Fat Consumption and Related Changes in Micronutrients Intake and Child Anthropometric Development

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Abstract
Imbalanced food intake due to high fat consumption tends to have important consequences over general health conditions, regardless of age. The aim of this paper was to analyze fat intake considering the child’s general nutritional needs, micronutrient requirements and the main anthropometric development data. A transversal study has been conducted on a sample of 287 healthy Romanian children aged 36 to 84 months. The sample was divided into: underweight, normal weight and overweight study groups. Among the study subjects, the total fat intake was lower than the daily references depending on gender and age (p=0.0001). Differences were identified between both saturated (p=0.0001) and unsaturated (p=0.0001) fat intake. Saturated fat intake was significantly correlated with the body weight (p=0.0001), the height (p=0.001) and the BMI (p=0.001). Both dietary cholesterol (p=0.018; r=0.189) and saturated fat (p=0.01; r=0.265) were related to individual height. Lack of relationship was seen regarding zinc, selenium, sodium and fat intake (p>0.05). Yet, monounsaturated fat intake was correlated with iron, magnesium and phosphor. Polyunsaturated fat intake was correlated with both phosphorus and potassium in the underweight group. Conclusions: Daily lack of dietary fats have been associated with a significant decrease in growth speed, weight gain and a higher risk of general developmental delay.

Keywords: cholesterol, food intake, lipids, stunting

Introduction
Excessive energy intake is usually related to abnormal macronutrient consumption, while fat intake is most commonly involved in cases of improper body weight management conditions. Therefore, excessive energy intake can induce various physical and psychosocial health conditions during early age. All conditions may also extend further into adulthood period.

High food intake does not necessarily represent an excessive daily energy consumption, but it may also represent a deficit over micronutrient intake. However, this topic is insufficiently described in various papers (Rolland-Cachera et al., 2016; Scaglioni et al., 2018). Recent studies on healthy children confirmed that several anthropometrical changes are a result of daily food intake. However, optimal macronutrient intake is discussed in light of energy requirements (Butte, 2000), while less data is available regarding the food quality. Depending of age, further food intake is strongly influenced by the parents’ nutritional education.
Following several papers published on topics regarding fat intake, we can easily accept that its role in nerve tissues development, macronutrient balance and cell metabolism is well described (Hoare et al., 2019). Yet, to isolate with success both micronutrient and macronutrients intake is challenging, given the complex mixture of nutrients and their components that make up the participants diet (Naude et al., 2018). Given the knowledge regarding its role in the body development, recent studies published data relating fat intake and micronutrient needs. Based on Morales-Suarez-Varela et al., 2019 results fat-soluble vitamins are consumed in excess while lack of iron, magnesium and phosphor along with lack of fiber, fruits and vegetables are frequently observed. We can observe that a restrictive and repetitive diet can represent a trigger for specific phenotypic changes in adolescence and adults, manifested as eating disorders (Herle et al., 2019). Yet, the consequences can be multiple, but there are more often manifested as obesity. The cause of obesity is not fully understood as concluded by Sahoo K et al., 2015. Obesity is believed to be a disorder with multiple cause. Yet, many papers limit the causes to macronutrient and energy intake next to daily physical activity level (Chao, 2018; Brasoveanu et al., 2019; Cordos et al., 2019, Bach et al., 2019).

New papers are needed to strengthen the role of nutrition planning during early age. A small number of papers concluded growth deficiency cases due to fat intake (Chao, 2018; Aiga et al., 2019). As referred to, several papers conclude that high fat intake can increase the risk of developing asthma and dysmetabolic syndrome (Lee et al., 2012; Brady, 2017). Fat intake and long term influence regarding anthropometric development is well described, but less data refer to other diet nutrients, which can influence body weight management, anthropometric development next to physical or psychosocial health status (Girma et al., 2014; Amoutzopoulos et at., 2018; Dao et al., 2019). Therefore, our aim was to evaluate overall fat and micronutrient consumption in relationship with the anthropometric development of normal body weight, low body weight and obese individuals. Based upon our hypothesis, we consider that excessive fat intake can negatively influence cell metabolism and anthropometric development through excessive energy intake and key micronutrient deficiency.

Materials and methods

A transversal, analytical study was conducted between March and September 2019 in Mures County, Romania to test the existing hypothesis. The study was approved by the „George Emil Palade” University of Medicine, Pharmacy, Science and Technology from Târgu Mureș Ethical Committee, via decision no. 259/14.11.2018. To take part in the study, written consent was obtained from the participants’ parents or legal care takers.

Study sample

The study sample was comprised of 287 healthy Romanian children, aged 36 to 84 months. The inclusion was made by applying the following criteria: age between 36 to 84 months, normal birth weight, no chronic or acute medical conditions and no dietary restrictions. The exclusion criteria were: breastfeeding, incompliance to the anthropometrical measurements, the existence of any pathology, any suspicion of food allergies or intolerances, acute or chronic use of dietary supplements or medication three months prior the study period.

Study sample subgroups

The study sample (n=287) was divided into three subgroups (n=3): group 1, group 2 and group 3. The individuals were distributed in the study groups by using the body weight, the body height and the Z score data, calculated as body mass index for age (BMI-for-age). (Anderson et al, 2017) The body mass index for age was assessed by using the Anthropo Survey Analyzer (property of the World Health Organization, Switzerland) (WHO, 2006) and SAS (property of SAS Institute INC., USA) analysis software. Group 1 was referred to as the normal weight study group, composed of 133 subjects. The subjects from this group reported normal body weight and a Z-score between -2 and +2. Group 2 was comprised of 74 subjects and represented the wasted sample with a Z-score
below -2. Group 3 represented the overweight sample, which consisted of 80 subjects with a Z-score above 2.

**Anthropometrical measurements**

The anthropometrical measurements included the body weight and the body height assessment in a single visit, scheduled at the beginning of the study period. The measurements took place by using a mechanical stadiometer (ADE GmbH, Germany). Prior to measurements, all subjects and legal caretakers were informed on the researcher procedure. During the single visit, three consecutive measurements (n=3) were performed at 60-second intervals.

To assess the physical development of each subject mean values were calculated for all anthropometrical measurements; by using the anthropometrical results, the Z score and the body mass index (BMI) was determined for each subject. The anthropometrical measurements were automatically interpreted by using the Anthro Survey Analyzer (property of the World Health Organization, Switzerland) (WHO, 2006) and SAS (property of SAS Institute INC., USA) analysis software.

**Body weight and Body height measurement procedure**

A standard calibrated mechanical stadiometer (error < 2 mm) and a mechanical scale (ADE GmbH, Germany) were used to assess the anthropometric data. Prior the measurement the legal caretaker was asked to remove the subjects’ shoes, hair ornaments or other accessories. The body weight was measured from a standing position. The subject was kindly asked to stand up straight and touch the stadiometer with the back, buttocks, calves and heels while looking ahead. During body height measurement, a similar protocol was applied. The participants were kindly asked to stand in the center of the scale, to distribute the body weight on both feet while looking ahead.

**Nutritional assessments – the food diary method**

Food intake was assessed by using the food diary method. The food diary method represents a daily record of food and drink intake which provides data regarding energy, macronutrients and micronutrients daily intake (Ortega et al., 2015; Dao et al., 2019).

Following the study methodology, the food diary was kept by the subjects’ legal caretakers during three consecutive days (n=3). The diary included data regarding the food serving time, the food product along with specific data regarding the producer and the exact food quantity. The food dairy data was manually introduced in a Microsoft Office Excel database (V. 2010). To evaluate the nutritional value of each product, the data was logged in and analyzed by using USDA Food Composition Databases, property of United States Department of Agriculture, USA (United States Department of Agriculture, 2019). The results were used to evaluate fat along with 24 hours period micronutrient intake.

**Data use**

For each product listed in the food diary, we obtained specific content data regarding product energy (kcal), total fat (g), saturate fat (SF; mg), monounsaturated fat (MUF; mg), polyunsaturated fat (PUF; mg), trans fat, dietary cholesterol (mg), along with calcium (mg), iron (mg), magnesium (mg), sodium (mg), potassium, (mg), zinc (mg), selenium (mg), phosphorus (mg), vitamins A (μg), C (mg), B12 (μg), B1 (μg), B6 (μg), E (μg) and K (μg). The nutritional data was compared with the official 2015-2020 Dietary Guidelines (U.S. Department of Health and Human Services, 2015) - WHO, FAO and CDC approved (Table 1).

| Table 1. Daily nutritional needs according to the 2015-2020 Dietary Guidelines (U.S. Department of Health and Human Services, 2015) |
|---|---|---|---|---|---|
| Gender | Age, months | Energy, kcal/day | Carbohydrate, g | Protein, g | Fat, g |
| Male - Female | 36 to 47 | 1000 | 130 | 13 | 43.4 |
| Female | ≥47 | 1200 | 130 | 19 | 38 |
| Male | 48-84 | 1500 | 130 | 19 | 48.3 |
Statistical analysis

Statistical information was obtained by using the IBM SPSS Statistic Data Editor 20.0. The level of significance α was set at 0.05. The descriptive statistical indicators used in this study were: mean value±SD (standard deviation), median, minimum and maximum values.

Inferential statistical information was calculated by applying 3 distinct statistical tests to the data sets. The Wilcoxon Matched-Pair Signed-Rank test was used to evaluate the differences between two related data samples, while the Kruskal-Wallis test was used to analyze the differences between the 3 study groups. The correlation level between two indicators was evaluated using the Spearman r test.

Results

Anthropometric data

The underweight sample had a mean age of 39.14 months, as against the normal weight sample (43.65 months) and the overweight study sample (39.08 months). The median body weight in the first sample was 12.11 kg body weight while the height was 94.92 cm unlike the normal weight study sample whose height reached 96.8 cm and 14.55 kg body weight. The overweight study sample had 16.15 kilograms body weight and 92.65 cm height, as further detailed in Figure 1.

Male participants represented 54.05% whereas female participants reached 45.9% of the sample. Both the normal body weight and underweight study samples were correlated with the age (p=0.01), as against the overweight study
Further on, the age was correlated with the Z score in the underweight sample ($p=0.01$) unlike both the normal weight and the excessive weight sample ($p>0.05$).

**Daily food intake – analyzing daily fat consumption**

Fat intake was significantly different between the study samples ($p=0.0009$). Saturated ($p=0.0001$), monounsaturated ($p=0.0001$), polyunsaturated fat ($p=0.0001$) and trans-fat ($p=0.0001$) intake differed between the samples unlike dietary cholesterol ($p=0.268$), as seen in Table 2.

Total fat intake was lower than the daily references for gender and age ($p=0.0001$) among all subjects. Differences were identified between both saturated ($p=0.0001$) and unsaturated ($p=0.0001$) fat intake. In the normal weight sample, saturated fat reached 4.14 g/day, similar to the underweight group of which saturated fat reached 4.12 g/day, different from the reference values. Yet, in the overweight sample (6.85 g/day), lack of differences were reported between the reference value and the daily intake, as detailed in Table 3. Unsaturated fat was significantly different from the reference value in all three samples ($p<0.05$).

### Table 3. Inferential statistics – Difference between fat intake and fat requirements

<table>
<thead>
<tr>
<th></th>
<th>Underweight group</th>
<th>Normal weight group</th>
<th>Overweight group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturated fat</td>
<td>$p$ value</td>
<td>0.0001</td>
<td>0.0016</td>
</tr>
<tr>
<td>Sum of signed ranks ($w$)</td>
<td>-825.0</td>
<td>-879.0</td>
<td>-351.0</td>
</tr>
<tr>
<td>Unsaturated fat</td>
<td>$p$ value</td>
<td>0.0001</td>
<td>0.0001</td>
</tr>
<tr>
<td>Sum of signed ranks ($w$)</td>
<td>-2775</td>
<td>-8791</td>
<td>-2422</td>
</tr>
</tbody>
</table>

**Fat intake and anthropometric values in all three-study samples**

To evaluate fat intake and anthropometric development, all three-study groups were analyzed as one sample. Within the study sample, saturated fat was significantly correlated with the anthropometric measurements, including body weight ($p=0.0001$), height ($p=0.001$) and BMI ($p=0.001$). Both dietary cholesterol ($p=0.018$; $r=0.189$) and saturated fat ($p=0.01$; $r=0.265$) were associated with individual height. Yet, no correlations were obtained between dietary cholesterol, age or BMI ($p>0.05$), but with individual body weight ($p=0.018$; $r=0.189$). Several correlations resulted between monounsaturated, saturated fat intake and individual body weight, as illustrated in Table 4.

### Table 4. Inferential statistics – monounsaturated vs. polyunsaturated fats - associations between fat intake, anthropometric data and age.

<table>
<thead>
<tr>
<th></th>
<th>Monounsaturated fat</th>
<th>Polyunsaturated fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>$p$ value</td>
<td>0.735</td>
</tr>
<tr>
<td></td>
<td>$r$ value</td>
<td>-0.027</td>
</tr>
<tr>
<td>Weight</td>
<td>$p$ value</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>$r$ value</td>
<td>0.273</td>
</tr>
<tr>
<td>Height</td>
<td>$p$ value</td>
<td>0.008</td>
</tr>
<tr>
<td></td>
<td>$r$ value</td>
<td>0.208</td>
</tr>
<tr>
<td>BMI</td>
<td>$p$ value</td>
<td>0.008</td>
</tr>
<tr>
<td></td>
<td>$r$ value</td>
<td>0.208</td>
</tr>
</tbody>
</table>

**Fat and minerals intake**

Similar to the total fat intake, SF, MUF and PUF were significantly correlated with iron and calcium along with phosphorus, zinc and selenium intake. Lack of relationship was seen over magnesium and potassium intake, specific with MUF and PUF, unlike the SF and the dietary cholesterol intake. Table 5. contains further data regarding minerals and fat intake.
Specific in the underweight sample, calcium was correlated with SF, unlike MUF, PUF. Lack of relationship was seen regarding zinc, selenium, sodium and fat intake (p>0.05). Yet, MUF consumption was correlated with iron, magnesium and phosphor, while PUF were correlated with both phosphorus and potassium in the underweight study group, as against both over weight and normal weight study groups, as seen in Table 5.
**Fat intake and vitamin use**

Vitamin C failed to correlate with SF, MUF and PUF daily intake. However, Vitamins B1, B6, B12 were all correlated to SF, MUF and PUF intake. Correlations were obtained between vitamin K and SF, next to folic acid and MUF (p<0.05). Table 6 contains further data on vitamins and fat intake.

Table 6 summaries the relationship between fat intake and vitamins. Lack of correlations were obtained between dietary cholesterol, vitamin E and Folic Acid (p>0.05). Following the normal weight group, MUF intake was significantly correlated with vitamins A-B, along with vitamin E and Folic Acid, as against the overweight and the lower weight study group (p>0.05).

**Discussions**

This paper studied fat and micronutrient intake in normal weight, over weight and underweight individuals. In the current study, we encountered a low daily fat intake, next to low unsaturated fat, regardless the body weight. Yet, SF intake differed from the daily needs in the normal weight group unlike the overweight sample. Overall, daily fat and micronutrient intake were related to both lower body height and body weight.

**Energy balance - fat intake and anthropometric measurements**

The body weight measurements were correlated with daily fat intake, whether related to saturated fat, monounsaturated fat or cholesterol reach products. Although this study only focused on the ingested food quantity, Reedy et al. (2010) suggested that an increased fat intake and excessive weight gain could possibly be related to high-fat dairy and other refined food products. Other studies, published by Beck et al. (2017) and Xu et al. (2019) propose opposite outcomes, through which high-fat dairy products are not related with obesity, as against low-fat dairy products. However, such topics were not reached in the current study.

In the current study, fat intake influenced micronutrient availability. Yet, lower micronutrient, due to daily intake, was seen in the underweight study sample, similar to Liu et al. (2019), which found a severe nutritional imbalance and related negative anthropometric measurements, due to both negative energy balance and low macronutrient intake. Of the analyzed data, calcium, selenium and vitamin B intake were most frequently related to the individual body weight. However, in Gröber et al. (2015) review, magnesium could influence the cell energy production, the bone structural development along with glycolysis, having therefore a major role over preschoolers body weight (Illner et al., 2012; Veldhorst et al., 2018). Following our study results, lower fat, magnesium, folic acid, vitamin B and daily energy intake were associated with negative growth and anthropometric development conditions.

In our study sample, in addition to fat intake, improper anthropometrical development was related to zinc intake, which was lower in all study samples, similar to Strand, (2019). According to Bach et al. (2019), zinc deficiency can increase the risk of chronic renal disease as well as albuminuria. Similar results are reported over selenium intake and its importance in the body height growth curve, as confirmed by Prabhu et al. (2016). According to Prabhu et al. (2016) outcome, lower selenium intake can negatively influence both the energy metabolism and the individual response to oxidative damage. Similar results were obtained over folic acid, confirming its importance in both amino acids and iron metabolism. Eldridge et al. (2019) obtained similar partial results. According to his papers, low fat intake is accompanied by sodium, potassium, vitamin D, vitamin E and fiber deficit. Yet, no changes were seen in the body weight, as against our paper results.

Following the ANIVA study results, a drop in micronutrients intake should have no severe influence on body skeletal muscle mass (Morales-Suarez-Varela et al., 2019). Lack of vitamins B were correlated to anorexia and non-specific symptoms as anthropometrical and neurological development delay, similar to our body development study condition, seen in all three study groups.

Building on the correlations between fat, cholesterol intake and micronutrient deficiencies, Olson RE (2000) mentioned that low dietary fat intake should require medical support. Such conclusions may refer to the associated risk developed through changes in the physiological development, also supported through our results. Further on, Priest et al (2019) stated that unhealthy snack foods and beverages represent an important cause for an imbalanced micronutrient intake. However, such food products could be related to

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the actual lower body weight, high saturated fat, cholesterol, monounsaturated and saturated fat intake, in the current overweight group. Further on, Priest et al. (2019) reported lack of changes in the body weight, while observing iron deficit, coupled with stunted growth. In order to influence the subjects’ height, Aiga et al (2019) recommended a higher animal based protein intake, without specifying an exact quantity that can positively influence anthropometric development during early age. However, such a measure could not possible solve the current imbalance due to both macronutrient and micronutrient deficit.

**Community and daily dietary influence**

Dietary preferences can influence food and energy intake in controlled environments. (Martínez-Ospina et al., 2019) In the vast majority of the Romanian preschool units, meal planning is severely imbalanced, surpassing the energy and nutritional intake, as seen in Cordos A et al. (2019) outcome. The food servings tend to increase daily fat and carbohydrate intake. Such measures can increase the risk of obesity in preschoolers (Brasoveanu et al. 2019) while creating negative food preferences (Scaglioni et al., 2018). In our case, food preferences could have had a contribution in the results, by increasing the supply of saturated products and reducing those containing unsaturated fats.

In the current study, the short-term energy intake analysis can represent a study limitation. We consider that future studies should analyze both blood lipid profile, mineral values, next to a 14 consecutive days food diary, in order to conclude the current findings and to exclude transitory preferences. Because a possible cause of changes in fat intake is sleep deprivation (Cordova et al., 2018; Illner et al., 2012), sleep quality should be taken into account while further analyzing daily energy and food intake. Another study limitation is that all nutritional data (products, amounts, cooking method) where provided by the legal guardian of the child, thus we have to take into account the possibility of human error.

**Conclusion**

A low fat intake was measured in all three samples. Diets lacking in dietary fats have been associated with a significant decrease in growth speed, weight gain and a higher risk of general development delay. Low fat intake was associated with both vitamin and mineral deficits, which can jeopardize the physical development of children.

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and young children from 3 feeding infants and toddlers studies (FFTs). J Nutr. 149(7): 1230-1237