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Lifestyle Modification for Autism-Spectrum Disorder, the Effects of Functional Training Along With Online Nutritional Education on Physical Fitness Parameters: A Randomized Clinical Trial

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Abstract

Introduction: COVID-19 pandemic has affected individual lives in several aspects, including physical activity and dietary pattern, which are common challenges among children with autism spectrum disorder (ASD). The purpose of this clinical trial was to investigate the effect of functional training along with online nutritional education on physical fitness indicators in 8-12 years old children with ASD.

Methods: Eighty children with ASD (age=9.73±1.29 years, weight=49.94±2.08 kg, height=146.08±40 cm, BMI percentile=64.88±2.89, fat mass percentage=24.71±1.48) were randomly divided into four groups, including: (1) functional training, (2) online nutritional education, (3) functional training+nutritional education, and (4) control group. The interventional groups received their specific interventions for eight weeks and three session per week. The control group did not receive any intervention. Physical fitness indicators were assessed prior to the intervention and at the end of eight weeks.

Results: There was no significant difference between the demographic and physical fitness parameters (PFPs), including upper limb, lower limb, abdominal, trunk strength, cardio-respiratory fitness, dynamic and static balance, flexibility, speed, and 1 repetition-maximum (1RM) between the groups before the interventions ($P>0.05$). There was a significant improvement in physical fitness indicators in all the interventional groups in comparison with the control group ($P\leq0.001$).

Conclusion: The results of this study indicated that functional training and online nutritional education may improve physical fitness indicators in ASD children, offering beneficial health outcomes during the COVID-19 pandemic.

Keywords: Autism spectrum disorder, COVID-19, Functional training, Online nutritional education, Physical fitness

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Introduction

Since the late 2019, the COVID-19 pandemic has been considered a global health concern[1] affecting the quality of life and causing physical inactivity due to quarantine. These effects seem to be more apparent for individuals with health-related complications such as individuals with autism spectrum disorder (ASD).[2]

It is well-known that physical activity can have beneficial effects on children's health, although it has been indicated that most of children do not meet

the optimal physical activity level which may lead to negative health and wellness outcomes.[3] Physical activity becomes more important in children with developmental disorders, as it is crucial for healthy life. There are several types of physical activities suggested for children with developmental disorder, including rhythmic activities and functional training which may improve physical fitness indicators such strength[4] and cardio-respiratory system capacity.[5,6]

This may become more important as it seems that children with ASD are more susceptible to health-related problems due to sedentary lifestyle and inactivity.[7] Besides the importance of physical activity, nutrition is another important factor for school-aged children and has been suggested to be associated with poor physical fitness.[8] Recent studies have suggested that children with ASD usually experience food sensitivity, food selectivity, and restricted dietary pattern, which are considered as common nutritional challenges.[9] Poor nutrition knowledge may lead to unhealthy food choices that can impact both physical and mental aspects.[10] It seems that improvement in nutritional knowledge may enhance PFP.[11] Furthermore, a relationship has been suggested between nutritional knowledge, nutrition status, and aerobic fitness.[12]

Health related problems in children with ASD may be partly due to low physical activity level and poor nutritional knowledge. It is assumed that improving caregiver's knowledge along with increase in physical activity may improve health status in comparison with each intervention when assessed individually.[13] Due to insufficient and inconsistent data from previous studies, the aim of this study was to investigate the effect of functional training along with online nutritional education on PFP in children with ASD during the COVID-19 lockdown.

Materials and Methods

Study Settings

This study was a randomized-controlled clinical trial with pre-test and post-test assessments. The participants were 8-12 years old children with ASD (age = 9.73 ± 1.29, weight = 49.94 ± 2.08 kg, stature = 146.08 ± 40 cm, BMI percentile = 64.88 ± 2.89, fat mass percentage = 24.71 ± 1.48), approved by a neurologist, referred to selected autism care organizations during 2020 in Tehran, Iran. Eighty verified participants were randomly selected by targeted sampling out of 100 available individuals according to Morgan's chart. Participants received specific codes using random allocation software without researcher awareness and were randomly divided into four groups as following: (1) functional training, (2) online nutritional education, (3) functional training + nutritional education, and (4) control. Codes 1-20 were specified for the functional training group, codes 21-40, 41-60, and 61-80 were specified for online nutritional education, functional training + nutritional education, and control groups, respectively. The researcher was blinded to all subject recruitment, randomized code specification, and grouping were to prevent bias.

Inclusion/Exclusion Criteria

Inclusion criteria for this study were as follows:

- No contraindication for exercise
- No physical exercise experience within the past six months
- Not reaching puberty according to a specialist

Participants were allowed to leave the study whenever they desired and excluded in case of absence for more than two sessions (Figure 1).

Study Procedure

Anthropometric and PFP were measured prior to the intervention. The Beurer digital scale (PS160) was used to measure participant's weight with the lightest clothing possible. Seca stature meter 206 with the precision of 1 mm (Germany) was used to measure the participant's stature. Participants should have taken off their shoes. A tape meter was used to measure waist and hip circumferences. To measure body fat, caliper was used in 5 points including biceps, triceps, abdominal, super iliac, and subscapular point considering the ICC = 0.9.[14] Body mass index (BMI) was assessed according to Centers for Disease Control and Prevention (CDC) growth chart and was recorded in percentile.

Physical Fitness Indicators Measurements

Lower limb strength was assessed using the Sit-to-Stand test. Participants were asked to sit on a chair with a holder and sit and stand as many times as he/she could within 30 seconds while the feet were on the floor. Movements were assumed as valid if there was at least 75 degrees extension in the hip joint.

For upper limb strength, 1 kg dumbbell press was used, and the participants were asked to lift 1 kg dumbbell as many times as they could within 30 seconds until exhaustion.

Abdominal strength was measured by sit-ups. The participant was asked to do sit-ups as many times as he/she could within 30 seconds, and maximum record was registered.

For trunk strength assessment, participants were asked to lift their trunk from the floor for at least 1 second, and the best time was recorded. The test was repeated for three times. 1RM was measured using the elbow flexion in biceps test. The modified sit & reach test was taken for flexibility, and the participants were asked to sit against the board and bend their both hands and hold for at least 1 second, while one leg was straight and the other

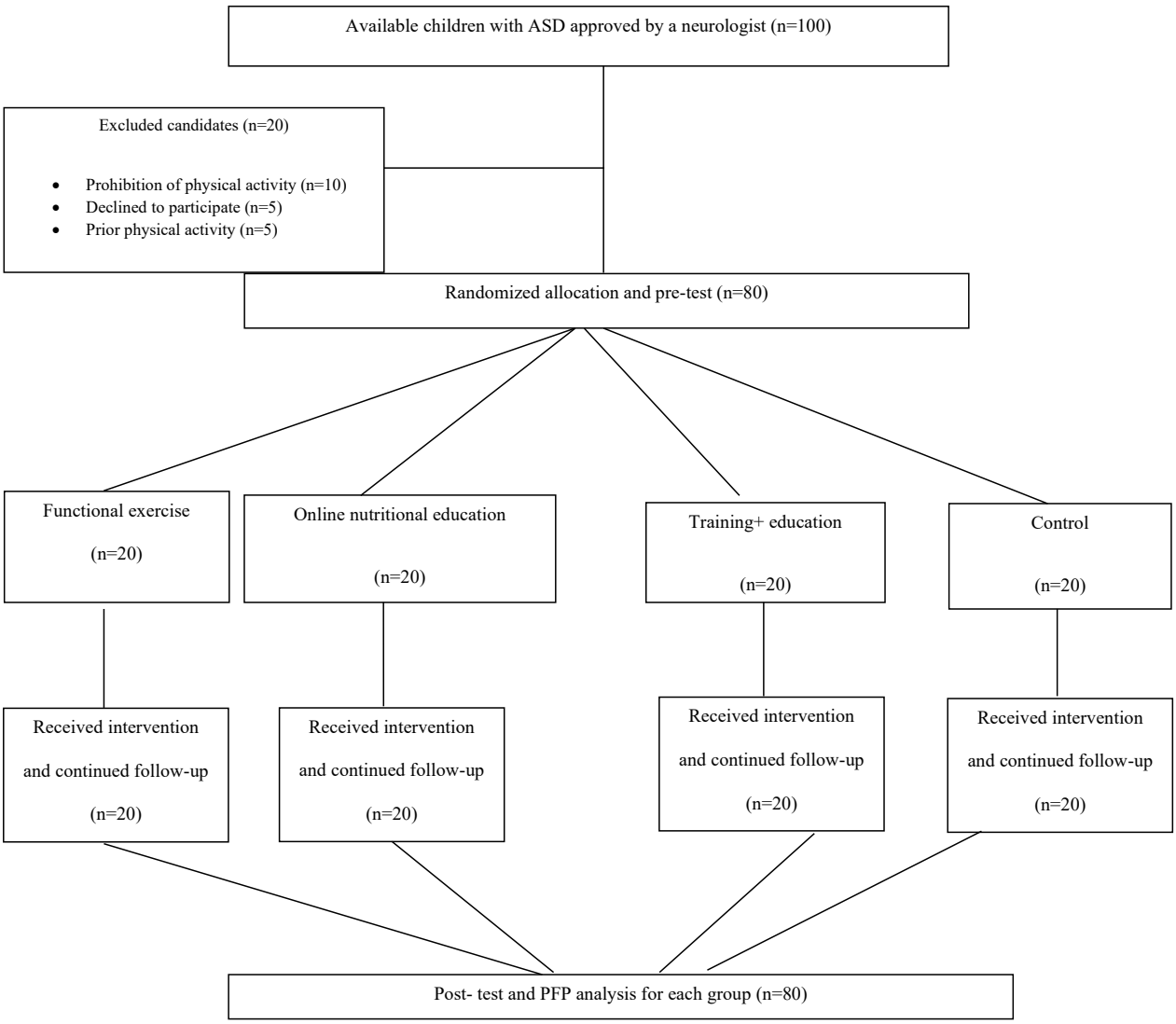

Figure 1. Study Flowchart. PFP; physical fitness parameter

was bent. The test was repeated for three times, and the best record was registered. The test was repeated for the opposite side.

Static balance and dynamic balance were assessed using the Flamingo test and TUGT (Time-Up-Go-Test), respectively. For the flamingo test, participants were asked to stand on their dominant feet and bend the opposite feet from their side with hands on the waist while looking at the tester. Best records were registered in seconds. In TUGT, participants were asked to sit on an adjustable chair without a sit cushion and holder (the angle between knee and hip must be 90 degrees and feet should be on the floor). Participants were asked to walk a 3-m distance, turn around the barrier, come back to the start position, and sit. The test was repeated three times, and the best record was registered in second.

Cardio-respiratory fitness (VO2max) was assessed using the Indoor 6 minutes walking test (6MWT). Participants were asked to walk as much distance as they could within six minutes at their own pace (the rest time was measured) on a route which was marked every 2 meters and had `1 m width. The heart rate was measured using a digital pulse-oximeter.

Interventions

Functional Training

The functional training program and its progression within eight weeks have been shown in Table 1 and Figure 2. Functional training group participants took part in a functional training program for eight weeks, three sessions per week, and 60-45 minutes for each session. Each session included warm-up, stand-sit with weights, going up and down the stairs, stretch movements, and cooling down under a specialist's supervision.[15-17]

Online Nutritional Education

Participants in the nutritional education group participated in an online nutritional education program for eight weeks, three times per week for 30-15 minutes.[18]

Table 1. The Functional Training Program

Training	Protocol	Repeats	Rest	Set Number	Progression	Acceptance Criteria
Sits to stand	Participants were asked to: sit according to following situation: Hip flexion at 90◦, knee flexion at 105◦, ankle dorsiflexion at 15◦, feet on the floor and hands, on the chest crosswise. The participant was asked to stand from sitting position without any change in situation at his own pace. Repeats were counted.	8-10	3 min	3-5	Freeload for the first week 30% 1RM for the second week Progress from 50% to 60% and 60%-70% 1RM every 2 weeks	Movements were acceptable in case of 15 degree extension between the hip and knee
Step up and down	Participant was asked to: stand in front of a 17 cm height stair go up and down the stair at his own pace	8-10	3 min	3-5	Freeload for the first week 30% 1RM for the second week Progress from 50% to 60% and 60%-70% 1RM every 2 weeks	Reaching the foot to the start position

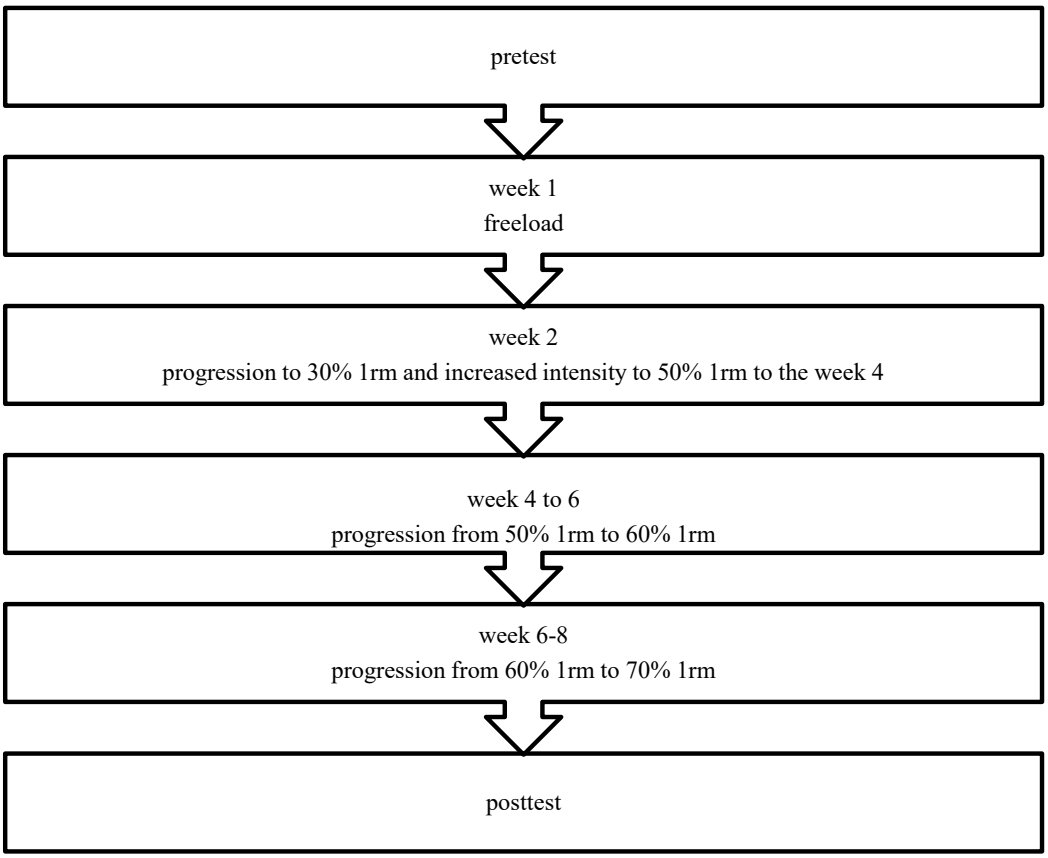

Figure 2. Functional Training Progression During Eight Weeks of the Intervention

The aim of the online nutritional educational program was to improve caregivers' nutritional knowledge in order to improve children's dietary pattern quality and included four areas according to the NKQ approach as following: (1) nutritional advises, (2) food groups, (3) healthy food choices, and (4) diet-related disease and weight management (Table 2).[15-18]

Exercise + online Nutritional Education

Participants in the exercise + education group participated in functional training, three sessions per week for 60-45 minutes, as well as the online nutritional education program three times per week, 30-15 minutes each time, for eight weeks.

Control Group

Anthropometric and physical fitness measurements were assessed before and after the study, and the control group did not receive any intervention.

Posttest

Physical fitness indicators were again measured after

eight weeks of the intervention.

Statistical Analysis

Demographic and physical fitness parameters' (PFPs') mean values were compared between the experimental and control groups using one-way ANOVA in SPSS version 22 software before the intervention. ANCOVA and Bonferroni tests were used to assess the intervention effects and to designate the origin of difference in paired comparisons. All statistical analyses were done in the level of significance of $P \leq 0.05$.

Results

The participants of this study were 8-12-year-old boys with ASD diagnosed by a specialist. Table 3 shows the

Table 2. The Online Nutritional Education Program

Titles	Subtitles	Duration
Food groups	Bread and grains Meat and substitutes Fruits and vegetables Fats (saturated fats, MUFAs and PUFAs) Dairy Salt Water and fluids Food portions and balanced food plates	• 2 weeks • 3 sessions per week • 15-30 minutes per session
Food recommendations	Food calorie Processed foods Simple sugars Fiber Protein sources Starchy sources Food fats (natural fats, trans fats) Vitamins and minerals	• 2 weeks • 3 sessions per week • 15-30 minutes in each session
Healthy food choices	Healthy food choice in outdoor Sweeteners Best cooking ways (grilling, broiling or frying) Nutrition facts label and their colors Calorie intake importance and moderate calorie dietary choices	• 2 weeks • 3 sessions per week • 15-30 minutes in each session
Nutrition-related disease and weight management	Fiber and disadvantages of its low intake Simple sugars and disadvantages of their excessive intake Salt/sodium and its related diseases Food additives and cancer Fats and cardio-vascular disease (comparison between healthy fats including fish or vegetable oil with trans fats) Bread, grains and diabetes (importance of whole grain intake instead of refined carbohydrates) Cholesterol and lipids (eggs, vegetable oils, saturated fats and animal-based fats) Glycemic index (difference between whole grains and white bread, fruits, and vegetables) Fats and weight management Weight management and high protein diets False and myths (elimination of fats or bread for weight loss) Fiber importance in weight management Health behavior for weight management in normal range (including not watching TV while eating, addressing nutrition label facts, regular weight assessment, supplements necessity) Body Mass Index (BMI) and weight ranges (underweight, normal, overweight and obesity) Obesity categories definition and diseases risk (e.g., cardiovascular disease)	• 2 weeks • 3 sessions per week • 15-30 minutes in each session

Table 3. Comparison of Demographic Features Between the Experimental Groups

Variables	Groups				*P* Value*
	Functional Training	Online Nutritional Education	Functional Training + Online Nutritional Education	Control	
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
Age (y)	9.60 ± 1.39	9.60 ± 1.18	9.95 ± 1.43	9.80 ± 1.24	0.80
body weight (kg)	50.45 ± 2.67	49.94 ± 1.20	49.64 ± 1.36	49.74 ± 2.68	0.63
Stature (cm)	145.81 ± 2.63	146.83 ± 2.33	146.44 ± 1.86	145.26 ± 2.60	0.18
BMI (percentile)	64.20 ± 1.36	64.65 ± 1.42	66.00 ± 5.18	64.70 ± 1.49	0.23
Fat mass (%)	24.9 ± 1.41	24.3 ± 1.59	24.9 ± 1.44	24.75 ± 1.51	0.54
WHR	0.83 ± 0.02	0.83 ± 0.02	0.83 ± 0.01	0.82 ± 0.02	0.35

BMI; body mass index, WHR; waist to hip ratio.
* $P \leq 0.05$ was considered as significant.

demographic information of the participants who were randomly divided into four groups. There was no significant difference in terms of biological characteristics, including age, body weight, and height ($P>0.05$). Table 4 indicates PFP measurements before the interventions, showing no significant difference ($P>0.05$).

The results indicated that there was no significant difference for upper limb strength before the study ($P=0.30$) but the significant difference was seen after the interventions ($P<0.001$). The Bonferroni test results showed a significant difference between training and online education group ($P<0.001$). Also, there was a significant difference between training and training + education group ($P=0.002$). There was a significant difference between online education and training + education groups ($P<0.001$).

There was a significant difference for lower limb strength between the groups prior to the intervention ($P=0.001$) and this significant difference was remained after the intervention ($P<0.001$). Lower limb strength increase was significant for training and training + education in comparison to control group, respectively. The Bonferroni test results showed a significant difference between the training and education groups ($P=0.003$) and between the education and training + education groups ($P=0.003$).

There was significant difference in terms of trunk strength prior and after the intervention ($P=0.008$ and $P<0.001$, respectively). There was a significant difference between the training and training + education in comparison to the control group. There was a significant difference for endurance after the intervention ($P<0.001$), which was related to the difference between the training and training + education groups in comparison to the control group.

Table 4. Comparison of Physical Fitness Parameters Between the Study Groups at the Baseline

	Groups				*P* Value*
	Functional Training	Online Nutritional Education	Training + Education	Control	
Upper limb strength	3.85 ± 0.67	3.95 ± 0.75	4.20 ± 0.61	4.15 ± 0.58	0.30
Lower limb strength	7.93 ± 0.19	8.14 ± 0.20	7.87 ± 0.24	8.03 ± 0.19	0.001
Abdominal strength	8.30 ± 0.92	8.50 ± 0.82	7.85 ± 1.22	7.90 ± 1.16	0.15
Trunk strength	6.05 ± 1.27	6.95 ± 0.99	7.10 ± 0.85	6.95 ± 0.99	0.008
Cardio-respiratory endurance (6MWT)	289.55 ± 2.89	289.00 ± 2.49	289.40 ± 2.72	289.75 ± 2.81	0.85
Dynamic balance	9.05 ± 0.76	9.20 ± 0.76	8.95 ± 0.82	9.05 ± 0.82	0.79
Static balance	6.90 ± 0.75	6.40 ± 1.04	6.32 ± 0.91	9.40 ± 13.11	0.41
flexibility	17.95 ± 0.31	17.89 ± 0.39	18.03 ± 0.27	17.97 ± 0.32	0.57
Speed (10MWT)	1.08 ± 0.10	1.10 ± 0.11	1.11 ± 0.11	1.15 ± 0.10	0.30
1RM	3.50 ± 0.51	3.55 ± 0.51	3.45 ± 0.60	3.50 ± 0.51	0.95

6MWT; 6 minutes walking test 1RM; one-repetition maximum.
* $P \leq 0.05$ was considered as significant.

Table 5. Physical Fitness Parameters Measurement in Comparison with the Control Group

PFP	Group				*P* Value*
	Functional Training	Online Nutritional Education	Training + Education	Control	
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
Upper limb strength	5.25 ± 0.85	4.00 ± 0.56	4.90 ± 0.79	4.30 ± 0.57	<0.001
Lower limb	10.15 ± 1.27	8.70 ± 0.66	10.15 ± 2.41	8.56 ± 0.76	<0.001
Abdominal strength	10.50 ± 1.36	8.45 ± 0.83	10.25 ± 1.89	7.95 ± 1.10	<0.001
Trunk strength	8.00 ± 0.79	7.40 ± 0.88	8.05 ± 0.83	7.40 ± 0.75	<0.001
Endurance	292.60 ± 3.12	289.70 ± 3.53	307.85 ± 4.34	290.20 ± 2.63	<0.001
Dynamic balance	11.95 ± 0.76	10.00 ± 0.86	12.15 ± 1.18	9.15 ± 0.81	<0.001
Static balance	6.47 ± 0.68	6.56 ± 1.04	6.40 ±	9.40 ± 13.11	0.001
Flexibility	18.39 ± 0.51	17.82 ± 0.43	18.21 ± 0.30	17.97 ± 0.32	<0.001
Speed (10MWT)	1.43 ± 0.07	1.15 ± 0.12	1.38 ± 0.13	1.16 ± 0.09	<0.001
1-RM	5.60 ± 0.75	3.60 ± 0.68	5.20 ± 1.11	3.60 ± 0.50	<0.001

6MWT; 6 minutes walking test 1RM; one-repetition maximum.
* $P \leq 0.05$ was considered as significant.

The difference between groups was significant regarding 1RM after the intervention ($P<0.001$). The Bonferroni results indicated the significant difference was between the training and online education ($P<0.001$), as well as between the online education and training + education groups ($P<0.001$).

There was a significant difference for dynamic and static balance ($P<0.001$) and flexibility ($P=0.001$) after the intervention comparing the experimental groups to the control group. Table 5 shows the comparison of PFP between the study groups.

Discussion

The purpose of this study was to evaluate the effects of eight weeks of functional training along with online nutritional education on PFPs in children with ASD. Physical fitness and performance indicators were assessed prior to the study and after the interventions using modified tests. Physical inactivity and nutrition-related problems, including food choices, food sensitivities, and restricted dietary pattern, are common challenges among children with ASD, exaggerated due to the COVID-19 lockdown and lack of caregiver's knowledge, which may increase these children's vulnerability to health-related complications in their future life, especially during the COVID-19 pandemic.[19] Our results indicated that functional training could improve physical fitness indicators in ASD children. Previous studies have suggested that an increase in physical activity level may be beneficial in improving physical fitness in children with developmental disorders.[6] Functional training has been introduced as an effective intervention for improving PFP, including upper limb strength, lower limb strength and cardio-respiratory endurance, which may be observed following 8-12 weeks of functional training.[20]

Furthermore, nutritional education has been introduced as an effective strategy for nutritional challenges in ASD.[21] The results of the current study indicated that eight weeks of functional training was the most effective intervention for upper limb strength improvement. Also, there were significant improvements in the online nutritional education group as well, both individually and when combined with functional training, in comparison to the control group. These results were similar for lower limb strength with this difference that online nutritional education could not affect lower limb strength significantly. The effectiveness of functional training + online nutritional education was higher in comparison to functional training alone. Functional training could improve abdominal muscular strength especially when combined with online nutritional education. The results were similar for trunk strength. Although online nutritional education alone could improve trunk strength, this effect was not significant.

The most effective intervention among all of the three strategies for improving cardio-respiratory endurance was the combination of functional training and online nutritional education. No study was found on the combination of training and nutritional education. More research is suggested to determine if functional training can lead to continuous and moderate improvement in physical fitness and cardio-respiratory capacity.[22] Our results indicated that functional training could improve endurance. Although it seems that nutritional knowledge is related to aerobic capacity, which is represented in maximum oxygen consumption (VO2max). A study showed a significant effect for nutritional knowledge on the improvement of aerobic fitness,[11] but no significant improvement in endurance was observed in the education group. Functional training and online nutrition education could enhance dynamic balance especially in combination with each other. Although the least effect was seen for online nutritional education, but nutritional education should be considered as a key component and a preventative intervention, especially in school-aged children.[23] Moreover, PFPs, including balance, is affected by nutritional knowledge, as knowledge can affect BMI which has been shown to have adverse effects on some physical fitness indicators, including balance, strength, and aerobic performance.[9] Functional training could significantly improve static balance while the two other interventions were not able to improve static balance significantly. So, it seems that functional training was an effective intervention for static balance improvement.

The results of this study have indicated that functional training was the most effective intervention for improving flexibility, speed, and muscular strength (represented as 1RAM) in comparison to nutritional education. Previous studies have suggested that nutrition plays an important role in physical fitness, and a poor dietary pattern can lead to poor physical fitness.[24]

Conclusion

This was the first study on the effect of functional training and online nutritional education on PFP in children with ASD in Iran. As other studies, this clinical trial had some limitation including family's low tendency for attending outdoor sessions, need for special laboratory staff for blood sampling, and difficulties for referring to a laboratory. In conclusion, both functional training and online nutritional education, alone or in combination, were proven to be effective and beneficial interventions to improve PFPs in children with ASD during the COVID-19 pandemic. More clinical trials are needed to further confirm the efficacy and effectiveness of each intervention.

Acknowledgments

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and physical education trainers in the collaborating centers.

Authors' Contribution

KM carried out the assessments, study protocols, sequence alignment, and drafting the manuscript. MG arranged the requirements for the study, participated in statistical analysis and preparing the manuscript. HD participated in clinical arrangements and study design. ME participated in clinical assessments and participants arrangements. SR provided required equipment for the study.

Conflict of Interests

The authors declare that there is no conflict of interest.

Ethical Approval

The study was approved by the ethics committee of the Islamic Azad University, Science and Research Branch, Iran (IR.IAU.SRB.REC.1400.003), and was registered at Iranian Registry for Clinical Trials (IRCT20201211049678N1) available at https://ethics.research.ac.ir/ and https://www.irct.ir/search, respectively.

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