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CLINICAL SERIE

Therapeutic use of robotics in children with Autism Spectrum Disorder

Uso terapéutico de robótica en niños con Trastorno del Espectro Autista

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What do we know about the subject matter of this study?

Robotic technology and building blocks appeal to children with autism and can be adapted to therapeutic spaces. It has been found to be useful for initiating social interactions, collaborative problem solving, and turn-taking.

What does this study contribute to what is already known?

Robot-assisted therapy was applied as a therapeutic tool to children who are patients of a center from the Chilean public health system. There was a good level of adherence and positive impact on some social behaviors.

Abstract

Robot-assisted Therapy (RAT) can improve the behavior of children with Autism Spectrum Disorder (ASD) in a spontaneous and entertaining way. There are no previous experiences of this type of intervention in our country. **Objective:** To describe a clinical experience of using RAT and its impact on the behaviors of a group of children with ASD, in a therapeutic context. **Patients and Method:** Quasi-experimental clinical experience type study. 4 children with a clinical diagnosis of ASD were selected, supported by the ADOS-2 (Autism Diagnostic Observation Schedule); aged between 9 and 13 years, and normal IQ according to the WISC-III (Wechsler Intelligence Scale for Children). This study was approved by the Central Metropolitan Ethics Committee. Patients attended 10 structured robot-assisted therapy sessions, working collaboratively in pairs. Workshop attendance and parent and child satisfaction were evaluated through surveys, the adaptive behavior with the Vineland scale, and social interaction with video coding guidelines. **Results:** Patients presented a very good adherence and satisfaction with the activity. There was an improvement in socialization behaviors and social age. Video-coding showed an increase in social interaction and improvement in the behavior of the patients after attending workshops. **Conclusions:** We observed that the experience with RAT, adapted to the context of a Chilean public health center, was highly attractive and beneficial for patients with ASD, improving core symptoms such as difficulties in social interaction and behavioral problems.

Keywords:
Autism Spectrum Disorders;
Robot-Assisted Therapy;
Behavior;
Video-Coding and Social Interaction

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Introduction

Autism Spectrum Disorders (ASD) are a group of clinical disorders, which include persistent deficits in communication and social interaction in various contexts, as well as restrictive and repetitive patterns of behavior, interests, or activities[1]. Worldwide, the current prevalence of ASD is 1%[2]. The therapeutic pillars are based on multidisciplinary management, including occupational therapy, speech therapy, and psychology, aimed at improving the interaction and communication of these children[3].

Previous researches have suggested that the use of technology can be an efficient support tool for the education and therapy of children with ASD[4]. The definition of a therapeutic context for the use of robots that are collaboratively built and programmed may lead to a decrease in disruptive behaviors and improvement of social skills in children with ASD, in a spontaneous and entertaining way[5,6].

Despite more than a decade of research on the effects of robot-assisted therapy (RAT) on the social skills of children with ASD, there are still no conclusive studies. The main reasons for this have been related to the low standardization of research methodologies, the diversity of needs and preferences of children with ASD, and the use of robots with different features and appearances[7].

In Chile, no studies have been reported on the therapeutic use of RAT in children with ASD. The objective of this study is to describe the clinical experience of the use of RAT and its impact on the behaviors of a group of children with ASD, in a therapeutic context.

Patients and Methods

Clinical experience type study. RAT was implemented in a center of the Chilean public health system.

Participants

Four patients who were willing to attend the workshops and who met the inclusion criteria were selected from the database of the Child Neuropsychiatry Service of the *Hospital Clínico San Borja Arriarán* (HCSBA), Santiago, Chile. All patients with an updated clinical diagnosis of ASD by a Child Neurologist, complemented with the Autism Diagnostic Observation Schedule second edition (ADOS-2) test[8] were considered. Patients between 9 and 13 years of age and IQ equal to or higher than 70 points, measured with the Wechsler Intelligence Scale for Children third edition (WISC-III)[9] were included, due to the complexity of manipulation of the robot used in the study (LEGO Mindstorm EV3)[10].

Protocol

The selected patients were invited to participate in 10 sessions of robotics workshops held every two months at the Child Neuropsychiatry Service of the HCSBA. The therapy was supported by a multidisciplinary therapeutic team that consisted of an Occupational Therapist, a Child Neurologist, and an Engineer. The children worked in pairs, forming two pairs. The members of each pair remained for the 10 sessions. The work was carried out in a one-way mirror room and the parents stood behind the mirror while the workshop was taking place.

Each session lasted 90 minutes and was divided into structured, stereotyped, and timed sub-steps that were previously informed to the participants, considering the behavioral characteristics of these patients. The time limitation favored collaboration in the activities. In each workshop, the therapists planned a task to be carried out for both pairs of participants. This helped to avoid misunderstandings and delays in decision making, due to the children's lack of flexibility. An intermediate space was assigned to express emotions and exchange opinions about the work, in order to verify enjoyment, frustrations, and conflicts. Whenever an issue came up, it was contained by the treating team.

Two LEGO® Mindstorm EV3 sets and a laptop were used for pair programming. The workshops were recorded using small cameras attached to the corners of the worktables to avoid distracting the children. A wide-angle lens was used to record as many of the participants' behaviors as possible.

In order to objectify the results regarding the impact of the experience on the children's behavior, we made different measurements, comparing the first and last workshops, in which all the participants attended. In the workshops where a child was absent, she/he was replaced by a therapist.

Instruments

Satisfaction surveys were administered to parents and children regarding their behavior, enjoyment, and perception of the activity at the beginning and end of each session. Surveys consisted of 12 questions for children and 10 questions for parents. The same surveys were administered repeatedly. The total score assigned to responses according to the Likert scale was added up. The maximum score for the survey completed by the participants was 50 and the highest score of the parent was 25.

Chilean adaptation of the Vineland Social Maturity Scale proposed by Otero-Quiroz (1959) was used to evaluate adaptive behavior. This scale was adapted in Chile considering only linguistic aspects and was not standardized to our population. We considered the domains of Communication, Socialization, Total Sco-

re, and Social Age because they are useful to evaluate the impact of RAT on the core symptoms of ASD.

Behaviors were coded through the observation of the videos following the coding guidelines proposed in previous studies conducted in the United States and Europe[10,12]. This instrument has been validated in Spain, but not in our country. We identified from the videos nineteen dimensions of behavior, which were classified into 4 types: Nonverbal Communication, Conversation, Construction, and Behavior. For each pair of participants, we observed the behaviors and determined the frequency (number of times) of occurrence of each one of them, and compared them with the behaviors recorded in the first and last workshop of each pair of children.

Interactions were considered by working pairs. A single observer analyzed, on several occasions, the recording of each pair of children in the initial and final workshop, and then recorded the number of times that each child demonstrated the interactions specified (Table 1) with her/his partner or another participant in the session. Children's socialization and communication behaviors, both positive and negative, were considered.

Ethics

The study was approved by the Scientific Ethical Committee of the Central Metropolitan Health Service, ensuring that the procedures were following legal and ethical provisions in force, both national and international.

Results

Four male patients were included, aged between 9 and 12 years. Their total IQ ranged from 88 to 115. All children were in follow-up controls and treatment by a multidisciplinary team and had attended occupational therapy for 2 to 8 years. Table 2 details the information of each child.

All children attended more than 7 workshops, so no workshop had less than 3 attendees. The average attendance for the total of the 10 workshops was 90 (Table 2).

We compared the surveys answered by parents and participants at the end of the first and the last workshop. The scores reflected a high level of satisfaction, which was maintained throughout the experience, with no statistically significant changes in the scores obtained at the beginning and the end of the intervention.

Regarding adaptive behavior, 3 children improved their adaptive ability in the Socialization and Social Age domains on the Vineland Scale, while one patient maintained unchanged scores (Table 3).

In relation to the difficulty in social interaction and behavioral rigidity, in the non-verbal Communication domain, pair 1 decreased positive interactions, while pair 2 considerably increased positive interactions. If all 4 children are considered, there was a 20% increase on average of positive behaviors associated with Nonverbal Communication. The Conversation domain improved in both pairs, with a 110% increase on average in positive interactions. Regarding the Construction domain, pair 1 did not experience changes, while pair 2 had an increase. Considering all the participants, there was a 29% increase on average of positive interactions in Construction. Concerning the Behavior domain, both pairs improved significantly (Table 4).

Through narrative and videos captured at the end of the RAT, the parents' appreciation was recorded, reporting a high level of enjoyment of the children linked to the intervention, better following of instructions at home, and improvement in their fine motor skills evidenced in their daily life, favoring their autonomy. They were also very happy with the experience lived by their children. This instance allowed them to meet other families with ASD children with very similar characteristics, forming a support network.

Discussion

This is the first experience of RAT with ASD children carried out in a specific therapeutic environment in a Chilean public health care center. Very good adherence of the participants to the workshops was observed, as well as a high satisfaction. Progress was evidenced in the adaptive behavior of the patients, with an increase in socialization and social age according to Vineland Scale. It was also observed through video coding, improvement in social interaction, and good behavior in a collaborative activity. In addition, through narratives and videos of unstructured interviews, parents evaluated the experience very positively.

The fact that the children were attracted and motivated by working with robotic technology breaks new ground in enhancing positive behaviors and decreasing deficient and disruptive behaviors in children with ASD. This is very important because it allows us to think of technology, especially this strategy, as a great tool to enhance the social skills of these patients.

The good adherence, satisfaction, and enjoyment observed in this intervention with RAT may be related to the children's attraction to the interactive features of the technology used, which has been observed before in similar studies[5,6]. The increase in socialization measured with the Vineland Scale coincides with what has been observed in studies where an equivalent robotics workshop methodology, technology, and struc-

Table 1. Video coding description

Dimension	Behavior	Observation Code	Description
Social Interaction	Non-verbal communication	Eye contact	Number of times children in the same group look at an object or at themselves together
		Gestures / point	Number of times pointing to the robot, code, materials when addressing another person
		Joint attention	Number of times that two children demonstrate initiation and response to stimulus
		Group mates look at the same object	Number of times that participants indicate / observe the same event / artifact
	Conversation	Significant, in relation to the activity	Number of times a child talks about something related to the activity
		Not significant, tangential	Number of times a participant talks about something not related to the activity
		Echolalia, performance	Number of times that participant involuntarily repeats words or phrases
		Initiation of the conversation	Number of times a participant initiates a spoken interaction with a partner
		Interrupts the other child	Number of times that one participant does not allow the other's interaction to end
		Share positive emotions	Number of times the participant smiles or says something positive to the other
State of the Game	Construction	Taking turns	Number of times the participant takes action after the end of the partner's action
		Collaboration, sharing, asking for opinion or help	Number of times a child performs joint construction actions of the artifact
		They solve alone	Number of times the child isolates himself from his group and solves something alone
		Ask for help from an adult	Number of times the child asks an adult for help
		Withdraws or discourages constructive activity	Number of times the participant does not show focus on the activity or on what his partner is doing
	Behavior	Repetitive body or object movements	Number of times a participant starts and ends a repetitive movement
		Hyper / Hypoactive	Number of times the participant shows an over or under stimulated behavior
		Unmotivated	Number of times the participant shows disinterest in the activity
		Difficulty with changes / transitions	Number of times the participant shows inappropriate behavior in the face of a change in activity or a sudden event

Table 2. Participant characteristics

ID	Gender	Age	IQ	ADOS Results	Occupational Therapy Time	Under professional control	Attendance
1	M	9	115	Mild ASD	4 years	Child neurologist	10/10
2	M	12	102	Severe ASD	2 years	Psychologist	7/10
3	M	12	112	Severe ASD	Intermittent therapy	Psychologist, Speech therapist, Psychiatrist	10/10
4	M	12	88	Moderate ASD	8 years	Child neurologist	9/10

Table 3. Adaptive behavior measured with Vineland

	Communication			Socialization			Total score			Social age		
ID	Initial	Final	df	Initial	Final	df	Initial	Final	df	Initial	Final	df
1	11	12	1	8	8.5	0.5	65	72	7	7	8.5	1.5
2	9.5	9.5	0	2	2	0.0	76	76.5	0.5	9.7	9.7	0
3	10	10.5	0.5	6.5	9	2.5	67	73	6	7.4	8.8	1.4
4	13	13	0	4.5	7	2.5	69	73	4	7.8	8.8	1

ture were used[10]. Although in the video coding there was a tendency to increase mainly in social interaction and behavior, in the first group, there was a decrease in non-verbal communication. This may be due to the formation of pairs with a lack of homogenization of patients in terms of their intellectual level, family environment, therapies received, and ASD severity degree.

The methodology and physical space used in this intervention with RAT, including observation from the one-way mirror room, facilitated the participation of parents as observers of their children's work. This allowed them to observe the children's abilities and to train themselves to replicate the behavioral management of the professionals, learning strategies to improve social interaction through play and their own restricted interests, in addition to improving the management of undesirable behaviors. The group of parents had the option of getting to know each other, sharing useful experiences to resolve their difficulties. This is supported by descriptions in the literature that indica-

Table 4. Video coding

ID		Pair 1		Pair 2	
		1	2	3	4
	Observed behavior	Workshop 1 Nº Times	Final Workshop Nº Times	Workshop 1 Nº Times	Final Workshop Nº Times
A. Non-Verbal Communication					
A1	Eye contact	6	0	0	8
A2	Gestures / point	8	1	0	0
A3	Joint attention	6	0	0	1
A4	Group mates look at the same object	20	12	11	15
B. Conversation					
B1	Significant, in relation to the activity	17	31	12	47
B2	Not significant, tangential	10	4	6	8
B3	Echolalia, performance	2	0	1	2
B4	Initiation of the conversation	14	24	5	32
B5	Interrupts the other child	14	1	8	6
B6	Share positive emotions	9	1	1	1
C. Construction					
C1	Taking turns	8	8	6	8
C2	Collaboration, sharing, asking for opinion or help	22	16	12	25
C3	They solve alone	2	4	12	25
C4	Ask for help from an adult	11	6	11	11
C5	Withdraws or discourages constructive activity	9	0	15	10
D. Behavior					
D1	Repetitive body or object movements	0	0	2	0
D2	Hyper / Hypoactive	0	0	4	3
D3	Unmotivated	4	1	8	2
D4	Difficulty with changes / transitions	0	0	0	0

te that active family participation can generate support networks among parents, reducing their anxiety[13].

This study was carried out with restrictions of space, time, and availability of the professional team. Interventions of this type are limited by the current cost of the technology used, which makes it difficult to increase the number of patients included. However, in recent years, these tools have been reducing their cost and, in our country, they are now being used in education[14], which leads us to believe that they could soon be introduced in health care centers on a massive scale for therapeutic purposes. Although this intervention seems very positive from an observational point of view, there are still no conclusive studies regarding the effectiveness of this type of therapy, which makes its repetition questionable.

On the other hand, in this experience the differences in IQ and symptomatology severity were not homogenized, which may constitute a bias, especially considering that the behavioral measurements were made on the interaction of pairs of children.

Conclusions

The relevance of this clinical experience is that it explores cutting-edge techniques that can facilitate the management of patients with ASD in our sphere. We observed that the experience with RAT adapted to the context of a Chilean public health center was highly attractive and beneficial for patients with ASD, improving symptoms such as difficulties in social interaction and behavioral problems.

Ethical Responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Rights to privacy and informed consent: The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is in the possession of the correspondence author.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

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