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MODIFYING DIETARY INTAKE AND PHYSICAL ACTIVITY IN PRESCHOOL CHILDREN AND ITS INFLUENCE ON NUTRITIONAL STATUS AND PHYSICAL FITNESS – METHODOLOGY OF AN INTERVENTION STUDY IN POLISH PRESCHOOLERS[1]

***Wojciech Chalcarz, Sylwia Merkiel**

Food and Nutrition Department, Eugeniusz Piasecki University School of Physical Education in Poznań, Poland
Head of Department: Prof. Wojciech Chalcarz, MD, PhD

Summary

Introduction. Following nutrition recommendations and physical activity guidelines by the whole society would largely solve the problem of the increasing prevalence of diet-related diseases.

Aim. The aim was to present the methodology of an intervention study on Polish preschoolers which was focused on the modification of diet and physical activity in preschool children in order to improve nutritional status and physical fitness.

Material and methods. Children's dietary intake was assessed using a seven-day weighed food record. Physical activity was measured using tri-axial accelerometers, ActiGraph GT3X. Body weight, height and BMI were assessed using growth charts. The bioelectrical impedance analyser BIA 101 and the Akern computer programme Bodygram 1.31 were applied to assess body composition. Blood samples were taken to measure biochemical and haematological indices. Blood pressure was measured using BpTRU Vital Signs Monitor, model BPM200. Physical fitness was measured using physical fitness test for 3-7-year-old children.

Preschool staff and parents were educated on nutrition recommendations and physical activity guidelines and instructed how to improve their children's daily diets as well as how to increase physical activity. The kitchen staff was educated how to prepare meals. The recipes used in the preschools were modified and many new recipes were introduced. After seven months of the intervention programme all the measurements were repeated.

Results. This section does not apply to this article because it is a methodological article.

Conclusions. The methodology of this intervention programme may be used in future research not only in preschool children but also in school children and adults.

Keywords: preschool children, intervention, diet, physical activity, physical fitness

INTRODUCTION

The prevalence of diet-related diseases is nowadays one of the major problems in the developed countries. These diseases not only reduce the quality of life and cause premature deaths but also pose a serious economic burden to the society. This problem could be largely solved if people would follow the recommendations on nutrient intake and physical activity. Diet-related diseases in adulthood stem from inadequate dietary intake and insufficient physical activity in childhood, therefore governments should provide more funds for programmes aimed at improving dietary habits and increasing physical activity in the society, especially for programmes aimed at acquiring healthy lifestyle habits by preschool children.

The studies published so far showed unhealthy food habits (1, 2), inadequate dietary intake (3-6) and low physical activity (7-10) in Polish preschool children, as well as insufficient nutrition knowledge of both preschoolers' parents (11, 12) and preschool staff (13, 14). However, we did not find in the Polish literature intervention studies in preschool children aimed at improving

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dietary intake and physical activity. Therefore, we worked out and carried out an intervention study which, to our knowledge, is the first such intervention programme carried out in this age group in Poland. We hypothesised that dietary factors have influence on nutritional status of children as early as in preschool age and that increasing physical activity would improve the children's physical fitness. The methodological outline of the intervention study was presented in our previous article (15). In the current article, we present the methodology in detail.

AIM

The aim of this study was to present a detailed methodology of an intervention study on Polish preschoolers which was focused on the modification of diet and physical activity in preschool children in order to improve the children's nutritional status and physical fitness.

THE METHODOLOGY OF THE INTERVENTION STUDY

General information

The study was carried out in two preschools in Piła, a city located in north-western Poland. The preschools were selected randomly. First, the approvals of the local authorities and the directors of the preschools were obtained. The directors and the preschool staff were informed in detail about the aim and methods of the study and were instructed how to prepare for the intervention.

The next step was to arrange the meetings with parents organised in each preschool. During the meetings, parents were informed about the aim and methods of the study, about the benefits of taking part in the study and were instructed in detail about their role they would play in the study in order to make them aware of the effort required from them to complete the study successfully. Parents were also informed that they may withdraw their children from the study at any moment and that they will be provided with all the necessary advice and help throughout the study.

The study began in September 2010 and lasted until June 2011. In September 2010, dietary intake, nutritional status, physical activity and physical fitness were assessed. In October 2010, parents and preschool staff were prepared for the intervention programme. In June 2011, assessment of dietary intake, nutritional status, physical activity and physical fitness was repeated.

The study was approved by the Bioethics Committee of the Poznań University of Medical Sciences.

Subjects

In total, parents of 234 children who attended both preschools were invited to take part in the study. Although the initial questionnaires on general information and physical activity were filled in by parents of 165 preschoolers, written consents to take part in the whole study were finally received from parents of 154 children. However, we did not manage to obtain all the target data from 154 children because some parents withdrew their children at different stages of the study, some children fell ill or had accidents and had to give up taking part in the study, some parents did not provide all the necessary questionnaires or food records, some parents provided incomplete food records, and some families moved out to another city so that the children could no longer take part in the study, etc. Therefore, we will report various numbers of children in our future articles presenting various parts of the results.

Dietary intervention

First, dietary intake in the studied children was assessed using a weighed food record kept over seven consecutive days. Parents and preschool staff received special sheets prepared for the purpose of keeping a food record and they were instructed in detail how to fill in the sheets, how to weigh foods and beverages, including all ingredients of complex dishes, and how to weigh leftovers. Both parents and preschool staff were equipped with electronic scales (Soehnle Page 66100). Preschool staff kept the food records during preschool hours individually for each child. The authors helped the staff in keeping the food records at preschools. The studied children in both preschools had access to water during preschool hours, therefore, intake of water was also recorded. Additionally, the children were asked to inform the teacher each time they would like to drink water. Parents kept the food records when the children were out of preschool. They were also asked to record any supplements taken by their children. If the children were cared for by other persons for some time, for example a grandparent or a baby-sitter during late afternoon, those persons were asked to keep the food record. However, only one child was cared for by a baby-sitter, while other children stayed either with their parents or grandparents. After the seven-day food records were completed, the authors analysed them with the parents to explain any imprecisions and to get information on recipes if not provided in the food record. The authors also conducted an interview with the kitchen staff in order to get detailed information on all ingredients of preschool meals and dishes, including recipes and the way of food processing.

The next step was to organise meetings with the preschool staff and parents. During the meetings with preschool staff, current nutrition recommendations for preschool children were presented, as well as the principles of composing menus and the recommendations on the ways of food processing and preparing meals. Apart from these meetings with the preschool staff, many individual meetings were organised with the kitchen staff, mainly with the chefs. The kitchen staff was educated how to prepare meals which are in line with the current recommendations. The recipes used in the preschools were modified and many new recipes were introduced.

The strongest emphasis was put on replacing unhealthy fats with healthy plant oils, and on reducing salt and sugar intake or eliminating them if possible, for example it was recommended to serve mineral water and beverages without added sugar. To increase children's acceptance, the addition of salt and sugar was reduced gradually and was replaced by new ingredients, for example the reduced content of salt was compensated by the addition of herbs (such as marjoram, basil, oregano, mint, tarragon etc.) or garlic, while vegetables were served in an attractive form accompanied by foods which were preferred by the children.

The aim of the meetings with parents was to present the consequences of inadequate dietary intake and the benefits of following a balanced diet, especially in preschool age. The inadequacies in the children's diets observed when collecting and analysing the food records were discussed. Detailed recommendations on food and nutrient intake in preschool children were presented, with particular emphasis on practical guidance. All the questions asked by parents and preschool staff were answered. Parents and preschool staff received printed version of the presentation together with additional educational material. Parents and preschool staff were provided with help from the authors at any time during the study and were offered to receive more advice and individual help.

After seven months of serving modified meals at preschool and enhancing parents to follow nutrition recommendations when preparing meals for their children and for themselves, a seven-day weighed food record was repeated.

Physical activity intervention

Parents filled in questionnaires on their children's physical activity. We used the same questionnaires as in our previous studies (7-10). Children's physical activity was also measured using tri-axial accelerometers, ActiGraph GT3X (ActiGraph, LLC, Pensacola, FL, USA). The accelerometers were initialised with the ActiLife Data Analysis Software, version 5 (ActiGraph, LLC, Pensacola, FL, USA) to record counts over 15-second intervals (epochs). Each device was placed on the anterior part of the child's body slightly to the left of the right iliac crest using an elastic belt secured around the waist. The children were wearing the accelerometers for seven consecutive days, the same days when food records were kept.

After the measurements had been completed, meetings with preschool staff and parents were organised to present the importance of physical activity to preschool children's growth, physical and mental development, as well as present and future health. Preschool teachers were instructed how to increase children's physical activity during preschool hours and parents were informed about practical methods of increasing children's physical activity when spending free time at home, including indoor and outdoor activities, using help of other family members, cooperation with neighbours and friends whose children are of similar age, and increasing children's access to sports facilities and sports equipment. Parents and preschool staff were provided with help from the authors at any time during the study and were offered to receive more advice and individual help.

After seven months parents filled in the same questionnaires on their children's physical activity and the measurements using the ActiGraphs over seven consecutive days were repeated. The results of the first survey on the studied preschoolers' physical activity have already been published (16, 17).

The indices measured in the studied children

Socio-demographic characteristics and selected indices of health status

The questionnaires filled in by the studied preschoolers' parents included questions about socio--demographic characteristics. These characteristics are of great importance because they may determine food behaviour and physical activity. Parents' education, economic status of the family or the number of children in the family are among the most important factors. Moreover, questions about selected indices of health status were included in the questionnaires, first of all the history of diet-related diseases in the family, which should be taken into account when assessing dietary intake and giving nutrition recommendations. Both socio-demographic characteristics and selected indices of health status of the studied children and their families have already been published (18).

Dietary intake

Energy and nutrient intakes were calculated in Dieta 4 computer programme described in detail in our previous article (15). From this programme we obtained intake of: energy (kcal, kJ); total protein (g); animal and plant protein (g); total fat, saturated fatty acids, polyunsaturated fatty acids and monounsaturated fatty acids (g); cholesterol (mg); total carbohydrates (g); available carbohydrates, lactose, sucrose and starch (g); dietary fibre and total water (g); fat-soluble vitamins, that is vitamin A (retinol equivalent), retinol, beta-carotene, vitamin D (μg) and vitamin E (mg); water-soluble vitamins, that is vitamin B_1, B_2, B_6, niacin, vitamin C (mg), folate and B_{12} (μg); as well as minerals: calcium, phosphorus, magnesium, sodium, potassium, iron, zinc, copper, manganese (mg) and iodine (μg). We used Microsoft Excel 2010 computer programme to calculate intake of energy expressed in kcal/kg body weight and in kJ/kg body weight, intake of total protein expressed in g/kg body weight, as well as intake of animal and plant protein expressed as % of total protein.

It is important to note some problems which we encountered when introducing the data from the food records into the database created in the Dieta programme. We described them in detail in our previous article (15). One of those problems was the fact that the studied children ate some foodstuffs which were not included in the database of the Dieta programme, such as some brands or types of milk and rice gruel for babies, lollipops and other sweets with added vitamins and minerals, as well as some brands of supplements. Therefore, we asked the producers for detailed information on the composition and nutritional value of these foodstuffs and supplements. These values were added to the results obtained from the Dieta programme using the Microsoft Excel programme and, therefore, also the Microsoft Excel was used to calculate intake of energy from macronutrients: total protein (% of energy); total fat, saturated fatty acids, polyunsaturated fatty acids and monounsaturated fatty acids (% of energy); and available carbohydrates, lactose, sucrose, and starch (% of energy).

As mentioned in the section 'Dietary intervention', the seven-day food record was kept twice, before and after the intervention, therefore, dietary intake was estimated both before and after the intervention.

Anthropometric indices

The studied children's weight and height were measured in the morning using standard techniques (19) by means of electronic scales equipped with stadiometer (WPT 100/200 OW, RADWAG, Poland). Weight was measured to the nearest 0.05 kg and height was measured to the nearest 0.1 cm. Both weight and height were assessed using Polish growth charts (20) and CDC growth charts (21). Body mass index (BMI) was calculated and assessed using the abovementioned growth charts. BMI z-scores were calculated using the LMS method (21, 22) and the tables provided by Kuczmarski et al. (21).

To receive the information about children's body composition, bioelectrical impedance analysis (BIA) was used. BIA was chosen because it is a non-invasive method and the studied children are not exposed to radiation. Moreover, BIA shows a very close correlation to dual-energy X-ray absorptiometry (23, 24).

By means of the bioelectrical impedance analyser (Body Impedance Analyser BIA 101, Akern), resistance and reactance were measured with two pairs of adhesive skin electrodes: one pair placed on the dorsal side of the right hand and one pair placed on the right foot. During the measurements the children were lying in supine position with their arms and legs slightly abducted to avoid skin contact between the extremities and the trunk. To calculate body composition indices, the Akern computer programme Bodygram 1.31 was used. The body composition indices included: body cell mass (BCM), muscle mass (MM), fat free mass (FFM), fat mass (FM), total body water (TBW) and extracellular water (ECW) expressed in absolute terms in kg and as percentages of body weight (%BCM, %MM, %FFM, %FM, %TBW, %ECW), and also intracellular water expressed as percentage of body weight (%ICW).

All of the abovementioned anthropometric measurements were performed twice: before and after the intervention.

Blood indices

Biochemical and haematological indices were determined by the staff of a certified laboratory. The blood samples were taken from the studied children after an overnight fast by nurses trained especially to take blood from children. Biochemical indices included serum glucose (mg/dl), protein (g/dl), total cholesterol (mg/dl), HDL cholesterol (mg/dl), LDL cholesterol (mg/dl), triacylglycerols (mg/dl), iron (μg/dl), total iron binding capacity (μg/dl), unsaturated iron binding capacity (μg/dl), ferritin (ng/ml), transferrin (mg/dl), sodium (mmol/l), potassium (mmol/l), calcium (mmol/l), magnesium (mg/dl), phosphorus (mg/dl) and chlorides (mmol/l). Haematological indices included: red blood cell count (M/μl), haemoglobin (g/dl), haematocrit (%), mean corpuscular volume (fl), mean corpuscular haemoglobin (pg), mean corpuscular haemoglobin concentration (g/dl), red cell distribution width (%), white blood cell count (K/μl), neutrophils (%), lymphocytes (%), monocytes (%), eosinophils (%), basophils (%), platelet count (K/μl), mean platelet volume (fl), plateletcrit (%), platelet distribution width (%) and platelet-large cell ratio (%).

All of the abovementioned blood indices were measured twice: before and after the intervention.

Blood pressure

Blood pressure was measured in the studied children using BpTRU Vital Signs Monitor, model BPM200 (BpTRU Medical Devices, Coquitlam, BC, Canada). This is a fully automated sphygmomanometer, which uses the oscillometric technique, and has been clinically validated to BHS A/A accuracy (25, 26) and is approved for children three years and up. Blood pressure was measured on the child's right upper arm after 10-minute rest and was repeated after one minute. The cuff size was matched individually for each child depending on the mid arm circumference. Systolic and diastolic blood pressure, as well as pulse rate were recorded. Children's blood pressure was assessed both before and after the intervention.

Physical activity

The ActiGraphs GT3X quantify three dimensions of movement and measure acceleration, that is change in velocity with respect to time expressed in m/s^2 (27). The data recorded by the ActiGraphs are processed in the ActiLife Data Analysis Software to values expressed as movement counts. The number of counts per minute is used to set thresholds for determining the intensity of physical activity as moderate or vigorous intensity physical activity and sedentary behaviour.

The data recorded by the ActiGraphs may also be used for predicting energy expenditure equations (27), however, few equations for children have been developed and so far we have not found any equation for children aged from 4 to 6 years.

As mentioned in the section "Physical activity intervention", children's physical activity was measured twice using the ActiGraph GT3X, therefore, we received physical activity indices both before and after the intervention.

Physical fitness

Physical fitness was measured using physical fitness test for children aged 3 to 7 years developed by Sekita (28) which we described in detail in our previous article (29). As a result we received measures of agility, power, strength, speed and the level of physical fitness. Children's physical fitness was measured twice: before and after the intervention.

CONCLUSIONS

We expect to show that dietary factors have influence on nutritional status of children as early as in preschool age and that increasing physical activity would improve the children's physical fitness.

The methodology of this intervention programme may be used in future research not only in preschool children but also in school children and adults after few modifications such as adjusting the physical fitness test to the studied subjects' age.

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Conflict of interest
None

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Correspondence to:
*Wojciech Chalcarz
Food and Nutrition Department
Eugeniusz Piasecki University School
of Physical Education in Poznań
Królowej Jadwigi 27/39 Str., 61-871 Poznań, Poland
tel.: +48 (61) 835-52-87
e-mail: wojciech.chalcarz@wp.pl