellum, as well as the hippocampus and thalamus related with them, but primarily, the just developing structures of the cerebral cortex, especially the prefrontal regions [3]. There occur disorders in the neuronal migration process and partial atrophy in many structures of the brain, as well as a clear decrease in the volume of the cerebral cortex, white matter and the total brain volume [4]. Apart from deficits concerning brain structures, disorders of the neurohormonal system occur, mainly the dopaminenergetic system, through a decrease in the level of dopamine, primarily in the structures of the mesencephalon and cortex. Their consequence is primarily a decrease in cognitive processing activities [5]. Apart from many symptoms, sensory integration disorders often occur in these children [6]. Learning the reception of external sensations, as well as those originating from the body, begins even before birth [7]. The foetus receives tactile, motor, proprioceptive, auditory and balance sensations [8]. Tactile sensations are related to contact with the amniotic fluid and the walls of the uterus [9]. As early as at that time, motor, priopriоceptive and balance sensations are closely inter-connected [10]. The child receives them while floating in the amniotic fluid, changing body position, moving hands and legs, kicking and thumb-sucking [11]. The amount of sensory impressions rapidly increases at the moment of birth [12]. The birth itself is an experience for a baby which is rich in many new and needed sensations. In children after prenatal exposure to alcohol, the learning of reception, ordering, and combining sensory impressions takes an abnormal course [13]. Sensory integration disorders may manifest themselves as early as at the age of infancy, sometimes they are observed at the pre-school age, while frequently, they do manifest themselves until school age, depending on how profound the disorders of the sensory system functions are [14]. Due to poor integration of senses, the child may have various types of

problems in daily functioning at home, nursery school, in the yard or at school. The disturbed activity and interaction between senses may be manifested by problems with perception, behaviour, learning, performance of precise actions, reading, writing, motor activity and social functioning [15]. If a child incorrectly receives and processes tactile stimuli, s/he may hate hair-washing, pat or scratch without evident reason, fidgets in a chair, avoids close contact or demands this contact more often than peers. With abnormal proprioceptive sensations, the child may stay in constant motion: running instead of walking, jumping instead of sitting or may assume very abnormal positions [16]. If any abnormalities occur in the vestibular system, the child may be afraid of stairs, dislike swings, seeks assistance when the ground changes, or to the contrary, performs locomotor manoeuvers which make others dizzy and sick by just looking at them [17,18]. Children with abnormalities in sensory integration have many problems with which they cannot cope. The problems with which they struggle are often manifested by disorders in behaviour [19]. A child not able to sit still in a chair, performs lots of unnecessary movements, or to the contrary, is slow, shy and avoids motor skill games with colleagues is frequently perceived as ill-mannered, impolite, rebellious and maladjusted [20]. Such a child has no opportunity to adjust to environmental requirements. It usually happens that the problems concern all three systems of basic senses, and are especially evident in one of them. This is so because the activities of individual senses overlap [16]. Abnormalities in the reception and processing of a specified type of information result in a decrease in the quality of functioning of the remaining senses. Disturbed reception of sensory impressions also causes impairment of praxis [17]. The equilibrium system, as the first fully developed system, begins to function in the sixteen week of foetal life, and its myelization is completed at the moment of birth, which provides a baby the sense of direction and orientation in the uterus. It enables coping with the gravitation problem, which the child experiences for the first time at the moment of birth [18]. All living creatures are connected by the relationship with gravity which provides a sense of centre in space, time, motion, depth or self-awareness [19]. The equilibrium mechanism allows the monitoring of all sensual impressions between the body and the brain [20]. It is like a nucleus, from which everything originates [21]. Problems with the equilibrium system are transferred onto other sensory systems, because all sensations pass via the vestibular system at the level of the brain stem before they are transmitted further to the CNS [22]. Disorders in the functioning of the equilibrium system may be manifested in the form of subtle, sometimes difficult to explain problems with learning, as well as those related with a child's behaviour. The goal of this

study was evaluation of the effectiveness of SI therapy in children after prenatal exposure to alcohol, based on the equilibrium processes.

MATERIAL AND METHODS

The study covered a group of 20 children (14 boys and 6 girls) aged 4-5 with a history of prenatal exposure to alcohol. The majority of children came from adoptive, foster families or orphanages. All children were diagnosed with SI disorders and dysfunctions typical of children with FAS spectrum, including: hyperactivity, pertinacity, passiveness, impulsivity, sleep problems, malice, hypersensitivity to touch and sound, adaptation difficulties, problems with organization, low self-esteem, difficulty with self-control and ease of falling into depressive states. The examination of sensory integration disorders consisted of three 50-minute diagnostic meetings. The diagnosis of SI included: an interview with a parent/caregiver, observation of controlled and spontaneous movements of the child in the therapeutic room, response to the basic sensory stimuli administered, as well as clinical observation. The evaluation included gross and fine motor skills, muscle tone and balance responses of the body The main evaluation areas were gross and fine motor skills, muscle tone, and balance responses of the body. The article comprehensively presents the effect of SI on the equilibrium system. While evaluating the equilibrium system, 5 trials with clinical observations were performed according to Ayres: the Schilder test, dynamic and static balance, gravitational uncertainty and postrotary nystagmus. Each child systematically participated in a one-hour SI therapeutic session once a week for 6 months. The therapeutic programme covered: normalization of the vestibular and prioprioceptive systems, normalization of the tactile system, strengthening of muscle tone, development of motor planning, development of oculomotor performance, development of motor coordination, hand therapy, integration of ATOS, STOS, development of locomotion and balance functions, as well as improvement of gross and fine motor skill efficacy. The study was conducted in 2012 at the Centre of Advanced Physiotherapy in Kielce. Measurement data were collected using a Microsoft MS EXCEL spreadsheet, and after preliminary processing, data were imported to Statistica StatSoft software. Data analysis included anthropometric characteristics (height, body mass, BMI) and tests for SI. Basic statistical parameters were calculated such as: arithmetic mean (x), standard deviation (s), median value (Me), skewness (Sk), and kurtosis (Ku), as well as extreme values and confidence intervals for the level of 95%. The variables were verified from the aspect of normality of distribution using the Shapiro-Wilk test. In addition, Cronbach's Alpha analysis of reliability was performed. In order to reveal

differences between studies prior to and after SI therapy, the Wilcoxon matched pairs test was applied.

RESULTS

The mean age of children in the study was (x=4.45), standard deviation (s=0.51), mean body height (x=1.01), standard deviation (s=0.03), body mass (x=16.35), standard deviation (s=1.34), mean BMI (x=15.73), standard deviation (s=0.52) (Tab. 1).

Table 1. Anthropometric data of children in the study.

Variables	*N*	Mean	Median	Minimum	Maximum	*SD*	Skewness	Kurtosis
Age	20	4.45	4	4	5	0.510	0.218	-2.183
Body height	20	1.0185	1.02	0.94	1.08	0.036	-0.393	-0.228
Body mass	20	16.35	16	14	19	1.348	0.283	-0.771
BMI	20	15.738	15.893	14.704	16.340	0.527	-0.671	-0.666

The mean result in the Schilder test was 0.417 prior to therapy, and 0.717 after SI therapy, the difference 0.300; the mean result in dynamic balance was 0.317 before therapy and 0.950 after SI therapy, the difference 0.633; the mean result in static balance was 0.233 prior to therapy and 0.800 after SI therapy, the difference 0.567; the mean result for gravitational insecurity was 0.600 before therapy and 0.983 after SI therapy, the difference 0.383; the mean result for postrotary nystagmus - 0.100 prior to therapy, and 0.217 after SI therapy, the difference - 0.117; equilibrium system general result - 0.333 before therapy and 0.733 after SI therapy, the difference - 0.400 (Tab. 2).

Table 2. Equilibrium system before and after SI therapy

Equilibrium system prior to SI therapy						
Tests for equilibrium system	*N*	Mean	Median	Minimum	Maximum	*SD*
Schilder test	20	0.417	0.333	0.000	0.667	0.183
Dynamic balance	20	0.317	0.333	0.000	0.333	0.075
Static balance	20	0.233	0.333	0.000	0.333	0.157
Gravitational insecurity	20	0.600	0.667	0.333	1.000	0.205
Postrotary nystagmus	20	0.100	0.000	0.000	0.333	0.157
Equilibrium system general result	20	0.333	0.333	0.067	0.533	110
Equilibrium system after SI therapy						
Tests for equilibrium system	N	Mean	Median	Minimum	Maximum	*SD*	Difference
Schilder test	20	0.717	0.667	0.667	1.000	0.122	0.300
Dynamic balance	20	0.950	1.000	0.667	1.000	0.122	0.633
Static balance	20	0.800	1.000	0.333	1.000	0.313	0.567
Gravitational insecurity	20	0.983	1.000	0.667	1.000	0.075	0.383
Postrotary nystagmus	20	0.217	0.333	0.000	0.333	0.163	0.117
Equilibrium system general result	20	0.733	0.767	0.533	0.867	0.104	0.400
Schilder test	20	0.717	0.667	0.667	1.000	0.122	0.300
Trunk stabilisation	20	0.767	0.667	0.333	1.000	0.244	0.267
Muscle tone - overall result	20	0.851	0.854	0.715	0.938	0.057	0.176

A non-significant result of the Shapiro-Wilk test before therapy evidences that the distribution of the observed variable (equilibrium system) was similar to the normal distribution (p = 0.221). A significant result after therapy confirms that the distribution of the observed variable - the equilibrium system - is not similar to the normal distribution (p = 0.005) (Tab. 3). The high effectiveness of SI therapy was confirmed in children after prenatal exposure to alcohol, based on the equilibrium system. Positive outcomes of SI therapy were obtained for the following tests: the Schilder test (p<0.001) dynamic balance (p<0.001), static balance (p<0.001), gravitational insecurity (p<0.001) and postrotary nystagmus (p<0.05). The Wilcoxon matched pairs equilibrium system test for standardized values showed significant differences in tests prior to and after SI therapy (p=0.00009) (Tab. 3).

Table 3. Wilcoxon matched pairs test for the equilibrium system

Tests for muscle tone	Initial examination		Final examination		Difference	*p*
	N	Mean	*N*	Mean		
Schilder test	20	1.25	20	2.15	0.9	<0.001
Dynamic balance	20	0.95	20	2.85	1.9	<0.001
Static balance	20	0.7	20	2.4	1.7	<0.001
Gravitational uncertainty	20	1.8	20	2.95	1.15	<0.001
Postrotary nystagmus	20	0.3	20	0.65	0.35	<0.05
Wilcoxon test for equilibrium system prior to and after SI therapy (n = 20)						
N		*T*		*Z*		*p*
20		0		3.9199303		0.00009

DISCUSSION

The report by the Birth Defects Monitoring Program conducted by the Center for Disease Control (CDC), based on data from 1,500 hospitals, showed that the incidence of FAS cases in the American population is 0.3-0.9 per 10,000 births [23]. In turn, Abel and Sokol, after reviewing 19 epidemiological reports from the whole world, estimated the incidence of FAS at 1.9 per 1,000 live births. According to the CDC reports, the rates of occurrence of FAS per 10,000 births differ according to the ethnic origin of their mothers. The incidence of FAS worldwide is estimated at 3-9 per 1,000 live births [24]. Knuiman, Rijk, Hoksbergen et al. [25] examined a group of children adopted from Poland by Dutch parents. The study included 121 children aged 6-17. Three groups were distinguished: children with the diagnosis of FAS (31%), children whose adoptive parents suspected FAS (21%), and children whose adoptive parents did not suspect FASD (49%). In children with the diagnosis of FAS, the most frequently observed problems were: body height insufficiency, education in special schools and difficulties with social functioning. However, the features of FAS were also observed in the other two groups. Children adopted from Poland showed a high risk of FAS. The researchers presumed that the Dutch adoptive parents must have realized the potential consequences of prenatal exposure to alcohol in the children adopted from Poland [26]. It is estimated that in Poland, there are 900 cases of fully symptomatic FAS in infants annually, whereas in 9,000 children, the occurrence of some of its symptoms is observed [26]. The study conducted at the Institute of Mother and Child in Warsaw, consisting in the examination of urine samples from pregnant women who declared abstinence. This tested the presence of

markers of alcohol consumption (beta-hexosaminidase and gamma-glutamyltranspeptidase) and showed that every third woman consumed alcohol while knowing that she was pregnant. Alcohol was most frequently consumed by women with secondary school education, while most rarely by those with primary school education. The highest consumption of alcohol was observed among women from small and medium-size towns, whereas the lowest – among those from large cities and rural areas. In 2005, the IBSOS International Research Group Laboratory, by order of the Childbirth with Dignity Foundation, conducted a survey in a representative group of 1,000 Poles aged 15 and older [27]. One-third of the women (33.5%) who had given birth to one or more child admitted that they had consumed small amounts of alcohol during pregnancy. Although 83% of respondents had heard that even the smallest amount of alcohol may be dangerous, one-third of them (31.7%) mentioned that a small amount of alcohol may exert a positive effect on the mother and child. The prepared expertise based on an all-Polish survey in 2009 showed that 29% of women consuming alcohol within the previous year were pregnant [28]. The effect of ethyl alcohol on the foetus still remains a poorly described and recognized problem. In children whose mothers consumed alcohol, problems with functioning difficult to diagnose and classify are observed, as well as sensory integration disorders. For these children, effective SI therapy is necessary. The objective of my other studies was analysis of the effect of SI therapy on gross motor functions in children after prenatal exposure to alcohol. Positive effects of SI therapy were observed for the following tests: finger to nose, in prone extension position, in supine flexed position, ATOS, STOS, the Schilder test, dynamic balance, static balance, gravitational insecurity and trunk stabilisation. The effectiveness of SI therapy was not confirmed only in the tests for cocontraction and muscle tone [29]. In my other studies, the effect of SI was analyzed on fine motor functions in children after prenatal exposure to alcohol. A high effectiveness of SI therapy was confirmed in children after prenatal exposure to alcohol based on fine motor functions ($p<0.001$). Positive effects of SI therapy were proved for the following tests: quick rotation of the forearms ($p<0.001$), eye movements ($p<0.001$), fingers to thumb and in prone extension position ($p<0.001$). Also, the effect of SI therapy on muscle tone was investigated in children with Foetal Alcohol Syndrome. A high effectiveness of SI therapy was confirmed in children after prenatal exposure to alcohol on an example of muscle tone ($p<0.001$). Positive outcomes of SI therapy were proven for the following tests: in prone extension position ($p<0.001$), in supine flexed position ($p<0.05$), ATOS ($p<0,001$), STOS ($p<0.001$), the Schilder test ($p<0.001$) and trunk stabilization ($p<0.001$) [30]. Similar results of therapy were obtained in studies among children with developmental deficit from Kielce. The study

covered a group of 153 children admitted for therapy in the third year of life. The objective of the study was analysis of the effects of sense integration : mainly proprioception, vestibular system on vocabulary development. The presented results of the performed diagnoses of the sensor integration processes indicate that the most impaired areas are related with static and dynamic balance, as well as post-rotatory nystagmus. They also indicate considerable disorders in development of the vestibular system An early diagnosis of sensory integration disorders in the population examined will, to a great extent, prevent more serious problems in the development of children. Disorders in the processes of sensory integration hinder normal development of speech and language. The greatest deficits in the sphere of vocabulary development were noted in the area of creating sub-words, and defining concepts in combination with dynamic and static balance disorders. A relationship was also observed between vestibular system disorders and acquisition of skills with respect to vocabulary [31].

CONCLUSIONS

A high effectiveness of SI therapy was confirmed in children after prenatal exposure to alcohol on an example of the equilibrium system. The positive effects of SI therapy were confirmed for all the applied tests: the Schilder test, dynamic balance, static balance, gravitational insecurity and post-rotatory nystagmus. The method of sensory integration exerts a positive effect on the balance functions in children after prenatal exposure to alcohol.

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