Araştırma Makalesi
Research Article

Adnan Menderes Üniversitesi Sağlık Bilimleri Fakültesi Dergisi 2023: 7(3); 565-578
Journal of Adnan Menderes University Health Sciences Faculty
doi: 10.46237/amusbfd.1321226

Otizmli Çocuklarda Pilates Eğitiminin Fiziksel Performans ve Sosyal Becerilere Etkisi: Randomize Kontrollü Bir Çalışma

The Effect of Pilates Training on Physical Performance and Social Skills in Children with Autism: A Randomized Controlled Trial

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ÖZ

Amaç: Aerobik eğitim, çocukların fiziksel, bilişsel ve davranışsal işlevleri üzerindeki önemli faydaları nedeniyle otizmli çocuklar için önerilmektedir. Buna rağmen, otizmli çocuklarda pilates eğitiminin etkilerine ilişkin herhangi bir kanıt bulunmamaktadır. Bu çalışmada, otizmli çocuklarda pilates eğitiminin kas kuvveti, denge performansı, kaba motor beceriler ve sosyal beceriler üzerindeki etkilerinin karşılaştırılması amaçlandı.

Yöntem: Çalışmaya toplam 22 otizmli çocuk dahil edildi. Sonuç ölçütleri olarak maksimal izometrik kas kuvveti, denge performansı, kaba motor beceriler ve sosyal beceriler değerlendirildi.

Bulgular: Her iki eğitim grubunda da denge performansı ve kaba motor becerileri skorlarında iyileşme gözlenirken, sosyal beceri skorunda iyileşme gözlenmedi ($p < 0,05$). Kas gücünde sadece aerobik eğitim grubunda anlamlı bir iyileşme görüldü ($p < 0,05$). Gruplar arası karşılaştırmalarda, tüm sonuç ölçümlerinin hem aerobik eğitim hem de pilates eğitim grupları için istatistiksel olarak benzer olduğunu gösterdi ($p > 0,05$).

Sonuç: Bu çalışma, aerobik eğitim ve pilates eğitiminin her ikisinin de otizmli çocuklarda denge performansının ve kaba motor becerilerin geliştirilmesinde etkili olduğunu ve aerobik eğitimde kas gücünde daha fazla iyileşme olduğunu göstermektedir. Pilates eğitimi, otizmli çocuklarda denge performansını ve motor becerileri arttırdığı için alternatif bir eğitim olarak düşünülebilir.

Anahtar Kelimeler: Otizm, Pilates, Aerobik Eğitim, Kaba Motor Beceriler, Sosyal Beceriler.

ABSTRACT

Objective: Aerobic training has been recommended for children with autism due to its important benefits on physical, cognitive and behavioral functions of children. Nevertheless, there is no evidence regarding the effects of pilates training in children with autism. The present study was aimed to determine the effects of pilates training by comparing the effects of AT on muscle strength, balance performance, gross motor skills and social skills in children with autism.

Method: A total of 22 children with autism were included in the study. As outcome measures, maximal isometric muscle strength, balance performance, gross motor skills and social skills were evaluated.

Results: Improvements were observed in both training groups in balance performance and gross motor skills scores, but no improvement in social skills score ($p < 0.05$). There was a significant improvement in muscle strength only in the aerobic

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Geliş Tarihi: 01.07.2023 – Kabul Tarihi: 10.08.2023
Yazar Katkıları: A) Fikir/Kavram, B) Tasarım, C) Veri Toplama ve/veya İşleme, D) Analiz ve/veya Yorum, E) Literatür Taraması, F) Makale Yazımı, G) Eleştirel İnceleme

training group ($p < 0.05$). The between group comparisons showed that all included outcome measures were statistically similar for both aerobic training and pilates training groups ($p > 0.05$).

Conclusion: The present study shows that aerobic training and pilates training are both effective in the improvement of balance performance and gross motor skills in children with autism, with more improvement in muscle strength in aerobic training. Pilates education can be considered as an alternative education as it increases balance performance and motor skills in children with autism.

Key words: Autism, Pilates training, Aerobic training, Gross motor skills, Social skills.

1. INTRODUCTION

Autism spectrum disorder (ASD) includes a group of disorders with similar characteristics. Autism, included in this group, is a neurodevelopmental disorder that manifests in the early stages of life, and negatively affects individuals' social interaction, communication and behavioral development (1). In addition to these primary symptoms, delays, or abnormalities in various developmental areas, including balance, gait patterns, and motor skills are common in autism (2-5).

Since motor skills influence the language, cognitive, and social functions that enable children to interact with the environment, their development in children with autism is critical. For instance, the acquisition of motor skills such as crawling and walking provides opportunities for social interaction between the child and other individuals, and the environment (5). Another important issue in autism that also negatively affects motor function is muscle weakness. Some recent studies have shown that children with autism have poorer overall muscle strength and handgrip strength when compared to typically developing children (2,3). All of these problems negatively affect the level of participation of children with autism in physical activities and sports programs, and cause lower physical activity levels (6,7). Today, since even typically developing children prefer a sedantery lifestyle, it is crucial for children with autism to engage in physical activities. A sedentary lifestyle coupled with the problems faced by children with autism concerning social interaction, communication, and behavior may lead to various negative consequences, including obesity and other cardio-metabolic risk factors, and impaired psychosocial well-being and cognitive functioning. Engaging in physical activity programs can positively affect a range of outcomes, including socialization with peers, emotional, behavioral, cognitive and developmental functioning, improvement in motor skills, and thereby physical health. Therefore, it is important to increase the level of physical activity and prevent a sedentary lifestyle in children with autism (6). Due to the increase in the prevelance of autism and the understanding of the importance of physical activity for these children, the determination of the most appropriate and effective intervention for this group has been gaining traction.

There is growing evidence with the contribution of recent studies in the literature, which investigate or review the impact of physical activity interventions on motor and social skills in autism (7-9). Ruggeri et al. reported that many motor and physical activity interventions improve different types of motor skills (7). Healy et al., reported that all types of motor intervention had moderate to large effects on locomotor skills, manipulative skills, social skills, muscular strength and endurance in children with ASD in their meta- analysis (8). Among these interventions, aerobic training (AT), which includes walking, jogging or cycling is one of the most preferred ones in autism. As previous studies have shown, AT improves academic responding, motor skills, and sleep (10,11), increases exercise capacity and monthly calorie

expenditure with a decrease in Body Mass Index (BMI) (12), provides cognitive benefits (13), and reduces maladaptive and stereotypical behaviors in ASD (14) .

In contrast, only a few studies have investigated the effects of mind-body exercises, such as yoga and Thai Chi Chuan, that reported benefits in children with ASD concerning motor skills and balance performance (15-17). Moreover, the effects of pilates training (PT), another mind-body exercise in children with autism is yet to be addressed. PT according to previous studies, improves children's physical function in terms of flexibility, strength, and postural control (18). Since it demands cognitive concentration to produce slow, controlled, and fluid body movements, PT also engages children's mental functions (18,19). Moreover, it is a safe and motivational method. To our knowledge, no study has evaluated the effects of PT on children with autism. PT, we hypothesized, would be an alnernative, useful and valuable physical activity intervention that would help children with autism enhance their physical and social skills.

In this study, we aimed to determine the effects of PT on muscle strength, balance performance, gross motor skills and social skills by comparing the effects of AT in children with autism.

2. METHOD

Design

This randomized-controlled trial was conducted at Aydın Autism Sports Center in Turkey. This study was conducted using a randomized controlled trial design. Participants were blinded to their assignment to either the intervention groups PT or AT. However, due to the nature of the interventions, the practitioners were not blinded to the research. The interventions were done by the same researcher lasted for 12 weeks. The study protocol was approved by Aydın Adnan Menderes University Faculty of Health Sciences Dean's Office Non-Interventional Clinical Research Ethics Committee (Protocol number: E-92340882-050.04.04-21828). Informed consent was obtained from the parents of the participants prior to the study.

Participants and Procedure

This RCT study was conducted in Autism Sports Center between 08/2017 - 08/2018 in Aydin city. The inclusion criteria were (i) being diagnosed with ASD, (ii) not having physical disabilities or neurological disorders, (iii) having the ability to follow the instructions given during evaluations and training, and (iv) having the ability to perform the requested training. Parents of all participants signed an informed consent form for participation.

Randomization, Allocation Concealment and Blinding

In the pre-study power analysis (A-Priori) to determine the power of the sample, it was found that "73% power at 95% confidence interval at 5% effect size" would be obtained if the study was conducted with 22 children.

Children were allocated into two groups named AT (n=11) and PT (n=11) groups. Participants were randomly assigned following simple randomization procedures (computerized random numbers created by using www.randomization.com) to 1 of three treatment groups. Since one child in the PT group did not continue PT, the study was completed

with the participation of 21 children with autism. A schematic of the study design is given in Figure 1.

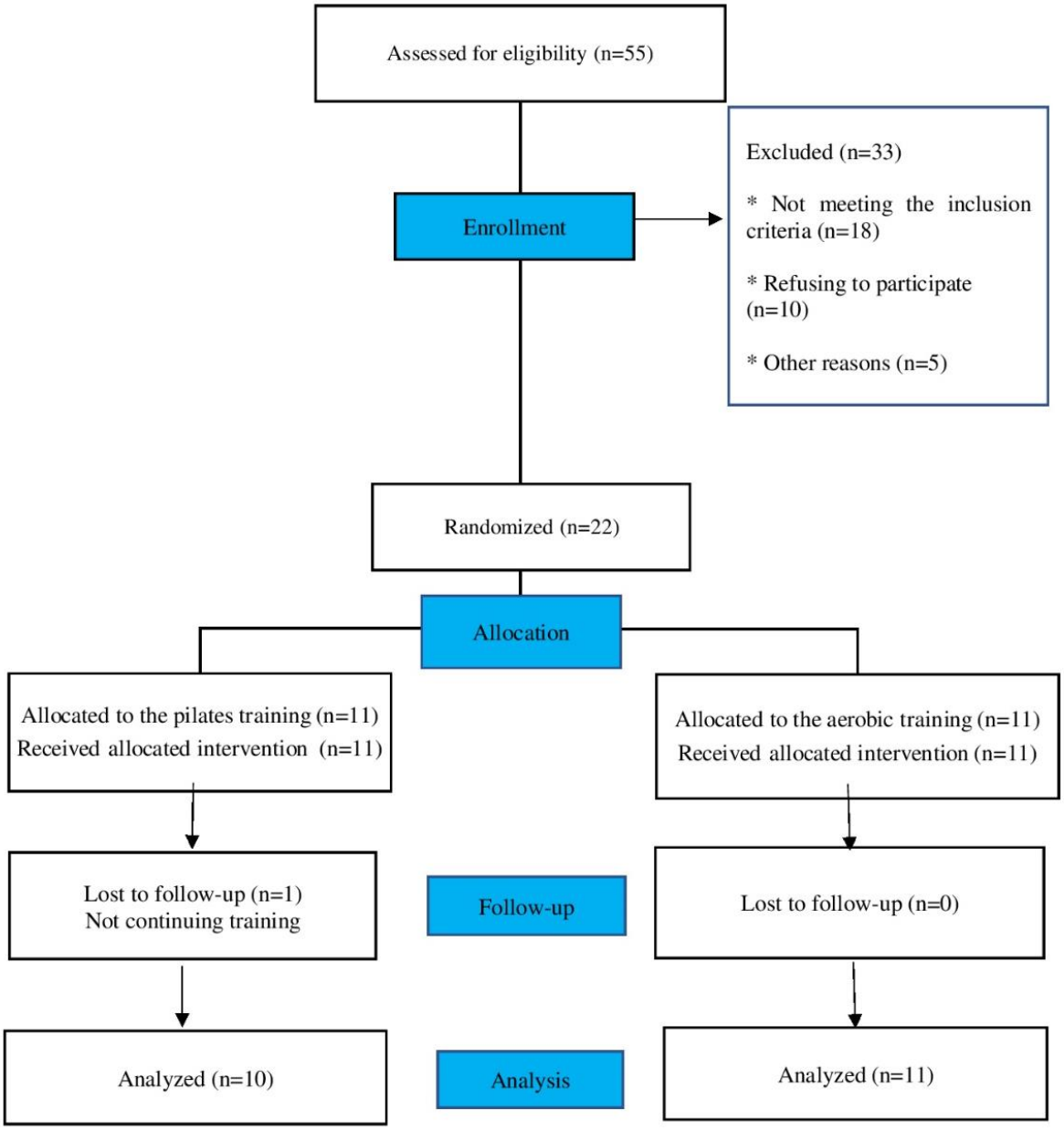

Figure 1. The study protocol

Intervention

Pilates training group

According to previous studies, an individual PT plan was developed for children in the PT group (20,21). Exercises loading weight in both the upper and lower extremities, balance and spinal mobility exercises were selected. The PT program consisted of warm-up, work-out and cool-down sections. For the warm-up section, breathing, standing roll down, and spine twist exercises were selected; for the work-out section, the hundred, shoulder bridge, scissors, swimming, and quadruped exercises, and for cool-down section, torso twist, cat-camel, and

standing stretches. The PT progression was achieved by increasing the number of repetitions of the selected exercises and adding some equipment (balls, foam rollers) to challenge postural stability. In the first five sessions, after each exercise was performed for six to eight repetitions, the number of repetitions was increased to 10-12. Moreover, the environment where the training took place was carefully arranged according to the needs of children with autism (20,21).

Aerobic training group

For children in the AT group, and individual AT plan was created. Each training session consisted of a 20-minutes treadmill workout (using the motorized Ultıma Ac 3500 treadmill) followed by 20-minutes bicycle workout (Voit Yellow Collection 112u exercie bike). The intensity of training, which began at 50% to 60% of maximum heart rate (HR), was increased each week so that by week five, the children were at 75% to 80% maximum HR (22). The maximum HR, as recommended for children, was calculated using the formula 208 - 0.7 x (age) (23). To ensure that the exercise intensity remained in the target HR zone during training, the child's HR was continuously monitored by the treadmill and exercise bike monitors.

A room quiet and free from distractions was chosen for both groups. During the exercises, simple, understandable sentences were used in the instructions. The same instructions were used for each session. Additionally, if necessary, visual instructions were added in addition to verbal instructions. Children in both groups completed their training program for 12 weeks, once a week (a total of 40 minutes per session) with the supervision of a physical therapist who has 5 years of experience in PT (22).

Data Collection

All assessments were done before and after 12-weeks of training programme by a physical therapist blinded to the group allocation. Descriptive characteristics including age, height weight and gender were recorded. Muscle strength, balance performance, gross motor skills and social skills were evaluated. Since it is known that visual instruction is more effective than verbal instruction for children with autism (7), one of the researchers became a role model for children during the evaluations.

Muscle Strength

Evaluations of maximal isometric muscle strength for shoulder flexors, hip flexors and knee extensors were performed with Hand-held dynamometry (Jtech Commander PowerTrack II Muscle Tester). Participants were asked to apply the maximum voluntary force they could exert under certain test conditions. Each test procedure for each muscle groups was repeated 3 times, and the best score was used for analysis. The results were recorded for both the right and left side.

For shoulder flexors evaluation, the participant seated on a chair with a straight back shoulder flexed at 90°, elbow extended. The dynamometer was placed on proximal to epicondyles of humerus (24). In lower extremity evaluations, the participant seated and hip and knees flexed at 90°. The dynamometer was placed on the anterior aspect of the thigh, proximal to the knee joint for hip flexors, and dynamometer was placed on the anterior aspect of the shank, proximal to the ankle joint for knee extensors (25).

Balance

The one-legged standing test was used to evaluate static balance performance. The participants were asked to maintain a one-legged stance for as long as they can with their eyes open and arms at the side of the trunk. The time recorded in seconds from the moment a foot is lifted off the ground to the moment it touches the ground. The test was performed for right and left side. The participants performed 3 trials, and the longest time was used for analysis. (26).

Gross Motor Skills

The Turkish version of the Test of Gross Motor Development (TGMT-2) was used to evaluate gross motor skills of participants (27). The test has two sub-test including locomotor skills tasks such as hopping, sliding, galloping, jumping, running, and the object control skills consists of striking and kicking a stationary ball, dribbling, catching, overhand throwing and underhand rolling. The locomotor skills focus on coordinated movements, while object control skills focus on the child's ability to play with or manipulate balls. The highest total score that can be obtained from TGMT-2 is 86, and higher score indicates better motor performance (27).

Social Skills

The Autism Social Skills Profile Turkish Form (ASSP- T) was used to evaluate social skills of participants. The test consists of items related to social participation and socially inappropriate behaviors that lead to negative peer relationships. Higher score indicates proficiency in social functions, and lower score indicates inadequacy in social functions. It was adapted into Turkish by Demir (2009) (28).

Statistical Analysis

The IBM-SPSS for Windows version 20 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. Descriptive statistics was calculated as a number/percent (n/%) for qualitative data and mean±standard deviation for quantitative data. The Shapiro Wilk's test was performed for normality assumption. The Wilcoxon signed-rank test was used to compare the differences between baseline and post intervention scores within groups. The differences between groups in terms of changes induced by trainings were analyzed using the Mann–Whitney U test for continuous variables. A p-value of less than 0.05 was considered to show a statistically significant result.

3. RESULTS

There were 55 children with autism registered in the Autism Sports Center. Eighteen children with autism did not meet the inclusion criteria, ten children did not want to participate in the study, and five children were not included in the study due to different reasons. A total of 22 children between the age of 7 and 12 years were participated in this study (Figure 1).

There were no differences between groups in terms of gender, age, height, and weight ($p > 0.05$). The descriptive characteristics of children are shown in Table 1 (Table 1).

Table 1. Descriptive Characteristics of Children

Characteristics	Pilates training group (n=10)		Aerobic training group (n= 11)		
	X±SD	min-max	X±SD	min-max	*P*
Age (years)	9±1.65	7-12	9.09±2.02	7-12	0.908
Height (cm)	135.30±10.58	125-150	134±9.79	122-148	0.904
Body weight (kg)	31.15±11.99	24-48	30.68±12.80	25-47	0.630
BMI (kg/m^2)	19.06±4.01	18.55±24.05	20.22±4.14	18.96±23.79	0.367
Gender	**N**	**%**	**N**	**%**	
Female	1	10	3	27	0.326
Male	9	90	8	73	

Within comparison showed that in the PT group, there was significant improvement only in the left hip flexor muscle strength after 12 weeks of training ($p = .038$) (Table 2). In AT group, a statistically significant improvement was detected in the right shoulder flexors ($p = 0.024$), right hip flexors ($p = 0.019$), left hip flexors ($p = 0.015$), right knee extensors ($p = 0.007$) and left knee extensors ($p = 0.028$) muscle strengths after 12 weeks of training.

No significant difference was detected between groups in terms of changes regarding all muscle strength parameters induced by trainings ($p > 0.05$) (Table 2). Both groups showed significant improvement in terms of balance performance after 12 weeks of training ($p < 0.05$) (Table 1). There was no significant difference between groups in terms of changes in balance performance induced by trainings ($p > 0.05$) (Table 2).

Both groups showed significant improvement after training in the gross motor skills (TGMT-2 total score and in TGMT-2 object control skills score) ($p < 0.05$). No significant difference was found between groups in terms of changes in TGMT-2 scores induced by trainings ($p > 0.05$) (Table 2).

According to the ASSP-T, there were no improvement in social skills in both groups after 12 weeks of training ($p > 0.05$) (Table 2).

4. DISCUSSION

Children with autism exhibit various disabilities related to muscle strength, balance performance, and motor skills, and these deficiencies affect the general physical health of the child (6). Moreover, they also negatively affect their interaction with the environment and their social participation (5). Therefore, it is vital to identify interventions that will contribute to physical and social well-being in autism. This study showed that AT and PT improved muscle strength, balance performance, and gross motor skills in children with autism, but they did not improve social skills.

As a result of this study, we found that 12-week AT and PT improved hip flexor, knee extensor, and shoulder flexor muscle strength and balance performance in children with autism. Although the improvement in muscle strength in the PT group was not statistically significant, it was clinically significant. One of the main reasons for this improvement may be the nature of the training program we have chosen for the groups. It is known that cycling, treadmill, and Pilates training performed for more than 10 minutes are activities that improve muscle strength and balance performance (29). In the present study, the treadmill and bicycle ergometer preferred as part of AT basically require the activity of the lower extremity muscles; therefore, they strengthen the lower extremity muscles in particular (30-33). In addition, the treadmill,

Table 2. Changes in Muscle Strength, Balance, Gross Motor Skills and Social Skills After 12 Weeks of Training

Parameters		Pilates training group (n=10) median (IQR 25th-75th)	min-max	p*	Aerobic training group (n= 11) median (IQR 25th-75th)	min-max	p*	p#
Muscle Strength								
Right shoulder flexors	pre	19.80 (8.80-29.70)	6.6-44	0.313	8.8 (6.6-11)	4.4-15.4	**0.024**	0.472
	post	25 (15.4-38.5)	8.8-61.6		15.6 (9.9-26.8)	6.6-30.8		
Left shoulder flexors	pre	14.30 (8.80-27.25)	4.4-48.4	0.086	8.8 (4.4-15.4)	4.4-19	0.126	0.698
	post	26.2 (15.4-41.8)	6.6-63		13.2 (8.25-27.5)	6-33.4		
Right hip flexors	pre	18.7 (13.2-26.2)	11-57.2	0.059	11 (8.8-13.2)	8.8-17.6	**0.019**	0.427
	post	35.2 (22.15-41.55)	22-83.6		18.7 (12.5-45.1)	8.8-48.4		
Left hip flexors	pre	17.6 (12.7-32.95)	8.8-48.4	**0.038**	8.8 (8.8-15.4)	8.8-17.6	**0.015**	0.910
	post	29.6 (19.45-48.40)	17.6-94.6		17.7 (12.1-45.1)	6.6-55.4		
Right knee extensors	pre	22 (12.65-31.95)	8.8-48.4	0.074	13.2 (8.8-17.6)	6.6-17.6	**0.007**	0.909
	post	29.7 (20.95_40.15)	15.4-55		19.8 (12.8-37.4)	8.8-50.6		
Left knee extensors	pre	24.2 (8.25-35.25)	6.6-48.4	0.126	13.2 (8.8-13.2)	6.6-17.6	**0.028**	0.677
	post	30.8 (19.8-36.95)	13.2-63.8		18.7 (12.1-43.45)	8.8-52.8		
Balance Performance								
Right (second)	pre	16.5 (3.75-37)	3-50	**0.015**	6 (2-8)	1-21	**0.005**	0.231
	post	33 (19.5-44.5)	5-98		10 (7-15)	2-40		
Left (second)	pre	8 (3.75-29.5)	3-80	**0.037**	3 (2-6)	1-23	**0.016**	0.290
	post	28.5 (13.25-38.75)	7-150		11 (6-19)	2-25		
Gross motor skills								
TGMT-2 total score	pre	50.5 (28.5-69.5)	18-84	**0.005**	26 (9-32)	4-58	**0.047**	0.359
	post	74 (53.5-80)	26-86		36 (14-53)	8-54		
TGMT-2 Locomotor skills	pre	30 (15-38.5)	7-46	0.126	12 (4-16)	0-36	0.444	0.397
	post	37(20-46.5)	8-48		14 (0-22)	0-45		
TGMT-2 Object control skills	pre	21.5 (13.5-31)	6-38	**0.011**	12 (8-18)	2-22	**0.028**	0.525
	post	37.5 (31.5-38)	18-38		24 (14-32)	8-38		
Social skills								
ASSP total score	pre	98 (87.75-111.25)	85-119	0.959	82 (72-92)	68-104	0.624	0.778
	post	102.5 (92-109.5)	90-113		93 (72-99)	65-127		

Abbreviations: TGMT-2, Test of gross motor development-Second Edition; ASSP, Autism Social Skills Profile; $p < .05$, **p*,** Wilcoxon test; **p#,** Mann-witney test. p*; from baseline to 12 weeks p value within groups. p#; from 12 weeks to 12 weeks p value between groups

due to its non-stationary surface, develops the postural control mechanism which is necessary to maintain balance while transferring body weight from one leg to the other, and thus, it contributes to the improvement of balance performance (32). On the other hand, some features of PT, due to its methodology, are important in terms of increasing muscle strength and improving balance performance. PT usually includes a wide variety of exercises against body weight; therefore, depending on the exercises chosen, it can increase strength in both trunk muscles and lower and upper extremity muscles (18,21). Another important feature of PT is that it includes closed kinetic chain exercises. As known, closed kinetic chain exercises contribute to the sense of proprioception (18). In addition, exercises used for PT group rely on movement control, which can lead to changes in the nervous system through the alteration of synaptic connections and cortical remapping, and contribute to the development of body awareness and movement coordination (18,34). All these reasons support that PT may be an option to improve balance performance.

In addition to the negative effects of cognitive and sensory impairment on balance performance in children with autism, accompanying motor problems also play a role in the deterioration of balance performance (4). It has been reported that trunk and lower extremity muscle strength may be one of the motor problems affecting balance performance (32,35). Therefore, another factor contributing to the improvement of balance performance in both groups within the scope of our study may be the gain in muscle strength obtained with AT and PT training.

In addition to the characteristics of the training modes chosen for both groups, the inclusion of children with autism, who adopt a sedentary lifestyle, into the regular physical activity program may be among the factors that cause physical gains in this population. A few studies have shown that AT including training with a treadmill or bicycle ergometer improves lower extremity muscle strength and balance performance in individuals with Down syndrome, who adopt a sedentary lifestyle similar to individuals with autism (30-32). It was reported in another study that AT including treadmill training improved dynamic balance in children diagnosed with hemophilia (33). Unlike our study, previous studies have generally examined the effect of PT on trunk muscle strength, and studies investigating the effect of PT on lower and upper extremity muscle strength are quite limited. In a study investigating the effect of PT on muscle strength in MS patients, it was reported that there was an improvement in both lower extremity and upper extremity muscle strength after 8 weeks of training (35). Consistent with our results, in a study comparing the effects of core stability exercises and treadmill training on balance performance in individuals with Down syndrome, it was reported that both training modes improved balance performance and there was no difference between the groups (30). The findings of this study show that AT and PT may be among the preferred interventions to improve lower and upper extremity muscle strength and balance performance in individuals with autism.

Inadequate motor function in children with autism prevents children from playing with their peers and participating in physical activities and negatively affects the child's social acceptance, language and behavioral development, physical fitness, general well-being, and quality of life (7). Therefore, it can be said that one of the most important results of our study is that the gains in muscle strength and balance performance are reflected in function, namely gross motor skills. As a result of our study, there was an improvement in object control skills

after the training in both groups. To perform complex motor patterns such as object control, afferent information must be processed swiftly and efficiently. This requires the coordination of cognitive function and executive functions, as well as motor competence such as muscle strength and postural stability (36). A previous study reported that children with ASD exhibited more postural sway during the gross motor performance, and their gross motor skills were negatively affected by postural sway (37). This result suggests that the improvement in balance performance in both groups will contribute to gross motor skills. In addition, it was emphasized in the literature that mind-body exercises improve attention and executive functions more than standard physical exercises (17), which suggests that the contribution of PT to executive functions may be another factor that positively affects motor skills in this group. When the current studies are examined, it is seen that studies investigating the effects of AT including bicycle ergometer/treadmill training and mind-body exercises on motor skills in ASD are limited. Several studies have shown that yoga and Tai Chi Chuan training, which are mind-body exercises, have some benefits in various motor areas such as bilateral coordination, motor skills, ball skills, and balance performance (16,17). When we look at the studies on AT, one study reported that motor skills improved after a program consisting of 30 minutes of bicycle ergometer and motor skill training lasting 3 weeks (9 sessions in total) (10). In another study, the effect of a camp involving outdoor cycling for 1 week on motor skill acquisition was investigated, and it was reported that, after the camp, all participants exhibited motor skill acquisition and half of the participants were able to independently ride a bicycle (38).

Social skills are defined as an individual's ability to interact and communicate appropriately with others through talking, actions, and body language. Social skill deficits typical of autism include impairment in initiating, maintaining, and ending interaction, making eye contact, reading others' non-verbal cues, and responding appropriately (9). As a result of this study, although physical gains were achieved, no improvement in social skills was observed in both AT and PT groups. Within the scope of our study, we think that the three main factors affecting the development of social skills are: (i) In ASD, after physical activity interventions, social skills are more difficult to develop and they are less developed than other affected skills (39), (ii) social interaction and participation opportunities are insufficient within the scope of individually planned AT and PT, and (iii) the training dose is not at a level that will reveal the development of social skills. Current evidence emphasizes that the key factor in promoting social skill development is increasing the experience of social interaction. It is emphasized that the physical activity intervention to be implemented should include peer interaction, therapist-participant interaction, or interaction with animals, as in hippotherapy (9,40). In our study, although AT did not require social participation and communication, PT required visual and verbal communication between the participant and the physiotherapist. However, PT may not have offered as many opportunities for social communication and participation as interventions involving group play and peer interaction. In addition, when previous studies that provided improvement in social skills in ASD are examined, it is seen that the duration or intensity of intervention is longer than that in our study (9). AT and PT, consisting of a total of 12 sessions, may not be sufficient to achieve improvement in social skills. For this reason, AT and PT, which provide longer and more intense social participation and communication opportunities in children with autism, can improve social skills.

Limitations and Future Directions

The small sample size is the limitation of this study. In future research, we suggest investigation of the following aspects: (i) long-term effects of physical gains with AT and PT, (ii) the impact of these interventions in other age groups, (iii) the impact of AT and PT on the quality of life of children with autism and the caregiver's psychosocial status, and (iv) whether social skills improve with more intense and longer-lasting PT intervention.

5. CONCLUSION

Results from this study provide the first evidence that individually planned PT can improve muscle strength, balance performance, gross motor skills but not social skills in children with autism. On the other hand, PT is not superior to AT for improving the mentioned physical domains. PT may be a safe, cost-effective, attractive, and beneficial alternative to AT for children with autism and can be adapted for the child's needs.

Ethical Consideration of the Study

Aydın Adnan Menderes University Faculty of Health Sciences approved all procedures with the 1964 Helsinki declaration. Parents provided written consent and children verbal assent for participation.

Conflict of interest statement

No conflicts of interest.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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