

Latex Insole with Sensor System for Investigation of Plantar Pressure Distribution in Autistic Individuals

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Abstract—Autism is a behavior syndrome in which developing process of the affected children is changed. One of the biggest challenges to identify the person with Autistic Disorder lays on the wide range of autism spectrum. As autism affects the abilities of each child differently, like the corporal posture and gestures, it is assumed that the way of moving has as a differentiated result of pressure and energy applied in plant foot. Foot alterations produce differences in plantar pressure during walking and present a modified mechanical etiology due to the cinematic and dynamic alterations. Before the exposed, the aim of this study is to analyze the gait of the person with Autism Spectrum Disorder. For this purpose, it is necessary to, i) make a custom insole derived from latex (biomaterial) integrated with electronic sensors; II) detect differences of pressures applied during gait between individuals with and without ASD. Preliminary results point to a slight difference between both groups of children.

Keywords — autism disorder, footprints, instrumentation.

I. INTRODUCTION

Invasive developmental disorders are characterized by severe and pervasive impairment in several areas of development, in which disorders of Autistic Spectrum Disorder (ASD) are included. The autistic disorder is inserted in a spectrum of diseases that can be manifested through various characteristics and different symptoms. This disorder is considered congenital when anomalies are identified until three years old and occur under a rate of four or five children per 10,000 born without syndrom [1, 2].

The etiology of autism remains unknown. There are descriptions of environmental factors, such as viral infections, exposure to chemicals, obstetric complications and genetic factors, whose evidence is familiar recurrence (between 2 to 3% for brotherhood). However, autism is

more likely to be a condition resulting from a multifactorial mechanism, i.e. determined by the association of genetic factors (polygenic) and non-genetic factors [3]. It is prevalent in boys, every four autistic children three are male [4].

As regards the motor behavior, people affected by ASD have demonstrated stereotyped motor mannerisms and marked deficit in motor coordination [5]. These individuals may run into people or collide with someone as if they do not see them. Digitigrade gait, which refers to walk on their toes, is frequent as well as hypotonia, when occurs a reduction in muscular strength. Other neurological signs commonly described are: nystagmus, anomalous body posture, spasticity and primitive reflexes abnormal persistence [6, 7].

In the various studies [8, 9, 10, 11] in which autistic prevalent symptoms are exposed, there is the accentuated injury in the use of multiple nonverbal behaviors such as body posture and gestures, which may indicate damage during the child's walking, possibly applying undue pressure on the sole. However, there is no consensus about whether the associated variables or gait are indicator of the disorder.

Thus, the objective of this study is to analyze the gait of the Autism Spectrum Disorder children. A sequence of comparisons among a sample of children with no problems and a sample of children with autism clinical picture was performed using a custom insole derived from natural latex with pressure sensors placed at certain points of the foot.

II. MATERIALS AND METHODS

This cross-sectional study was carried out with students from 4 to 13 years old. All volunteer group under study was invited to participate and the sample consisted of 5 (five) children, a girl and four boys, of whom 2 (two) are diagnosed with ASD and 3 (three) are non-autistic. Evaluations were carried out on dates and times

previously agreed in a private clinic. At the place, children’s parents accompanied the entire procedure that involved not only the children but their parents and/or responsible for children, researchers and clinical team. The study project was approved by the Ethics Committee of the University of Brasília, UnB. Parents and/or responsible for children signed a Short term approval and patients participated voluntarily.

The research consists of the collection and analysis of plantar pressure in subjects with and without ASD, with the help of sensors that were placed in a custom insole, made of natural latex, because when vulcanized this material becomes inert and biocompatible. The insole presents the property to maintain the same format and chemical composition during its use; it does not cause allergies with skin contact and is minimally invasive. The insoles were constructed from a cast made with alginate and pink plaster with the anatomical shape of the foot of each volunteer. After making the insole, the sensors are engaged in certain points of it and the individual walks freely. The same is based on the use of sensors that are isolated or as a matrix group and allow to measure local pressure.

Fig. 1 shows the locations where sensors were inserted to obtain the pressures, in which 8 sensors were used for each participant. They were distributed at the points where greatest pressure is applied during walking. Points from 1 to 3 belong to the foot heel, 4 and 5 to the middle part of the foot and 6 to 8 to the metatarsus. Such regions, except point 4, were chosen because they bear most of the body weight; therefore according to this layout, sensors distribution allows the identification of plantar pressure in the points of greater strength application [12]. Point 4 enables to identify whether the foot studied is characterized as a flat foot, where the entire foot sole makes contact with the ground.

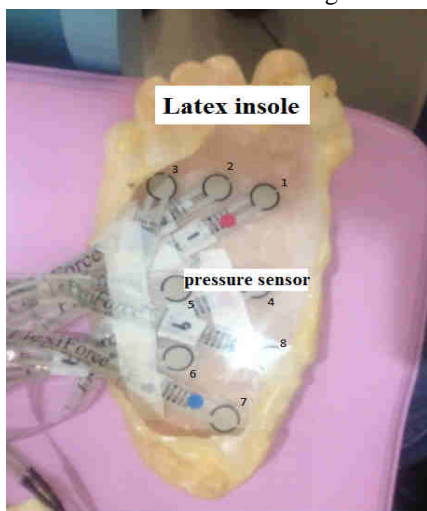


Fig. 1- Latex insole made with pressure sensors.

The absence of sensors on the fingers occurs due to the difficulty of setting them in these places with a reduced area. However, the fingers are of great importance to the recognition of gait stages. The advantages of this measurement are: easy to use and a reduced acquisition cost even for a high sampling frequency due to the small number of sensors used. The collection of signals was made from a specific hardware and software developed by the team. The software is used to display the plantar pressure curve as a function of time on the computer.

III. RESULTS

Table 1 presents average energies normalized by the masses squared of the respective participant. The use of square mass is due to quadratic relationship present in energy of the signs, so the results are both in the numerator and in the denominator quadratic units. Being the measurement unit of the values listed in V² /Kg².

Table 1 - Average energy normalized

Participants					
Sensor Number	Autistic 1 (26 Kg)	Autistic 2 (26 Kg)	Not Autistic 1 (28 Kg)	Not Autistic 2 (60 Kg)	Not Autistic 3 (30 Kg)
1	0,000148	0,000203	0,000135	0,000134	1,11E-13
2	3,35E-05	8,49E-05	0,000253	3,66E-05	4,02E-05
3	0,00019	5,21E-05	0,000146	0,000131	0,000688
4	0,000152	2,90E-06	0,003122	1,15E-05	3,74E-05
5	2,23E-05	4,93E-10	1,28E-13	2,78E-14	1,11E-13
6	0,00048	3,30E-05	8,29E-05	2,65E-05	3,19E-05
7	0,000955	0,000199	0,003534	0,00037	3,27E-05
8	1,48E-05	2,41E-06	0,000236	8,33E-05	0,000121

Table 2 presents the average normalized by the mass of each of the groups studied and in the end the average total energy applied to each of the groups.

Table 2 - Average normalized by groups

Participants		
Sensor Number	Autistic group	Group Not Autistic
1	0,00017553	8,96833E-05
2	5,91975E-05	0,000109863
3	0,000121268	0,000321773
4	7,74314E-05	0,001056932
5	1,11572E-05	8,88127E-14

Participants		
Sensor Number	Autistic group	Group Not Autistic
6	0,000256575	4,71133E-05
7	0,00057663	0,001312077
8	8,58235E-06	0,000146622
Total	0,000160796	0,000385508

From a more detailed analysis of the captured signals it was possible to observe that, for most sensors, children diagnosed with autism showed average energies smaller than non-autistic children, for the conditions under which the acquisition of signals was performed. This suggests that there may be observable differences between gait patterns of autistic and non-autistic children in similar conditions. It is noted that there are reports that autistic children present footsteps that are sometimes more intense and sometimes less intense than non-autistic children, while in the experiment conducted the second case was apparently shown.

The mapping of their occurrence and etiology is extremely important for the development of primary prevention effective programs of posture and harmful diseases to the lower limbs of these individuals.

IV. DISCUSSION

Autism is a behavior syndrome in which developing process of the affected children is changed. One of the biggest challenges to identify the person with Autistic Disorder lays on the wide range of autism spectrum. As autism affects the abilities of each child differently, like the corporal posture and gestures, it is assumed that the way of moving has as a differentiated result of pressure and energy applied in plant foot. Foot alterations produce differences in plantar pressure during walking and present a modified mechanical etiology due to the cinematic and dynamic alterations.

As already evidenced in several studies, the gait of every individual is different and significantly influences the person's quality of life. Thus, it is natural and important worrying about the manner in which the individual steps, since this could bring damage to their health. Even more important is to study children's gait since, at this time, orthopedic corrections are important in order to minimize possible damage to gait, feet, lower limbs and, moreover, all the person's health. In particular, people can over time notice these anomalies in gait, reporting them to professionals due to symptoms such as pain in feet or legs, backache, irregular wear on their shoes, among other symptoms.

However, specific groups show great difficulties to do that, such as children with ASD. Autism is a disorder or syndrome characterized by the presence of the autistic

triad, namely, difficulties in interpersonal relationships, communication difficulties and "imprisonment in their own world". Due to the first two factors of the triad-difficulty in communication and difficulty in interpersonal relationships- is often impossible for the autistic children to properly express what they are feeling, or what is bothering them, which complicates the identification of problems, such as changes in gait.

Besides, it is possible to see in many cases significant changes in gait involving children with this syndrome, while some step pressing against the ground, as is the case with classic autism, others step very lightly, only on tiptoe, as is the case of children with Asperger syndrome, which is part of the autistic spectrum. Thus, this research tried to make a study of autistic children gait, in direct comparison with non-autistic children in the same age group which may help therapists in the treatment of possible changes. As presented, it has been done a study with five children aged from 4 to 13 years old, one girl and four boys, 2 of them with a defined autistic diagnosis and 3 non-autistic. It was noted, from the results, it is possible to perceive some differences in pressure applied in different areas of feet, both in comparison between autistic and non-autistic as well as between individual sensors. Still, it was possible to note that within the group studied, autistic children generally applied less pressure throughout the plantar area, observed by lower-energy of sensors compared to non-autistic children, indicating, at first glance, they step on a lighter way.

Despite these facts presented, results are not conclusive in this preliminary analysis, pointing out that it is essential to increase the number of individuals included in the survey to have a significant sampling group for statistical analysis, promoting a deepening in the study, raising chances and performing statistical tests on the samples collected. In future investigations, it is intended to monitor continuously on a daily basis, which could show differences due to everyday or unusual situations during walking.

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