A Follow-up Study of Overweight Children and Adolescents with Diet Therapy Adjusted by Indirect Calorimetry

Estudo longitudinal de crianças e adolescentes com excesso de peso, com dietoterapia ajustada por calorimetria indireta

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Abstract

Introduction Changes in lifestyle have led to an increase in the prevalence of excess weight. Several interventions intended to reverse this situation have been tested.

Methods We evaluated changes in the z-score for body mass index in children and adolescents after dietary management adjusted by indirect calorimetry. During 1 year, a monthly follow-up was performed on 27 children and adolescents (8–15 years) with overweight/obesity (z-score for body mass index $\geq +1$); body weight and stature measurements were collected at inclusion, at 6, and at 12 months after indirect calorimetry. Each participant received a diet adjusted by the value of indirect calorimetry. The basal metabolic rate (BMR) was evaluated to understand how to behave according to the bodily changes induced by the intervention. For statistical analyses, repeated-measures analysis of variance (ANOVA) were performed.

Results The z-score for body mass index showed a reduction by the end of the study (-0.17 ± 0.05 [$p = 0.014$]). The BMR dropped during the first 6 months but returned to baseline values after 12 months ($p = 0.231$).

Conclusion Dietary management adjusted by BMR for obese children and adolescents with excess weight, with monthly appointments, was effective after 12 months of intervention; the weight loss did not cause significant change of BMR in this period.

Keywords
- obesity
- child
- adolescent
- diet
- indirect calorimetry
- body mass index

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Resumo

Introdução Mudanças no estilo de vida têm levado a um aumento na prevalência de excesso de peso. Muitas intervenções com o intuito de reverter esta situação têm sido testadas.

Métodos Nós avaliamos as mudanças no escore-Z do índice de massa corporal em crianças e adolescentes depois de uma intervenção dietoterápica ajustada por calorimetria indireta. Durante 1 ano, um seguimento mensal foi feito com 27 crianças e adolescentes (8–15 anos) com sobrepeso/obesidade (escore-Z para índice de massa corporal $\geq +1$); medidas de peso corporal e estatura foram coletadas na inclusão, em 6 e em 12 meses depois da calorimetria indireta. Cada participante recebeu uma dieta ajustada pelo valor da calorimetria indireta. A taxa metabólica basal (TMB) foi medida para entender como se comportaria de acordo com as mudanças induzidas pela intervenção. Para a análise estatística, análise de variância para medidas repetidas (ANOVA) foi realizada.

Resultados O escore-Z do índice de massa corporal mostrou uma redução no final do estudo ($-0{,}17 \pm 0{,}05$ [$p = 0{,}014$]). A TMB diminuiu durante os 6 primeiros meses mas retornou ao valor basal depois de 12 meses ($p = 0{,}231$).

Conclusão Manejo dietoterápico ajustado pela TMB para crianças e adolescentes com excesso de peso, com encontros mensais foi efetivo depois de 12 meses de intervenção; a perda de peso não causou mudança significativa na TMB neste período.

Palavras-chave

- obesidade
- criança
- adolescente
- dieta
- calorimetria indireta
- índice de massa corporal

Introduction

The current model of social development has changed contemporary lifestyle. This includes changes in eating habits and physical activity, which have led to an increase in the number of overweight people and in diseases associated with excess weight, such as hypertension, hypercholesterolemia, and diabetes mellitus.[1] In Brazil, recent research on overweight and obese children has reported prevalence in children between 5 and 9 years of age of 43.8% for boys, and 51.4% for girls; for adolescents (between 10 and 19 years), the prevalence is 23.4% for boys, and 27.6% for girls.[2]

The scientific literature is very rich in studies showing interventions to promote weight loss in obese children and adolescents, although the results are often disappointing.[3] The isolation of a single strategy has been often tried to determine the actual contribution of each element in weight loss. As a consequence, there are studies checking the effect of different diets, drugs, physical activity, psychosocial changes, and many others.[4]

To evaluate the effect of a dietary intervention, one of the difficulties is to establish the caloric value to be set for each research subject.[5] The use of a single value in the pediatric group cannot be admitted. The correction for age or even by pubertal stage can be inadequate, since weight and body composition of obese children are very different from the population average.[6] The individual calculation of the energy value to be prescribed seems, therefore, to be a good option.[7] Additionally, with this strategy, it is possible to know the changes in basal metabolic rate (BMR) of obese children and adolescents during a treatment for weight loss.

The objective of this study was to evaluate the changes in the z-scores for body mass index (zBMI) of overweight or obese children and adolescents submitted to a diet intervention based on energy consumption estimated by indirect calorimetry (IC). The BMR evolution and the factors associated with changes in the zBMI (height and weight) were also investigated.

Materials and Methods

An experimental study was performed, in which each participant was his or her own control. The study was conducted for 1 year with monthly appointments. Body weight and stature measures, IC, and bioelectrical impedance analysis (BIA) were taken upon inclusion in the study, at 6, and at12 months.

The study included 30 participants. Three were lost due to withdrawal during the year after two, seven, and eight consultations. The final population, therefore, included 27 children and adolescents aged 8 to 15 years and with a zBMI $\geq +1$. The participants responded to an advertisement published in newspapers with wide circulation in southern Brazil. This study was part of a larger study that compared these results with those obtained through the exclusive management with physical activity and data from an outpatient referral center for child and adolescent obesity.[8] Participants with chronic diseases, continuous use of medication, mental or psychiatric disorders that could interfere in their understanding or participation, problems that hindered anthropometry, those who refused to participate (did not sign the informed consent form), and participants who, after the initial laboratory evaluation, had abnormal

thyroid function or diabetes mellitus were excluded. The parents or legal guardians responsible for the participants signed an informed consent form. The project was approved by the Ethics in Research Committee of the Hospital de Clínicas de Porto Alegre (HCPA), number 09–473. The main research that contains the present study is registered at clinicaltrials.gov NCT01297374.

The socioeconomic profile of the participants was established according to criteria by the Brazilian Association of Survey Companies.[9] Anthropometric measurements were always obtained by the researcher responsible for the inclusion of a child or adolescent in the study.

The measurement of body weight and stature followed parameters determined by the Food and Nutrition Surveillances System.[10] The electronic scale (model MIC PPA; Filizola, Brazil). Used had a 50-g sensitivity and a 200-kg maximum capacity. Participants were weighed barefoot, wearing a sleeveless hospital gown, whose weight was subtracted from the final measurement. Stature was measured using fixed stadiometer with a 0.1-cm scale. Subsequently, the body mass index was calculated, defined as the weight in kilograms divided by the squared height (in meters) (kg/m^2). For classification we used the Centers for Disease Control and Prevention (CDC) curves,[11] implemented in EpiInfo 2005, version 3.3.2. (Atlanta, GA, EUA); we also used the World Health Organization (WHO) curves,[12] implemented in Anthro Plus (Geneva, Switzerland). Children and adolescents whose zBMI was $\geq +2$ were considered obese. Children whose zBMI $\geq +1$ and $< +2$ were considered overweight.

Indirect calorimetry exams were performed using the exercise and nutritional assessment system VO2000 (Medgraphics, St. Paul, MN, USA) and following the Associação Brasileira de Nutrologia (Brazilian Association of Nutrology) guidelines.[13] The equation for total energy value (TEV) was: TEV = ([BMR – kcal sleep] x AF + kcal sleep) – 20%, in which TEV = total energy value; BMR = basal metabolic rate; kcal sleep = kilocalories corresponding to hours of sleep; AF = activity factor (1.5 for girls, 1.6 for boys). This equation was developed based on a Food and Agriculture Organization (FAO)/WHO publication, which considers that the energetic value of sleep equals BMR[14]. For this reason, the activity factor suggested by the FAO/WHO for children and adolescents with light activities was multiplied only by the waking hours. Diet calculations were performed using the NutWin software – Nutrition Support Program, Federal University of São Paulo.[15]

The BIA was performed following Kyle et al (2004) recommendations[16] and using Byodynamics model 310 (Seattle, WA, EUA). Self-classification of sexual maturity followed the criteria described by Marshall and Tanner.[17,18] The charts were presented to the child or adolescent who informed their choice to the observer.

At the monthly evaluations, participants were always scheduled for appointments with the principal investigator. They received a customized dietary plan, based on 100% of the TEV calculated. Individual orientation and issues associated with food portions, eating fruits, vegetables, and whole foods, increasing calcium and iron intake, and reducing consumption of simple sugars were also emphasized.

Statistical Analyses

We used repeated-measures ANOVA with Bonferroni correction or Friedman test for the analysis. Variables are described showing their distribution. The statistical analysis was performed using the Predictive Analysis Software (PASW) 18.0 for Windows (SPSS Inc., Chicago, IL, EUA); we adopted $p < 0.05$ as the level of statistical significance.

Results

The final population included 27 individuals. The general characteristics are presented in ►**Table 1**. There was a significant difference in BMR measured by IC assessed at 3 moments ($p = 0.007$). The BMR showed a non-significant reduction during the first 6 months of the study ($= -267$ [interquartile range - IQR: $-1{,}101$ to 554]; $p = 0.521$). Between the 6th and 12th months, the BMR increased ($= 685.8$ [IQR: $-1{,}351$ to -62]; $p = 0.005$), and in 12 months of follow-up the increase was not significant ($= 447.6$ [IQR: $-1{,}035$ to 299.6]; $p = 0.231$) (►**Fig. 1**).

►**Table 2** shows the comparison between zBMI in all three evaluations. There was a significant decrease in the average

Table 1 Characteristics of the 27 participants at the time of inclusion in the study and body mass index z-score after and before the intervention

	Characteristics	Values[a]
	Age	12.03 ± 2.13
	Female	14 (51.9)
inclusion	BMI z-score-WHO	3.20 ± 0.59
	BMI z-score-CDC	2.29 ± 0.24
12th month	BMI z-score-WHO	3.03 ± 0.57
	BMI z-score-CDC	2.21 ± 0.26
	Pubertal stage	
	Prepubertal	9 (33.3)
	Pubertal	16 (59.3)
	Postpubertal	2 (7.4)
	Origin	
	Capital	14 (51.9)
	Metropolitan area	12 (44.4)
	Coastal region	1 (3.7)
	CCEB/ABEP[b]	
	B	5 (18.5)
	C	19 (70.4)
	D	3 (11.1)

Abbreviations: BMI, body mass index; CDC, Centers for Disease Control and Prevention; WHO, Word Health Organization.
[a]Data presented as average ± standard deviation or n (%).
[b]CCEB/ABEP: Brazil economic classification criteria/Brazilian Association of Survey Companies.

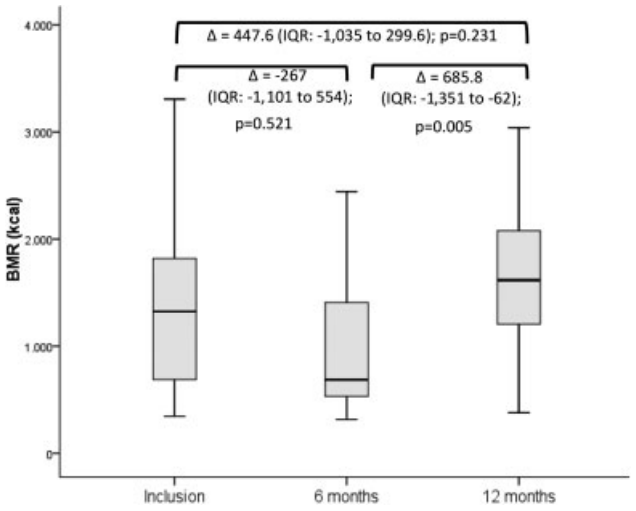

Fig. 1 Variation in basal metabolic rate measures by indirect calorimetry at three different evaluations. Abbreviations: BMR, basal metabolic rate; IQR, interquartile range.

zBMI for the first 6 months, as well as for the 12 months of follow-up, according to both WHO and CDC criteria. Twenty of the 27 participants had a decrease in zBMI in 12 months according to the WHO criteria.

Discussion

Physiological changes that take place during childhood and adolescence may influence te biochemical[19] and anthropometric parameters. Studies that investigate populations within this age range should, therefore, take sexual maturation into consideration. In our study, of the 27 participants, 9 were prepubertal at inclusion, with an average age of 12 ± 2 years. The improvement in zBMI in our study was not due to the stage of sexual maturation of the children and adolescents, but rather in all stages most children had a decrease in zBMI. Similar findings were reported by Codoner-Franch et al (2010).[19]

The mean BMR in this study was 1,324.2 kcal (IQR: 685.2–1,934.5) at inclusion and 1,616.8 kcal (IQR: 1,205.5–2,085.2) at the end of follow-up. In the final 6 months, there was a significant increase in BMR ($p = 0.005$). The reduction in BMR seen in the first 6 months was expected because the beginning of a dietetic management is perceived as an aggression, and the body will try to stop the weight reduction, which could lead, in extreme cases, to death. Over time, there is an adaptation to the new (reduced) food supply, but if this is not accompanied by an increase in energy expenditure through physical exercise, there is a tendency for the BMR not to increase.

A similar BMR value was reported among Brazilian obese adolescents in another study ($1,489 \pm 282$ kcal).[20] The result reported by Benedetti et al (2011), which was also obtained by IC, was slightly higher. In the study, the result for obese asthmatic participants was $1,550.2 \pm 547.2$ kcal, and for non-asthmatics, $1,697.2 \pm 379.8$ kcal.[21] The intervention made by Tang et al (2014), in Shanghai, on the other hand, had no impact on the BMR of the children involved.[22]

The WHO growth curves are more up to date and recommended for use with this population.[12,23] However, we did not find studies using the WHO classification that could be compared with our results. As a consequence, we also used the CDC zBMI.[11] The z-score for weight and height was also evaluated according to CDC standards.[11] The WHO classification showed, on average, a decrease 2-fold higher than the decrease observed with the CDC classification; nonetheless, both were significant for the first 6 months and at the end of the follow-up.

After 8 months of a school intervention program, Singh et al (2007) observed that all anthropometric measurements evaluated had improved in the intervention group, though a significant change in BMI was not found.[24] In this sense, our results from using only the diet therapy and no apparent change in environment were comparatively better.

The evaluation performed by Salas et al (2010) demonstrated that after 12 months of a multidisciplinary program for the treatment of obesity in children and adolescents,

Table 2 Variation in anthropometric measures during the periods: inclusion to 6th month evaluation, 6th to 12th month evaluation, and inclusion to 12th month evaluation for the 27 participants in the study

	0–6 months	6–12 months	0–12 months	*p*-value[b]
BMI z-score - WHO	-0.19 ± 0.04 *	0.02 ± 0.04	-0.17 ± 0.05 *	<0.001
improvement[c]	**22 (81.5)**	**15 (55.6)**	**20 (74.1)**	
BMI z-score - CDC	-0.08 ± 0.02 *	0.01 ± 0.02	-0.07 ± 0.03 *	0.001
improvement	**22 (81.5)**	**14 (51.9)**	**18 (66.7)**	
Height z-score - CDC	-0.02 ± 0.02	-0.08 ± 0.02 *	-0.10 ± 0.04 *	0.002
improvement	**11 (40.7)**	**8 (29.6)**	**5 (18.5)**	
Weight z-score - CDC	-0.08 ± 0.02 *	0.01 ± 0.02	-0.07 ± 0.04	0.013
improvement	**22 (81.5)**	**12 (44.4)**	**18 (66.7)**	

Abbreviations: BMI, body mass index; CDC, Centers for Disease Control and Prevention; WHO, World Health Organization.
[a]Values shown as average of the difference ± standard error of the mean and n (%).
[b]*: $p < 0.05$ using analysis of variance for repeated measures and Bonferroni correction.
[c]: improvement: how many individuals showed z-score improvement in the period assigned.

there was only a trend toward a decrease in BMI both in the intervention as in the control groups.[25] A follow-up study similar to that of the present study found a significant reduction in zBMI (-0.13) after one year of intervention, with 79.5% of youths showing a reduction or maintenance in the parameter.[26] Sabin et al (2007) found that 70.0% of children had a decrease in zBMI and 18.0% a reduction of at least 0.5 in the score,[27] a considerable decrease. In a 1-year study, 22.0% of individuals showed a zBMI reduction of ≥ 0.5, 23.0% between ≥ 0.25 and < 0.5, 33.0% between > 0 and < 0.25, and 23.0% showed an increase in the score.[28] In our study, there was a reduction of ≥ 0 to -0.37 in 18 participants; the remaining showed an increase of up to 0.14 in CDC zBMI (data not shown).

The initial stage (2 months) of a controlled randomized study conducted by Shrewsbury et al (2011) with adolescents found a reduction in zBMI (-0.05; $p < 0.01$). During the period, 22.0% of the participants had a reduction greater than 5.0% in the zBMI.[29] In our research, after the first 6 months of intervention, there was also reduction in zBMI (-0.19; $p < 0.01$), with 81.5% of participants presenting some improvement in this indicator.

The present research was innovative for using IC to obtain BMR. This equipment has not been widely used since it is not available in all research centers, with professionals trained for its use. Besides, there are many prerequisites for the examination to be properly performed, making the process difficult specially in the studied age range. The use of IC allows the personalization of dietary plans and this certainly makes a difference in treatment, as well as changes in lifestyle and actions in the school environment.

The analysis of the food records requested in the three evaluations was not possible because many participants did not deliver one or more records. Another limitation of the present study is the absence of a control group. However, similarly to Shrewsbury et al (2011), we found it unethical to leave a group without treatment.[29] Lifestyle interventions in children and adolescents provide better results as compared with control conditions.[30]

Conclusion

The results of the present study may be considered promising. The BMR showed a reduction during the first 6 months and an increase between the 6th and 12th months. In the 12 months of follow-up, the increase was not significant.

We observed that dietetic management with children and adolescents based on BMR measured by IC, with a monthly appointment, is an effective intervention to reduce the zBMI (with improvement in the z-score for height and weight) after 12 months; more intense in the first 6 months. After the initial 6-month period, it may be beneficial to add another treatment strategy, such as physical activity, to maintain the magnitude of the effect of the first 6 months.

Conflict of Interest

Dr. Nogueira-de-Almeida reports non-financial support from FIPE-HCPA during the conduct of the study.

Dr. Beghetto reports Research and Events Incentive Fund (FIPE) of the Hospital de Clínicas do Porto Alegre: office supplies and exams.

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