MODERN TECHNOLOGY IN AUTISM EDUCATION

Białystok, 2018
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INTRODUCTION

The term “Autism” is derived from Greek language meaning self. In 1911 Eugen Bleuler first used the term autism to describe symptoms of schizophrenia. In 1943 Leo Kanner of Johns Hopkins Hospital began using the term autism as we know it today [1].

Before 2013, the American Psychiatric Association’s Diagnostic and Statistical Manual defined five disorders such as: autistic disorder, Asperger’s syndrome, PDD – NOS, Rett syndrome, and childhood disintegrative disorder [5]. After May 2013, the APA recognised ASD as a collective with two distinct categories: impaired social communication and/or interaction; restricted and/or repetitive behaviours.

Autism is a developmental disability that usually shows up before age 3. It is part of a group of neurological disorders that may involve impaired communication, social interaction and cognitive skills [2-4]. Autism Spectrum Disorders (ASD) may include: extreme resistance to changes in daily routines, repetitive activities, inability to interact with environment, and unusual responses to things such as touch. Children with ASD may also have major problems with both speech and nonverbal communication [1,4].

The proliferation of modern technology changed how service providers deliver educational and behavioral services to individuals with ASD.
CHAPTER 1

Modern technology in gait assessment of children with Autism Spectrum Disorders

Children with diagnosed autism are accompanied by numerous movement stereotypes that are different from the typical patterns [8]. Changes in children’s movement patterns with the autism spectrum disorders (ASD) have already been noticed in 1943 by Kanner, who stated that people with ASD often show "clumsy" gait [9]. Ghaziuddin and Butler found that children with ASD show worse motor coordination than people with Asperger syndrome [10]. Subsequent work confirmed [11,12] that gait disturbances are common in children with ASD.

In adults, the first study on kinematic and kinetic gait patterns in ASD was performed by Hallett et al. [13]. In the study it has been found that adults with ASD show "mild clumsiness" during gait, and the only significant abnormality is the reduced range of ankle movement.

The purpose of this chapter is to review diagnostic devices that can be used to assess individuals with ASD movement disorders. Identification of these disorders may contribute to earlier diagnosis and better treatment planning.
1.1. Force platforms

The following devices are used for the measurement and analysis of human gait: mechanical, electrical, electro-mechanical, electronic, photographic, photomechanical, photoelectric, magnetic, optoelectronic. They allow the measurement of ground reaction forces, relative angles between lower limb segments, muscle electrical activity, duration of support phase and swing phase, gait speed, etc. Force platforms (Figs. 1-2) are modern devices used to record ground reaction forces [14].

![Force Platform Image](image1)

**Fig. 1. Force platform**

Force platforms are classified as single-pedestal or multi-pedestal and by the transducer (force and moment transducer) type: strain gauge, piezoelectric sensors, capacitance gauge, piezoresistive, etc., each with its advantages and drawbacks.

![GRF Components Image](image2)

**Fig. 2. GRF components [21]**

The GRFs are quantified by three vectors in the vertical (Fz), anterior-posterior (Fx) and medial-lateral (Fy) planes. The forces are normalized to the body mass, N/kg.

A novelty in the field of human gait analysis are pressure sensor mats that allow to measure of several steps simultaneously (Figs. 3-4).
Pressure sensor mats are built from a large number of piezoelectric or tensometric sensors. Sample size of the mat is between 40 cm x 40 cm and 300 cm x 50 cm.

The result obtained from the pressure sensor mat presents the distribution of pressures under the foot.

Treadmill is a device that can be used to assess and train children’s gait and posture (Figs.5-6).

Treadmills consist of a matrix of sensors (from 3000 to more than 11 000 sensors).
The treadmill allows to measure the distribution of foot pressure. It is possible to evaluate: speed, length, width and step symmetry.

Fig.6. The results obtained from a treadmill [37]

1.2. Pedobarography systems for plantar pressure measurements

The pedobarography system provides an accurate and reliable data for insights into foot function, gait, balance, pressure offloading and musculoskeletal injury assessments [49] (Figs.7–9).

Foot pressure data are recorded using a pedobarography system with 1 to 3 steps, based on shoe insoles with capacitive sensors (max. 240 SSR sensors per insole, depending on the size and shape).

Fig.7. Pedobarography system T&T medilogic Medizintechnik, GmbH Munich, Germany

To quantify plantar pressure distribution, the maximum magnitude of plantar pressure (peak pressure) under seven anatomical masks such as: Toes (mask 1), Head of 2-5th Metatarsal (mask 2), Head of 1st Metatarsal (mask 3), Lateral Arch (mask 4), Medial Arch (mask 5); Lateral Heel (mask 6); and Medial Heel (mask 7) is measured.

Fig.8. Anatomical masks of the foot
1.3. Motion Capture systems

In many clinical settings, motion capture systems and computerized gait analysis (Figs.10-12) have become an integral part of the clinical decision-making process in human gait classification, and gait abnormalities treatment. Instrumented gait analysis is a tool that provides quantitative data on subjects' gait.

The motion capture system consists of an unlimited number of cameras and force platforms placed along the measuring path.

Instrumented gait analysis is a tool that provides quantitative data on subjects' gait. It uses reflective markers which are placed on known anatomical landmarks. As the subject walks, cameras placed around the lab record the light reflected from the markers.
The results interpretation utilizes relationships between magnitude, timing and pattern differences in the gait, clinical data (relative to typical) and the potential reasons for those differences.

Fig.12. Report from motion capture system
CHAPTER 2

Gait analysis of children with Autism Spectrum Disorders using modern diagnostic technology

The evaluation was carried out on 22 children with Autism Spectrum Disorders (63.5% of girls) and 30 age-matched children as a control group aged between 6-15 years old. None of the participants in the control group had a known developmental or other health problem that would interfere with their performance. The exclusion criteria were: Rett syndrome, Asperger syndrome and disintegrative disorders of childhood. Autism has been also evaluated based on IQ measurement test. Criteria for autism were as follow: IQ>80. The children participated in the study with their parents consent according to the declaration of Helsinki and the approval of the Ethical Committee.

2.1. Kinematics analysis of children with Autism Spectrum Disorders

For measuring gait parameters an optoelectronic system with six cameras, sampling at 60 Hz (SMART, BTS, Italy), and two Kistler (Kistler, model 9286AA-A, Kistler Instruments, Switzerland) platforms were used. The markers were positioned according to the Davis protocol. Recordings of the typical children and the
children with autism were performed in different sessions in a quiet laboratory room (15 m long, 6 m wide) under the same conditions regarding the light, temperature, technician, and therapist. Prior to data collection, several ‘warm-up’ trials were conducted to allow the participants to adjust to the markers and the lab environment. The typical participants walked at a comfortable gait speed in three trials. As a result of the specific problems associated with autistic children due to their difficulty in understanding verbal instructions, we decided to reinforce the verbal instruction with children’s walking inside the laboratory in the direction of attractive toy (teddy bear, doll) placed at the end of the path. The number of trials used for analysis varied among the children with autism from three to six. For each subject three successfully completed trials were considered for the analysis. The spatial-temporal gait parameters included walking velocity (m/sec), the stance duration (sec), stride length (m), step length (m), stance phase duration (%), cadence (steps/min.), and double support (%). Joint angles were computed from the relative orientations of the embedded coordinate systems using Euler angles, corresponding to flexion/extension, adduction/abduction, and internal/external rotation. Displacement data was filtered with a low-pass Butterworth filter prior to differentiation. The comparison of gait parameters in children with autism to typical developing are presented in Tab.1.

Table 1: Comparison of gait parameters in children with autism to typical developing

<table>
<thead>
<tr>
<th>Gait parameters</th>
<th>Control group Mean (SD)</th>
<th>Autism group Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum hip flexion (deg) in stance</td>
<td>35.2 (4.9)</td>
<td>41.0 (5.9)</td>
</tr>
<tr>
<td>Sagittal knee range of motion (deg)</td>
<td>60.5 (6.2)</td>
<td>50.3 (5.8)</td>
</tr>
<tr>
<td>Maximum plantarflexion moment (Nm/kg) in stance</td>
<td>1.2 (0.07)</td>
<td>1.0 (0.11)</td>
</tr>
</tbody>
</table>

The results indicate greater maximum hip flexion in stance for children with autism compared with typical children. This parameter is an average of 16.5% higher in children with autism. The results suggest a 16.9% reduction of sagittal knee range of motion autism children compared with the typical children. The maximum plantarflexion moment in stance was also reduced in both experimental groups. The reduction was an average of 16.7% in autism compared with the control group.
2.2. Kinetic analysis of children with Autism Spectrum Disorders

The Ground Reaction Forces were quantified by three vectors in the vertical (Fz), anterior-posterior (Fx) and medial-lateral (Fy) planes. The vertical ground reaction force (Fz) was characterized by Fz1 (maximum force within first 50% of stance phase), Fz2 (maximum within the second 50% of stance phase) and Fz0 (the minimum value between opposite foot off and foot contact). The anterior-posterior ground reaction force (Fx) was characterized by Fx1 (maximum posteriorly directed force), Fx0 (minimum posteriorly directed force), and Fx2 (maximum anteriorly directed force). The medial-lateral force Fy was characterized by Fy1 (maximum lateral force), Fy0 (minimum lateral force), and Fy2 (maximal medial force). The forces and moments were normalized to the body mass [21]. Net joint moments for the hip, knee, and ankle joints were estimated using an inverse dynamics approach. The results show the differences in the vertical ground reaction force (Fz1) between control group and children with autism (p<0.05). No significant differences were observed for the anterior-posterior ground reaction (Fx) and the mediolateral force (Fy), p>0.05.

For measurement of plantar pressure distribution, subjects were instructed to walk a distance of approximately 50 meters at their habitual speed inside of a gait laboratory. Children were measured while wearing acceptable athletic shoes, which had almost the same shoe characteristics across participants. The data during walking were measured with a pedobraograph (T&T medilogic Medizintechnik, GmbH Munich, Germany) based on shoe insoles with capacitive sensors (max. 240 SSR sensors per insole, depending on size and shape). The sample frequency was 60 Hz. Trial replications were done three times for left and right foot separately. To quantify plantar pressure distribution, the maximum magnitude of plantar pressure (peak pressure) under five anatomical masks such as: toes (mask 1), metatarsal heads (mask 2), lateral arch (mask 3), medial arch (mask 4); heel (mask 5) was measured using a commercially available toolbox. Each participant was asked to wear pedobarographic pressure insoles in their shoes for 3 minutes to allow insole
Acclimatization and potentially enhance the reliability of the measurement. No between-lower limbs difference was observed for pressure distribution ($p > 0.05$). Thus, further assessment was performed for both sides. Table 2 summarizes the mean (SD) magnitude of plantar pressure distribution extracted from pedobarograph insoles during walking for typical group and children with autism.

### Table 2: Plantar pressure [N/cm²] comparison between Autism and control subjects

<table>
<thead>
<tr>
<th>Masks</th>
<th>Typical group Mean (SD)</th>
<th>Autism group Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toes</td>
<td>2.6 (1.2)</td>
<td>2.2 (1.3)</td>
</tr>
<tr>
<td>Metatarsal Heads</td>
<td>1.5 (0.8)</td>
<td>0.7 (0.2)*</td>
</tr>
<tr>
<td>Lateral arch</td>
<td>2.8 (1.1)</td>
<td>1.8 (0.8) *</td>
</tr>
<tr>
<td>Medial arch</td>
<td>2.7 (1.4)</td>
<td>1.7 (0.6) *</td>
</tr>
<tr>
<td>Heel</td>
<td>4.1 (1.3)</td>
<td>2.4 (1.1) *</td>
</tr>
</tbody>
</table>

*p < 0.05

The analysis shows significant differences between typical and children with autism in the magnitude of pressure distribution under the metatarsal heads (mask 2), the lateral arch (mask 3), the medial arch (mask 4) and the heel (mask 5), ($p < 0.05$).
CHAPTER 3

FM method for children with Autism Spectrum Disorders

FM is the abbreviation for Frequency Modulation. Frequency Modulation is a wireless transmission method used to transmit the sound. FM System is the generic name or term that has been given to Radio Aids.

3.1. FM method

A personal FM system uses radio waves to send speech and other signals to hearing aids. FM is the same type of signal as your FM radio, only it’s tuned to a frequency band designated for personal use. They allow sound to be captured up closer to a speaker, sound source or connected directly to the sound source and transmitted to the individual providing greater clarity of speech/sound and a reduction in background noise. The main advantage for Hearing Aid wearers is that FM transmission is resilient to noise and interference helping to preserve the quality and clarity of the sound transmitted (Fig.13).
There are many benefits of FM systems. People with hearing loss often struggle with clearly understanding speech in loud environments, even though their hearing aids are working overtime to pick out the speech signal in the presence of the background noise.

1) **Reduced background noise.** People with hearing loss, and even those without, often have trouble hearing in the situations with loud background noises. FM systems reduce this noise and only amplify the voice of the speaker you are trying to hear.

2) **Improved clarity.** By receiving the signal of interest directly to ears or hearing aids, the sounds are much clearer than sounds disturbed by loud environment. It’s like having the conversation partner speaking directly into your ear.

3) **Hearing from a distance.** If someone enjoying going to lectures or speeches, FM systems can be a great way to ensure hearing every word that speaker saying.

4) **Reduced fatigue.** Just like any part of the body, if you are trying too hard to hear, you will suffer from mental fatigue. FM systems amplify speech signals in challenging environments, so that the user has the nessesary energy to do the activities he wants to do.

5) **FM systems works in public settings.** Many large auditoriums have the capabilities to provide excellent sound quality without interference. FM technology in a theatre mode allows to use the hearing aid with an FM receiver, and the signal goes straight through to the device so the sound is clear. For those who don’t wear hearing aids, FM systems are paired with traditional headsets available to wear during the show.
A traditional FM System comprises of two main parts – a radio transmitter and radio receiver (Fig.14). The transmitter captures sound via a microphone or direct connection to a sound source and transmits it to the receiver. The receiver may be integrated into a pair of hearing aids or a set of headphones.
Microphones for FM systems

The speaker (like a teacher, friend or family member) wears the microphone portion of the FM system. A microphone encodes voice into a frequency-modulated signal. There are several types of microphones that may be used:

- **Lapel microphone** (Fig.15A): The most common type of microphone, a lapel microphone hangs around a person’s neck like a lanyard or it’s clipped to a person’s shirt at chest level. It should be within about 15 cm from the speaker’s mouth to pick up the strongest speech signal possible.
- **Boom microphone** (Fig.15B): This microphone hangs off the ear so the microphone is positioned about 8 cm away from the face. A boom microphone is the sort of style.
- **Table-top microphone** (Fig.15C): As you might expect, table-top microphones are placed in the centre of a table in order to pick up all the voices at the table instead of a single voice. These are suited for conference rooms or quiet restaurants.
- **Pen microphone** (Fig.15D): Pen is a handy microphone for various listening situations. Thanks to its portable design, it can be conveniently used where additional support is needed over distance and in noise. It can also transmit the sound of multimedia devices e.g. TV and has wideband Bluetooth for cellphone calls [15].
Fig. 15. Microphones for FM system: A- Lapel, B- Boom, C - Table-top, D – Pen.

Receivers for FM systems

Commonly, the person with hearing loss wears the receiver portion of an FM system. The receiver picks up the low-power radio signals transmitted by the microphone. The range of personal FM transmission is around 15 meters. Receivers have different physical outlines, functions and methods of working with hearing aids or cochlear implants. One functional difference is that some receivers have an inbuilt microphone which depending on the situation can be used without the transmitter. Like microphones, there are several different receiver types (Fig.16):

- **Ear level receivers** (Fig.16A): Often referred to as a "hearing aid boot," these receivers attach directly to BTE (Behind-The-Ear) hearing aids or cochlear implants. This is the most integrated solution for individuals who wear hearing aids. Children with hearing loss wear these receivers in school.

- **Neck loop receiver** (Fig.16B): This type of receiver, also called an induction loop, is worn around the neck and transmits the signal to the hearing aids via electromagnetic energy. This receiver requires the use of telecoil in the hearing aids.

- **Body-worn receiver** (Fig.16C): Body-worn receivers can be slipped into a pocket or clipped to a waistband. Although bulkier, they are portable. Paired with traditional headphones, they are a perfect solution for someone who does not


wear hearing aids, or is temporarily without hearing aids during a repair. Physicians often use this type of receiver to talk with elderly patients who have hearing loss but don’t wear hearing aids. Teachers use it to talk to children with concentration disturbances.

![Receivers for FM system: A- Ear level, B- Neck loop, C- body-worn.](image)

**FM systems for children**

Children who are experiencing hearing loss may struggle with being able to hear properly in the classroom. This can hinder their education and cause them to lag behind because they cannot understand what the teacher is telling them. Some classrooms use a sound-field amplification system so that all children may benefit from an amplification of the teacher’s voice. A sound-field amplification system uses a microphone to amplify the speaker's voice through a loudspeaker system that is positioned strategically in the classroom. This way all students can benefit from the amplification, and those with hearing loss are freed from the burden of wearing a special receiver. An FM system is especially important for children with hearing loss as they attend school. It ensures that these children receive consistent speech signals even when they aren't looking at the teacher or when the teacher is moving
around. A microphone can also be passed around to other students as they participate in a lesson so that the child with hearing loss has an opportunity to hear those comments and questions as well. An FM system at home gives children with hearing loss a better opportunity to interact during daily activities with their families and better enjoy daily activities.

Even kids with normal hearing sometimes struggle to focus in noisy situations. By sending a teacher’s voice directly into the ear, wireless FM systems can help children with Unilateral Hearing Loss (UHL), Auditory Processing Disorder (APD) and Autism Spectrum Disorder (ASD). School-aged children with ASD could hear the teacher’s words better, communicate with their fellow students better and were generally more engaged in the classroom activities [15, 16]. Testing has found that children who wore FM system improved their speech understanding by an average of 53% compared to children who didn’t wear the technology [15, 16].

3.2. Research and evaluation of the effectiveness of the FM method

Only a few researches are published about the benefits of using FM system for children with ASD [19]. ASD can have a major impact on children’s lives, affecting their development especially interfering with their ability to communicate and interact with others. This not only impacts their home life, but can be particularly challenging when it comes to their success in school. Studies have found that children with ASD particularly struggle in noisy environments like classrooms. They are often unresponsive, and they struggle to pay attention to auditory stimuli such as the teacher’s voice (the most significant predictor of educational performance). Luckily, there is a solution to help bridge this concentration gap. A technological approach that scientific studies have proven that it can help children with ASD to concentrate better on the speaker’s words. There are no drugs involved. It’s not a form of therapy; rather it’s simply technology that makes it easier for child to focus on what’s being said. Phonak Field Study News announced that their testing showed that children who wore FM system improved their speech understanding by an average of 53% compared to children who didn’t wear the technology [15, 16].

ASD has a major impact on the development of children’s communication skills. Luckily, there is a management strategy proven to help. The easy-to-use Roger™ Focus (FM system by Phonak [26, 27]) cuts out distracting noise and can enhance children’s auditory function in the classroom, at home and in social situations [17]:

**17% better speech perception and speech recognition [6];
Enhance children’s attentiveness, understanding and behaviour [6];
Improve children’s ability to listen and concentrate [7].**

Many children with ASD find it particularly difficult to listen effectively in noisy environments like classrooms [6].
This can make paying attention to their teacher’s voices very challenging. It is important that we identify and manage listening challenges in school-aged children given that the ability to process speech and maintain concentration are two of the most significant predictors of academic performance [28].

In 2013, the journal Journal of Communication Disorders published a study about use of FM system for children with ASD and children with hyperactivity (ADHD) [26]. The purpose of this study was to find out the potential use of the FM system for children with the above-mentioned disorders.

The study involved 11 subjects aged 9-12 years old. 7 subjects were children with ASD and 4 - hyperactivity disorder children. There were no children with hearing impairment among the subjects. All children were analyzed by 5 different methods:

1. Set speech recognition in noisy environment;
2. Behavioural observation in class;
3. Teacher’s Questionnaire. Responses related to training;
4. Teacher’s Questionnaire. Answers to the child’s ability to hear;
5. Questionnaire filled by the teacher and parents.

The FM system significantly improved speech recognition (Tab.3) in noisy environment among children diagnosed with ASD and/or ADHD when compared to a no-FM system condition. Typically, functioning children had significantly better no-FM performance than the children with ASD and ADHD; however, use of the FM system provided improvements in speech recognition to the level of performance of the typically functioning peers. Two independent observers recorded a significant increase in on-task behaviours when the FM system was used by the children with ASD and ADHD in two separate trial periods, and off-task behaviours relating to inattention and distractibility significantly decreased when the FM system was used. Informal questionnaires given to the teachers and the participants yielded positive reports about the FM system and validated the FM benefit found in the speech recognition measures, observations, and formal teacher questionnaires.
Table 3: Speech recognition testing results [26]

<table>
<thead>
<tr>
<th>Group</th>
<th>Participant</th>
<th>No-FM 1</th>
<th>FM 1</th>
<th>No-FM 2</th>
<th>FM 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASD</td>
<td>1</td>
<td>-7,0</td>
<td>-11,0</td>
<td>-5,0</td>
<td>-10,5</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0,0</td>
<td>-10,5</td>
<td>-3,0</td>
<td>-10,5</td>
</tr>
<tr>
<td></td>
<td>3</td>
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<td>-13,0</td>
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<tr>
<td></td>
<td>4</td>
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<tr>
<td></td>
<td>5</td>
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<tr>
<td></td>
<td>6</td>
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<td>13,0</td>
<td>-4,0</td>
<td>-13,0</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>-4,0</td>
<td>-8,5</td>
<td>0,5</td>
<td>-7,5</td>
</tr>
<tr>
<td></td>
<td>Mean ±SD</td>
<td>-4,6±3,2</td>
<td>-10,7±2,3</td>
<td>-3,5±2,7</td>
<td>-11,3±2,2</td>
</tr>
<tr>
<td>ADHD</td>
<td>8</td>
<td>-8,0</td>
<td>-13,0</td>
<td>-3,5</td>
<td>-9,5</td>
</tr>
<tr>
<td></td>
<td>9</td>
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<td>10</td>
<td>-6,5</td>
<td>-12,0</td>
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<td></td>
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<td>-6,0</td>
<td>-4,5</td>
<td>-9,5</td>
</tr>
<tr>
<td></td>
<td>Mean ±SD</td>
<td>-6,5 ±1,2</td>
<td>-9,9±3,2</td>
<td>-5,3±2,9</td>
<td>-10,9±1,6</td>
</tr>
</tbody>
</table>

Overall, the two FM system trials yielded positive results for most of the children with ASD and ADHD, and as a result, future research is warranted to examine potential benefits of FM system use for children with ASD and ADHD in other school environments. Although much of this initial investigation focused on average improvements in speech recognition, classroom behaviour, and teacher ratings, determining the need for an FM system for a child with ASD and ADHD should be done on an individualized basis [26].

Another study, 2014 published in the journal The Journal of Pediatrics, also shows good results (Fig.17). 20 children (8-15 years old) participated in this study, and the aim was to assess whether the FM system can increase the ability of children to hear [6].
Auditory temporal processing and spatial listening ability were poorer in subjects with ASD than in matched controls, spatial and performance on both of these basic processing measures was correlated with speech perception ability. The provision of FM listening systems resulted in improved discrimination of speech in noise. Furthermore, both participant and teacher questionnaire data revealed device-related benefits across a range of evaluation categories including Effect of Background Noise and Ease of Communication. Eight of the ten participants who undertook the 6-week device trial remained consistent FM users at study completion. Sustained use of FM listening devices can enhance speech perception in noise, aid social interaction, and improve educational outcomes in children with ASD [6].
CHAPTER 4

Review of modern technology in the therapy of children with Autism Spectrum Disorders

Sensory processing disorder is a condition in which the brain has trouble receiving and responding to information that comes in through the senses [1-3].

Occupational therapists may recommend a weighted vest, a caps or blanket, etc. to help with hyperactivity, focus, and/or self-stimulatory behaviors [4].

4.1. Weighted vests

A weighted vest is a garment that is worn over clothing, with some additional weight either sewn into pockets or embedded in the fabric lining. Figs.18-24 show different models of weighted vests.
Weighted vests are produced in the following sizes:
- small (body height 110 - 125 cm, waist circumference 50 cm);
- medium (body height 125 - 140 cm, waist circumference 60 cm);
- large (body height 140 - 155 cm, waist circumference 70 cm) [29].

Fig.18. Weighted vest [29]

Weighted vests should be recommended by occupational therapists [30]. Child’s weighted vest should weighs around 5-10% of their body weight. If the child wears the weighted vest for the 20-40 minute activity, it should be remove for the same time period to allow the nervous system to reset.

It is produced in the following sizes:
- small (body height 110 - 125 cm); standard load - 2.1 kg (12 bags);
- medium (body height 125 - 140 cm); standard load - 2.8 kg (16 bags);
- large (body height 140 - 155 cm); standard load - 3.6 kg (20 bags).

A single pouch weighs 180 g [29].

Fig.19. Special weighted vest [29]

The weight of the vest is 1.5 kg. Maximum weight 3 kg with 12 bags [32].

Fig.20. Weighted vest [32]
This lightweight air-filled vest features a hand-held pump to control the level of compression [32, 33].

It simulates the feeling of a hug with laterally applied air pressure to calm, comfort and soothe the nerves of anyone who is stressed or anxious [34].

The Big Hug allows the caregiver to simultaneously apply different amounts of soft, wrap-around pressure to five separate areas of the body. The caregiver or user is then able to release the Big Hug’s wraps after the desired amount of individualized sensory needs are obtained [35].
TheraSuit improve and change proprioception (pressure from the joints, ligaments, muscles), reduce patient's pathological reflexes, restore physiological muscle synergies (proper patterns of movement) and load the entire body with weight [36].

Weighted blanket

Weighted blanket (Fig.25) are heavier than the typical blankets. They typically weigh anywhere from 4 to 30 pounds. For many people who have disorders such as anxiety, insomnia, or autism, weighted blankets may provide a safe alternative to medication or other types of treatment. They can also be used to complement existing therapies [31].
The Benefits of weighted blankets for Autism:
- improve sleep
- improve transition times
- sensory input
- improve classroom performance [31].

**Weighted Cap**

The unique design features non-removable weights sewn into the cap’s entire rim, providing comfortable and calming weight around your entire head.

![Weighted Cap](image)

The weighted cap provides calming weight around the head to support focus and concentration. Supports kids and adults with ADHD, sensory integration disorder or autism [29].

*Fig.26. Weighted Cap [29]*

**Weighted collars**

Weighted collar is a daytime product which helps reduce tension. Provides even, stable pressure to the shoulder area. Applies pressure to muscles and gives the user a pleasant feeling of being embraced [29].
**Sensory toys**

Sensory toys provide the particular sensory input that many children with autism crave. The toys have the power to capture kids' attention, making the right sensory toy a powerful reinforcer in applied behavioral analysis programs.
Ankle or wrist weights

The weights strength the muscles of the upper or lower limbs (Fig.29). They are equipped with Velcro, which allows them to adapt to the users needs [29].
Air Compressor

The Air Compressor was constructed at Bialystok University of Technology (Poland). It allows the caregiver to simultaneously apply different amounts of soft, wrap-around pressure to seven separate areas of the body. The caregiver or user is then able to release the Air Compressor wraps after the desired amount of individualized sensory needs are obtained [22].

Fig.31. Air compressor for deep pressure therapy [22]

The compressor is proposed in different configurations (Fig.32).
Fig. 32. Air compressor’s configuration [22]
4.2. Sensory tunnels

These sensory tunnels help child develop body awareness and motor planning as they stretch and crawl their way through from one end to the other. The crawling provides loads of sensory input.

Fig. 33. Sensory barrel [38]

Fig. 34. Soft tunnel [38]

Tunnels are longer than barrels and their dimensions exceed 2 meters. They are made from polyester, foam, expanded polystyrene, etc. [38].
The new SENSO tunnel for children with autism spectrum disorders (Fig.36) was developed at Białystok University of Technology (Poland). SENSO tunnel properties:
- light construction;
- covered with a dirt-resistant material;
- soft-touch case;
- high resistance to destruction;
- fixed entrance and exit doors to / from the tunnel;
- hidden electrical and electronic installations;
- equipped with a light system;
- equipped with a sound system;
- equipped with ventilation;
- equipped with a set of textures;
- equipped with objects and special effects;
- controlled from the tablet.

An application has been developed for the tunnel that provides:
- the ability to control lighting;
- the ability to control sound;
- the possibility of implementing therapeutic programs;
- interface for communication with a computer.
Fig. 36. SENSO tunnel

Fig. 37. Interior of the SENSO tunnel.
CHAPTER 5
The role of tablets and robots in education of children with Autism Spectrum Disorders

In the present world, many needs can be met with technological devices. Thanks to digitization, most things are easily available. Tablets are playing an increasingly important role in the education of children and adolescents. They are perceived as electronic tools used in education. During the therapy of autism or education, the use of a tablet is often the only means of communication [30].

5.1. Applications for tablets

Currently, there are many tablet applications on the Polish and foreign market that allow the user to use games adapted to the needs of autistic children. They allow you to develop skills in the areas of: eating, knowing colors, knowing words and shapes, expressing emotions and much more. These applications are characterized by extremely simple graphic design - clear objects on clear backgrounds.
The applications available for tablets should be mentioned [39]:

- Friendly Plan and Friendly Plan Manager - they allow you to prepare and use the method of activity plans and script methods in working with people with autism;

- Friendly Lines - educational game supporting the development of small motor skills.

- Friendly Words and Friendly Words Manager - support the development of speech understanding.

- Friendly Emotions and Friendly Emotions Manager - a game that allows the development of emotional intelligence of the child.

- Friendly Data (MROZA) - an application dedicated to therapists, automating work related to the collection, management and visualization of therapy results.

In [40] are presented many applications:

1. Training faces (Fig.38) - the user is to identify the type of emotions on their faces.

![Fig.38. Training faces [40]](image)

2. TapSpeak - when you touch a letter or write a word, the system communicates the name of the element (Fig.39).
3. Grace app - allows to communicate using a set of images (Fig.40).

4. FindMe - the user searches for a person in different situations on the screen (Fig.41).
5. Ball.e- the application allows the child to get to know the surroundings by playing with the ball (Fig.42).

Fig.41. FindMe [40]

Fig.42. Ball.e [40]
DrOmnibus - is an application developed by the DrOmnibus company and with the support of the Krakow Hippotherapy Foundation (Fig.43). It consists of several games: "In the countryside (Fig.46)", "Wardrobe", "Magic Words", "Sheeps", "Something does not fit here"[41].

Fig.43. In the countryside [41]

Look At Me is a smartphone app that was developed by Samsung and professionals from the Universities of Seoul and the Yonsei University Department of Psychology. It aims to increase the frequency of contacts between autistic children and those around them. The child has the opportunity to look at faces, to read expression and emotions [42], Fig.44.
A mobile application for communication with autistic people was developed at Białystok University of Technology [23]. It allows to develop child’s skills in the form of a quiz. It consists of the following games: at the doctor’s office; at school; at the swimming pool (Figs.45-46).
Fig. 45. Mobile application dedicated to ASD children [23]
The application includes educational games:
- colors and numbers recognition (Fig.47).

- figures recognition (Fig.48).
5.2. Robots dedicated to children with Autism Spectrum Disorders

Robotics has a potential in education of autistic children. For some children with autism, interacting with other people may be an unpleasant experience. Robots can perform various functions in interaction with child. The study compares selected robots that can be successfully used in the education of autistic children.

**QTrobot**

QTrobot - is a semi-humanoid robot developed by LuxAI at LuxFutureLab in Luxembourg (Fig.49). It is dedicated to children with autism, it enables increasing the child's attention and teaching new social and communication skills. QTrobot is easily programmable.
Robot Buddy

Buddy - is a small robot that improves social skills by playing games, telling stories and doing small exercises with children (Fig.50). Children use it to play games, learn new subjects and practice speech.

BUDDY is 60 cm high. He presents many emotions that he expresses naturally throughout the day based on his interactions with family members. He happily presessis a family member returning home or he is grouchy, if he in not paid enough attention to him, and sometimes without a reason he is in a bad mood [45].
Robot Kaspar

Kaspar - is a moving, talking humanoid developed especially for children with Autism Spectrum Disorders (Fig.51). It can be programmed to conduct conversations with children who are discouraged by social interactions. Kaspar was developed at the University of Hertfordshire in England and every aspect of the robot’s appearance was carefully thought out. The robot is intentionally the size of a small child, so it does not scare off the target audience. Kaspar has minimal mimic expression so as not to overwhelm children and allow them to individually receive the behavior of the robot. It is also programmed to improve specific social situations: conducting a conversation or meeting a new person [46].

![Fig.51. Robot Kaspar [46]](image)

KASPAR looks like a little boy. He has the ability to move his arms and legs, head, blinks his eyes, reacts to the touch. KASPAR has 8 degrees of freedom in the head and neck and 6 in the arms and hands. The face is made of silicone material, which is supported by a special aluminum construction. In addition, the robot has video cameras [46].
**Robot Milo Robokind**

Robot Milo Robokind has been specially designed to help students with Autism Spectrum Disorders (ASD) in communication and improving social skills (Fig.52). It allows to:
- practice communication skills;
- visual support using icons;
- expressing emotions;
- strengthening of targeted behaviors;
- social skills training.

He can walk, talk and even model facial expressions [47].

Fig.52. Robot Milo [47]
Robot NAO

NAO - is a humanoid robot that serves to communicate between the child and the people around him. NAO features:
- predictable,
- tireless,
- interactive,
- easy to use,
- helps reduce anxiety of children,
- minimizes the risk of over-stimulation.

Through touch, voice or vision, NAO also offers an extremely wide range of possible interactions (Fig.52) [48].

NAU educational applications are inspired by models (ABA, PECS, TEACCH, DENVER, SCERTS). They can be personalized and adapted to the individual needs of each child. They cover a wide range of skills: interpersonal communication, knowledge of everyday activities, vocabulary lesson, recognition of emotions, etc.
SUMMARY

This study shows the possibilities of using modern technologies in therapy and education of children with the Autism Spectrum Disorders. The progress in new technologies is very dynamic. They can support not only self-control, but also reduce the need for help from loved ones.

Currently, assistive technology can be a standard equipment that is easily accessible, socially accepted and mobile. Technologies can be used in therapy and education, the workplace and recreation. Market analysis proves that there are many options available to support the oral and written communication skills of people with the Autism Spectrum Disorders.

The increasing use of technology by children has a positive impact on both education and communication practices among children. A computer or tablet is now the dominant element in their lives, and many children feel better in interacting with inanimate objects.
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