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Original article

Diet quality index as a predictor of treatment efficacy in overweight and obese adolescents: The EVASYON study

Pilar De Miguel-Etayo [a, b, c, *], Luis A. Moreno [a, b, d], Javier Santabárbara [e], Miguel Martín-Matillas [f, g], Maria Cristina Azcona-San Julian [h, i], Amelia Marti del Moral [b, i, j], Cristina Campoy [k, l], Ascensión Marcos [m], Jesús Mª Garagorri [a, c], on behalf of the EVASYON Study Group[1]

[a] Growth, Exercise, NUtrition and Development (GENUD) Research Group. Instituto Agroalimentario de Aragón (IA2), Instituto de Investigación Sanitaria Aragón (IIS Aragón). University of Zaragoza, Zaragoza, Spain
[b] CIBER Fisiopatología de la Obesidad y Nutrición (CIBERobn), Instituto de Salud Carlos III, Madrid, Spain
[c] Department of Paediatrics, Faculty of Medicine, University of Zaragoza, Spain
[d] Department of Psychiatry and Nursing, Faculty of Health Sciences, Universidad de Zaragoza, Spain
[e] Department of Microbiology, Preventive Medicine and Public Health, University of Zaragoza, Spain
[f] Department of Physical Education and Sport, School of Sport Sciences, University of Granada, Spain
[g] PROFITH (PROmoting FITness and Health through physical activity) Research Group, University of Granada, Spain
[h] Paediatric Endocrinology Unit, Department of Paediatrics, Clínica Universidad de Navarra, Pamplona, Spain
[i] Instituto de Investigación Sanitaria de Navarra, Pamplona, Spain
[j] Department of Food Sciences, Nutrition and Physiology, Universidad of Navarra, Pamplona, Spain
[k] Department of Paediatrics, School of Sport Sciences, University of Granada, Spain
[l] EURISTIKOS Excellence Centre for Paediatric Research, Biomedical Research Centre, Health Sciences Technological Park, University of Granada, Spain
[m] Immunonutrition Research Group, Dept. Metabolism and Nutrition, Institute of Food Science and Technology and Nutrition (ICTAN), Spanish National Research Council (CSIC), Madrid, Spain

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SUMMARY

Background & aim: A diet quality index (DQI) is a tool that provides an overall score of an individual's dietary intake when assessing compliance with food-based dietary guidelines. A number of DQIs have emerged, albeit their associations with health-related outcomes are debated. The aim of the present study was to assess whether adherence to dietary intervention, and the overall quality of the diet, can predict body composition changes.
Methods: To this purpose, overweight/obese adolescents (n = 117, aged: 13–16 years; 51 males, 66 females) were recruited into a multi-component (diet, physical activity and psychological support) family-based group treatment programme. We measured the adolescents' compliance and body composition at baseline and after 2 months (intensive phase) and 13 months (extensive phase) of follow-up. Also, at baseline, after 6 months, and at the end of follow-up we calculated the DQI.
Results: Global compliance with the dietary intervention was 37.4% during the intensive phase, and 14.3% during the extensive phase. Physical activity compliance was 94.1% at 2-months and 34.7% at 13months and psychological support compliance were growing over the intervention period (10.3% intensive phase and 45.3% during extensive phase). Adolescents complying with the meal frequency criteria at the end of the extensive phase had greater reductions in FMI z-scores than those did not complying (*Cohen's d* = 0.53). A statistically significant association was observed with the diet quality index. DQI-A variation explained 98.1% of BMI z-score changes and 95.1% of FMI changes.

Non-standard abbreviations: BMR, Basal metabolic rate; DQI, Diet quality index; FBDG, Food-based dietary guidelines; FFM, Fat-free mass; FFMI, Fat-free mass index; FFQ, Food frequency questionnaire; FM, Fat mass; FMI, Fat mass index; MVPA, Moderate-to-vigorous physical activity; RD, Registered dietitians; TEE, Total energy expenditure; WHtR, Waist-to-height ratio; W-to-H, Waist-to-hip ratio.

* Corresponding author. GENUD (Growth, Exercise, NUtrition and Development) Research Group, Faculty of Health Sciences, Universidad de Zaragoza, C/ Domingo Miral s/n, 50009 Zaragoza, Spain.
E-mail address: pilardm@unizar.es (P. De Miguel-Etayo).

[1] Members of EVASYON Study Group were listed in Appendix section.

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Conclusions: We conclude that assessment of changes in diet quality could be a useful tool in predicting body composition changes in obese adolescents involved in a diet and physical activity intervention programme backed-up by psychological and family support.

1. Introduction

Obesity during adolescence is associated with several adverse health consequences in adulthood [1]. Recent reviews have shown that multidisciplinary interventions are the most effective in adolescent weight management [2,3]. The main goal of interventions aiming at treating obesity in the adolescent is to reduce fat mass (FM) and to maintain fat-free mass (FFM) while performing periodic monitoring to ensure an appropriate growth pattern [4].

The cornerstone of a weight loss programme is to achieve a negative energy balance, with a healthy contribution of carbohydrates, proteins and lipids while improving eating habits [5]. Further, increasing the adolescent's diet quality is of interest because food habits acquired during childhood predict adult food habits, and diet-related diseases [6]. Diet quality indices (DQIs) are tools that provide an overall score of an individual's dietary intake to assess the compliance with food-based dietary guidelines (FBDG). A number of DQIs have emerged, but their associations with health-related outcomes are debated [7]. Vyncke K et al. showed good validity of the DQI for adolescents (DQI-A) by confirming the expected associations with food and nutrient intakes and biomarkers in European adolescents participating in the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) study [8].

We selected BMI and fat mass index (FMI) to assess effectiveness of treatment since these are the best anthropometric indices for assessing body fat changes in adolescents [9]. Complying with dietary advice in the treatment of obese adolescents should result in positive outcomes in terms of body composition indices. In studies assessing the effectiveness of dietary interventions to treat obesity in adolescents, measures of adherence to dietary interventions are poorly described [10] and the proportions of participants achieving and maintaining dietary goals have not been reported [11–13]. The existing scant evidence limits the possibility of estimating whether the changes in diet determine the efficacy of the interventions in overweight adolescents.

The aim of the present study (a multidisciplinary obesity treatment programme for adolescents) was to assess whether compliance to the dietary intervention, and the overall quality of the diet can predict body composition changes.

2. Material and methods

The study has been named ‘Development, implementation and evaluation of the efficiency of a therapeutic programme for overweight and obese adolescents: a comprehensive education programme of nutrition and physical activity [*Desarrollo, aplicación y evaluación de la eficacia de un programa terapéutico para adolescentes con sobrepeso y obesidad*: *educación integral nutricional y de actividad física*], the EVASYON Study’. The original programme was implemented in adolescents from five cities across Spain: Granada, Madrid, Pamplona, Santander and Zaragoza. The adolescents were aged 13–16 years, and all were overweight or obese. The intervention was multidisciplinary (diet, physical activity and psychological support within the family). The general aims of the EVASYON Study were to assess the feasibility of this programme and to evaluate the determinants of treatment effectiveness [14].

The project followed the ethical standards recognised by the Declaration of Helsinki (reviewed in Hong-Kong in September 1989 and in Edinburgh in 2000) and the EEC Good Clinical Practice recommendations (document 111/3976/88, July 1990), and current Spanish legislation regulating clinical research in humans (Royal Decree 561/1993 on clinical trials). The study was approved by the Ethics Committee of each hospital that participated in this project, and by the Bioethics Committee of the Spanish National Research Council (CSIC). The study was explained to the participants before commencement. The volunteers and the parents or guardians then signed an informed consent form.

2.1. Study population

The goal of the study was to achieve a clinically-relevant 2.7% reduction in total body fat. For a statistical power of 90% and an alpha error of 0.05, the number of participants required was 153. This calculated sample size was increased by 25% to account for potential dropouts and loss-to-follow-up in the participating hospitals. The recruited sample comprised 206 adolescents (84 males and 122 females). Of the adolescents initially recruited, 44 left the programme before the end of the follow-up period (attrition rate of 28.2%) [15]. The flowchart of the adolescents included are shown in Fig. 1.

Participants were recruited among those attending the local obesity clinics. Inclusion criteria were: 1) aged 13–16 years; 2) overweight or obese according to the criteria of Cole et al. [16]; 3); of Spanish ancestry, or being educated in Spain; and 4) not having concomitant diseases.

2.2. Intervention

The EVASYON treatment programme has been described elsewhere [14]. Briefly, it was conducted in small groups of 9–11 adolescents, and included parents or guardians to facilitate family involvement and support. The protocol consisted of an intensive intervention period (over the first 2 months) and an extensive intervention period (from 2 to 13 months). The programme covers dietary intervention [17], physical activity intervention, and psychological support.

2.2.1. Intensive phase

Dietary intervention was a moderate calorie restriction of between 10 and 40% of estimated energy requirement, as described below. Energy restriction was adapted to the BMI categories according to reference values generated in Spanish adolescents [18], as described below. A fixed full-day meal plan was followed for the first 3 weeks. A food portion exchange protocol was then followed for the remaining 6 weeks. The main goal of the physical activity intervention was to achieve at least 60 min of moderate-to-vigorous physical activity (MVPA) 3 days per week in the first 3 weeks. In the remaining 6 weeks, the goal was to achieve at least

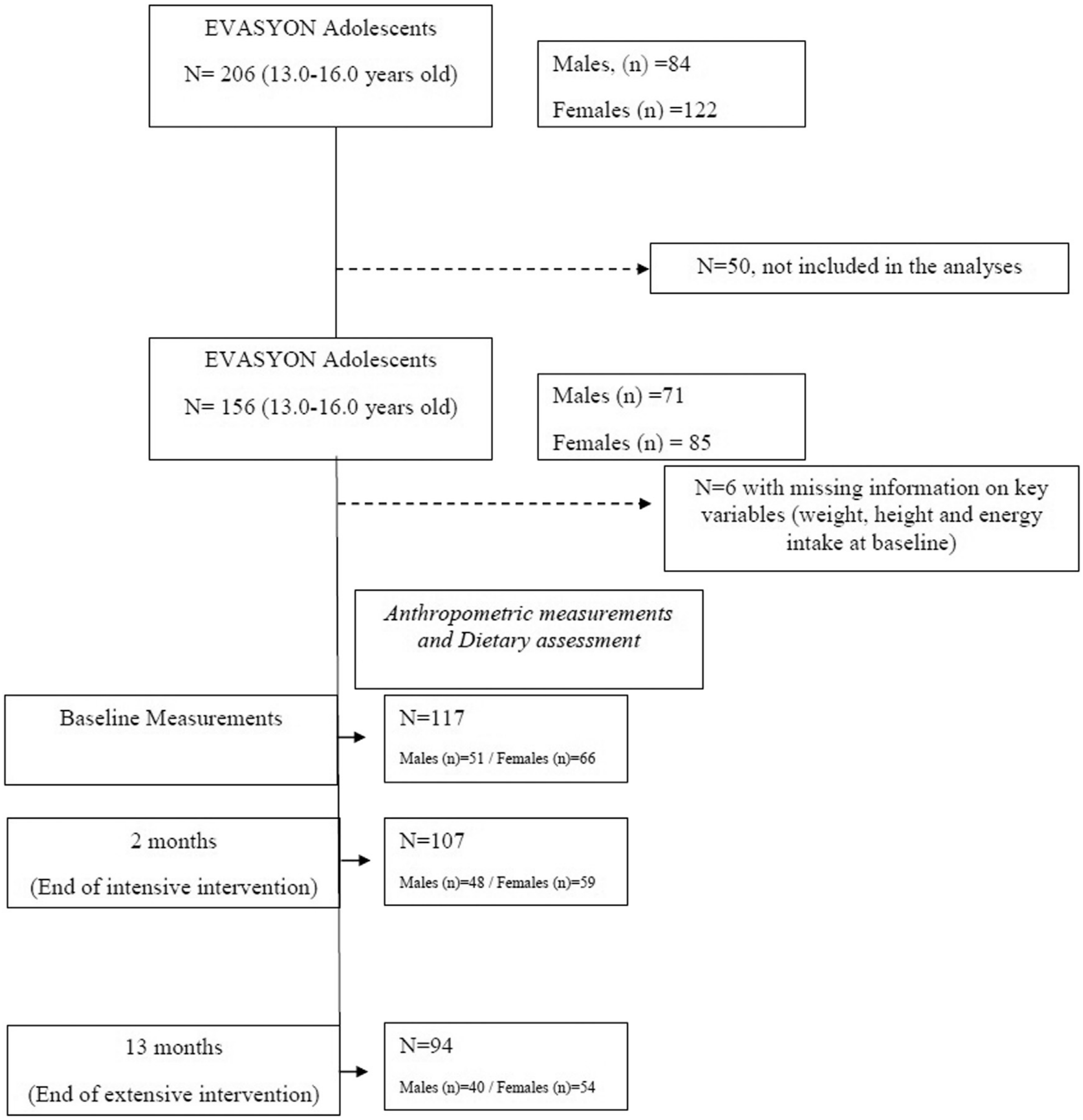

Fig. 1. Flow of participants in the current EVASYON-derived sub-population.

60 min of MVPA, 5 days per week. Psychological support included workshops focusing on eating and physical activity behaviour patterns. 'Ping-pong' techniques were used to identify negative as well as positive situations, and troubleshooting techniques to encourage adherence and to prevent relapses [19].

2.2.2. Extensive phase

Dietary intervention involved iso-energetic flexible meal plans, based on food-portion exchanges. In addition, to achieve at least 60 min of MVPA 5 days per week, the goal of the physical activity intervention was to increase ordinary daily-life physical activity (such as walking or cycling to school). Psychological support was aimed at monitoring the psycho-educational progress, and resolving any difficulties appearing in the adolescents and their families.

2.3. Assessing energy intake and calorie restriction

Schofield's equation [20], adjusted by gender and take into consideration the weight and height of adolescents, was used to determine basal metabolic rate (BMR). To estimate total energy expenditure, we multiplied BMR by an activity factor of 1.3 [14].

With respect to the BMI z-score, the suggested restriction percentage was estimated as follows: If $Z \leq 2$, total energy expenditure (TEE) was reduced by 10%; If $Z = 2–3$, TEE was reduced by 20%; if $Z = 3–4$, TEE was reduced by 30%; and if $Z > 4$, TEE was reduced by 40%. A daily calorie restriction range was established on this basis. In no case were the diets <1300 kcal or >2200 kcal. At the end of each dietary period, it was necessary to adjust the equations depending on the body weight status. Also, the basal metabolic rate was calculated again to identify possible shifts in energy consumption/expenditure [18].

2.4. Dietary assessment

The EVASYON food and nutrition programme involved trained registered dietitians (RD), professionals who were directly responsible for the dietary and nutrition assessment (MªJP in Granada; BZ in Madrid; MM and TR-U in Pamplona; PR and PM-E in Zaragoza).

A detailed dietary history collected information on the family's food organisation including meal-related habits before starting the therapy (e.g. meal frequency) at the beginning of the program, and at 2 and 13 months later were filled.

Face-to-face interviews with participants and their parents (father, mother or tutor) at the beginning of the program, and at 2, 6 and 13 months later were performed. Details of food intake, dietary patterns, and nutritional knowledge were collected to evaluate adherence to the recommended diet as well as changes in food intake habits during the intervention programme. The 72 h dietary records were filled by the adolescents at the beginning of the program, and at 2, 6 and 13 months later at home. Once these were filled-out, the RD and adolescents cross-checked the information in order to reduce the common forgets as water, bread, olive oil and some food from nibbling habits. Nutrient intakes from 72 h dietary records were computed with an *ad hoc* computer programme specifically developed for this purpose. A trained dietician updated the nutrient data bank using the latest available information on food-composition tables from Spanish studies [21,22]. Data on food intakes from 72 h dietary records were transformed into energy and macronutrient intake. After that, the intake was transformed on percentage of total energy intake to assess dietary intervention compliance.

Moreover, a semi-quantitative food frequency questionnaire (FFQ), previously validated in Spain, was administered at the beginning, at 6 months and at the end of the programme [23]. FFQ contained 132 food items divided into the following categories: dairy products, meat and eggs, fish, fruits and vegetables, legumes, potatoes and cereals, nuts, oils and fat, sweets and beverages. For each food item, an average portion size was specified, and participants and their parents were asked how often they had consumed that unit throughout the previous period. There were nine options for the frequency of intake (ranging from never/almost never to at least six times per day). This tool was used to record usual food frequency consumption according to the standard portion size as well as energy and nutrient intake, and to detect possible nutritional risks and misbehaviours/non-compliance [23]. FFQ food intake data were transformed into food volume/weight (in mL or g) per day in order to calculate the DQI for each adolescent [24].

2.5. Diet quality index for adolescents (DQI-A)

Based on the Spanish FBDG [25], we adapted the DQI for adolescents that had been previously validated by Vyncke et al. [8] and which have been used to evaluate adolescent adherence to the Spanish dietary recommendations. The major components of this DQI are dietary quality, dietary diversity and dietary equilibrium. Details of the technical aspects of the DQI have been described elsewhere [8,26].

Diet quality reflects whether the adolescent made the optimal food quality choices within food groups classified as: 'preference group', 'moderation group'; 'low-nutritious, energy dense group'. A comprehensive description of the food item allocation is given in the Supplementary table (SM1). Dietary diversity explains the degree of variation in the diet from the recommended food groups, as illustrated in the Spanish pyramid [25]. Dietary equilibrium was calculated from the difference between the adequacy component and the excess component.

These three components of the DQI-A are presented in percentages. The dietary quality component ranged from −100 to 100%, while dietary diversity and dietary equilibrium ranged from 0 to 100%. To compute the DQI-A, the mean of these components was calculated. As such, the DQI-A ranged from 33 to 100%, with higher scores reflecting higher diet compliance. The score was calculated at baseline, 6 and 13 months. DQI scores for an individual provide an estimate of diet quality relative to national guidelines.

2.6. Physical activity assessment

The EVASYON physical activity programme involved trained professionals who were directly responsible for the physical activity intervention and assessment (MMM in Granada; DM-G in Madrid; AM and TR-U in Pamplona; JPR-L and PM-E in Zaragoza). The physical activity assessment was through questionnaire and accelerometer, although this objective measurement was not available at the end of the programme. Therefore, the participants were asked for frequency of physical activity during week and weekend-days inside the questionnaire of physical activity in adolescents (PAQ-A) [27]. To compute the score of physical activity frequency Likert scale (none, low, normal, much and too much, being 1 to 5 points respectively) were applied. As such, the ranged from 7 to 35, with higher scores reflecting higher physical activity level. The score was calculated at baseline, 2 and 13 months.

2.7. Psychological support assessment

The EVASYON psychological support involved trained professionals who were directly responsible for the psychological assessment (M^{a}JP in Granada; GM in Madrid; MM and TR-U in Pamplona; CM and PM-E in Zaragoza). The psychological support had assessed thought EDI-2, ABOS and AF-5 questionnaires [14]. The EDI-2 is a self-reported instrument assessing the cognitive and behavioural characteristics commonly found in individuals at risk of eating disorders [28]. This questionnaire includes a social insecurity subscale which were found related with attrition in a group-based programmes [15]. The psychological support was assessed at baseline, 2 and 13 months.

2.8. Compliance to EVASYON treatment

According to the main goals of dietary intervention [17], dietary compliance criteria are: (1) Adequacy of proposed energy intake (TEI ± 20%) according to individual recommendations based on energy restriction according to the individual's BMI z-score; (2) Adequacy of carbohydrate intake; percentage of carbohydrate in energy intake, between 50 and 55% ± 5%; (3) Adequacy of protein intake; percentage of proteins in energy intake, between 10 and 15% ± 5%; (4) Adequacy of fat intake; percentage of fat in energy intake, between 30 and 35% ± 5%; (5) Adequacy of meal frequency, based on 3 main meals (breakfast, lunch and dinner) and 2 snacks (mid-morning and mid-afternoon). Adolescents who achieved 3 or more main goals of the 5 dietary intervention criteria were considered as showing "global compliance".

According to the main goals of physical activity intervention [29], physical activity compliance criteria are: during intensive (1) adequacy of physical activity level, between 42 ± 5% phase and during extensive phase (1) adequacy of physical activity level, between 71 ± 5% phase.

According to the previous findings related with attrition [15], psychological support compliance criteria are: during intensive and extensive phase (1) had filled the social insecurity scale included in EDI-2 questionnaire being assumed their session attendance.

2.9. Body composition measurements

Body composition was assessed by anthropometry in the overall study sample at baseline, 2, 6 and 13 months. The anthropometric measurements were performed using the standardised protocols of the AVENA study [30]. Measurements were performed by the same trained investigators in each Centre (MM-M in Granada; BZ in Madrid; MM and TR-U in Pamplona; PR and PM-E in Zaragoza). Each set of variables was measured 3 times and the means used in the statistical analyses. Weight and height were obtained by standardised procedures. Body mass index (BMI) was calculated as weight/height squared (kg/m^2). Skinfold thicknesses were measured to the nearest 0.2 mm on the left side of the body using a skin-fold calliper (Holtain Calliper; Holtain Ltd., Wales, UK) at the following sites:1) triceps, 2) biceps, 3) subscapular and 4) supra-iliac. Body fat is usually expressed as percentage of total body weight, but an alternative is to express this variable in relation to height squared since more valuable index is: FMI [FM (kg)/height (m^2)] [31].

The z-score was calculated according to age and sex-specific weight and BMI reference standards for Spanish adolescents aged 13–18 years [32,33]. Cut-off points of FMI were calculated using the sample from the AVENA Study which included 2851 Spanish adolescents (52.5% females, 15.29 ± 1.33 years of age, with BMI 21.63 ± 3.44 kg/m^2) (unpublished data).

In the present study the anthropometric indices (BMI and FMI) were used to evaluate body composition changes over the 13 months of follow-up.

2.10. Statistical analyses

Normality of distributions was assessed with the Kolmogorov–Smirnov test, and the Lilliefors correction. For comparisons of continuous variables segregated with respect to gender, parametric or non-parametric tests were used depending on whether the variables met the assumption of normal distribution. Age, weight, height, fat mass and fat-free mass percentages and body mass index (BMI) were non-normally distributed and, hence, the non-parametric Man-Whitney U test was applied. For the remaining variables with normal distribution, the Student *t*-test was used for comparisons between group means. The χ^2 test was used for discrete variables, with the Fisher exact test when necessary. The comparison of dietary compliance distribution between intensive (2 months) and extensive phases (13months) was carried out with McNemar paired proportion test.

Cohen's *d* was calculated to document differences between those adolescents adhering, and those not-adhering, to dietary compliance criteria. This coefficient measures the effect size, and may be especially relevant in cases of small samples, when the differences found do not reach statistical significance. The effect size (Cohen's d) was classified as 'small' (~0.2), 'medium' (~0.5) or 'large' (~0.8). Non-parametric Spearman's rho correlation coefficients were used to assess associations between DQI-A and indices based on anthropometric measurements during follow-up. To assess the association between both anthropometric indices (BMI and FMI z-scores) and dietary compliance criteria and DQI-A during follow-up, we used random coefficient regression models adjusted by physical activity and psychological support compliance criteria, taking into account that successive measurements in each subject are related to each other. The proportions of body composition changes during follow-up explained by dietary compliance criteria and DQI-A were calculated using pseudo-R^2. Regression modelling was carried out with 'R' programme, version 2.9.2 (R Foundation for Statistical Computing, Vienna, Austria), with 'nlme' library. All descriptive analyses were performed with SPSS STATISTICS v.19 (IBM Corp., New York, NY, USA, 2010) for Windows.

3. Results

Baseline characteristics of 117 participants (51 males and 66 females) from four Spanish cities participating in the EVASYON Study who completed anthropometric and dietary measurements are shown in Table 1. Compared with females, males had greater height and FMI ($p < 0.001$). With respect to dietary measurements, males also had higher energy intake than females ($p = 0.001$) and females had higher scores on DQI-A than males ($p = 0.007$). In terms of meal frequency, more males than did their female counterparts consumed 5 meals/day (52.9% and 51.5%, respectively; n.s.)

The compliance from single dietary criteria at 2 and 13 months of follow-up is shown in Table 2. The compliance to energy restriction was observed in <50% participants at 2 and 13 months of follow-up. With respect to compliance to macronutrient recommendations, the highest compliance rate was observed for fat intake during intensive (68.2%) an extensive (53.8%) phases ($p = 0.050$) and the lowest compliance was observed for protein intake in the intensive phase (23.4%) and carbohydrate intake (20.9%) during the extensive phase. Compliance to meal frequency was observed in 85.1% of adolescents in the intensive phase and 69.3% in the extensive phase ($p = 0.021$). Global compliance to the dietary intervention was 37.4% during intensive and 14.3% during extensive phase ($p = 0.002$).

Moreover, the compliance physical activity intervention was 94.1% at 2-months and 34.7% at 13-months ($p < 0.001$). Males had better physical activity compliance than their female's counterparts during the intensive phase (74.5% vs 63.6%, $p = 0.047$). On the other hand, the psychological support compliance was 10.3% at intensive phase and 445.3% at extensive phases ($p < 0.001$).

BMI and FMI z-score changes in relation to dietary compliance during 2 and 13 months are shown in Table 3. The dietary compliance criterion showed a medium Cohen's size effect in energy intake at the end of the intensive phase; adolescents not complying with the meal frequency criteria at the end of the intensive phase had higher FMI z-score reductions than those complying (*Cohen's d* = 0.63). Cohens size effect also applied with respect to meal frequency at the end of extensive phase i.e. adolescents complying with the meal frequency criteria at the end of the extensive phase had higher FMI z-score reductions than those not complying (*Cohen's d* = 0.53).

In relation to the main variables and outcomes during follow up, mean of BMI- and FMI z-score calculated at 2-months (2.14 (1.04) and 1.85 (0.82), respectively) and 13-months (2.15 (1.22) and 1.85 (1.02)) were similar. Moreover, the DQI-A at 6-months were 71.84 (8.4) and 69.00 (70.49) at 13-months.

There was a significant correlation between DQI-A and BMI z-score changes between baseline to 13 months (rho = −0.178, $p = 0.037$): increases in DQI-A during the follow-up are associated with decreases in BMI-z. However, the correlation between DQI-A changes and FMI z-score changes were not statistically significant (rho = −0.011, $p = 0.905$) (Fig. S2).

A statistically significant association between changes in BMI-z scores and FMI-z scores and DQI changes during follow-up adjusted by physical activity and psychological support was observed: 5-unit increases in DQI-A score resulted in BMI z-score decrease of 0.07 units ($p < 0.001$) and in FMI z-score decrease of 0.053 units ($p < 0.001$) (Table 4). DQI-A variation explained 98.1% of BMI z-score changes (pseudo $R^2 = 0.981$) and 95.1% of FMI z-score changes (pseudo $R^2 = 0.951$).

4. Discussion

The main finding of the present study was that quality of diet (DQI-A) is a predictor of BMI and FMI z-score changes during the 13 months follow-up of overweight adolescents in a multidisciplinary treatment programme. Our survey of the current literature indicates that there has not been any study that examined the association between diet quality and body composition changes in

Table 1
Characteristics of the study sample at baseline.

	Total			Males			Females			p
	N	Mean	SD	N	Mean	SD	N	Mean	SD	
Anthropometric measurements										
Age, years	117	14.62	1.25	51	14.49	1.08	66	14.40[a]	(13.70–16.00)	0.373
Weight, kg	117	84.34	14.53	51	86.64	14.70	66	81.0[a]	(72.00–90.80)	0.066
Weight (z-score)	117	3.20	1790	51	2.74	1.22	66	3.55	1.93	0.007
Height, cm	117	164.45[a]	(159.50–170.00)	51	166.98[a]	(161.87–172.00)	66	162.73[a]	(156.85–166.00)	<0.001
Height (z-score)	114	0.25	1.03	51	0.26	0.80	63	0.23	1.19	0.027
Body Mass Index, BMI kg/m^2	117	31.22	4.31	51	30.87	3.69	66	30.53[a]	(27.69–35.27)	0.779
Body Mass Index (z-score)	117	2.61	1.11	51	2.35	0.84	66	2.80	1.25	0.022
Fat Mass Index, FMI kg/m^2[b]	116	10.09	2.14	51	11.42	2.28	65	9.05	1.30	<0.001
Fat Mass Index (z-score)	116	2.10	0.92	51	2.78	0.51	65	1.57	0.53	<0.001
Dietary measurements										
Diet Quality Index for Adolescents; DQI-A	117	49.27	12.69	51	46.40	13.59	66	54.85[a]	(44.77–59.28)	0.007
Energy intake, kcal	117	2119.95	688.40	51	2336.23	689.03	66	1867.42[a]	(1583.52–2217.48)	0.001
Carbohydrate, %	117	37.95	6.94	51	38.88	6.87	66	37.25	6.95	0.207
Protein, %	117	18.74	3.66	51	19.18	3.38	66	18.39	3.86	0.241
Fat, %	117	42.90	7.26	51	41.67	6.63	66	43.85	7.61	0.103
Meal frequency‡[c]		n	%		n	%		n	%	
3		18	15.4		9	17.6		9	13.6	0.751
4		38	32.5		15	29.4		23	34.8	
5		61	52.1		27	52.9		34	51.5	

Student *t*-test was applied for normally distributed variables (mean (SD)) and Mann–Whitney U test for non-normally distributed variables (median (interquartile range)), ‡: χ^2 test for meal frequency.
[a] Data presented as median (interquartile range).
[b] FMI calculated, Fat Mass (kg) obtained by skin-fold thickness.
[c] Data presented as frequency (%).

Table 2
EVASYON compliance distribution in the study.

	Intensive phase (2 months)		Extensive phase (13 months)		p
	Non-adherence n (%)	Adherence n (%)	Non-adherence n (%)	Adherence n (%)	
Dietary criteria					
Global compliance (≥3 dietary compliance criteria)	67 (62.6)	40 (37.4)	78 (85.7)	13 (14.3)	0.002
Energy intake, kcal	63 (58.9)	44 (41.1)	60 (65.9)	31 (34.1)	0.458
Carbohydrate, %	71 (66.4)	36 (33.6)	72 (79.1)	19 (20.9)	0.210
Protein, %	82 (76.6)	25 (23.4)	60 (65.9)	31 (34.1)	0.687
Fat, %	34 (31.8)	73 (68.2)	42 (46.2)	49 (53.8)	0.050
Meal frequency, n	11 (14.9)	63 (85.1)	19 (27.9)	49 (72.1)	0.021
Physical activity criteria	5 (5.9)	80 (94.1)	49 (65.3)	26 (34.7)	<0.001
Psychological support criteria	105 (89.7)	12 (10.3)	64 (54.7)	53 (45.3)	<0.001

p: p-value for McNemar paired proportion test.

adolescents, during a long follow-up intervention period while using the approach of food-based diet index quality.

Dietary interventions alone have been widely studied in weight loss programmes [34–36]. A recent systematic review indicates that an improvement in body weight can be achieved in overweight or obese children and adolescents, regardless of the macronutrient distribution of a reduced-energy diet [37]. The highest BMI reductions were achieved with the low-carbohydrate diets [34,38] and with different protein-content diets [39,40]; albeit the studies have had limited quality. In agreement with some previous studies [34,38–40], our adolescents complying with the carbohydrate and protein recommendations during the intensive phase had higher losses in FMI z-scores than their counterparts who did not comply. However, the observed differences were of small effect size. Assessment of an adolescent's diet is of considerable interest because food habits and behaviour acquired during childhood and adolescence predict the adult's diet. Recently, a meta-analysis evaluating the effect of meal frequencies on body composition showed that increased meal frequency appeared to be positively associated with reductions in fat mass and body fat percentage [41]. In concordance with this meta-analysis, FMI z-score changes in our study during the extensive phase were higher in the adolescents complying with the meal frequency recommendation, despite non-significance effects being observed in the random coefficient models. This body-fat reduction associated with the increased meal frequency could have healthy benefits in the long term.

There are studies assessing the associations between diet quality and body composition, but they are all cross-sectional and had shown varying outcomes. Some of the studies showed no significant associations with BMI [42,43] and obesity status [43], while another observed a positive association with both BMI and waist circumference [44] while yet another also showed a positive association but only after adjustment for potential confounders such as age, overall education and economic level of the household [45,46]. Conversely, other studies found an inverse association with BMI [47,48]. The lack of consistent results could be due to BMI the optimal adiposity index, compared to other direct estimates of body fat. The use of different types of diet quality indices could also contribute to these conflicting results.

Our study obtained similar results to those that had examined diet *vs.* body composition associations among adolescents using a country-specific diet quality index [49,50]. Inverse associations were observed with body-fat percentage, assessed by laboratory techniques [49] and with body-fat percentage assessed by BIA

Table 3
Comparisons of BMI and FMI z-score changes during intensive and extensive phase; non-adherence *vs.* adherence to dietary compliance criteria.

	Body Mass Index, BMI (kg/m^2)			Fat Mass Index, FMI (kg/m^2)		
	ΔBMI z-score Mean (SD)		Differences in BMI between groups	ΔFMI z-score Mean (SD)		Differences in FMI between groups
Intensive phase	Non-adherence	Adherence		Non-adherence	Adherence	
Overall compliance	−0.48 (0.33)	−0.44 (0.23)	0.04	−0.24 (0.39)	−0.19 (0.33)	0.05
(≥3 dietary compliance criteria)	N = 65	N = 38		N = 60	N = 38	
Energy intake, kcal	−0.47 (0.33) N = 60	−0.45 (0.27) N = 43	0.02	−0.31 (0.37) N = 57	−0.09 (0.33) N = 41	0.22**
Carbohydrate, %	−0.45 (0.29) N = 69	−0.48 (0.33) N = 34	−0.03	−0.19 (0.37) N = 64	−0.28 (0.37) N = 34	−0.09*
Protein, %	−0.47 (0.32) N = 79	−0.44 (0.23) N = 24	0.03	−0.19 (0.35) N = 74	−0.32 (0.41) N = 24	−0.13*
Fat, %	−0.45 (0.23) N = 32	−0.46 (0.33) N = 71	−0.01	−0.22 (0.39) N = 30	−0.22 (0.36) N = 68	0
Meal frequency, n	−0.51 (0.47) N = 10	−0.43 (0.25) N = 61	0.08*	−0.31 (0.50) N = 9	−0.22 (0.32) N = 59	0.09*
Extensive phase	Non-adherence	Adherence		Non-adherence	Adherence	
Global compliance	−0.17 (0.62)	0.02 (0.57)	0.19*	−0.17 (0.59)	−0.01 (0.65)	0.16*
(≥3 dietary compliance criteria)	N = 74	N = 13		N = 65	N = 11	
Energy intake, kcal	−0.21 (0.63) N = 59	0.01 (0.56) N = 28	0.22*	−0.19 (0.58) N = 53	−0.06 (0.64) N = 23	0.13*
Carbohydrate, %	−0.13 (0.62) N = 68	−0.17 (0.61) N = 19	0.04	−0.15 (0.54) N = 56	−0.09 (0.79) N = 16	0.06
Protein, %	−0.15 (0.65) N = 58	−0.11 (0.56) N = 29	0.04	−0.13 (0.63) N = 48	−0.14 (0.54) N = 24	−0.01
Fat, %	−0.17 (0.58) N = 38	−0.11 (0.64) N = 49	0.06	−0.23 (0.66) N = 33	−0.05 (0.53) N = 39	0.18*
Meal frequency, n	−0.09 (0.73) N = 23	−0.18 (0.60) N = 50	−0.09	0.08 (0.38) N = 20	−0.23 (0.67) N = 45	−0.31**

FMI calculated, Fat Mass (kg) obtained by skin-fold thickness; * Cohen's *d* ranging from 0.2 to 0.5; ** Cohen's *d* ranging from 0.5 to 0.8; *** Cohen's *d* ranging from 0.8 to 2.0.

Table 4
Regression model to assess the relationships between BMI z-score, FMI z-score changes, and dietary compliance criteria and DQI-A changes adjusted for physical activity and psychological support.

	Model			
	β	95%CI	*p*	Pseudo R^2
BMI z-score				
DQI, per 5 units	−0.073	(−0.095; −0.052)	<0.001	0.981
Global compliance (≥3 dietary compliance criteria)	0.158	(−0.082; 0.399)	0.193	0.955
Energy intake, kcal	0.145	(−0.032; 0.322)	0.107	0.955
Carbohydrates, %	0.121	(−0.136; 0.378)	0.351	0.956
Protein, %	0.001	(−0.169; 0.170)	0.995	0.956
Fat, %	0.155	(−0.025; 0.335)	0.091	0.958
Meal frequency, n	−0.023	(−0.337; 0.291)	0.883	0.966
FMI z-score				
DQI, per 5 units	−0.053	(−0.078; −0.028)	<0.001	0.951
Global compliance (≥3 dietary compliance criteria)	0.008	(−0.249; 0.265)	0.949	0.932
Energy intake, kcal	0.048	(−0.149; 0.249)	0.629	0.933
Carbohydrates, %	0.051	(−0.199; 0.302)	0.682	0.932
Protein, %	0.039	(−0.137; 0.216)	0.660	0.932
Fat, %	−0.038	(−0.234; 0.157)	0.698	0.932
Meal frequency, n	−0.143	(−0.476; 0.188)	0.386	0.948

Diet Quality Index-A adapted from DQI–A as developed previously by Vyncke et al. (2013) [8] and used as reference. Anthropometric indices were normalised according to sex-specific BMI and FMI reference standards for Spanish adolescents aged 13–18 years [31,32]; Regression model was adjusted by physical activity and psychological support. β = estimated regression coefficient; CI = confidence interval.

technique [50]. Further, height-related indices such as BMI and FMI, were also investigated and the BMI associations were not found with healthy eating index [49] and the New Zealand Diet Quality Index (NZDQI-A) [50]. However, significant results were obtained following sex- and age-adjustment of FMI. Despite direct comparisons not being possible, our longitudinal results showed that every 5-point increase in DQI-A score was associated with BMI z-score as well as FMI z-score reductions. Observations in adults are in agreement with the current analysis i.e. longitudinal DQI is associated with less weight gain in adults [51].

The main limitation of this study is the possible presence of under-reporting which is common in nutritional studies, especially among those performed with individuals having overweight or obesity [52]. Under-reporting could more likely affect energy and macronutrients intake, than diet quality assessment. This may be the reason of some body composition changes observed in non-adherence adolescents although in a marginal significance. This could explain the stronger associations observed for DQI-A when compared to nutrient intake. Nevertheless, there is a need to design an obesity-specific diet quality index to assess compliance to obesity treatment in adolescents. On the other hand, the findings should be taken with care, because we found a low dietary compliance rate after 2 months and decrease compliance rate over time was observed. Although the obtained dietary compliance rate, our results shown a very good association with body composition changes showing the importance of multidisciplinary and family-based obesity treatment in a short and long term. The strengths of this study are the low attrition rate in dietary and anthropometric measurements despite the relatively long follow-up duration, as seen in few other studies [15]. Furthermore, we used standardised measures for collecting detailed dietary information from dietary records; a methodology that has been widely used [53].

In conclusion, our study showed diet quality (DQI-A) is a good predictor of body composition changes in overweight adolescents participating in a multidisciplinary group-based treatment programme. As such, assessment of changes in diet quality could be a useful tool in predicting body composition changes in obese adolescents involved in a diet and physical activity intervention backed-up by psychological and family support.

Authorship

LM, JM-G and PM-E conceived and designed this study; LM, AM, CC, JM-G and AsM conceived and designed the original EVASYON Study; PM-E and JS analysed and interpreted the data; PM-E carried-out measurements. All authors were involved in drafting the manuscript and had final approval of the version submitted for publication. EVASYON Study Group provided technical and logistic support during the study. Editorial assistance was by Dr Peter R Turner of Tscimed.com.

Conflict of interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.clnu.2018.02.032.

References

[1] Biro FM, Wien M. Childhood obesity and adult morbidities. Am J Clin Nutr 2010 May;91(5):1499S–505S.
[2] Oude Luttikhuis H, Baur L, Jansen H, Shrewsbury VA, O'Malley C, Stolk RP, et al. Interventions for treating obesity in children. Cochrane Database Syst Rev 2009;1: CD001872.
[3] de Miguel-Etayo P, Moreno LA, Iglesia I, Bel-Serrat S, Mouratidou T, Garagorri JM. Body composition changes during interventions to treat overweight and obesity in children and adolescents; a descriptive review. Nutr Hosp 2013 Jan-Feb;28(1):52–62.
[4] Moreno LA. Effects of diet on growth of children with obesity. J Pediatr Gastroenterol Nutr 2010 Dec;51(Suppl 3):S147–8.
[5] De Miguel-Etayo P, Bueno G, Garagorri JM, Moreno LA. Interventions for treating obesity in children. World Rev Nutr Diet 2013;108:98–106.
[6] Patterson E, Warnberg J, Kearney J, Sjostrom M. The tracking of dietary intakes of children and adolescents in Sweden over six years: the European Youth Heart Study. Int J Behav Nutr Phys Activ 2009;6:91.
[7] Marshall S, Burrows T, Collins CE. Systematic review of diet quality indices and their associations with health-related outcomes in children and adolescents. J Hum Nutr Diet 2014 Dec;27(6):577–98.
[8] Vyncke K, Cruz Fernandez E, Fajo-Pascual M, Cuenca-Garcia M, De Keyzer W, Gonzalez-Gross M, et al. Validation of the Diet Quality Index for Adolescents by comparison with biomarkers, nutrient and food intakes: the HELENA study. Br J Nutr 2013 Jun;109(11):2067–78.
[9] De Miguel-Etayo P, Moreno LA, Santabarbara J, Martin-Matillas M, Piqueras MJ, Rocha-Silva D, et al. Anthropometric indices to assess body-fat changes during a multidisciplinary obesity treatment in adolescents: EVASYON Study. Clin Nutr 2015 Jun;34(3):523–8.
[10] Smith KL, Kerr DA, Howie EK, Straker LM. Do overweight adolescents adhere to dietary intervention Messages? Twelve-Month detailed dietary outcomes from Curtin University's activity, food and attitudes program. Nutrients 2015;7(6):4363–82.
[11] Nguyen B, Shrewsbury VA, O'Connor J, Steinbeck KS, Hill AJ, Shah S, et al. Two-year outcomes of an adjunctive telephone coaching and electronic contact intervention for adolescent weight-loss maintenance: the Loozit randomized controlled trial. Int J Obes (Lond) 2013 Mar;37(3):468–72.
[12] Janicke DM, Sallinen BJ, Perri MG, Lutes LD, Huerta M, Silverstein JH, et al. Comparison of parent-only vs family-based interventions for overweight children in underserved rural settings: outcomes from project STORY. Arch Pediatr Adolesc Med 2008 Dec;162(12):1119–25.
[13] Bean MK, Mazzeo SE, Stern M, Evans RK, Bryan D, Ning Y, et al. Six-month dietary changes in ethnically diverse, obese adolescents participating in a multidisciplinary weight management program. Clin Pediatr (Phila) 2011 May;50(5):408–16.
[14] Martinez-Gomez D, Gomez-Martinez S, Puertollano MA, Nova E, Warnberg J, Veiga OL, et al. Design and evaluation of a treatment programme for Spanish adolescents with overweight and obesity. The EVASYON Study. BMC Publ Health 2009;9:414.
[15] De Miguel-Etayo P, Muro C, Santabarbara J, Lopez-Anton R, Morande G, Martin-Matillas M, et al. Behavioral predictors of attrition in adolescents participating in a multidisciplinary obesity treatment program: EVASYON study. Int J Obes (Lond) 2016 Jan;40(1):84–7. https://doi.org/10.1038/ijo.2015.183. Epub 2015 Sep. 18.
[16] Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. Bmj 2000 May 6;320(7244):1240–3.
[17] Marques M, Moleres A, Rendo-Urteaga T, Gomez-Martinez S, Zapatera B, Romero P, et al. Design of the nutritional therapy for overweight and obese Spanish adolescents conducted by registered dieticians: the EVASYON study. Nutr Hosp 2012 Jan-Feb;27(1):165–76.
[18] Moreno LA, Mesana MI, Gonzalez-Gross M, Gil CM, Fleta J, Warnberg J, et al. Anthropometric body fat composition reference values in Spanish adolescents. The AVENA Study. Eur J Clin Nutr 2006 Feb;60(2):191–6.
[19] Pool R. Fat: fighting the obesity epidemic. Oxford University Press; 2001. p. 214.
[20] Schofield WN. Predicting basal metabolic rate, new standards and review of previous work. Hum Nutr Clin Nutr 1985;39(Suppl 1):5–41.
[21] Moreiras O. Tablas de composición de alimentos. 7th ed. Madrid, Spain: Ediciones Pirámide; 2003.
[22] Mataix J. Tabla de composición de alimentos. 4th ed. Granada, Spain: Universidad de Granada; 2003.
[23] Martin-Moreno JM, Boyle P, Gorgojo L, Maisonneuve P, Fernandez-Rodriguez JC, Salvini S, et al. Development and validation of a food frequency questionnaire in Spain. Int J Epidemiol 1993 Jun;22(3):512–9.
[24] Huybrechts I, Vereecken C, De Bacquer D, Vandevijvere S, Van Oyen H, Maes L, et al. Reproducibility and validity of a diet quality index for children assessed using a FFQ. Br J Nutr 2010 Jul;104(1):135–44.
[25] The European Food Information Council (EUFIC). Food-based dietary guidelines in Europe (FBDG). 2015. http://wwweuficorg/article/en/expid/food-based-dietary-guidelines-in-europe/ [Accessed February 2015].
[26] Huybrechts I, Vereecken C, Vyncke K, Maes L, Slimani N, De Henauw S. The 'Diet Quality Index' and its applications. In: Diet Quality. New York: Springer; 2013. p. 301–14.
[27] Martinez-Gomez D, Martinez-de-Haro V, Pozo T, Welk GJ, Villagra A, Calle ME, et al. Reliability and validity of the PAQ-A questionnaire to assess physical activity in Spanish adolescents. Rev Esp Salud Publica 2009 May-Jun;83(3):427–39.
[28] Schoemaker C, Verbraak M, Breteler R, van der Staak C. The discriminant validity of the eating disorder Inventory–2. Br J Clin Psychol 1997 Nov;36(Pt 4):627–9.
[29] De Miguel-Etayo P, Moreno LA, Santabarbara J, Bueno G, Martin-Matillas M, Zapatera B, et al. Body composition changes during a multidisciplinary treatment programme in overweight adolescents: EVASYON Study. Nutr Hosp 2015 Dec 1;32(6):2525–34.
[30] Moreno LA, Joyanes M, Mesana MI, Gonzalez-Gross M, Gil CM, Sarria A, et al. Harmonization of anthropometric measurements for a multicenter nutrition survey in Spanish adolescents. Nutrition 2003 Jun;19(6):481–6.
[31] VanItallie TB, Yang MU, Heymsfield SB, Funk RC, Boileau RA. Height-normalized indices of the body's fat-free mass and fat mass: potentially useful indicators of nutritional status. Am J Clin Nutr 1990 December 1;52(6):953–9.
[32] Sobradillo B, Aguirre A, Aresti U, Bilbao A, Fernández-Ramos C, Lizárraga A, et al. Curvas y tablas de crecimiento. Estudio longitudinal y transversal. Fundación F Orbegozo; 2002.
[33] Moreno L, Mesana M, Gonzalez-Gross M, Gil C, Ortega F, Fleta J. Body fat distribution reference standards in Spanish adolescents: the AVENA study. Int J Obes 2007;31:1798–805.
[34] Sondike SB, Copperman N, Jacobson MS. Effects of a low-carbohydrate diet on weight loss and cardiovascular risk factor in overweight adolescents. J Pediatr 2003 Mar;142(3):253–8.
[35] Avenell A, Sattar N, Lean M. ABC of obesity. Management: Part I–behaviour change, diet, and activity. BMJ 2006 Oct 7;333(7571):740–3.
[36] Collins CE, Warren J, Neve M, McCoy P, Stokes BJ. Measuring effectiveness of dietetic interventions in child obesity: a systematic review of randomized trials. Arch Pediatr Adolesc Med 2006 Sep;160(9):906–22.
[37] Gow ML, Ho M, Burrows TL, Baur LA, Stewart L, Hutchesson MJ, et al. Impact of dietary macronutrient distribution on BMI and cardiometabolic outcomes in

overweight and obese children and adolescents: a systematic review. Nutr Rev 2014 Jul;72(7):453−70.

[38] Kirk SF, Penney TL, McHugh TL, Sharma AM. Effective weight management practice: a review of the lifestyle intervention evidence. Int J Obes (Lond) 2012 Feb;36(2):178−85.

[39] Garnett SP, Gow M, Ho M, Baur LA, Noakes M, Woodhead HJ, et al. Optimal macronutrient content of the diet for adolescents with prediabetes; RESIST a randomised control trial. J Clin Endocrinol Metab 2013 May;98(5):2116−25.

[40] Mirza NM, Palmer MG, Sinclair KB, McCarter R, He J, Ebbeling CB, et al. Effects of a low glycemic load or a low-fat dietary intervention on body weight in obese Hispanic American children and adolescents: a randomized controlled trial. Am J Clin Nutr 2013 Feb;97(2):276−85.

[41] Jon Schoenfeld B, Albert Aragon A, Krieger JW. Effects of meal frequency on weight loss and body composition: a meta-analysis. Nutr Rev 2015 Feb;73(2): 69−82.

[42] Asghari G, Mirmiran P, Rashidkhani B, Asghari-Jafarabadi M, Mehran M, Azizi F. The association between diet quality indices and obesity: Tehran Lipid and Glucose Study. Arch Iran Med 2012 Oct;15(10):599−605.

[43] Mariscal-Arcas M, Romaguera D, Rivas A, Feriche B, Pons A, Tur JA, et al. Diet quality of young people in southern Spain evaluated by a Mediterranean adaptation of the Diet Quality Index-International (DQI-I). Br J Nutr 2007 Dec;98(6):1267−73.

[44] Gregory CO, McCullough ML, Ramirez-Zea M, Stein AD. Diet scores and cardio-metabolic risk factors among Guatemalan young adults. Br J Nutr 2009 Jun;101(12):1805−11.

[45] Chiplonkar SA, Tupe R. Development of a diet quality index with special reference to micronutrient adequacy for adolescent girls consuming a lacto-vegetarian diet. J Am Diet Assoc 2010 Jun;110(6):926−31.

[46] Golley RK, Hendrie GA, McNaughton SA. Scores on the dietary guideline index for children and adolescents are associated with nutrient intake and socio-economic position but not adiposity. J Nutr 2011 Jul;141(7):1340−7.

[47] Feskanich D, Rockett HR, Colditz GA. Modifying the healthy eating index to assess diet quality in children and adolescents. J Am Diet Assoc 2004 Sep;104(9):1375−83.

[48] Kosti RI, Panagiotakos DB, Mariolis A, Zampelas A, Athanasopoulos P, Tountas Y. The diet-lifestyle index evaluating the quality of eating and life-style behaviours in relation to the prevalence of overweight/obesity in adolescents. Int J Food Sci Nutr 2009;60(Suppl 3):34−47.

[49] Hurley KM, Oberlander SE, Merry BC, Wrobleski MM, Klassen AC, Black MM. The healthy eating index and youth healthy eating index are unique, nonredundant measures of diet quality among low-income, African American adolescents. J Nutr 2009 Feb;139(2):359−64.

[50] Wong JE, Parnell WR, Howe AS, Lubransky AC, Black KE, Skidmore PM. Diet quality is associated with measures of body fat in adolescents from Otago, New Zealand. Publ Health Nutr 2014 Jun;18(8):1453−60.

[51] Quatromoni PA, Pencina M, Cobain MR, Jacques PF, D'Agostino RB. Dietary quality predicts adult weight gain: findings from the Framingham Offspring Study. Obesity (Silver Spring) 2006 Aug;14(8):1383−91.

[52] Fisher JO, Johnson RK, Lindquist C, Birch LL, Goran MI. Influence of body composition on the accuracy of reported energy intake in children. Obes Res 2000 Nov;8(8):597−603.

[53] Vereecken CA, Covents M, Sichert-Hellert W, Fernández-Alvira JM, Le Donne C, De Henauw S, et al. Development and evaluation of a self-administered computerized 24-h dietary recall method for adolescents in Europe. Int J Obes (Lond) 2008 Nov;32(Suppl 5):S26−34.