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ORIGINAL STUDIES

Dietary aspects related to height growth rate and the risk of malnutrition in children

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Abstract

Background. Malnutrition in children is bound to an imbalanced food intake. A negative energy intake can lead to improper anthropometric changes.

Aims. The aim of the study is to analyze the protein intake and the main food groups in preschool children to identify the possible food-related causes that favor changes in the weight and/or height-growing rate.

Methods. The study protocol included a transversal and observational assessment held between March and September 2019. The sample comprised 207 subjects, which were divided into two groups depending on their anthropometric development and the BMI for age Z score. Daily food intake was assessed by using an accurate feeding log obtained from the subjects' legal guardian.

Results. A reduced protein intake was associated with a deficient body height growth, as seen in both G1 (p=0.048, r=0.254) and G2 study samples (p=0.004, r=0.399). In the underweight sample (G2), protein intake was related to age (p=0.024, r=0.317), body weight (p=0.001, r=0.452) and the consumption of fruit juice (p=0.001, r=-0.428). The changes in body mass index were related to the meat food products in the normal weight subjects (p=0.040, r=0.187) and to the cereal products in the underweight subjects (p=0.0007, r=-0.385).

Conclusions. The lack of protein intake is associated with changes in anthropometry development, especially with a drop in the height growth rate.

Keywords: height growth rate, malnutrition, food intake, protein

Introduction

Malnutrition in children is bound to an imbalanced food intake. A negative energy intake alongside the lack of several nutrients can lead to improper anthropometric changes, of which the most important is described as *weak development of the muscle tissue* (Cederholm et al., 2017). Even though such changes are often seen in adult patients, similar cases are also seen in young age patients. Therefore, various papers describe an increased risk of related pathologies (Rytter et al., 2014; Ibrahim et al., 2017), by stating important changes in the growing up rate, which can affect long-term height and body weight development (Rytter et al., 2017). By using similar based measurements, several papers described malnutrition as being a leading risk factor for various medical conditions. Based on the current statistical data, malnutrition is underdiagnosed; the real impact that malnutrition has upon the risk of developing a disease is therefore insufficiently known.

Clinical evaluation alongside anthropometric measurements can be used to assess the nutritional status of individuals regardless of age and condition. Various papers cited the need for implementing constant monitoring systems for the early identification of individuals and communities that require interventions. Such actions are important in order to limit the nutritional deficit and to rebalance the physical development in risk related groups (Corkins, 2017). The assessment of the child that suffers from malnutrition, along with the treatment intervention

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and the prevention protocol should be carried out in a multidisciplinary manner (Bouma, 2017); therefore, age-adapted medical, diet-related and psychological consult is important during early age.

As seen in the paper of Alasfoor et al. (2007), the physical maternal and child prenatal characteristics can strongly influence individual anthropometric development. Yet, other factors can be included: economic, dietary and socio-environmental factors are used to assess the risk of malnutrition. According to Jackson et al. (2006), the main consequence of malnutrition refers to the survival condition due to improper anthropometric development, while on the other hand, more children are consuming energy-dense and nutrient-poor food products. Excessive energy intake can decrease resting energy expenditure in time due to less active tissue, which can easily cause excessive energy intake (Müller & Geisler, 2017).

Each of the two eating patterns can negatively affect long-term anthropometric development. Over time, few papers have studied the differences regarding daily energy intake in underweight, normal weight and overweight study groups, while taking into account all factors that can influence each of the conditions. It is generally known that protein intake is related to anthropometric development. Yet, less data is available regarding fat and carbohydrates in underweight study groups, while more data is illustrated for obesity, mainly under excessive carbohydrate, protein and fat intake.

Numerous papers have studied eating patterns and medical related conditions. Of them, various results are related to anthropometric development according to age, while less data is related to daily food intake. Therefore, the study aim is to analyze protein intake and the main food groups in preschool children to identify the possible food-related causes that favor changes in the weight and/or height-growing rate.

Material and methods

Research protocol

A transversal and observational study was conducted on a group of 207 healthy children.

a) Period and place of the research

The study was conducted between March and September 2019 in Mureș county, Romania.

b) Subjects and groups

The study sample was composed of 207 subjects. The study sample was divided into two groups (n=2) depending on their anthropometric development and the BMI for age Z score. Therefore, the normal weight group (G1) included 133 subjects (64.25%), which had a Z score higher than -2 and lower than +2. The underweight study group (G2) included 74 subjects (35.74%) which had a Z score lower than -2.

The following criteria were used for inclusion in the study: age between 36 and 84 months old, clinically healthy children with no history of acute diseases in the past 6 months, normal weight at birth, due time delivery, legal guardians willing to collect data regarding daily food intake. Exclusion criteria: age outside the range of interest, lack of compliance for determining weight and height, presence of any chronic or acute pathology diagnosed during the collection of anthropometric and food-related data, consumption of food supplements or medicines, including medically prescribed products.

c) Applied tests

Anthropometric development assessment

To assess physical development, we determined the individuals' body weight and body height; according to the results, the body mass index and the BMI for age Z score were subsequently calculated by using both age and gender related information. Weight was measured in the morning, after a feeding rest of at least 8 hours, in an upright position, in casual clothes, by means of a calibrated standard scale (ADE GmbH, Germany). The measurements were repeated 3 times in a row, at 30-second intervals, with the exclusion of any aberrant data; statistical analysis used the average of the 3 measures carried out. The height of the subjects was established in upright position, shoes off, by means of a standard wall height meter (ADE GmbH, Germany). During each measurement, the subjects were instructed to stay still, eyes straight ahead, upper limbs along the body, lower limbs brought together while normally breathing.

The body mass index (BMI) was determined by using the weight to the height data, according to the standard calculation formula W/H^2. BMI was interpreted by entering the values obtained, along with the child's age (expressed in months) and gender, into the *Anthro Survey Analyzer* (WHO) software. The Z score was calculated automatically by using the above-mentioned software.

All data was interpreted in the following way: the subjects whose score was less than -2 were included in the underweight group (G2) and those who scored more than -2, but less than +2, were included in the normal weight group (G1). The children whose Z score was higher than +2 were deemed to have an excessive weight and were excluded from the study group.

Eating scheme assessment

Daily food intake was assessed by using means of an accurate feeding log obtained from the subjects' legal guardians who were instructed to put down the food items eaten by the child, jointly with their quantity. The subjects whose logs did not contain the grams corresponding to the products consumed were excluded from the study group. In the food log, the individuals wrote down the consumed products, not the offered ones, which enabled the subsequent calculation of protein ingestion over a 24-hour period. The nutritional value of each food product was calculated by using means of the accredited food composition tables provided by the *USDA's Food Composition Databases*, a property of the United States' Department of Agriculture (2019).

d) Statistical processing

Statistical evaluation was carried out with the GraphPad Prism 6.0 software, with a level of significance set at $\alpha=0.05$. The tests used for the inferential assessment were: Mann Whitney test for the differences between the two study groups and the Spearman r test for assessing the relation between two analyzed parameters. The data were presented by using descriptive data as the median value, the minimum-maximum values and the coefficient of variation (CV). Due to food intake variability, the average values were not used in this study.

Results

Anthropometric data

The normal weight sample (G1) had a median age of 39 months, with the CV reaching 27.91%. The underweight sample (G2) had a median age of 38 months, with the CV reaching 14.07%. There were no considerable differences between the age of the two study groups ($p = 0.1112$).

The body weight reached a median value of 12 kg (Min-Max: 10-15 kg; CV = 21.51%) in G2 and 14 kg (Min-Max: 8-28 kg; CV = 12.79%) in G1. Further data regarding the body height and the individuals' body mass index are comparatively analyzed in Table I and Fig 1.

Important differences are observed regarding the BMI value between the two groups ($p < 0.05$); yet, no differences in the body height values are seen (> 0.05).

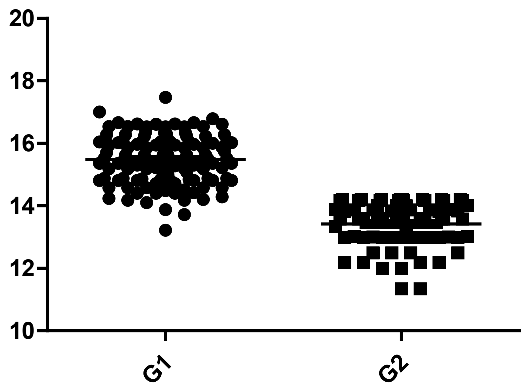

Fig. 1 – Body mass index - differences between the groups.

Eating frequency data

The daily water intake reached 500 ml/day in G2 study group, with a 53.62% CV, and 600 ml in G1, with a 46.17% calculated CV. Furthermore, a median intake of 250 ml milk was monitored in G1 and 275 ml in G2, with no statistically significant differences between the two groups ($p = 0.5207$). Further data regarding the group patterns and eating frequency are comparatively set out in Table II.

No considerable differences are seen regarding protein sources - meat (p=0.4910), cheeses (p=0.9586), oleaginous products (p=0.5129) or fish (p=0.2902) between the two study groups.

Table II

Number of portions consumed in one day-descriptive statistics (mean±SD).

Indicator	Group of normal weight subjects (G1)	Group of underweight subjects (G2)
White meat	3.63±1.59	3.35±1.52
Red meat	1.88±1.36	2.1±1.22
Fish	1.22±0.92	1.13±1.05
Cheeses	1.97±1.19	1.97±1.33
Fruits	2.58±1.1	2.64±1.38
Vegetables	2.54±1.13	2.27±0.99
Fruit juice	0.33±0.76	0.21±0.41
Oleaginous products	1.33±0.85	1.29±0.98

Nutritional value of the eating scheme

As a result of the eating logs analyzed for the subjects belonging to the group of normal weight children (G1), a 17.03 gram protein ingestion could be observed, alongside the following results regarding the ingestion of minerals: 3.32 mg iron, 230.7 mg calcium, 59.55 mg magnesium, 645.9 mg potassium and 224.2 mg sodium. As for the underweight study group, there was a 19.38 gram protein ingestion, while the data regarding mineral intake were the following: 4.07 mg iron, 243 mg calcium, 76.2 mg magnesium, 534.1 mg potassium and 235.9 mg sodium. No considerable differences were seen between the two groups regarding protein (p=0.4642), iron (p=0.1269), calcium (p=0.8705), magnesium (p=0.1183), potassium (p=0.9127) or sodium (p=0.4899) daily intake.

Physical development vs. food ingestion

Protein ingestion was significantly correlated with the individual body height. Thus, a reduced protein intake was associated with a deficient body height growth, as seen in both G1 (p=0.048, r=0.254) and G2 study sample (p=0.004, r=0.399). However, in the normal weight sample group, protein ingestion was not significantly related to the body weight (p=0.067), age (p=0.432), body mass index (p=0.774), or to the daily intake of milk (p=0.818), white meat (p=0.279), fish (p=0.875), cheeses (p=0.309) or oleaginous foods (p=0.402). The height of normal weight subjects was considerably influenced by the total consumption of meat (red and white meat: p=0.025, r=0.203) and cereals (p=0.012, r=0.227), whereas in the case of underweight subjects, the total consumption of meat (p=0.234) or cereals (p=0.393) was not a factor that affected the individual body height development.

Table I

Anthropometric data – differences between the groups.

Indicator		Group of normal weight subjects (G1)	Group of underweight subjects (G2)	Differences between the medians (p value)
Height (cm)	Minimum value	71	84	
	Median value (CV%)	96 (10.34)	92 (7.05)	0.6616
	Maximum value	132	115	
Body mass index (BMI)	Minimum value	13.22	11.34	
	Median value (CV%)	15.5 (5.13)	13.58 (5.36)	< 0.0001
	Maximum value	17.47	14.2	

In the underweight sample (G2), protein intake was related to age (p=0.024, r=0.317), body weight (p=0.001, r=0.452), and the consumption of fruit juice (p=0.001, r=-0.428). However, no correlations were obtained regarding the intake of milk (p=0.353), cheeses (p=0.053), white meat (p=0.507), red meat (p=0.768) or oleaginous products (p=0.687). The changes in body mass index were related to the meat food products in the normal weight subjects (p=0.040, r=0.187) and to the cereal products in the underweight subjects (p=0.0007, r=-0.385), without reaching other significant associations (p>0.05).

Discussions

Our study aimed to analyze food intake and the changes in body development. No significant differences with regard to subjects' age were noticed within the study sample, as the two study groups had similar ages (38 months vs. 39 months). The main difference in terms of physical development was thus related to the body weight and the body mass index. No notable differences were obtained regarding the growth height between the two groups. However, the growing rate and the size upon measurement were influenced by the total amount of protein which was ingested, as seen in both G1 (p=0.048, r=0.254) and G2 (p=0.004, r=0.399) study groups.

In this respect, in the case of a protein-deficient diet, a diminishment of the growing rate along with a drop in the body height development can be seen. According to the data of Manary et al. (2016) regarding protein intake, not only the amount of protein is important in enhancing the risk of malnutrition or height growth deficit, but also the protein quality assessed through the PDCAAS score. According to Alderman et al. (2017), the cause of negative growth reports may also be related to several unbalanced eating habits seen until the age of 2, the height growing rate being thus slowed down ever since. Nonetheless, these data are not available in the case of our study, as the nutritional and anthropometric status at that age is unknown.

In the normal weight study group (G1), body height was influenced (p = 0.025) by the number of meat portions consumed (cumulated white meat and red meat, without including fish), along with cereal based foods (p=0.012), without important correlations with other food groups. In G2 study group, body height growth was not related to meat (p=0.234) or cereal products (p=0.393). In G1 study group, the body mass index was influenced by the total milk intake (amount/ day; p=0.040, r=0.187), unlike G2. In G2 study group, the body mass index was negatively affected by several other products: cereals and cereal-derived products (p=0.0007, r=0.385).

Recently published research shows that one of the main causes which induces changes in the body growth rate is hunger, due to a reduced social-economic income (Webb et al., 2018). Therefore, the basic problem is access to quality food. Nevertheless, access to food was not taken into account in this study; only the consumed food products were analyzed, without knowing whether the parent offered a qualitative product or not (Raiten & Bremer, 2020). We also noticed an enhancement in the amount of proteins consumed with age (p=0.024, r=0.317). The total amount of proteins was lower in the low weight subjects (p=0.001, r=0.452) in relation to age.

A reduction in protein intake in G2 due to high intake of fruit juice (p=0.001, r=-0.428) was detected in this study. One possible cause for these results is satiety due to the amount of liquid along with an important quantity of simple carbohydrates, which brings the sensation of satiety by reaching the gastric volume by means of a protein-low beverage. According to the current European Society for Paediatric Gastroenterology, Hepatology and Nutrition Committee recommendations, the consumption of saccharides, especially sweetened drinks, must be limited in the case of children, due to the high risk of malnourishment, mostly expressed by excessive body weight (Fidler et al., 2017). Based on our results, fruit juice was associated with a deficit of protein-rich products, which, in turn, was subsequently associated with a lower body height. In this case, the current recommendations include increased attention paid to the sensation of satiety or hunger (Bentley & Nutly, 2020). Other research projects that analyzed food consumption in low ages concluded that the limitation of high calorie, sweetened or salted snacks that are however poor in nutrients was one of the main indicators for reaching a normal, balanced nutritional status in small age children (6 to 36 months old); yet, limiting daily intake can be important even after 36 months of age, as seen in our results (Green et al., 2019).

According to the FITS (Feeding Infants and Toddlers Studies) research project, the quality of children's menus and feeding habits has considerably increased with time, and the risk of malnutrition is thus lower; however, diet-related interventions are required at a high community level (national, governmental, etc.) or at an individual level, to improve children's eating habits (Duffy et al., 2002).

The study limitations are related to the study methodology, including the data collection phase, which involves a prospective eating log. This data collection method enhances the level of error. For future researches, the use of an eating frequency questionnaire, as well as an eating log should indicate the consumption of the main food groups and the cross-correlation of the two types of assessments, in order to rule out any inconsistent data.

Conclusions

1. The lack of protein intake was associated with changes in anthropometry development, with a drop in the height growth rate, irrespective of the body weight.
2. Positive changes in the body weight and the body mass index were related to protein and cereal/cereal-derived product intake.

Conflicts of interests

The authors declare no conflict of interests.

References

Alasfoor D, Traissac P, Gartner A, Delpeuch F. Determinants of persistent underweight among children, aged 6-35 months, after huge economic development and improvements in health services in Oman. J Health Popul Nutr. 2007;25(3):359-369.

Alderman H, Behrman JR, Glewwe P, Fernald L, Walker S, Bundy DAP, de Silva N, Horton S, Jamison DT, Patton

GC. In Evidence of impact of interventions on growth and development during early and middle childhood. Child and Adolescent Health and Development. 3rd edition. Washington (DC): The International Bank for Reconstruction and Development / The World Bank; 2017, Ch 7. DOI: 10.1596/978-1-4648-0423-6_ch7.

Bentley ME, Nutly AK. When does it all begin: what, when and how young children are fed. Nestle Nutr Inst Workshop Ser. 2020;93:15-24. doi: 10.1159/000503353.

Bouma S. Diagnosing pediatric malnutrition. Nutr Clin Pract. 2017;32(1):52-67. doi: 10.1177/0884533616671861.

Cederholm T, Barazzoni R, Austin P, Ballmer P, Biolo G, Bischoff SC, Compher C, Correia I, Higashiguchi T, Holst M, Jensen GL, Malone A, Muscaritoli M, Nyulasi I, Pirlich M, Rothenberg E, Schindler K, Schneider SM, van der Schueren MAE de, Sieber C, Valentini L, Yu JC, Van Gossum A, Singer P. ESPEN guidelines on definitions and terminology of clinical nutrition. Clinical Nutrition. 2017. 36(1):49-64. doi: 10.1016/j.clnu.2016.09.004.

Corkins MR. Why is diagnosing pediatric malnutrition important? Nutr Clin Pract. 2017;32(1):15-18. doi: 10.1177/0884533616678767.

Duffy EW, Kay MC, Story M. Jacquier E, Catellier D, Hampton J, Anater AS, Story M. Trends in food consumption patterns of US infants and toddlers from Feeding Infants and Toddlers Studies (FITS) in 2002, 2008, 2016. Nutrients. 2019;11(11):2807. doi:10.3390/nu11112807.

Fidler MN, Braegger C, Bronsky J, Campoy C, Domellöf M, Embleton ND, Hojsak I, Jessie Hulst R, Indrio F, Lapillonne A, Mihatsch W, Molgaard C, Vora R, Fewtrell M. Sugar in infants, children and adolescents: A position of the European Society for Paediatric Gastroenterology, Hepatology and Nutrition Committee on Nutrition. J Pediatr Gastroenterol Nutr. 2017;65(6): 681-696. doi: 10.1097/ MPG.0000000000001733.

Green M, Hadihardjono DN, Pries AM, Izwardy D, Zehner E, Huffman SL. High proportions of children under 3 years of age consume commercially produced snack foods and sugar-sweetened beverages in Bandung City, Indonesia. Matern Child Nutr. 2019;15(S4): e12764. doi: 10.1111/mcn.12764.

Ibrahim MK, Zambruni M, Melby CL, Melby PC. Impact of childhood malnutrition on host defence and infection. Clin Microbiol Rev. 2017;30(4):919-971. doi: 10.1128/ CMR.00119-16.

Jackson AA, Ashworth A, Khanum S. Improving child survival: malnutrition task force and the paediatricians`s responsibility. Arch Dis Child. 2006;91(8):706-710. doi: 10.1136/ adc.2006.095596.

Manary M, Callaghan M, Singh L, Briend A. Protein quality and growth in malnourished children. Food Nutr Bull. 2016;37(S1):S29-S36. doi: 10.1177/0379572116629023.

Müller MJ, Geisler C. From the past to future: from energy expenditure to energy intake to energy expenditure. Eur J Clin Nutr. 2017;71(3):358-364. doi: 10.1038/ejcn.2016.231.

Raiten DJ, Bremer AA. Exploring the nutritional ecology of stunting: New approaches to an old problem. Nutrients. 2020;12(2):371. doi: 10.3390/nu12020371.

Rytter MJH, Kolte L, Briend A, Friis H, Chirstensen VB. The immune system in children with malnutrition – a systematic review. PLoS One. 2014; 9(8): e105017. doi: 10.1371/ journal.pone.0105017.

Rytter MJ, Michaelsen KF, Friis H, Christensen VB. Acute malnutrition in children. Ugeskr Laeger. 2017;179(20):V03170193.

Webb P, Stordalen GA, Singh S, Wijesinha-Bettoni R, Shetty P, Lartey A. Hunger and manultrition in the 21st century. BMJ. 2018; 361: k2238. doi 10.1136/bmj.k2238. doi: 10.1136/bmj. k2238.