Symbiosis

www.symbiosisonline.org
www.symbiosisonlinepublishing.com

Research article | Obesity & Control Therapies: Open Access | Open Access

An Overweight Program for Prepubertal Children, Assessed By an Accurate Early Indicator of Adiposity Reduction

Luís Pereira-da-Silva[1]*, Daniel Virella[2], Mónica Pitta-Grós Dias[1], Elisabete Dionísio[1], Marta Alves[2], Catarina Diamantino[3], Anabela Alonso[3] and Gonçalo Cordeiro-Ferreira[1,3]

[1]Nutrition Lab, Department of Pediatrics, Hospital Dona Estefânia, Centro Hospitalar de Lisboa Central

[2]Research Unit of Centro Hospitalar de Lisboa Central

[3]Outpatient Clinic for Prepubertal Obese Children, Department of Pediatrics, Hospital de Dona Estefânia, Centro Hospitalar de Lisboa Central. Lisbon, Portugal

Received: : October 21, 2016; Accepted: December 01 , 2016; Published: December 02, 2016

***Corresponding author:** *Luís Pereira-da-Silva, Department of Pediatrics, Hospital Dona Estefânia, Rua Jacinta Marto 1169-045 Lisbon, Portugal, Tel: +351 917235528; E-mail: l.pereira.silva@chlc.min-saude.pt*

Abstract

Introduction: The early effectiveness of a weight treatment program, combining diet with exercise, was assessed in compliant obese prepubertal children in a clinic-setting.

Methods: Body composition was assessed monthly via air displacement plethysmography in a convenience cohort of consecutively referred prepubertal obese children (body mass index > P_{95}), aged 3 to 9 years, to a hospital outpatient overweight treatment program. This program consisted of a dietary intervention based on macronutrients in proportions consistent with the recommendations for age combined with exercise counseling of more than one hour per day at least three times per week. A reduction of > 5% in fat mass index (as surrogate of adiposity), was the primary outcome; and the time to achieve it was the secondary outcome. *Per*-protocol analysis was performed.

Results: Sixty children fully compliant with the program were included. The median (min-max) time of follow-up was 105 (35 - 337) days. The early success rate was 70.0% (95% CI 57.5 - 80.1). Forty-two children achieved the outcome at a median 71 (35 - 316) days. No difference for sex was found. The lower the FMI at referral, the higher the probability of success.

Conclusion: The short-term effectiveness of this weight management program for compliant prepubertal children seems satisfactory. Early positive reinforcement based on a reliable indicator may contribute to the success of weight management programs.

Keywords: Dietary intervention; Exercising; Fat mass index; Prepubertal children; Weight management

Introduction

Early successful treatment of overweight and obesity contributes to prevent programming of obesity and associated comorbidities into adolescence and adulthood [1].

Dietary intervention and promotion of physical activity are commonly used in multicomponent interventions in pediatrics overweight management [2,3] In a recent systematic review on strategies for controlling childhood obesity in different settings, the clinic-based interventions revealed favorable effects on anthropometric indices, particularly those combining dietary intervention with physical activity counseling [4].

Different surrogates of adiposity have been used to monitor weight treatment in obese children [2]. An accurate indicator of changes in adiposity should be preferred for monitoring overweight treatment in children [5]. Since low levels of patient and family compliance may compromise the success of some interventions [6], early positive reinforcement based on reliable indicators may contribute to the success of weight management programs. In this context, we recently reported that the Fat Mass Index (FMI) is the indicator that provides the best combination of ability and precocity to detect reduction of adiposity during overweight treatment of prepubertal obese children, compared with the Body Mass Index (BMI) or the percentage of fat mass (%FM) [7].

This study evaluates the early, short-term effectiveness on reducing adiposity of compliant obese prepubertal children to an overweight treatment program that combines dietary intervention with exercise advice, in an outpatient clinic-setting.

Methods

This prospective, observational analysis is nested within a broader study on the performance of a multidisciplinary weight treatment program for childhood obesity used in the outpatient clinic of a tertiary pediatric hospital. The study was approved by the institution ethical committee and parental consent was obtained. As previously described [7], a convenience cohort of

consecutively referred prepubertal children with confirmed obesity was recruited during one year.

Obesity was confirmed in the first visit, defined as BMI over the 95th centile, adjusted for age and sex [8,9]. Height and weight were used for calculation of BMI and BMI z-scores, using WHO AnthroPlus (http://whoanthroplus.software.informer.com/). Height was measured using the Seca 240 Wall-Mounted Stadiometer (3M, A&D Medical, ACC, ADC) and body weight was measured using the Seca 763 scale (Seca Medical Measuring Systems and Scale, UK), according to the recommended technique [10]; the average of three measurements was recorded for analysis.

The overweight treatment program was prescribed by the same paediatrician (CD) and the same dietician (AA), complying with the outpatient clinic treatment protocol. Puberty was excluded based on the Tanner stages [11]. A customized weight management program was applied to all patients, including verbal and written prescriptions for: 1) a daily eating plan with a normocaloric diet composed of balanced macronutrients, in proportions consistent with Dietary Reference Intake recommendations for age. Special attention was given to recommend frequent small meals with foods with low simple sugar content, low energy density, and high fiber or water content [12,13]; and 2) exercising minimum of one hour per day at least three times per week [14].

The protocol includes scheduled assessments of weight, height and body composition measurements in the Nutrition Lab, at admission and monthly thereafter for follow-up. Observers performing the measurements were not aware of the weight management prescriptions. Individuals not complying with this scheduled were not included in the analysis (*per*-protocol analysis). No extra assessments were undertaken purposefully for this study.

Body composition was measured via Air Displacement Plethysmography (ADP), using the Bod Pod equipment (Life Measurements, Concorde, CA, USA), operated by the same observer (MPGD). According to the manufacturer's instructions, measurements were obtained with the subjects wearing tight-fitting swimsuit and swim cap only. This method measures body mass, Fat Mass (FM), and Fat-Free Mass (FFM) expressed in Kg, with precision of 0.1 Kg. The FM is calculated by the equipment, assuming the density of fat to be 0.9007, and pre-determined age- and gender- specific densities of FFM [15]. The FMI was computed as FM (kg) divided by height squared (m^2).

For this study, the end of follow-up was either the time when the primary outcome was achieved, or the day of the last body composition measurement up to twelve months, whichever occurred first.

The primary outcome was the variation of FMI; the achievement of a 5% reduction in FMI was arbitrarily chosen as the threshold for early success. The normal distribution of the variables at baseline was verified using the Kolmogorov-Smirnov test. As the distribution of FMI was asymmetrical, the Wilcoxon test for paired samples was used for comparisons over time. The incidence of early success is given with 95% Confidence Interval (CI), calculated using OpenEpi (CDC, Atlanta, GA, USA), and incidence rates were compared using Qui-square or Fisher exact test as adequate. Kaplan-Meyer survival curves were used to describe time (days) to detect a 5% reduction in FMI in the whole sample. For those cases that achieved a 5% reduction in FMI, the time required to achieve detection was described using median, quartiles and extremes. An exploratory analysis (Mann-Whitney test, Cox regression and Kaplan-Meyer survival curves) was performed to identify factors associated to the effectiveness of the overweight treatment program. A level of significance $\alpha = 0.05$ was considered. Statistics were performed using SPSS 22.0 (IBM Corp, Armonk, NY, USA).

Results

Ninety-four children were included in the overweight treatment program and 34 (36.2%) who did not comply with the scheduled assessments were excluded from the analysis. In the studied cohort of 60 children, 34 were females; the median (min.-max.) age at recruitment was 7.6 (3.0 - 8.7) years, without statistical difference between sexes. The median (min.-max.) time of follow-up was 105 (35 - 337) days. At admission, no significant differences were found between included and excluded children, in relation to the median age, sex distribution, and adiposity (median FMI).

The BMI and FMI assessed before the intervention and at the end of the follow-up are presented in Table 1. The BMI z-scores were significantly higher in males than females before the intervention and at the end of the follow-up, but no significant differences between sexes were found for FMI at either timeframe.

The FMI at the end of the follow-up was significantly lower than before the intervention ($p < 0.001$), with a median difference of 1 kg FM/ m^2 (Table 1). A 5% reduction in FMI was detected in 42 children (26 females), at a median (min.-max.) time of 71 (35 - 238) days, therefore the success rate was 70.0% (95% CI 57.5 - 80.1). Considering the whole cohort, the median time for detection of 5% reduction in FMI was achieved at 98 days (95% CI 70.0 – 126.0) (Figure 1).

Table 1: BMI and FMI assessments before the weight management intervention and at the end of follow-up, in the whole cohort, males and females

	Intervention	Females n = 34	Males n = 26	Total n = 60
BMI z-score median (min-max)	Before	3.25 (2.1-6.7)[a]	4.18 (2.6-10.8)[a]	3.49 (2.1-10.8)[c]
	End of follow-up	2.86 (1.7-6.1)[a]	3.48 (2.3-10.5)[a]	3.17 (1.7-10.5)[c]
FMI (Kg / m^2) median (min-max)	Before	8.7 (6.2-13.2)[b]	9.8 (6.0-19.7)[b]	9.0 (6.0-17.9)[c]
	End of follow-up	7.4 (5.1-12.8)[b]	8.9 (5.1-17.8)[b]	8.0 (5.1-17.8)[c]

BMI: Body Mass Index; FMI: fat mass index. Mann-Whitney test between sexes: [a]$p < 0.05$, [b]$p > 0.05$. [c]Wilcoxon test for paired samples: $p < 0.001$.

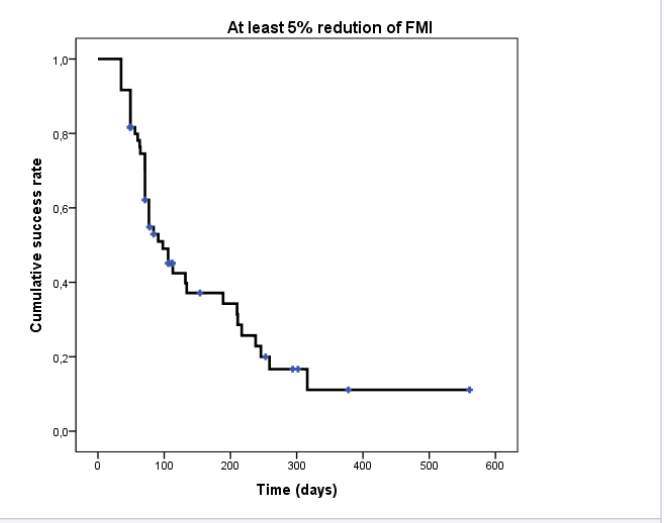

Figure 1: Time to achieve a reduction > 5% of Fat Mass Index (FMI) in the whole sample (n = 60); Kaplan-Meyer survival curve..

The lower the FMI at referral, the higher the probability to achieve 5% reduction in FMI (Cox regression, HR = 0.817; 95% CI 0.698 - 0.956; *p = 0.012*). Neither the incidence of the success nor time to achieve it was associated with sex and age at referral.

Discussion

This study was designed to assess compliant families through a *per*-protocol analysis. Therefore, these results concern the most motivated children and families, assuming that early reinforcement to already motivated individuals may further contribute to the treatment adherence. In this clinic-setting program combining dietary intervention with exercise counseling, 70% (95% CI 57.5 - 80.1) of the obese prepubertal children who complied achieved a significant early (median 10 weeks) reduction in adiposity (> 5% assessed by the FMI). Less obese prepubertal children were found to be more prone to early success.

Comprehensive interventions for childhood obesity treatment including diet and exercise as prescribed to our patients, have shown sustainable results in clinic-setting programs, as evidenced by anthropometric indices [4,16]. Dietary intervention based on low calorie-low fat diets have been largely used for treating obesity in children, but many experts instead recommend a normocaloric diet with macronutrients in proportions consistent with the recommendations for age [4,17], as used in the assessed program. Low calorie-low fat diet for childhood obesity management was found to have no further advantages compared with other calorically restricted diets and may have side-effects such as binge eating [18,19]. In the assessed program, children were counseled on physical activity and encouraged to exercise more than one hour per day at least three times per week. A comprehensive review of evidence on physical activity for school-aged youths reported that programs of 30- to 60-minute duration, performed 3 to 7 days per week, resulted in reductions in total body fat and visceral adiposity among obese children and adolescents [14]. In other systematic reviews on the efficacy of interventions for pediatric obesity, exercise was only found to have a moderate effect on adiposity [16,20].

The early effectiveness rate found in this observational study is difficult to compare with other studies, due to great variation in intervention programs, target age groups, outcome measurements, and defined thresholds for success [2]. Nevertheless, it has been reported in systematic reviews that most studies demonstrate beneficial effects of intervention programs on child adiposity from baseline to the end of intervention or follow-up [2,4]. Particularly, a significant short-term benefit has been reported [21].

Adherence to the programs remains an important issue, as it has been shown that rate of dropout from overweight treatment programs increases if family confidence is low [22]. Hence, early positive reinforcement may contribute to increase adherence [6].

It has been recommended that clinic-based childhood obesity interventions should be guided by established strategies and protocols in order to measure improvement over time [23]. While the definition of obesity is based on excessive adiposity, the best measurement for degree of body fatness remains controversial [24]. BMI has been recommended as the routine screening approach in clinical practice for children older than 6 years, but there is insufficient evidence to provide a similar recommendation in younger children [25,26]. BMI was found to have high specificity but low sensitivity for detection of excess adiposity in children [27]. In particular, BMI may be biased as a proxy for longitudinal adiposity assessment in children, since strong correlations exist between BMI and the components of weight other than body fat mass, such as lean mass and bone mass [28,29]. A systematic review [20] of trials measuring the effect of physical activity on adiposity (*i.e.,* %FM) found a moderate treatment effect, whereas trials measuring the effect on BMI found no significant effect; moreover, combined lifestyle interventions trials led to small changes in BMI. Therefore, it was recommended that adiposity rather than BMI-derived outcomes be considered in order to better reflect the efficacy of interventions [20]. In prepubertal obese children, FMI was found to have higher detection rate of adiposity reduction than BMI and similar but earlier detection rate than the %FM [7]. Thus, we used FMI instead of BMI to monitor weight management.

The best suited expression to describe adiposity change as an outcome of weight management in growing children, either as raw units, percentages, z-scores, or centiles, is not known [30]. To the best of our knowledge, no z-scores or centiles are available for ADP-measured FM in prepubertal children. Therefore, an arbitrary 5% reduction of FMI was considered the cut-off for short-term indicator of success, as it allows each child outcome to be adjusted to its own initial adiposity and focuses comparisons on the rate of successful cases rather than the linear distribution of FMI values. To assure some direct external comparability, the effectiveness was also assessed by comparing the distribution of FMI at referral and at the end of follow-up. The significant difference found is in line with other studies that used adiposity measurements as outcome indicators [2,4,21].

A recent Cochrane review [2] highlights that the questions on what interventions are most effective at different levels of obesity severity, at different ages and developmental stages, remain largely unanswered. We found that the lower the FMI at referral, the higher the probability to achieve significant early reduction in FMI. No associations were found between either sex or age at referral and the incidence of the success or time to achieve it. This finding is in contrast with Danielsson, et al. [31] who reported that the effect of behavioral treatment initiated between 6 and 9 years of age appeared to be greater among severely obese children than among moderately obese ones. This difference is probably due to the way the indicators were computed, as Danielsson, et al. [31] analyzed the absolute variation of BMI-SD score whereas we compared the relative variation of FMI adjusted to the FMI at referral. Nevertheless, we cannot dismiss the possibility that having analyzed the data as *per*-protocol might have biased the association between the severity of obesity at referral and the odds for effectiveness.

Effective treatment of obesity in prepubertal children is crucial; as the greater the BMI-SD score at earlier ages, the higher the odds for developing severe obesity in adolescence [31]. On the other hand, lifestyle interventions with parental involvement have evidenced a large effect in children aged 8 year or less [20]. Our data and data from the literature contribute to underline the importance of early detection and treatment of childhood obesity and the difficulty to treat the more severe cases.

Limitations of this study should be acknowledged. Eligibility for recruitment was based on the clinical diagnosis of obesity based on BMI and not on accurate indicators of excessive adiposity, such as indices providing reliable FM measurements by dual energy X-ray absorptiometry [27]. ADP has been validated in children aged 7 to 10 years [32], but not yet in younger children, making it unreliable for ascertainment of the recruitment of obese children. Therefore, BMI was used for eligibility assessment, once it is the most widely used clinical criterion to screen obesity in outpatient children [8,27]. Conceptually, this might have introduced a selection bias for including children with less adiposity, but the high BMI z-scores found in the baseline assessment (Table 1) makes this bias unlikely. The higher BMI z-scores found in males did not reflect on a significant difference on FMI, which is the outcome index used. A convenience sample was used to assess the effectiveness of the ongoing weight treatment program for childhood obesity. In spite of the convenience nature of the sample, the consecutive recruitment of patients and its number allowed the identification of statistical and clinical significant associations. Despite the absence of differences in age, sex, and adiposity at admission, between included and excluded individuals, the exclusion of non-compliant individuals from the *per*-protocol analysis causes a "loss for follow-up" bias, precluding any analysis of the early compliance to the intervention, and overestimates the treatment effect. The adherence to the prescribed dietary plan was not periodically verified in a structured manner, despite it was qualitatively enquired in the follow-up visits. A non-interventional external control group was not used because it would be unethical, considering that the overweight treatment protocol adopted has been considered good practice in the studied condition; hence, each child was its own historical control. Finally, this short-term study focused on early success of the overweight treatment program, thus sustainability of the effect is not presented.

To summarize, the short-term effectiveness of a clinic-setting overweight treatment program for compliant prepubertal children was assessed using FMI as early indicator of adiposity reduction. This program, consisting of a dietary intervention based on macronutrients in proportions recommended for age combined with exercise counseling of more than one hour per day at least three times per week seems satisfactory, since a significant adiposity reduction was achieved in 70% of the children who complied at a median 10 weeks.

Acknowledgment

The authors are grateful to Kayla M. Bridges, MS, RDN-AP, CSP, CNSC, Clinical Dietitian Specialist, Neonatology at Beaumont Children's Hospital, Michigan, United States, for the critical review of the manuscript.

References

1. Brown CL, Halvorson EE, Cohen GM, Lazorick S, Skelton JA. Addressing childhood obesity: Opportunities for Prevention. Pediatr. Clin. North Am. 2015;62(5):1241–61. doi: 10.1016/j.pcl.2015.05.013.
2. Oude Luttikhuis H, Baur L, Jansen H, et al. Interventions for treating obesity in children. Cochrane Database Syst Rev. 2009;(1):CD001872. doi: 10.1002/14651858.CD001872.pub2.
3. Hoelscher DM, Kirk S, Ritchie L, Cunningham-Sabo L. Position of the Academy of Nutrition and Dietetics: Interventions for the prevention and treatment of pediatric overweight and obesity. J. Acad. Nutr. Diet. 2013;113(10):1375–94. doi: 10.1016/j.jand.2013.08.004.
4. Kelishadi R, Azizi-Soleiman F. Controlling childhood obesity: A systematic review on strategies and challenges. J Res Med Sci. 2014;19(10):993–1008.
5. Kakinami L, Henderson M, Chiolero A, Cole TJ, Paradis G. Identifying the best body mass index metric to assess adiposity change in children. Arch Dis Child. 2014;99(11):1020-4. doi: 10.1136/archdischild-2013-305163.
6. Gibson LJ, Peto J, Warren JM, dos Santos Silva I. Lack of evidence on diets for obesity for children: a systematic review. Int. J. Epidemiol. 2006;35(6):1544–52.
7. Pereira-da-Silva L, Pitta-Grós Dias M, Dionísio E, Virella D, Alves M, Diamantino C et al. Fat mass index performs best in monitoring management of obesity in prepubertal children. J Pediatr(Rio J). 2016;92(4):421-6. doi: 10.1016/j.jped.2015.11.003.
8. WHO Multicentre Growth Reference Study Group. WHO Child Growth Standards based on length/height, weight and age. Acta Pædiatr. 2006;450:76-85.
9. de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bull World Heal. Organ. 2007;85(9):660–7.
10. National Health and Nutrition Examination Survey (NHANES). Anthropometry Procedures Manual, CDC. 2011.

11. Tanner JM, Whitehouse RH. Clinical longitudinal standards for height, weight, height velocity, weight velocity, and stages of puberty. Arch. Dis. Child. 1976;51(3):170–9.

12. Krebs NF, Jacobson MS; American Academy of Pediatrics Committee on Nutrition. Prevention of pediatric overweight and obesity. Pediatrics. 2003;112(2):424–30.

13. US Department of Health and Human Services UD of A. Dietary Guidelines for Americans, 2005. 6th ed. Washington, DC: Government Printing Office, 2005.

14. Strong WB, Malina RM, Blimkie CJ, et al. Evidence based physical activity for school-age youth. J Pediatr. 2005;146(6):732–7.

15. Elberg J, McDuffie JR, Sebring NG, Salaita C, Keil M, Robotham D, et al. Comparison of methods to assess change in children's body composition. Am J Clin Nutr. 2004;80(1):64–9.

16. Latzer Y, Edmunds L, Fenig S, Golan M, Gur E, Hochberg Z et al. Managing childhood overweight: Behavior, family, pharmacology, and bariatric surgery interventions. Obesity (Silver Spring). 2009;17(3):411-23. doi: 10.1038/oby.2008.553.

17. Barlow SE. Expert committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: summary report. Pediatrics. 2007;120 Suppl 4:S164–92.

18. Polivy J. Psychological consequences of food restriction. J Am Diet Assoc. 1996;96(6):589–92.

19. Summerbell CD, Cameron C, Glasziou PP. Withdrawn: Advice on low-fat diets for obesity. Cochrane Database Syst Rev. 2008;(3):CD003640. doi: 10.1002/14651858.CD003640.pub2.

20. McGovern L, Johnson JN, Paulo R, et al. Treatment of pediatric obesity: a systematic review and meta-analysis of randomized trials. J. Clin. Endocrinol. Metab. 2008;93(12):4600–5. doi: 10.1210/jc.2006-2409.

21. Whitlock EP, O'Connor EA, Williams SB, Beil TL, Lutz KW. Effectiveness of weight management interventions in children: a targeted systematic review for the USPSTF. Pediatrics. 2010;125(2):e396–418. doi: 10.1542/peds.2009-1955.

22. Gunnarsdottir T, Njardvik U, Olafsdottir AS, Craighead LW, Bjarnason R. The role of parental motivation in family-based treatment for childhood obesity. Obesity (Silver Spring). 2011;19(8):1654-62. doi: 10.1038/oby.2011.59.

23. Davis MM, Gance-Cleveland B, Hassink S, et al. Recommendations for prevention of childhood obesity. Pediatrics. 2007;120 Suppl:S229–53.

24. Cole TJ, Fewtrell MS PA. The fallacy of using percentage body fat as a measure of adiposity [letter]. Am J Clin Nutr. 2008;87(6):1959.

25. US Preventive Services Task Force, Barton M. Screening for obesity in children and adolescents: US Preventive Services Task Force recommendation statement. Pediatrics. 2010;125(2):361–7. doi: 10.1542/peds.2009-2037.

26. Gurnani M, Birken C, Hamilton J. Childhood obesity: causes, consequences, and management. Pediatr Clin North Am. 2015;62(4):821–40. doi: 10.1016/j.pcl.2015.04.001.

27. Javed A, Jumean M, Murad MH, Okorodudu D, Kumar S, Somers VK et al. Diagnostic performance of body mass index to identify obesity as defined by body adiposity in children and adolescents: a systematic review and meta-analysis. Pediatr Obes. 2015;10(3):234–44. doi: 10.1111/ijpo.242.

28. Weber DR, Moore RH, Leonard MB, Zemel BS. Fat and lean BMI reference curves in children and adolescents and their utility in identifying excess adiposity compared with BMI and percentage body fat. Am J Clin Nutr. 2013;98(1):49–56. doi: 10.3945/ajcn.112.053611.

29. Wells JC. Commentary: The paradox of body mass index in obesity assessment: not a good index of adiposity, but not a bad index of cardio-metabolic risk. Int. J. Epidemiol. 2014;43(3):672–4. doi: 10.1093/ije/dyu060.

30. Cole TJ, Faith MS, Pietrobelli A, Heo M. What is the best measure of adiposity change in growing children: BMI, BMI %, BMI z-score or BMI centile? Eur. J. Clin. Nutr. 2005;59(3):419–25.

31. Danielsson P, Kowalski J, Ekblom Ö, Marcus C. Response of severely obese children and adolescents to behavioral treatment. Arch. Pediatr. Adolesc. Med. 2012;166(12):1103–8. doi: 10.1001/2013.jamapediatrics.319.

32. Ittenbach RF, Buison AM, Stallings V a, Zemel BS. Statistical validation of air-displacement plethysmography for body composition assessment in children. Ann. Hum. Biol. 2009;33(2):187–201.