Research Article

Evaluation of functional training along with online nutritional education on autistic children's metabolic status during Covid-19 pandemic-A randomized clinical trial

Kimia Moiniafshari, Mandana Gholami*, Hamid Dalvand, Mohammad Efatpanah, Saeed Rezayi

Abstract

Physical inactivity and poor dietary pattern are considered as health related challenges in ASD (ASD) which seems to be affected by Covid-19 pandemic. The purpose of this clinical trial was to investigate the effect of functional training along with online nutritional education on metabolic related biomarkers in children with ASD. 80 verified 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, FM percentage+24.71 ± 1.48) were randomly divided into four groups including: (1) functional training, (2) online nutritional education, 3) training+ education and 4) control group. Pre-test was taken for metabolic related biomarkers and each experimental group received their interventions for 8 weeks. Post-test was taken at the end of 8 weeks. The results from this study, did not show significant changes for WHR (sig=0.06). Significant changes was indicated for FM (sig<0.001), TC(sig<0.001), TG (sig=0.006), HDL (sig<0.001), LDL (sig=0.001), HOMA (sig=0.04). In conclusion, functional training and online nutritional education can be considered as beneficial interventions for metabolic related biomarkers improvement in children with ASD during Covid-19 pandemic.

***Mandana Gholami, Kimia Moiniafshari**, Kimia Moiniafshari, Department of Physical Education and Sports Sciences, Islamic Azad University, Science and Research Branch , Tehran, Iran , **Hamid Dalvand**, Department of Rehabilitation, Tehran University of Medical Sciences, Tehran, Iran, **Mohammad Efatpanah, Saeed Rezayi**, Department of Psychology and Educational Science, Tehran University of Medical Science, Tehran, Iran.*

***Corresponding author:** Mandana Gholami,*

***e-mail:** gholami_man@yahoo.com*

***Received:** 29 December 2022, Manuscript No. ajdm-21-49328; **Editor assigned:** 31 December 2022, PreQC No. ajdm-21-49328 (PQ); **Reviewed:** 14 January 2022, QC No ajdm-21-49328; **Revised:** 21 January 2022, Manuscript No. ajdm-21-49328 (R); **Published:** 31 January 2022, **DOI:** 10.54931/ajdm- 30.1.3.*

Introduction

Covid-19 pandemic has affected individual's life in several aspects and it seems that people with health related condition including autistic individuals are the most affected.[1] Training is well known as one of the main treatment in diabetes type 2 and cardiovascular diseases and it seems to improve insulin sensitivity and cardiovascular system. Among all types of physical activities, high intensity functional training may have beneficial outcomes and protective effects on cardiovascular and metabolic system.[2] Besides physical activity and training, balanced dietary pattern, provides all the required macro nutrients and energy according to age and gender, though imbalanced diet and increased fat consumption may lead to metabolic disorder, dyslipidaemia and inflammation which seems to be modifiable via education.[3]

ASD (ASD), is a neuro developmental disorder which is diagnosed mostly at the early stage of childhood and is identified with social communication impairment.[4] ASD has gained a growing trend within the recent years.[5] According to Autism and Developmental Disabilities Monitoring (ADDM) and CDC reports, autism prevalence has increased from one per 60 one per each 54 person.[6] Studies have suggested that physical activity level is less in children with autism in comparison to typically developed children which may be as a result of both individual and environmental factors which have made physical activity to a challenge.[7,8] This challenge may lead to higher obesity and metabolic disorders prevalence in children with ASD.[9] On the other hand, Nutrition related problems are prevalent among children with ASD which can affect their obesity.[10] ASD children are prone to insufficient nutrition and nutritional deficiencies, although the consumption of calorie dense foods are more common in ASD which is responsible for 40% higher obesity prevalence in ASD children.[11]

Empowering caregivers with appropriate nutritional and physical activity interventions is necessary for children with ASD and their caregivers, in this area, anthropometric measurements and dietary pattern follow up and body composition, can be included.[12,13] Previous studies have shown a reverse relation functional training with metabolic syndrome and have suggested that this type of training may improve glucose metabolism, body FM and training capacity.[14] Regular functional training program can have beneficial effect on body composition and may lead to increase in Free FM (FFM) and decrease in FM (FM) in comparison with controls.[15] Furthermore, functional training seems to improve lipid profile and studies have suggested that functional training can decrease LDL cholesterol TG

(TG), cholesterol and improve insulin sensitivity.[16,17]

Recent studies on the effect of nutritional education on dietary pattern in children with ASD, have indicated that gastro intestinal problems and inflammation are common among these children and have led to more susceptibility against inadequate calorie intake and nutrients mal absorption, this may be modified through caregiver's nutritional education.[18] Low nutritional knowledge may be a leading cause for nutrition related problems in children with ASD.[19] It has been suggested that nutritional education may improve metabolic indicators including: Body Mass Index (BMI), Waist To Hip Ratio (WHR), lipid profile and can help obesity management and its related outcomes in children and adolescents, although the results are inconsistent and some studies have suggested no significant improvements, despite improvement in nutritional knowledge.[20-23] In the other word, it seems that the effective nutritional intervention for children with ASD, it is unknown yet.[24] The purpose of this study was to investigate the effect of functional training along with online nutritional education on metabolic indicators in children with ASD during Covid-19 pandemic.

Methods

This study was randomized controlled clinical trial with pre-test and post-test assessment. The participants were 8 years-12 years old children with ASD approved by neurologist who referred to selected autism organizations within the past year in Tehran, Iran. 80 verified participants were randomly selected by targeted selection among 100 available individuals according to Morgan's chart. Participants received specific codes using random allocation software without researcher awareness and were randomly divided into 4 groups as following: (1) functional training, (2) online nutritional education, (3) training education and (4) control group. Codes 1-20 was assigned for functional training group, codes 21-40, 41-60 and 61-80 were specified for online nutritional education, training+ education and control groups, respectively. All the sample selection, randomized code specification and grouping were without researcher awareness in order to prevent bias. All the study procedure was done under occupational therapist, physiotherapist and dietician supervision and cooperation. The study protocols were approved by the Islamic Azad university, science and research branch of Iran ethics committee and were registered as clinical trial at Iranian Registry of Clinical Trial with the IR.IAU.SRB.REC.1400.003 (approved at 16.0602021) and IRCT20201211049678N1 (approved at 29.07.2021) identification numbers and are available at https://ethics.research.ac.ir/and https://www.irct.ir/search, respectively.

The inclusion criteria for this study were as follows:

- No inhibition for training,
- No physical training experience within the past 6 month,
- Not reaching to puberty according to specialist approval.

Study procedure

Before the study and any interventions, caregivers were invited to familiarization session. All the study purpose and procedure were completely and clearly explained to the participants. All the volunteers signed letter of consent. Health file was made for each participant and previous biochemical laboratory data, medication, physical activity experience, 24 hour food recall and Food Frequency Questionnaire (FFQ) data were collected.[25]

Caregivers were instructed about how to complete FFQ prior to the study. All the completing processed were recruited under dietician supervision. In order to simplify, home based scales were used and were then transmitted to grams according to reference database and were calculated using N4 software and Nutrition Knowledge Questionnaire (NKQ) was used to assess caregiver's nutritional knowledge.[26]

Children's Physical Activity Questionnaire (CPAQ) was used to assess physical activity status in the participants before and after the intervention which assess physical activity level.[27]

Anthropometric measurements

Anthropometric measurements and metabolic related biomarkers were measured prior to the intervention. Beurer digital scale PS160 was used to measure participant's weight with the possible lightest clothing. Seca stature meter 206 with the precision of 1 mm made in Germany was used to measure participant's stature. Participants should take off their shoes. Tape meter was used to measure waist and hip circumference. To measure body fat, calliper was used in 5 points including biceps, triceps, abdominal, super iliac and subscapular. Body Mass Index (BMI) was assessed according to Centres of Disease Control (CDC) growth chart and was recorded in percentile.[20]

All of the metabolic related biomarkers, including lipid profile (TG, TC, LDL, HDL) indicator and insulin resistance (HOMA) were assessed using anterior cubital vein blood samples before the study and after 8 weeks Interventions.

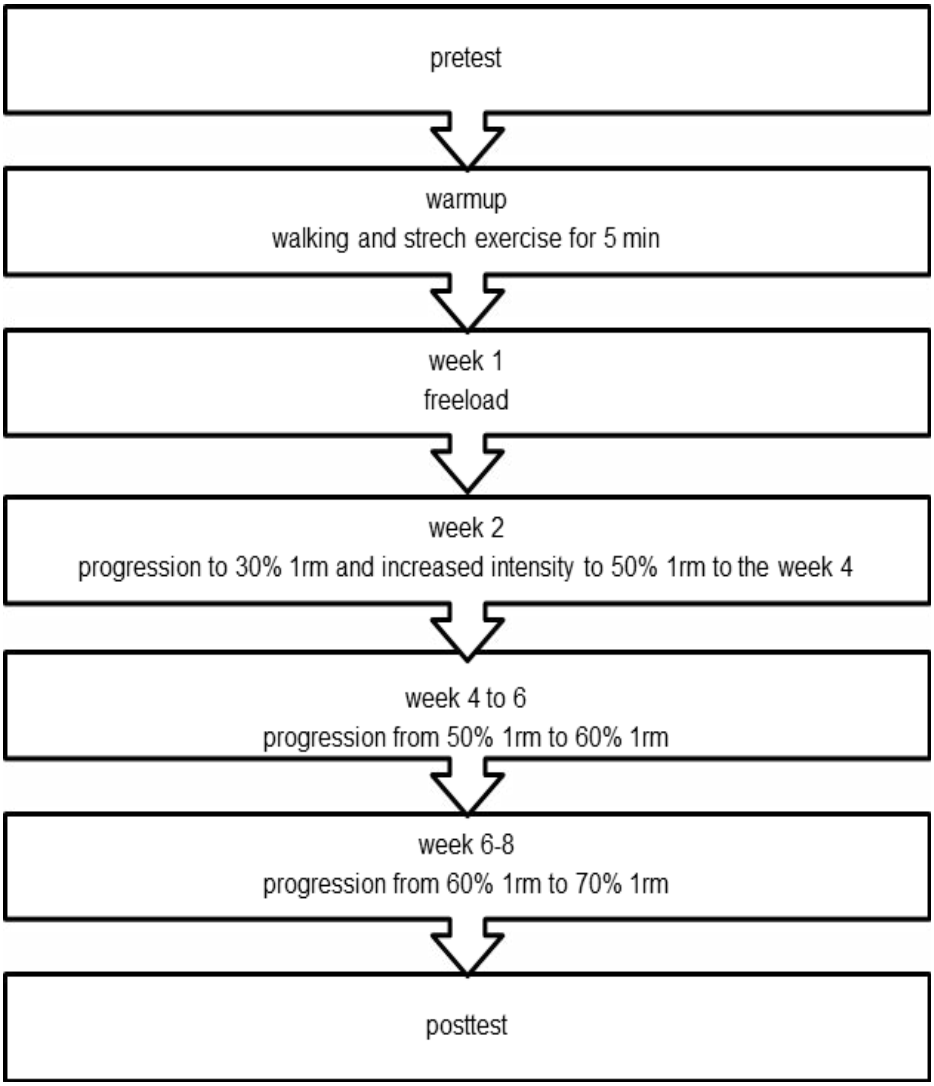
Functional training

Functional training program and it's progression within the 8 weeks, have been shown in Table 1 and Figure 1. Functional training group participants participated in functional training program for 8 weeks, 3 sessions per week and 45 minutes-60 minutes for each session. Each session included warm up, stand-sit with weights, going

Table 1: *Functional training program*

Training	Protocol	Repeats	Rest	Set number	Progression	Acceptance criteria
Sits to stand (STS)	Participants were asked to sit according to following situation: hip flexion at 90◦, knee flexion at 105◦, ankle dorsiflexion at 15◦ feets are on the floor and hands were on the chest crosswise participant was asked to stand from sitting position without any change in situation at his own pace. Repeats were counted	08-10	3 min	03-May	Freeload for the first week 30% 1RM for second week Progress from 50% to 60% and 60%-70% 1RM each 2 weeks	Movements were acceptable in case of 15 degree extension between hip and knee
Step up and down (SUD)	Participant was asked to: 1. stand in front of a 17 cm height stair 2. go up and down the stair at his own pace	08-10	3 min	03-May	Freeload for the first week 30% 1RM for second week Progress from 50% to 60% and 60%-70% 1RM each 2 weeks	Reaching the foot to the start position

Figure 1: *Unctional training progression within 8 weeks of intervention*



up and down the stairs, stretch movements and cool down under specialist supervision.[28-30]

Online nutritional education

Table 2 shows online nutritional education program. Participants in education group participated in online nutritional education program for 8 weeks, 3 times per week for 15 minutes-30 minutes.[31] Online nutrition educational program had targeted to improve caregivers nutritional knowledge in order to improve children's dietary pattern

Table 2: *Online nutrition educational program*

Titles	Subtitles	Duration
Food groups	·Bread and grains	· 2 weeks
	· Meats and substitutes	· 3 sessions per week
	· Fruits and vegetables	· 15-30 minutes in each session
	· Fats (saturated fats, MUFAs and PUFAs)	
	· Dairy	
	· Salt	
	· Water and fluids	
	· Food portions and balanced food plate	
Food recommendations	· Food calorie	· 2 weeks
	· Processed foods	· 3 sessions per week
	·Simple sugars	· 15-30 minutes in each session
	· Fiber	
	· Protein sources	
	· Starchy sources	
	· Food fats (natural fats, trans fats)	
	· Vitamins and minerals	
Healthy food choice	· Healthy food choice in outdoor	· 2 weeks
	· Sweeteners	· 3 sessions per week
	· Best cooking ways (grilling, broiling or frying)	· 15-30 minutes in each session
	· Nutrition facts label and their colors	
	. Calorie intake importance and moderate calorie dietary choices	
Nutrition related disease and weight management	·Fiber and disadvantages of low intake	. 2 weeks
	· Simple sugars and disadvantages of excessive intake	· 3 sessions per week
	· Salt/sodium and its related disease	· 15-30 minutes in each sess
	· 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)	

quality and included 4 areas according to NKQ approach as following: (1) nutritional advises, (2) food groups, (3) health food choices and (4) diet related disease and weight management.[32]

Training+ online nutritional education

Participants in training+ education group participated at functional training 3 session per week for 45 minutes-60minutes and online nutritional education program 3 times per week for 15 minutes-30 minutes for 8 weeks.

Control group

Metabolic related (Metabolic biomarkers) biomarkers were assessed before and after the study and control group did not receive any intervention.

Statistical analysis

Demographic and physical fitness biomarkers means were comprised using one-way ANOVA using SPSS version 22 software, before the interventions between the experimental and control groups. ANCOVA and LSD tests were used to assess the intervention effects, as ANCOVA test comprises the mean difference before and after the intervention with means modification and LSD test is used in case of any difference between the means and indicates the origin of difference in pair wised comparison. All of the statistical analysis was done in level of significance ≤0.05.

Results

The participants of this study were 80 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, FM percentage+24.71 ± 1.48) who participated and completed the study. There was no significant difference between the biological characters including age, body weight and stature (sig>0.05). Table 3 shows the demographic information of the participants who were divided into four groups randomly.

Table 3: *Frequency and demographic comparison within the experimental groups*

Groups	Functional training	Online nutritional education	Functional training+ online nutritional education	Control	Sig
variables	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
Age (yrs)	9.60 ± 1.39	9.60 ± 1.18	9.95 ± 1.43	9.80 ± 1.24	0.8
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 (kg/m^2)	64.20 ± 1.36	64.65 ± 1.42w	66.00 ± 5.18	64.70 ± 1.49	0.23
FM (percent)	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
TG (mg/dl)	113.85 ± 6.29	116.85 ± 6.33	115.50 ± 6.21	110.40 ± 6.83	0.01
TC (mg/dl)	187.70 ± 5.58	190.25 ± 5.81	189.70 ± 5.09	189.05 ± 5.15	0.48
HDL (mg/dl)	41.80 ± 2.65	42.60 ± 3.17	44.05 ± 2.98	43.00 ± 3.39	0.14
LDL (mg/dl)	150.20 ± 6.09	150.75 ± 6.39	150.50 ± 6.12	149.25 ± 5.99	0.88
Insulin resistance (HOMA)	63.95 ± 3.55	62.45 ± 3.23	64.00 ± 3.61	64.40 ± 3.38	0.3

Metabolic-related indicators

The comparison of metabolic biomarkers before and after the intervention and the difference between each groups, are indicated in Table 4. The results have shown that there was no difference in Body Mass Index (BMI) in groups before the intervention (sig=0.23), although there was a significant difference between the groups after the intervention (sig<0.001). The BMI in training group has decrease

Table 4: *Interventions effectiveness comparison for metabolic-related biomarkers within the experimental groups before and after the interventions*

Variables / Groups		Functional training Mean ± SD	Online nutritional education Mean ± SD	Functional training+online nutritional education Mean ± SD	Control Mean ± SD	Sig
FM (percentage)	Pre	24.9 ± 1.41	24.3 ± 1.59	24.9 ± 1.44	24.75 ± 1.51	0.54
	Post	24.45 ± 1.61	23.50 ± 1.99	24.00 ± 1.75	25.95 ± 1.47	<0.001
WHR	Pre	0.83 ± 0.02	0.83 ± 0.02	0.83 ± 0.01	0.82 ± 0.02	0.35
	Post	0.82 ± 0.02	0.83 ± 0.02	0.83 ± 0.01	0.83 ± 0.02	0.06
TG (mg/dl)	Pre	113.85 ± 6.29	116.85 ± 6.33	115.50 ± 6.21	110.40 ± 6.83	0.01
	Post	108.25 ± 7.45	113.70 ± 5.13	111.35 ± 5.82	110.50 ± 6.95	0.006
TC (mg/dl)	Pre	187.70 ± 5.58	190.25 ± 5.81	189.70 ± 5.09	189.05 ± 5.15	0.48
	Post	186.55 ± 4.38	189.90 ± 5.78	184.90 ± 4.85	189.00 ± 5.04	<0.001
HDL (mg/dl)	Pre	41.80 ± 2.65	42.60 ± 3.17	44.05 ± 2.98	43.00 ± 3.39	0.14
	Post	42.30 ± 2.68	44.65 ± 3.08	48.95 ± 5.12	42.15 ± 2.96	<0.001
LDL (mg/dl)	Pre	150.20 ± 6.09	150.75 ± 6.39	150.50 ± 6.12	149.25 ± 5.99	0.88
	Post	165.20 ± 39.57	141.00 ± 7.19	146.35 ± 7.03	149.60 ± 5.90	0.001
HOMA	Pre	63.95 ± 3.55	62.45 ± 3.23	64.00 ± 3.61	64.40 ± 3.38	0.3
	Post	62.50 ± 3.00	62.00 ± 2.73	63.60 ± 3.00	64.40 ± 3.32	0.04
	Pre	8.99 ± 1.06	8.41 ± 0.82	8.54 ± 0.75	9.69 ± 0.79	<0.001

Post	7.80 ± 0.95	7.60 ± 0.82	7.20 ± 0.83	8.20 ± 0.77	0.001
Pre	5.15 ± 0.88	5.08 ± 0.39	5.09 ± 0.44	5.47 ± 0.99	0.009
Post	1.72 ± 0.35	1.64 ± 0.41	1.52 ± 0.48	1.95 ± 0.37	0.003
Pre	0.04 ± 0.03	0.05 ± 0.02	0.03 ± 0.02	0.05 ± 0.02	0.01

by 2.56 unit (SE=0.58, sig<0.001). BMI in online education group has decreased by 2.79 (SE=0.58, sig<0.001) and for training and education group was 3.04 (SE=0.59 sig<0.001) in comparison to control group.

There was no significant difference for FM between the groups prior to the study, despite the significant difference was seen after the intervention. The fat mas for functional training, online nutritional education and training+ education, was decreases 1.58, 2.20 and 2.03 in comparison to control group respectively (SE=0.47, si <0.001 for all groups).

There was no significant difference between the groups in WHR before the study (sig=0.35). But after the intervention, the difference was near to significant level (sig=0.06). The WHR reduction for training and training+ education were 0.01 and 0.04, and for online education group no significant difference was seen in comparison to control group (sig=0.28). There was no significant difference according to LSD test for pair comparison between training and training+ education.

There was significant difference in participants TG level before the study (sig=0.01) and after modification at the end of the study (sig=0.006). The TG reduction was 4.82 units (SE=1.38, SIG=0.001) for training group. There was no significant difference for online education group (sig=0.27), although significant difference for training+ education group was seen (SE=1.41, sig=0.04). The LSD results showed no difference in paired intervention groups for training and training+ education group.

There was no significant difference for TClevel between the groups prior to the study (sig=0.48). There was a significant difference after modification at the end of intervention (sig<0.001). There was no significant difference between training and online education with control groups (sig=0.12 and sig=0.98 respectively). Although there was a significant difference between training+ education with control group (SE=0.89, sig<0.001). The LSD test results showed no significant difference between training and online education group.

There was no significant difference between the groups before the intervention (sig=0.14), although there was a significant difference after the intervention (sig<0.001). There was no significant difference between training group and control group (sig=0.14), although the difference was significant for online education and training+ education groups (sig=0.001, SE=0.78 and (sig<0.001, SE=0.79 respectively). The LSD test results showed significant difference between education and training+ education ((sig<0.001) and the HDL level was 3.05 mg higher in online education+ training group. There was no significant difference for LDL between the groups before the study, but there was a significant difference after the intervention (sig=0.001). There was an increase in LDL level in training group for 14.21 mg in comparison to control group (SE=5.91, sig=0.02), but there was no significant difference between online education and training+ education with control group (sig=0.07 and sig=0.39) respectively. The LSD test results, indicated significant difference between training and online education groups (sig=0.001) and the LDL level was 25.00 mg higher in training group. Moreover, there was a significant difference between training and training+ education groups (sig=0.002) and the LDL level was 19.29 mg higher in training group. There was no significant difference between online education and training+ education groups (sig=0.34).

There was no significant difference for HOMA between the groups before the intervention (sig=0.30), but the difference was significant at the end of the study (sig=0.04) the HOMA level decreased in training group by 1.58 (SE=0.56, sig=0.006) in comparison to control groups, although the difference was not significant for online education and training+ education groups (sig=0.08 and sig=0.36, respectively). The LSD test results indicated no significant difference between training and online education groups (sig=0.32) and training with training+ education groups (sig=0.06) and also online education with training+ online education group (sig=0.38).

Discussion

The purpose of this study was to evaluate the effect of 8 weeks functional training, online nutritional education and their combination on metabolic related biomarkers in 8 years-12 years old children with ASD. It has been suggested that training in higher intensities including functional training, may have adverse relation with metabolic related factors and has been introduced as an effective intervention for obesity management which may ensure children and adolescent health in their future life.[14,21] In this study, online nutritional education effect was assessed for anthropometric, metabolic related biomarkers, although previous studies have more focused on the effect of nutritional education, not in online type and have showed positive effect on nutritional knowledge improvement of better management of ASD symptoms and complications including metabolic status. It has suggested, nutritional education may improve metabolic related indicators including BMI in individuals. [18-20]

The findings from this study have indicated that the participant's BMI was within 5 percentile-85 percentile and there was a significant difference before and after the study. All of the recruited interventions, including func-

tional training, online nutritional education and the combination of mentioned interventions, had significant effect on BMI percentile. The reduction in BMI was highest in functional training+ education group, while, online nutritional education and functional training had less significant effect on BMI reduction, respectively and functional training had the least effect on BMI.

Functional training may have beneficial effects for body composition which seems to be an important indicator for metabolic status and can be considered as a predictor factor. The importance of functional training may be due to its effect on FM reduction and increase in lean body mass which lead to better body composition.[15]

This investigation indicated a significant difference for FM in participants with ASD. The comparison of interventional groups has suggested that participant's FM had a descending trend following functional training which was parallel with previous investigations, online nutritional education and their combination.[14]

The comparison for the effectiveness of interventions showed that online nutritional education could have the most significant effect on FM reduction. Moreover, the combination of functional training and online nutritional education was more than functional training alone. Although the results for WHR was near to significant and functional training could decrease WHR. Both online nutritional education and its combination with training, had significant effect, also, but their effectiveness was less which was parallel with study which showed beneficial effect on nutritional education on WHR.[20]

Functional training has been introduced as a protective intervention for lipid profile improvement which is considered as metabolic syndrome indicator and predictor. It has also been suggested that this type of physical training may improve lipid profile by decreasing TG, TCand LDL cholesterol level.[16,2] TG decreased significantly in functional training and its combination with online nutritional education, but there was no significant difference for online nutritional education alone, despite the effectiveness of nutritional education and nutritional knowledge improvement had significant effect on lipid profile in previous studies.[20] Although the TG level reduced in comparison to the first of study. Total cholesterol, HDL and LDL were the other indicators for lipid profile as indicators for metabolic status and metabolic syndrome which were assessed in the study. The results indicated that functional training for 8 weeks could not cause significant decrease in TCand increase in HDL level, despite the partial reduction in TCand partial increase in HDL level were seen. Although, 8 weeks of functional training could significantly decrease LDL level. Online nutritional education could not decrease TCand LDL level significantly but significant difference was indicated for HDL level in education group. The combination of functional training and online nutritional education, could not cause significant decrease in TCand LDL and increase in HDL level after the intervention.

Insulin resistance which is one of the indicators for metabolic syndrome was assessed as HOMA factor via plasma insulin concentration. The decrease in HOMA seems to be an indicator for less insulin sensitivity and better glucose tolerance. Researches have suggested that functional training may improve insulin sensitivity.[2] The HOMA level decreased due to all of the interventions, but it was significant only for functional training group. According to these results and previous studies, functional training seems to be most effective intervention for glucose metabolism improvement.[14]

Conclusion

In conclusion, functional training and online nutritional education can be suggested as effective interventions especially during Covid-19 pandemic for children with ASD as they can have beneficial effects on body composition and metabolic indicators. The results for the effectiveness of alone interventions or their combination, varies for each variable, but as these are considered as non-invasive intervention and may lead to better health related indicators and may improve autistic individual quality of life.

Acknowledgment

The authors acknowledge all the personnel and colleagues who cooperated for conduction of this study, including nutritionists, occupational therapists, physiotherapists, training physiologists and physical education trainer's colleague in collaborating centres.

Data Availability Statement

The datasets used and analysed during the current study are available from the corresponding author.

Funding Details

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors

Conflict of Interests

The authors declare that there is no conflict of interest.

References

1. Nowson C. Opportunities for innovation in nutrition education for health professionals. BMJ nutr. prev. healt. 2020:3(2):126.
2. Fealy CE, Nieuwoudt S, Foucher JA, et al. Functional high-intensity training training ameliorates insulin resistance and cardiometabolic risk factors in type 2 diabetes. Exp. Physiol. 2018:103(7):985-94.
3. Michalczyk MM, Zajac-Gawlak, Zając A, et al. Influence of nutritional education on the diet and nutritional behaviors of elderly women at the university of the third ageInt. J. Environ. Res. 2020:17(3):696.
4. Christensen D, Zubler J. From the CDC: Understanding ASD.The Am. J. Nurs. 2020:120(10):30-7.
5. Taylor MJ, Rosenqvist MA, Larsson H, et al. Etiology

of ASDs and autistic traits over time. JAMA psychiatry. 2020:77(9):936-43.

6. Knopf A. Autism prevalence increases from 1 in 60 to 1 in 54: CDC. The brown university child and adolescent behavior letter. 2020:36(6):4.
7. Liang X, Li R, Wong SH, et al. Accelerometer-measured physical activity levels in children and adolescents with ASD: A systematic review. Prev. Med. Rep. 2020:19:101147.
8. Brown DM, Arbour-Nicitopoulos KP, Martin Ginis KA, et al. Examining the relationship between parent physical activity support behaviour and physical activity among children and youth with ASD. Autism. 2020:24(7):1783-94.
9. Ferreira JP, Andrade Toscano CV, Rodrigues AM, et al. Effects of a Physical Training Program (PEP-Aut) on Autistic Children's Stereotyped Behavior, Metabolic and Physical Activity Profiles, Physical Fitness, and Health-Related Quality of Life: A Study Protocol. Public Health Front. 2018:6:47.
10. Şengüzel S, Cebeci AN, Ekici B, et al. Impact of eating habits and nutritional status on children with ASD. J. Taibah Univ. Medical Sci. 2021:16(3):413-21.
11. Tuncay C, Yektaoglu T. Nutrition in children with mental disorders and anticipated nutritional problems. In conference proceeding book near East University. 2020:101.
12. Curtin C, Hyman SL, Boas DD, et al. Weight management in primary care for children with autism: Expert recommendations. Pediatrics. 2020:145:126-39.
13. El-Kour T, Olive M, Neophytou N, et al. Nutrition and dietary considerations during treatment of ASD. In Autism. 2020:329-338.
14. Turri-Silva N, Ricci-Vitor AL, et al. Functional Resistance Training Superiority Over Conventional Training in Metabolic Syndrome: A Randomized Clinical Trial. Research quarterly for training and sport. 2020:91(3):415-24.
15. Cavedon V, Milanese C, Marchi A, et al. Different amount of training affects body composition and performance in High-Intensity Functional Training participants. Plos one. 2020:15(8):e0237887.
16. Bogataj Š, Pajek J, Ponikvar JB, et al. Functional training added to intradialytic cycling lowers low-density lipoprotein cholesterol and improves dialysis adequacy: a randomized controlled trial. BMC Nephrol. 2020:21(1):1-2.
17. Fealy CE, Nieuwoudt S, Foucher JA, et al. Functional high-intensity training training ameliorates insulin resistance and cardiometabolic risk factors in type 2 diabetes. Exp. Physiol. 2018:103(7):985-94.
18. Gulzar I, Rizwan B, Yaseen M, et al. Impact of nutrition education program on caregivers influencing the dietary practices of autistic children. AJAHS 2020:5(1):26-33.
19. Yaseen M, Rizwan B, Gulzar I, et al. Determination of Knowledge of Caregivers about Dietary Practices of Autistic Children. Biomedica. 2020:36(1).
20. Thuita AW, Kiage BN, Onyango AN, et al. Effect of a nutrition education programme on the metabolic syndrome in type 2 diabetes mellitus patients at a level 5 Hospital in Kenya: "A randomized controlled trial". BMC Nutr. 2020:6(1):1-4.
21. Leis R, de Lamas C, de Castro MJ, et al. Effects of nutritional education interventions on metabolic risk in children and adolescents: A systematic review of controlled trials. Nutrients. 202012(1):31.
22. Wilson K. Effects of a sport nutrition education intervention on nutritional knowledge, dietary behaviors, and self-efficacy in NCAA Division I softball players.
23. Sathe N, Andrews JC, McPheeters ML, et al. Nutritional and dietary interventions for ASD: a systematic review. Pediatrics. 2017:139(6).
24. Spratt E, Mercer MA, Grimes A, et al. Translating benefits of training on depression for youth with ASD and neurodevelopmental disorders. J. psychol. clin. Psychiatry. 2018:2.
25. Pongkiatchai R, Chongsuwat R, Howteerakul N, et al. Evaluation of a questionnaire to assess nutritional knowledge, attitudes and practices in a Thai population. Nutrition journal. 2019:18(1):1-0.
26. Putnoky S, Banu AM, Moleriu LC, et al. Reliability and validity of a General Nutrition Knowledge Questionnaire for adults in a Romanian population. Eur. J. Clin. Nutr. 2020:74(11):1576-84.
27. Anderson YC, Wynter LE, Grant CC, et al. Physical activity is low in obese New Zealand children and adolescents. Scientific reports. 2017:7(1):1-7.
28. Yarımkaya E, Esentürk OK. Promoting physical activity for children with ASDs during Coronavirus outbreak: benefits, strategies, and examples. Int. J. Dev. Disabil. 2020:21:1-6.
29. Oh HK, Escalante G, Gentry C. Teaching functional fitness to students with ASD. Palaestra; 2018:32(1).
30. Peungsuwan P, Parasin P, Siritaratiwat W, et al. Effects of combined training training on functional performance in children with cerebral palsy: A randomized-controlled study. Pediatric Physical Therapy. 2017:29(1):39-46.
31. Coleman RK. Benefits of a Nutrition Education Program on a Community of Developmentally Disabled Adults.
32. Shedlock K, Susi A, Gorman GH, et al. ASDs and metabolic complications of obesity. J. Pediatr. 2016:178:183