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Effect of Group Exercise Program on Social Skills and Bone Mineral Density in Children with Autism

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ABSTRACT

Background: The complex developmental disease known as autism spectrum disorder (ASD) is marked by impaired social interaction, communication, in addition to decreased bone mineral density (BMD). Physical therapy can be one of the complementary therapies for autistic children.

Purpose of the Study: To inspect the efficacy of group exercise program on social skills and BMD in children with ASD.

Patients and Methods: Thirty children diagnosed with mild ASD were included. They were randomized into two groups. Group A (control) was given calcium supplement, vitamin D, and speech therapy. Group B (study) was given the same program of the control group A in addition to group exercise program, which was conducted for conducted for 60 minutes, three sessions per week. All participants in both groups underwent treatment program for successive three months. They were assessed by The Autism Social Skills Profile (ASSP) and dual-energy X-ray absorptiometry (DEXA) pre and post intervention.

Results: The study group experienced a significant rise in ASSP after treatment in comparison with before treatment, whereas the control group didn't show any significant change. The study group and control group experienced a significant rise in BMD after treatment in comparison with before treatment. The study group exhibited a statistically significant enhancement in comparison with the control group across all assessed variables after treatment.

Conclusion: From the findings of the study, it can be concluded that the group exercise program has beneficial impacts on improving social interaction and BMD in children suffering from ASD.

Keywords: Autism spectrum disorder, Bone mineral density, Group exercise, Social skills.

INTRODUCTION

Svenaeus [(1)] defines autism spectrum disorder (ASD) as a collection of symptoms that include limited or repetitive behaviors, difficulties with social interaction, speech, in addition to nonverbal communication. Many other mental and physical health issues can coexist with this condition. Social function impairments and communication disorders were formerly thought to be distinct primary symptoms. One constant in the several definitions of autism that have been proposed over the last hundred years is the inclusion of a social function deficiency.

Several biases contribute due to the fact that men are more likely than women to have ASD, with sex ratios ranging from 4:1 to 2.0-2.6:1. There is a gender influence in the symptomatology and prevalence of autism, according to most physicians[(2)].

A number of recent researches in kids, teens, and adults with ASD has demonstrated a positive association among exercise and the decline of symptoms and complications related to ASD [(3)].

A study has demonstrated the majority of children with ASD are often less energetic than typically developing individuals. Furthermore, compared to their peers who are typically developing, parents of children having ASD have stated that parents spend less time each year and engage in fewer kinds of physical activity with their kids [(4)].

The peripubertal ASD children are more susceptible to fractures because their BMD is lesser than that of age-matched controls**.** Compared to controls, boys having ASD have lesser BMD, according to research by **Neumeyer *et al.*** [(5)]**.** Children diagnosed with ASD have a higher risk of fractures overall in comparison with children without the disease and younger individuals with ASD than 50 years of age are more likely than controls to suffer hip fractures [(6)]**. Neumeyer *et al.*** [(7)] studies have shown that ASD impairs bone microarchitecture and accretion, resulting in decreased bone strength as well as decreased BMD.

Based on literature review there has been limited studies available on the efficiency of group therapy exercise program on BMD and social skills in kids with ASD. Thus, the purpose of this study was to investigate how well a group fitness program affected the social skills and body mass index (BMD) of kids with ASD.

PATIENTS AND METHODS

Study Design:

This prospective randomized clinical trial was conducted between two groups of kids who had ASD. The study was conducted from January 2023 to January 2024.

Ethical consideration:

This study was approved by Cairo University's Ethics Committee of the Faculty of Physical Therapy

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(P.T.REC/012/004587). The Declarations of Helsinki's ethical guidelines were adhered. Prior to beginning the study, a consent form was required from each child's parents. The purpose of the present study, and the training program were explained to each participant's parents.

Sample size:

We used the following formula in the G-Power 3.1.9.7 program (Windows version) for calculating the sample size and power: we assumed a two-tailed comparison of the difference among three independent means, has a 0.5 effect size. Making use of a power of 75% and α=0.05 assumed, 30 participants were split into two groups.

Thirty children of both sexes with mild autism based on childhood autism rating scale (CARS) participated in this study. They were between the ages of 8 and 10.

Young people with epilepsy, visual, hearing, vestibular, cognitive, and skeletal deformities were excluded from the study.

They were chosen from the governmental integration schools in El-Fayoum Governorate, Egypt.

The kids were split into two groups at random (control A, study B).

Both pairs (A, B) were given calcium (Ca^{++}), vitamin (Vit) D under the supervision of the specialist, in addition to speech therapy.

The study group (B) was given a group exercise program as well as previous treatment given to group (A).

The programs were conducted for group (A) and (B) for three successive months.

All participants in both groups were assessed by Autism Social Skills Profile second edition (ASSP II) for assessing social skills and DEXA for assessing BMD pre and post three successive months treatment program.

Randomization: The assignment was concealed by placing it in opaque sealed envelopes sequentially numbered. Until the data analysis was finished, an external, blinded researcher was responsible for opening the envelopes; this individual had no knowledge of the groups' allocation. Plus, he had no familiarity with the treatment program or its participants.

Materials:

A) For selection

- Diagnostic and Statistical Manual of Mental Disorder, 5th edition (DSM-5):

It was utilized for the purpose of selecting participants. There are three progressively severe levels of ASD described in DSM 5, starting with (1) "needing support" and progressing to (2) "needing large support" and eventually (3) "needing very large support." [(8)].

Participants were classified as having ASD according to DSM 5 criteria because they had a severe impairment in social communication as well as interaction and had impaired interests and activities. All individuals did not have any intellectual disabilities. They required support because, according to the DSM 5 classification, they were at the lowest severity level of ASD (level 1). Their neurobehavioral and cognitive profiles, however, were very distinct from one another [(9)].

- Childhood Autism Rating Scale (CARS):

In the current investigation, it was utilized to choose the children with autism. CARS rates a child's traits, behaviors, and skills in relation to the typical child's anticipated developmental trajectory.

The 15-item rating scale is based on observation and produces a total score that indicates the severity of autistic symptoms.

Each of the 15 items is rated on a seven-point scale (1, 1.5, 2...4) ranging from "within normal limits for that age," which is coded as one, to "severely abnormal for that age", which has the code four. 1, 2, 3, and 4 represent typical for the child's age, slightly abnormal, substantially abnormal, and severely abnormal, respectively.

The ratings on each of the 15 items are added together to get the final score. The CARS total score ranges from 15 (all items within normal boundaries) at the lowest to 60 (all things significantly aberrant).

Overall scores can vary from 15 to 60; a person with less than 30 is considered non-autistic, a person with 30 to 36.5 is considered mild to moderately autistic, and a person with 37 to 60 is considered severely autistic.

According to CARS, all study participants had mild autism, with scores ranging from (30-36.5)[(10)].

B) For evaluation

- The Second Edition of The Autism Social Skills Profile (ASSP II) [(11)].

There are 49 items within the ASSP II, and each item has a 4-point Likert scale.

Its intended use is to detect specific deficiencies in social skills in autistic children and adolescents (those whose ages range from six to seventeen years old). To target certain social skills deficiencies, the ASSP questionnaire can be utilized as a tool for intervention planning. Intervention programs can be better planned and tracked with its help [(12)].

The exam produced a total score in addition to scores on three subscales: Detrimental Social Behaviors (DSB), Social Participation/Avoidance (SPA), and Social/Emotional Reciprocity (SER) are all related concepts. All normative data come from parent reports, and standardized scores (M = 100, SD = 15) were computed from raw scores.

It was used in the assessment of social skills at baseline and following the application of the treatment programs for all participating children in both groups A and B.

- A standardized height and weight scale was utilized to measure the weight (in kilograms) and height (in centimeters) of all participating children. These

measurements were collected as data for DEXA analysis.

- DEXA was utilized for measurement of bone density of L2-L4 of all participated children in two study groups (A and B), before and after three successive months of treatment. It is the standard for measuring BMD utilizing a very low dose of radiation, utilizing bone mineral content (gm) by the area of bone measured (cm^2).

C) For treatment

-Stopwatch: It was used for calculating the time spent by each participant in each exercise in minutes.

-Straps: a 150 cm strap was used for performing galloping exercise to ensure child safety.

-Trampoline: It was used to perform trampoline exercise with dimensions of (140L *120W *140H)

Procedures:

A) For selection

The participants were referred after diagnosis and assessment with a specialist, their score ranged 30 to 36.5 describes mild to moderate autism on CARS.

B) For evaluation

Social skill:

The second iteration of the ASSP employed a 4-point Likert scale to assess a total of 49 distinct items.

Each participant in the exam was given an overall score and scores on 3 domains: social/emotional reciprocity (SER), social participation/avoidance (SPA), as well as detrimental social behaviors (DSB).

Normative data were derived from parent reports and validated by the therapist. Standard scores were calculated from raw scores (M = 100, SD = 15).

All children in both groups A, B were assessed with this scale before and after the treatment for three successive months.

Bone mineral density:

Bone mineral content (BMC) was assessed by DEXA scans of the lumbar (L2-L4) regions of the spine in all subjects. (BMD g/cm^2), a projected areal density, was used to evaluate the strength as well as density of the bone in different regions.

It was utilized for measuring the BMD of the lumbar spine (L2-L4) by dividing the measured area (cm^2) by the bone mineral content (mg).

The test involved having the children lie on a padded surface for a short period of time while a mechanical device called an imager ran over their bodies without touching them. This device then released radiation via the exposed area of their bodies, which is the L2-L4 spine.

Weight and height measurement:

The standard height and weight scale was utilized for measurement of weight (kg) and height (cm) for all participated children to be used as data for DEXA.

C) Treatment procedures:

Both groups control (A) and study (B) group received the following:

- Calcium intake (the dose was adjusted from 800 mg to 1300 mg per day according to each child need under the instruction of the specialist physician).
- Vitamin D3 300 IU/kg/day, don't override 5,000 IU/day.
- Speech therapy applied behavior analysis (ABA) was done by a speech therapist. It involved all behaviors whether appropriate or not. Specifically, the individual utilized his/her behavior to communicate or to obtain a specific response from the other individual.

-Group exercise program:

It was given only to participants in group B (study group).

The exercise training program was conducted for three successive months with 3 sessions/week.

The exercise training program included 6 exercises for 60 minutes as each exercise took 10 minutes.

The exercise training program included walking, running, jumping, hopping, galloping which was done according to **Goodarzi and Hemayattalab** [13] in addition to trampoline jumping, which was done according to **Neely *et al.*** [14].

The sessions were carried out in the form of group therapy as the 15 participants were divided into 5 subgroups and each subgroup contained 3 children aiming to concentrate on the social interaction between them.

Statistical analysis

The gender distribution among the groups was compared utilizing a chi-squared test. Quantitative data were presented as mean ± standard deviation (SD) or as median and interquartile range (IQR). The data were checked to make sure they had a normal distribution using the Shapiro-Wilk test. Levene's test was utilized to test the homogeneity of variances. To compare BMD among groups, an independent t-test was used, while a dependent t-test was employed to compare BMD before and after treatment. To compare ASSP between groups, we used a Mann-Whitney U test, and to compare at baseline and following treatment scores, we used a Wilcoxon signed ranks test. The significance level for all statistical tests was set at $p < 0.05$. In this work, we utilized SPSS 25 for Windows (IBM SPSS, Chicago, IL, USA) to conduct all of our statistical analysis.

RESULTS

1) Subject characteristics:

The demographic information of participants in groups A and B are displayed in table (1). Regarding age, weight, height, BMI, as well as gender distribution, no statistically significant difference was detected among the groups ($p > 0.05$).

Table 1. Subject characteristics.

		Group A (n=15)	Group B (n=15)	MD	t- value	p-value	Sig
		$\overline{X}$ ±SD	$\overline{X}$ ±SD				
Age (years)		9.07 ± 0.88	9.20 ± 0.67	-0.13	-0.46	0.64	**NS**
Weight (kg)		36.07 ± 5.11	37.33 ± 4.17	-1.26	-0.74	0.46	**NS**
Height (cm)		136.86 ± 3.44	137.66 ± 3.22	-0.8	-0.65	0.52	**NS**
BMI (kg/m²)		19.20 ± 2.11	19.64 ± 1.53	-0.44	-0.66	0.51	**NS**
Sex	**Boys**	12 (80%)	12 (80%)		($\chi^2 = 0$)	1	**NS**
	Girls	3 (20%)	3 (20%)				

$\overline{X}$: Mean SD: Standard deviation MD: Mean difference. t values: Unpaired t values. $\chi 2$: Chi squared value p-value: Probability level. NS: Non-significant.

Table (2) and Table (3) showed comparison among before and following treatment values within group A and group B and among groups Post treatment concerning ASSP and BMD respectively.

There was no notable disparity in ASSP (Average Speech Sound Perception) across the groups prior to therapy (p = 0.53). After treatment, group B's ASSP significantly increased in comparison to group A's

Comparison among before and after treatment values within group of group A and B and among groups Post treatment:

Table (2): Comparison among baseline and post treatment median values of ASSP within group of group A and B and among groups Post treatment

	Group A, Median (IQR)	Group B. Median (IQR)
Pre treatment	102 (108-94)	104 (115-97)
Post treatment	104 (109-94)	120 (128-111)
Z- value	-1.49	-3.41
p-value	0.13	0.001
sig	**NS**	**S**
	S	
U- value	**18**	
p-value	**0.001**	

IQR: Interquartile range, p values: Probability values, U value: Mann-Whitney test value, Z- value: Wilcoxon signed ranks test value, NS: Non significant S: Significant

There was no substantial disparity in bone mineral density (BMD) across the groups prior to therapy (p = 0.51). BMD after treatment values for group A were 0.49 ± 0.07 g/cm² and group B were 0.53 ± 0.04 g/cm², with a mean ± SD value. BMD increased significantly after treatment in group B in comparison with group A

Table (3): Comparison among baseline and post treatment mean values of BMD within group of group A and B and among groups Post treatment

Group		BMD (g/cm²) $\overline{X}$ ± SD		MD		% of change	t- value		p-value		Sig	
Group A	**Pre treatment**	0.47 ± 0.06	0.49 ± 0.07	-0.02	-0.04	4.26	-7.4	-2.16	0.001	0.03	**S**	**S**
	Post treatment	0.49 ± 0.07										
Group B	**Pre treatment**	0.48 ± 0.05	0.53 ± 0.04	-0.05		10.42	-7.72		0.001		**S**	
	Post treatment	0.53 ± 0.04										

x̄: Mean, SD: Standard deviation, MD: Mean difference, t value: Paired t value, p value: Probability value, S: Significant, NS: Non-significant.

DISCUSSION

Autism spectrum disorder (ASD) is becoming more prevalent on a global scale. Peer engagement is challenging for these children due to social and behavioral problems. Children having ASD are less probable to engage in physical activity; less frequently than typically developing children due to societal and physical constraints. This poses a dilemma as lack of physical activity has detrimental impacts on a child's well-being, family relationships, as well as social adaptation abilities, among other factors [15].

Recently, it was shown that approximately three males for every female are diagnosed with autism when screening the general population utilizing gold standard tests. However, in clinical samples where an autism diagnosis has already been made, the ratio is even greater, at more than four males for every female [16].

Hence, this study was conducted to examine the influence of a group exercise program on social skills and bone mineral density (BMD) in children diagnosed with autism spectrum disorder (ASD).

Decreased the development of motor skills and engagement in physical activities in children with autism spectrum disorder (ASD) leads to a decrease in maladaptive behaviors associated with autism [17].

The results of this study revealed enhancement in BMD only without ASSP in control group A who received only Vit D and calcium supplement, however this improvement was lower than the improvement achieved with the study group B who engaged in group exercise therapy in addition to Vit D and calcium supplement and showed improvements of both BMD and ASSP. That indicates the importance of Vit D and calcium supplement for this category of children.

Additionally, our results support those of **Li *et al.*** [18] who detected that while vitamin D supplementation may help with hyperactivity, it does not seem to help with ASD core symptoms or any other co-occurring behaviors or circumstances.

Moreover, our results are compatible with **Neumeyer *et al.*** [19] in their study of assessing BMD in autistic and TDC whose age ranged from 8-17 years as they stated that in boys with ASD, there was a positive association between calcium and phosphorus intake from dietary sources along with supplements including vitamins, minerals, as well as high-protein drinks. However, this association wasn't present for TDC.

Contrary to what **Saad *et al.*** [20] discovered, these data show that ASD children who supplemented with 300 U/kg of vitamin D daily had a significant improvement in core symptoms, including the CARS score, stereotypes, and the capability to continue eye contact and attention for longer periods of time.

According to **Sefen *et al.*** [17]**,** young children in addition to adolescents with ASD benefit from physical activity in terms of their conduct and social abilities. Exercise-therapy, which uses physical activity to help autistic children increase appropriate behaviors or decrease problem behaviors, is regarded as an evidence-based intervention [21].

In comparison to group A, group B's BMD and ASSP significantly improved after therapy, based on this study's results. Which proved the importance of engaging autistic children in regular exercise programs to help in improving their physical and social skills, which will be reflected in their quality of life.

All children, including those with ASD, can benefit from regular physical exercise. But in comparison with normally developing (TD) children, those with ASD engage in less physical activity [22]**.** As **Green *et al.*** [23] observed, ASD is frequently linked to impaired motor coordination and balance, which could explain this. These children are unable to participate in team activities due to sensory, behavioral, as well as communication disorders. Consequently, when compared to typically developing individuals, adolescents with autism spectrum disorder (ASD) have lower levels of physical activity.

In this study the exercise training program was conducted for successive three months with 3 sessions / week and included 6 exercises for 60 minutes as each exercise took 10 minutes. The duration of session time was 60 minutes aiming to engage the children on extended time of physical activity with variation of exercises to help in participation in structured exercise program. This was compatible with **Zhao and Chen** [24] **as c**hildren with autism spectrum disorder (ASD) who participated in a 12-week organized physical activity program showed substantial improvement in their social function, according to a study that examined children aged 5 to 8 at a special school in China. There were two 60-minute exercise sessions per week as part of the program.

Applying the selected exercise program in form of group therapy instead of applying it individually for each child alone was aiming to enhance the interaction between the children in each group which will be reflected on their social interaction and behavior. That came in agreement with the findings of **Rinehart *et al.*** [25]**,** who found that children suffering from developmental disorders may benefit from physical activity programs that are organized around groups of people (such as teammates, classmates, coaches, and instructors) because these programs provide chances for social interactions. Social behavior as well as communication should be facilitated in group settings.

Bahrami *et al.* [26] showed that children with ASD exhibited substantial enhancements in communication and stereotypic behaviors after a 14-week training program of technically precise dance movements performed in set sequences, in comparison to neurotypical controls. It is worth noting that these enhancements persisted for a full month beyond the intervention's conclusion.

Furthermore, the study results were also in line with the findings of **Howells *et al.*** [27], The researchers discovered that group-based physical activity (PA)

programs provided opportunities for the development of social skills. Their study included a range of activities conducted in groups, although they only participated in a single program focused on team sports. The researchers suggested that future studies should give higher priority to team sports.

However, these results are in contrary to the findings of **Sowa and Meulenbroek** [28], who reported that both individual and group therapies involving physical activity significantly enhanced social skills and reduced maladaptive behaviors in social situations. They came to the conclusion that, compared to group activities, individual-based therapies provide better tailored programming and reduce stress. By using an individualized approach, we can protect the autistic child from the hurtful emotions that can result from being misunderstood by others in the group.

Selecting galloping exercises in the applied exercise program in the current study, which looks like horse dancing, was for its effect on improving body awareness and active participation with the involved group, which comes in agreement with **DeJesus *et al.*** [29]. They came to the conclusion that dancing alleviated symptoms related to ASD. These encompassed enhancements in areas such as mental health, physical awareness, behavior, and communication abilities.

Body mineral density (BMD) is decreased in autistic boys compared to normally developing controls (TDC). The protein, calcium, as well as phosphorus consumption, activity levels, as well the BMD Z-scores at the lumbar vertebrae, femoral neck, hip, and entire body excluding the head were calculated all lower in ASD boys compared to TDC. There was a positive association between BMD and protein, calcium, as well as phosphorus consumption. [19].

Loss of muscle mass and BMD occurs due to inactivity. Consequently, the study observed an enhancement, among children with autism spectrum disorder (ASD) group, of bone density that can be secondary to the gained improvement of the muscle mass after the practice of the selected exercises.

This is in line with the findings of **Behringer *et al.*** [30], who found that exercise raises skeletal mass in children. Research has shown that weight-bearing activity significantly impacts bone accrual in children and adolescents, so this population needs to be physically active .

These results came in accordance with **Willems *et al.*** [31], who found that the activation of osteoblasts in the body during weight-bearing activity increases the overall rate of bone production.

The results of this study align with those of **Aniszewski and Alvernaz** [32], who claim that children with ASD benefit from regular physical activity because it enhances their psychomotor development, motor coordination, agility, velocity, as well as strength, reduces stereotyped behaviours, and fosters social skills and activity participation.

Findings of the present study were compatible with the findings of **Iliadis and Apteslis** [33]. They discovered that decreasing stereotypical actions and enhancing motor skills have a positive impact on social ability. Therefore, it is crucial to incorporate physical activities into ASD children's daily lives in order to preserve their well-being and health .

Furthermore, they support the results of **Zeng *et al.*** [34], who discovered that physical exercise has been demonstrated to improve motor skills and cognitive abilities in preschoolers aged 4 to 6, specifically in the areas of attention, memory, behavior, and academic performance, particularly in children with autism.

Moreover these results measurements come in agreement with **Zhao and Chen** [24] who reported that activities with a structured program would have interactions between children and their teachers as a program of structure sporting activities would be a natural area in which to apply the fundamental principles of recognized ASD therapy.

The findings of the present study showed that including autistic children in group activities effectively addressed many social and emotional challenges by enhancing their mentalization, collaboration, and assertive behavior. It is worth noting that assertive behavior is a skill that can be acquired via learning, as mentioned by the researchers **Guivarch *et al.*** [35]. The findings indicated that the social skills training group, which included cooperative activities, had a positive impact on the social abilities of children with autism spectrum disorder (ASD). This improvement mostly influenced their cognitive processes.

Future research is encouraged to utilize a larger sample size and employ other objective assessment methodologies. In addition, the study should aim to assess the effects of different forms of physical activity on the motor skills and overall well-being of children with autism spectrum disorder (ASD).

CONCLUSION

According to the obtained results, it could be concluded that there were significant differences regarding BMD and social skills in autistic children who engaged in structural and prolonged group exercise therapy for a duration of three consecutive months.

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