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Diet quality index is a good predictor of treatment efficacy in overweight and obese adolescents: the EVASYON Study

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Running title: Diet quality index in obese adolescents

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

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ABSTRACT

Background and 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 compliance with dietary intervention, specifically the overall quality of the diet, can predict body composition changes.

Methods

To this purpose, overweight/obese adolescents (n=117, aged: 13 to 16 years; 51 males, 66 females) were recruited into a multi-component (diet, physical activity and psychological support) family-based group treatment program. We measured the adolescents' compliance 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. Adolescents complying with the meal frequency criteria at the end of the extensive phase had greater reductions in FMI z-scores than those not complying (*Cohen´s d*=0.53). A statistically significant association was observed with the diet quality index. DQI-A variation explained 97.7% of BMI z-score changes and 95.1% of FMI changes.

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.

Keywords: adolescents, multi-intervention approach, fat mass loss, dietary compliance, diet quality index

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 predicts 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 with the dietary intervention, specifically the overall quality of the diet, can predict body composition changes.

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 to 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.

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].

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.

All body composition and dietary intake measurements were performed at baseline, at the end of the intensive intervention (2 months), at midpoint of the extensive intervention (6 months), and at the end of the EVASYON treatment programme (13 months). The FFQ was applied at 0, 6 and 13 months [14]. As such, the DQI-A was measured at baseline, at the end of the intensive intervention (2 months), and at the end of the EVASYON treatment programme (13 months).

Intervention

The EVASYON treatment programme has been described elsewhere [14]. Briefly, it was conducted in small groups of 9 to 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.

<u>*Intensive phase*</u>

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 minutes 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 60 minutes 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.

Extensive phase

Dietary intervention involved iso-energetic flexible meal plans, based on food-portion exchanges. In addition, to achieve at least 60 minutes 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.

Assessing energy intake and calorie restriction

Schofield's equation [19] 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 ≤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 < 1,300 kcal or > 2,200 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].

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/shopping organisation, usual meal-time site during the week and week-ends, meal-related habits before starting the therapy (e.g. meal frequency) and personal beliefs about the role of food and meal-times in the family.

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. Nutrient intakes from 72h 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 [20, 21]. Data on food intakes from 72h dietary records were transformed into macronutrient intake and as percentage of total energy intake so as to assess dietary compliance.

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 [22]. It 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/noncompliance [22]. 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 [23].

Diet Quality Index for Adolescents (DQI-A)

Based on the Spanish FBDG [24], we adapted the DQI for adolescents that had been previously validated by Vyncke et al [8] and which had 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, 25].

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 [24]. 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.

Compliance to dietary 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 50-55% ± 5% ; (3) Adequacy of protein intake; percentage of proteins in energy intake, between 10-15% ± 5%; (4) Adequacy of fat intake; percentage of fat in energy intake, between 30-35% ± 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".

Further, DQI scores for an individual provide an estimate of diet quality relative to national guidelines.

Body composition measurements

Body composition was assessed by anthropometry in the overall study sample. The anthropometric measurements were performed using the standardised protocols of the AVENA study [26]. 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 0.1 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 and FFM are usually expressed as percentage of total body weight, but an alternative is to express these variables in relation to height squared since more valuable indices are obtained including: FMI [FM (kg)/height (m^2)] and fat-free mass index (FFMI) [FFM (kg)/height (m^2)] [27].

Circumferences were measured with an inelastic tape to the nearest millimetre, with the subject upright. Two circumferences were measured. For the waist circumference (WC), the measuring tape was applied horizontally midway between the lowest rib margin and the iliac crest, at the end of a gentle exhalation. The hip circumference (HC) measurement was taken at the point yielding the maximum circumference over the buttocks, with the tape held in a horizontal plane [26]. Waist-to-hip ratio (W-to-H) and waist-to-height ratio (WHtR) were calculated as indices of abdominal fat [28].

The z-score was calculated according to sex-specific BMI reference standards for Spanish adolescents aged 13-18 years [18, 29]. Cut-off points of FMI were calculated using the sample from the AVENA Study which included 2,851 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 anthropometry indices (BMI and FMI) were used to evaluate body composition changes over the 13 months of follow-up.

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, hip circumference, body mass index (BMI) and fat-free mass index (FFMI) 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. 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, 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.

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; 50 adolescents were not included in the analyses because, for technical reasons, the participating centre was unable to complete the research protocol. Compared with females, males had greater height, waist circumference, FMI and W-to-H ratio ($p<0.001$). However, females had higher hip circumference ($p=0.034$) and FFMI ($p<0.001$). With respect to dietary measurements, males 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 tended to consume 5 meals/day than did their female counterparts (52.9% and 51.5%, respectively; n.s.)

The compliance from single dietary criteria 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 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. Global compliance to the dietary intervention was 37.4% during intensive and 14.3% during extensive phase.

BMI and FMI z-score changes in relation to dietary compliance during the intensive and extensive phases 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).

There was a significant correlation between DQI-A and BMI z-score changes between baseline to 13 months (rho= -0.178, p=0.037). However, the correlations between DQI-A and FMI z-score changes were not statistically significant (rho=-0.011, p=0.905) (Figure 1).

In the random coefficients regression models (Table 4), using BMI and FMI z-score changes from baseline to the end of the extensive phase as the dependent variable, a statistically significant association was only observed with the DQI; 5-unit increases in DQI-A score resulted in BMI z-score decrease of 0.09 units (p<0.001) and in FMI z-score decrease of 0.06 units (p<0.001). DQI-A variation explained 97.7% of BMI z-score changes (pseudo R^2= 0.977) and 95.1% of FMI changes (pseudo R^2= 0.951).

DISCUSSION

The main finding of the present study was that quality of diet (DQI-A) is the best 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 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 [30-32]. 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 [33]. The highest BMI reductions were achieved with the low-carbohydrate diets [30, 34] and with different protein-content diets [35, 36]; albeit the studies have had limited quality. In agreement with some previous studies [30, 34-36], 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 [37]. 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 [38, 39] and obesity status [39], while another observed a positive association with both BMI and WC [40] 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 [41, 42]. Conversely, other studies found an inverse association with BMI [43, 44]. 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 [45, 46]. Inverse associations were observed with body-fat percentage, assessed by laboratory techniques [45] and with body-fat percentage assessed by BIA technique [46]. Further, height-related indices such as BMI and FMI, were also investigated and the BMI associations were not found with healthy eating index [45] and the New Zealand Diet Quality Index (NZDQI-A) [46]. 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 [47].

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 [48]. Under-reporting could more likely affect energy and macronutrients intake, than diet quality assessment. 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.

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. Further, we used standardised measures for collecting detailed dietary information from dietary records; a methodology that has been widely used [49].

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.

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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

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Table 1: Characteristics of the study sample at baseline

	Males			Females			p
	N	Mean	SD	N	Mean	SD	
Anthropometric measurements							
Age, years	51	14.49	(1.08)	66	14.40	(13.70-16.00)	0.373
Weight, kg	51	86.64	(14.70)	66	81.0	(72.00-90.80)	0.066
Height, cm	51	166.98	(161.87-172.00)	66	162.73	(156.85-166.00)	<0.001
Waist circumference, cm	51	101.81	(9.29)	65	94.23	(12.62)	<0.001
Hip circumference, cm	50	108.16	(9.21)	65	112.86	(10.59)	0.039
Body Mass Index, BMI kg/m^2	51	30.87	(3.69)	66	30.53	(27.69-35.27)	0.779
Fat Mass Index, FMI kg/m^2 [a]	51	11.42	(2.28)	65	9.05	(1.30)	<0.001
Fat-Free Mass Index, FFMI kg/m^2	51	19.49	(18.06-20.65)	65	21.59	(19.73-24.79)	<0.001
Waist-to-Hip Ratio	50	0.94	(0.05)	65	0.83	(0.09)	<0.001
Waist-to-Height Ratio	51	0.61	(0.05)	65	0.58	(0.07)	0.037
Dietary measurements							
Energy intake, kcal	51	2336.23	(689.03)	66	1867.42	(1583.52-2217.48)	0.001
Carbohydrate, %	51	38.88	(6.87)	66	37.25	(6.95)	0.207
Protein, %	51	19.18	(3.38)	66	18.39	(3.86)	0.241
Fat, %	51	41.67	(6.63)	66	43.85	(7.61)	0.103
Meal frequency ‡ [b]							
3; n, %		9	17.6		9	(13.6)	0.751
4; n, %		15	29.4		23	(34.8)	

5; n, %		27	52.9		34	(51.5)	
Diet Quality Index for Adolescents; DQI-A	51	46.40	(13.59)	66	54.85	(44.77-59.28)	0.007

Legend Table 1

Student *t*-test was applied for normally distributed variables; mean (SD) and Mann–Whitney U test for non-normally distributed variables; or median (interquartile intervals). Circumferences data obtained using the mean of three determinations; [a]: FMI calculated, Fat Mass (kg) obtained by skin-fold thickness; [b]: data presented as frequency (%). ‡: χ^2 test for meal frequency

Table 2: Dietary compliance distribution in the study

	Intensive phase (2 months)		Extensive phase (13 months)	
	Non-adherence n (%)	Adherence n (%)	Non-adherence n (%)	Adherence n (%)
Energy intake, kcal	63 (58.9)	44 (41.1)	60 (65.9)	31 (34.1)
Carbohydrate, %	71 (66.4)	36 (33.6)	72 (79.1)	19 (20.9)
Protein, %	82 (76.6)	25 (23.4)	60 (65.9)	31 (34.1)
Fat, %	34 (31.8)	73 (68.2)	42 (46.2)	49 (53.8)
Meal frequency, n	11 (14.9)	63 (85.1)	23 (30.7)	52 (69.3)
Global compliance (≥3 dietary compliance criteria)	67 (62.6)	40 (37.4)	78 (85.7)	13 (14.3)

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	
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 *
Overall compliance (≥3 dietary compliance criteria)	-0.48 (0.33) N=65	-0.44 (0.23) N=38	0.04	-0.24 (0.39) N=60	-0.19 (0.33) N=38	0.05
Extensive phase	Non-adherence	Adherence		Non-adherence	Adherence	
Energy intake, kca)	-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)	-0.11 (0.64)	0.06	-0.23 (0.66)	-0.05 (0.53)	0.18 *

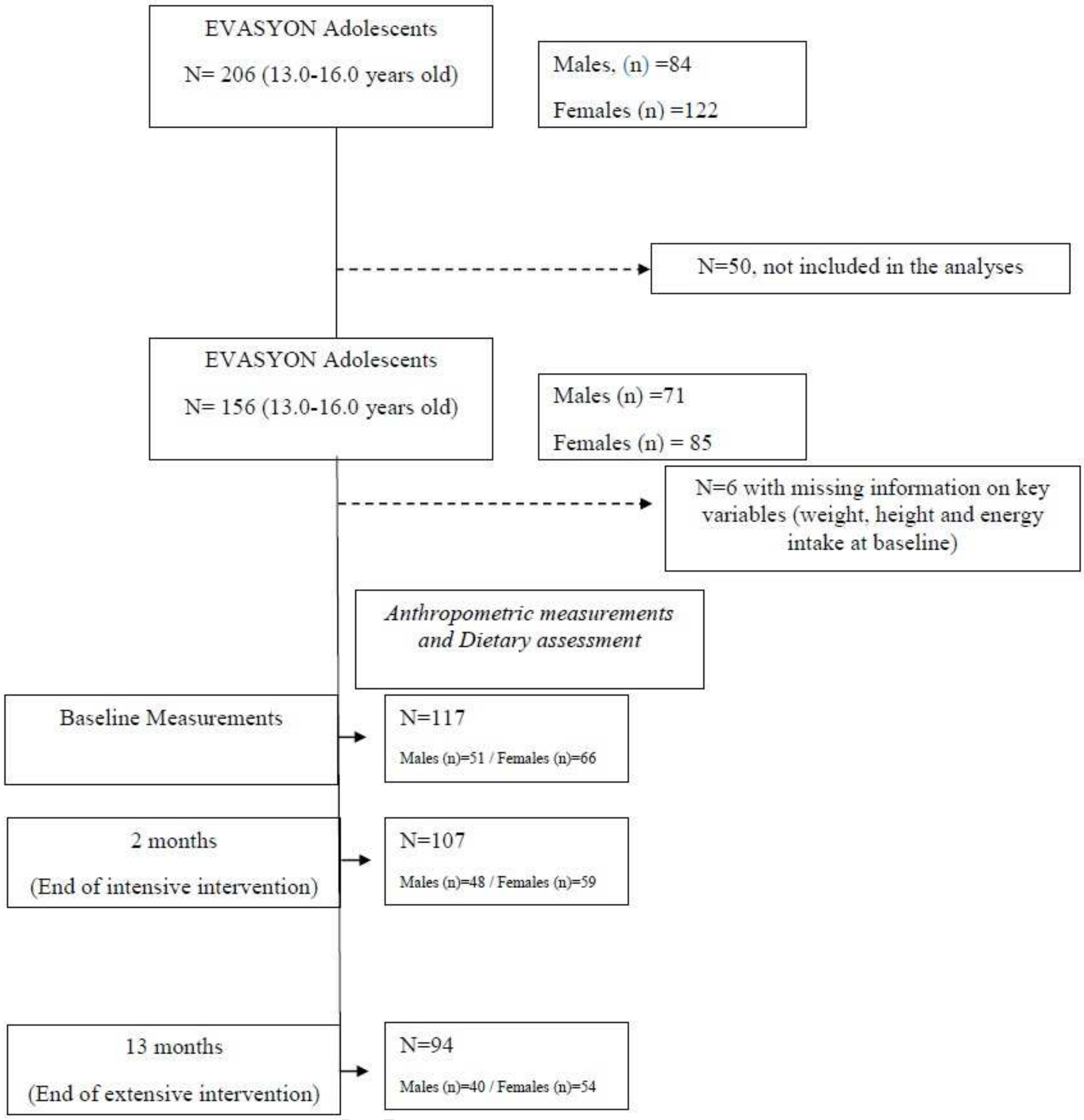
	N=38	N=49		N=33	N=39	
Meal frequency, n	-0.09 (0.73) N=23	-0.18 (0.60) N=50	-0.09	0.08 (0.38) N=20	-0.23 (0.67) N=45	-0.31 **
Global compliance (≥3 dietary compliance criteria)	-0.17 (0.62) N=74	0.02 (0.57) N=13	0.19 *	-0.17 (0.59) N=65	-0.01 (0.65) N=11	0.16 *

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: Random coefficients analyses in males and females with a random intercept and a random slope with time; evaluation of relationships between BMI z-score, FMI z-score, and dietary compliance criteria and DQI-A

	Model			
	β	95%CI	*p*	Pseudo R^2
BMI z-score				
Energy intake, kcal	0.140	(-0.037; 0.317)	0.120	0.954
Carbohydrates, (%	0.147	(-0.100; 0.394)	0.241	0.955
Protein, %	-0.002	(-0.171; 0.166)	0.979	0.955
Fat, %	0.177	(-0.002; 0.356)	0.053	0.957
Meal frequency, n	0.029	(-0.279; 0.338)	0.846	0.964
Global compliance (≥3 dietary compliance criteria)	0.191	(-0.038; 0.419)	0.101	0.948
DQI, per 5 units	-0.088	(-0.105; -0.067)	<0.001	0.977
FMI z-score				
Energy intake, kcal	0.058	(-0.133; 0.251)	0.543	0.934
Carbohydrates, %	0.095	(-0.145; 0.335)	0.433	0.934
Protein, %	0.045	(-0.126; 0.218)	0.599	0.935
Fat, %	-0.127	(-0.205; 0.179)	0.895	0.935
Meal frequency, n	-0.045	(-0.366; 0.275)	0.775	0.949
Global compliance (≥3 dietary compliance criteria)	0.075	(-0.165; 0.315)	0.535	0.933
DQI, per 5 units	-0.059	(-0.083; -0.035)	<0.001	0.951

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 [14, 29]; β = estimated regression coefficient; CI = confidence interval


EVASYON Adolescents
N= 206 (13.0-16.0 years old)
Males, (n) =84
Females (n) =122
N=50, not included in the analyses
EVASYON Adolescents
N= 156 (13.0-16.0 years old)
Males (n) =71
Females (n) = 85
N=6 with missing information on key variables (weight, height and energy intake at baseline)
Anthropometric measurements and Dietary assessment
Baseline Measurements
N=117
Males (n)=51 / Females (n)=66
2 months
(End of intensive intervention)
N=107
Males (n)=48 / Females (n)=59
13 months
(End of extensive intervention)
N=94
Males (n)=40 / Females (n)=54