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MODEL FOR PREDICTING THE OUTCOME OF A WEIGHT MANAGEMENT PROGRAM

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Abstract. *Introduction.* The approach to the problem of childhood obesity requires the use of an interdisciplinary weight management program (weight management program – WMP), accompanied by ongoing group educational activities and family support, which include healthy nutrition and physical activity.

The aim of the study: to predict the probability of an effective result of the body weight management program in the treatment of obesity in children aged 6-18 years at the initial visit.

Materials and methods. To predict the effective result of the body weight management program, 84 clinical and anamnestic parameters were analyzed with the determination of the relative risk (RR) and predictive coefficient (PC) after a 6-month follow-up of 350 children with an effective WMP result (first group, n =123) and an ineffective consequence of WMP (second group, n=227). Research methods: immunochemical (certified laboratory «Sinevo», city of Dnipro, Ukraine), psychological, bioimpedancemetry.

Results. The effective result of non-drug treatment of obesity with the help of WMP was diagnosed in 35.14% of treated children aged 6 to 18 years. 13 factors with sufficiently informative prognostic significance (I ≥ 0.5) were identified as predictors of the development of an effective outcome of obesity treatment in children using WMP: age 6-9 years (I=3); time spent watching TV, computer, phone < 180 minutes/day (I=2.5); high-intensity physical activity ≥240 minutes/day (I=2); positive food history — daily consumption of fresh vegetables and fruits (I=1.9); abdominal type of obesity (I=1); relative body fat content <90 percentiles (I=0.95); diastolic blood pressure in the range of 40-59 percentiles (I=0.9); body mass index <99 percentiles (I=0.8); physical development in the range of 4-69 percentiles (I=0.7); consumption of high-calorie foods less than once a week (I=0.64); average meal duration > 20 minutes (I=0.62); systolic blood pressure in the range of 40-59 percentiles (I=0.6); female gender (I=0.5).

Conclusions. The effectiveness of the treatment of obese children at the ambulatory stage is highly related to non-pharmacological methods of therapy: moderate-intensity physical activity of the aerobic type (more than 240 minutes/day) and compliance with the nutritional regime.

Key words: obesity, children, non-drug treatment, prediction of treatment effectiveness, predictors, Wald analysis.

Модель прогнозування результату програми управління масою тіла

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Резюме. *Вступ*. Підхід до проблеми дитячого ожиріння вимагає застосування міждисциплінарної програми менеджменту маси тіла (weight management program – WMP), що супроводжуються постійними груповими освітніми заходами та підтримкою сім'ї, які включають раціональне харчування та фізичну активність.

Мета дослідження: спрогнозувати вірогідність ефективного результату програми менеджменту маси тіла в лікуванні ожиріння в дітей 6–18 років при первинному візиті.

Матеріали та методи. Для прогнозування ефективного результату програми менеджменту маси тіла за допомогою послідовного аналізу Вальда було проаналізовано 84 клініко-анамнестичні параметри із визначенням відносного ризику (ВР) та прогностичного коефіцієнта (ПК) після катамнестичного спостереження протягом 6 місяців 350 дітей із ефективним результатом WMP (перша група, n=123) та неефективним наслідком WMP (друга група, n=227). Методи дослідження: імунохімічні (сертифікована лабораторія «Сінево», місто Дніпро, Україна), психологічні, біоімпедансометрія.

Результати досліджень. Ефективний результат немедикаментозного лікування ожиріння за допомогою WMP діагностовано в 35,14 % пролікованих дітей від 6 до 18 років. Предикторами розвитку ефективного результату лікування ожиріння в дітей за допомогою WMP було визначено 13 факторів із достатньою інформативною прогностичною значимістю (I≥0,5): вік 6–9 років (I=3); час, проведений за переглядом телевізора, комп'ютером, телефоном <180 хвилин/добу (I=2,5); фізична активність високої інтенсивності ≥240 хвилин/добу (I=2); позитивний харчовий анамнез – щоденне вживання свіжих овочів та фруктів (I=1,9); абдомінальний тип ожиріння (I=1); відносний вміст жирової маси тіла <90 перценти-

лів (I=0.95); діастолічний артеріальний тиск у діапазоні 40–59 перцентилів (I=0.9); індекс маси тіла <99 перцентилів (I=0,8); фізичний розвиток у діапазоні 4–69 перцентилів (I=0,7); вживання висококалорійних продуктів харчування рідше 1 разу на тиждень (I=0,64); середня тривалість прийому їжі >20 хвилин (I=0,62); систолічний артеріальний тиск в діапазоні 40–59 перцентилів (I=0,6); жіноча стать (I=0,5).

Висновки. Ефективність лікування дітей з ожирінням на амбулаторному етапі високо пов'язана з немедикаментозними методами терапії: з фізичною активністю середньої інтенсивності за аеробним типом (понад 240 хвилин/добу) та дотримання режиму харчування.

Ключові слова: ожиріння, діти, немедикаментозне лікування, прогнозування ефективності лікування, предиктори, аналіз Вальда.

Introduction

Obesity is a multifactorial chronic disease associated with environmental, social, behavioral, physiological, psychological, and genetic factors. The high prevalence of childhood obesity is a serious health problem. In high-income countries, almost 25% of boys and girls are overweight or obese. Obesity, especially metabolically unhealthy obesity (MUO), which arose in childhood often continues to persist in adulthood, predisposing to comorbid conditions such as arterial hypertension, dyslipidemia, diabetes and/or heart disease [1,2]. The approach to the problem of childhood obesity requires interdisciplinary interventions of several directions, accompanied by constant group educational activities and family support, which include rational nutrition and physical activity. These complex interventions can improve the evolution of BMI and components of metabolic risk if they are used in a structured and gradual manner to reduce or eliminate the risk of recurrence [3,4].

Given that obesity is a chronic disease that begins in childhood, all efforts should be focused on this age group in order to prevent it and prevent further progression.

Aim: to predict the effective result of a weight management program in the treatment of obesity in children aged 6-18 years at an early diagnostic stage.

Materials and methods

Ethical approval

Participants provided written informed consent, and research protocols and procedures were approved according to the ethical standards of the Helsinki Declaration 2013 and by the Human Research Ethics Committee (ethical approval DSMU/EC/1/10.02.2020 and DSMU/EC/18/17.04.2024). Time of data collection: January 2020 – March 2024.

Informed consent: Informed consent was obtained from all individual participants included in the study.

Study design. Clinical prognostic study assessing the risk of bias of the PROBAST prediction model [5]: 1). A clear definition or description of 'Prognostic Factor' is provided; 2). Method of prognostic factor measurement is adequately valid and reliable to limit misclassification bias; 3). Continuous variables are reported or appropriate cut-points (i.e., not data-dependent) are used; 4). The method and setting of measurement of prognostic factor is the same for all study participants; 5). Adequate proportion of the study sample has complete data for prognostic factor variable; 6). Appropriate methods of imputation are used for missing 'Prognostic Factor' data; 7). Prognostic factor is adequately measured in study participants to sufficiently limit potential bias.

Inclusion criteria: children with polygenic obesity (BMI≥95th percentiles) 6-18 years old.

Exclusion criteria: monogenic and secondary forms of obesity; hereditary syndromes accompanied by obesity; diseases, the treatment of which requires the use of medications that affect the metabolism of carbohydrates and lipids; pregnancy.

Setting. At the Children's Endocrinology Department of the Communal Non-profit Enterprise "Dnipro City Clinical Hospital No. 6" of the Dnipro City Council, 350 children of the Caucasian group aged 6-18 years with a diagnosis of obesity were examined. To verify the diagnosis, the classification of obesity recommended in clinical practice was used: Order of the Ministry of Health of Ukraine No. 1732 of 24.09.2022 About the approval of Standards medical assistance "Obesity in children."

Non-drug treatment was prescribed to all obese children aged 6-18 years under a comprehensive interdisciplinary WMP during 6months of observation. A 4 week standardized lifestyle modification program in the hospital (daily physical activity, calorie-restricted diet, and behavioral therapy). All children who participated in the observation received 25 consultation hours. Each lesson included theoretical and prac-

tical sections with didactic and experimental exercises for training content, including topics such as healthy eating (importance of breakfast, classification of foods, diversification of diet), managing eating at odd hours, physical activity (physical activity in daily life, planned exercise), hours in front of screens, misleading advertising, self-control, body image, communication, assertiveness and self-esteem. In addition, hands-on, one-hour interactive healthy cooking workshops led by nutritionists and a chef were conducted for parents and children [6].

The goal of the non-pharmacological intervention in children with obesity was a gradual weight loss to normal body weight at a rate of 4% per month from baseline BMI greater than the 95th percentile before treatment, or a weight loss of 0.45 kg/month for children in aged 6 to 11 years and 0.9 kg/month – for children aged 12 to 18 years.

The presence of various influences on predicting the effective outcome of the weight management program in the non-pharmacological treatment of obesity in children required its evaluation at the early diagnostic stage and during 6 months of observation by a combination of factors. to build a mathematical model for predicting the probability of an effective result of the weight management program in the treatment of obesity in children, 2 observation groups were formed.

- The first group (n=123) is represented by children with an effective WMP result.

- The second group (n=227) was formed by children in whom we received an ineffective WMP result.

The presence of abdominal obesity and two of the presented criteria were considered for inclusion in the MUO group: 1). Fasting glycemia ≥5.6 mmol/L [7]; 2). High-density lipoprotein (HDL) ≤1.03 mmol/L or less than 10th percentile of the age norm [8]; 3). TG ≥1.7 mmol/L or more than the 90th percentile of the age norm [9]; 4) Systolic blood pressure (SBP) above the 90th percentile for a given age, gender and height; 5). Diastolic blood pressure (DBP) above the 90th percentile for a given age, gender and height [10].

Anthropometric measurements

Anthropometric data were measured by a nurse in the admission department, the child was in underwear and without shoes. Height (m) was measured using Heightronic Digital Stadiometer® to the nearest 0.01 m. Weight (kg) was measured using Tefal Bodysignal body composition analyzer (France). Waist circumference (WC), hip circumference (HC) was measured using a standardized anthropometric tape, measuring the circumference at the midpoint between the top of the iliac crest and the lower part of the lateral rib cage to the nearest 0.01 m[11].As recommended by the United States Preventive Services Task Force (USPSTF), we used BMI (Level of Evidence B) as an indicator of obesity.BMI can be easily calculated using a link on the Centers for Disease Control and Prevention (CDC) website: https://www.cdc.gov/healthyweight/bmi/calculator.html. By abdominal obesity, we understood an increase in WC ≥90th percentile according to the Criteria of the International Diabetes Federation (IDF) and the National Educational Program on Cholesterol (NCEP-ATP) [12].

Immunochemical examination

The studies were carried out in a certified Synevo laboratory (Dnipro, Ukraine). The material for the study was venous blood.

To study carbohydrate metabolism disorders, the level of basal glycemia and insulinemia was determined by immunochemical testing with electrochemiluminescent detection (ECLIA). Obese children were included in the main group with a glycemic level equal to or greater than 5.6 mmol/L and/or they had an increase in insulinemia>90th percentile according to the percentile curves recommended by the IDEFICS consortium for the European population according to age and gender of the child [13; 14].

To study lipid metabolism disorders, the level of high-density lipoproteins (HDL-C) and triglycerides (TG) was determined by the enzymatic-colorimetric method using kits from Roche Diagnostics (Switzerland) on the analyzer Cobas 6000. Obese children were included in the main group with HDL-C≤1.03 mmol/L or less than 10th percentile of the age norm or an increase in ≥1.7 mmol/L or more than the 90th percentile of the age norm [8].

Leptin was determined using ELISA. Analyzer and test system: Tecan Sunrise, LDN (Germany). The reference value of leptin level for boys was 2-5.6 ng/ml, for girls - 3.7-11.1 ng/ml. Adiponectin was tested using ELISA. Analyzer and test system: Mediagnost GmbH (Germany). Interpretation of the results was carried out as follows: low cardiovascular risk - more than 10 μg/ml; moderate cardiovascular risk - 7-10 μg/ml; high cardiovascular risk - 4-7 μg/ml; very high cardiovascular risk - less than 4 μg/ml.

Bioimpedancemetry

The study of disorders of fat metabolism was carried out by the method of bioimpedancemetry on electronic floor scales "Tefal Bodysignal" (France), with the determination of bioelectrical impedance (Ohm) - the resistance of tissues during the passage of a safe electric current (50 kHz, 800 μA) between the contact electrodes located in the places of contact with with the child's feet on the weighing platform. The calculation of body fat percentage or body fat mass index (FMI) was performed automatically with a resolution of 0.1%, according to the requirements of "Tefal Bodysignal", with an evaluation of the results according to unified centile scales for children of a certain age [15,16].

Manometry

Systolic and diastolic blood pressure (SBP and DBP) were measured using a digital oscillimetric device, Dinamap ProCare (GE Healthcare) [17].

Psychological methods

The level of physical activity and time spent in a sedentary lifestyle were determined using the short IPAQ questionnaire [18,19].The intensity of physical activity was assessed in metabolic equivalent task [MET] hours/week.

In order to highlight the predominant modalities of taste preferences for the five most important categories (sweet, sour, umami, salty and bitter), a questionnaire was conducted using an adapted version of IDEFICS (Identification and prevention of Dietary and lifestyle-induced health EFfects In Children and infants Study) *Food and Beverage Preference Questionnaire* (FBPQ) on a 5-point scale with calculation of the average value of the level of taste preferences and analysis of food diaries. The questionnaire consisted of 63 photographs of individual foods (e.g., banana, spinach), mixed foods (e.g., hot dog, kebab), sauces (e.g., jam, mayonnaise), and beverages (e.g., Coca-Cola, lemonade). The estimated time for filling out the questionnaire about taste preferences for food and drinks was 7 minutes. Each subject rated their own taste preferences for the corresponding food or drink on a 5-point Likert scale (represented as "emoticons"), where "1" meant "not at all liked" and "5" meant "extremely liked" [20].

Statistical analysis

Algorithms based on the Bayes theorem (theorem of the inverse probability of an event) were used to build a prognostic model, and a sequential (sequential) Wald analysis was carried out by the method of processing 84 clinical and anamnestic parameters with the calculation of weighted prognostic coefficients. The informativeness of each of the prognostic coefficients was calculated according to the Kullback formula, with the calculation of weighted prognostic coefficients (PC) according to formula 1:

$$PC = 10 \times \lg P_1/P_2 \qquad (1)$$

where PC is the diagnostic coefficient; P_1 is the relative frequency of the characteristic in the first verified state, expressed in fractions of a unit; P_2 is the relative frequency of the characteristic in the second verified state, expressed in fractions of a unit.

The relative risk criterion (RR) was calculated according to formula 2:

$$RR = P_1(1 — P_2)/P_2 (1 — P_1) \qquad (2).$$

The informativeness of each of the diagnostic coefficients was calculated according to Kullback's formula according to formula 3:

$$I=\Sigma Ij \qquad (3)$$

where I is the informativeness of the diagnostic coefficient.

Ij is the informativeness of the range (gradation) of the feature, according to formula 4:

$$Ij = 0,5 \times PC \times (P_1 - P_2) \qquad (4).$$

Statistical processing of the research results was carried out using Microsoft Excel (Office Home Business 2KB4Y-6H9DB-BM47K-749PV-PG3KT) and the STATISTICA 6.1 software product (StatSoftInc, No. AGAR909E415822FA) using parametric or non-parametric methods, depending on the compatibility of their distribution with the Gaussian curve using the Shapiro-Wilk test. Quantitative data are presented using indicators of variation statistics. Categorical variables are presented using frequencies and percentages. Only significant relationships ($p<0.05$) were considered.

Results and discussion

Comparative characteristics of clinical parameters in children with obesity in observation groups during the implementation of the body weight management program is presented in table 1.

Table 1

Comparative characteristics of clinical parameters in children with obesity in observation groups at WMP

Parameter	Children with an effective outcome of WMP (n=123)	Children with an ineffective outcome (n=227)	P
Child's age, years	10.9±0.3	12.1±0.2	**0.004**
Share of boys in observation groups, %	46.0	50.0	**0.05**
Growth in percentiles before treatment	70.6 ±2.5	76.7 ±1.9	**0.05**
BMI in percentiles before treatment	96.9 ±0.2	97.7 ±0.1	**0.002**
Obesity rate relative to the 95th percentile before treatment	110.2 ±1.2	121.4±1.5	**0.0000001**
Waist circumference, WC (percentile) before treatment	86.1 ±1.3	94.1 ± 0.7	**0.0000001**
Obesity rate relative to 95th percentile after treatment	105.1 ±1.2	120.8±1.5	**0.0000001**
History of physical activity (over the past month) — high-intensity physical activity, minutes/day	105.6 ±4.4	42.3 ±2.9	**0.0000001**
Duration of outdoor walks, hours/day	3.5 ±0.1	2.1 ±0.1	**0.0000001**
Time spent watching TV, computer, phone, hours/day	3.0 ±0.2	5.2 ± 0.1	**0.0000001**
Daily consumption of fresh vegetables and fruits, %	62.0±1.1	22.0±0.9	**0.001**
Daily consumption of high-calorie foods	14.0±0.4	50.0±0.5	**0.001**
Average duration of meals, minutes	13±0.2	22± 0.1	**0.05**
SBP in percentiles before treatment	90.0 ±1.2	81.6±1.2	**0.000002**
DBP in percentiles before treatment	65.6±1.7	81.9±1.3	**0.0000001**
Relative body fat content, percentile	81.0±1.6	97.0±1.2	**0.001**

Note: WMP+ - presence of a positive result of non-drug treatment; WMP- - the presence of a negative result.

On the basis of the conducted sequential analysis and the selection of 13 factors with a statistically significant level (p≤0.05), a model was built for predicting the probability of an effective WMP result at the early diagnostic stage (at the initial outpatient visit to a general practitioner or pediatrician) in children with obesity.

Dietary predictors

In our study, a high relative risk of an effective WMP result was found with a positive dietary history characterized by daily consumption of fresh vegetables and fruits (RR=2.85; PC=4.6), while no effect of WMP was predicted by consumption of fresh vegetables and fruits less than 1 time per week (RR=0.5; PC= –6.1). A negative dietary history of foods high in fat, salt, and sugar (HFSS), such as margarine, chips, fast food, sweets, sweet drinks, was assessed by the frequency of HFSS consumption per week, namely it is possible to expect a positive effect from WMP if the frequency of their use is less than once a week (RR=2.6; PC=4.2), while with daily use of HFSS the prediction of an effective effect is reduced (RR=0.9; PC= –5.7). The formed skill of extended meal time also increased the probability of an effective WMP result: with a fixed meal time of more than 20 minutes, the relative risk of a positive effect increased by 3.8 times (RR=3.8; PC=6.9), while a decrease in meal time of less than 20 minutes was characterized by the absence

expected effect of non-drug treatment (RR=1; PC= –4.5).According to the review by S. Boushey et al. [21] in relation to nutrition, evidence suggests that children's and adolescents' diets, which are lower in fruits, vegetables, whole grains, and low-fat dairy products, but higher in sugar, refined grains, fried potatoes, and processed meats, are associated with higher body fat indices, BMI in later adolescence, which coincided with the results of our study.

Balance of active and passive recreation

The anamnesis of the child's physical activity was assessed for the last month preceding the visit to the doctor. The effective effect of non-drug treatment was more often observed in children with aerobic type of high-intensity physical activity exceeding 120 minutes/day (RR=4.62; PC=6.6), while its duration was less than 120 minutes/day (RR=0.5; PC= –3.2). Also, total screen time using gadgets less than 180 minutes/day had a high relative risk of an effective outcome of non-pharmacological treatment (RR=3.78; PC=5.8) with a gradual decrease in the effect on the outcome when increasing the screen time using gadgets up to 360 minutes/day (RR=0.5 ; PC= –3.8) and more than 360 minutes/day (RR=0.5; PC= –9.7). Numerous studies have demonstrated the beneficial effects of physical activity, especially of moderate and vigorous intensity, on MUO, bone strength, physical fitness and mental health in children and adolescents [22; 23].

Thus, in the study conducted by J. Bangsbo et al. [22]the following results were obtained: physical activity, measured in MET-hours/week, ranged from 5.4 to 36.0 (median 6.0). Each MET hour per week was associated with a reduction in BMI and body weight of 0.13 kg/m 2 (95% CI 0.08–0.19) and 0.33 kg (95% CI 0.08–0 ,59) respectively. In our study, the average level of physical activity associated with an effective outcome of non-pharmacological treatment was 28 MET-hours/week. Unlike previous works to monitor trends in physical activity, study the relationship between physical activity and health indicators, and evaluate the effectiveness of measures that increase physical activity, we conducted an analysis of the balance between active and passive rest in 350 children, determining the contribution of each of these factors in the effectiveness of the treatment, evaluating the effectiveness of the treatment by reducing the BMI, which was expressed in percentiles according to the age and gender of the child.

Age predictors

The eating habits of obese children gradually deteriorate as they grow older and transition from childhood to adolescence, namely from a positive characteristic containing the organization of rational nutrition to a negative one. The data we obtained coincided with the results of other researchers [24]. The effective result of non-pharmacological treatment was observed more often in children aged 6-9 years (RR=1.88; PC=2.8), with a gradual decrease in adulthood, namely at the age of 10-13 years (RR=0.75; PC= –1.3) with the lowest probability the effective result of WMP was observed at the age of 14-18 years (RR=0.7; PC= –1.53).

Gender predictors

The effective result of WMP was registered more often in girls (RR=1.8; PC=0.5), while in boys the effectiveness of non-drug treatment was lower (RR=0.92; PC= –0.5).According to the study of K.D. Tambalis et al. [25],also in childhood, girls had healthier eating habits than boys; however, during adolescence, boys appear to reverse the data.

Peculiarities of physical development

The effective effect of non-pharmacological treatment was more often noted in children with physical development in the range from 4 to 69 percentiles (RR=1.81; PC=2.8) and decreased with the indicator of physical development over 70 percentiles and a tendency to tallness (RR=0.5; PC= –3). In the population-based LIFE Child cohort and the Leipzig Obesity Childhood Cohort (8,629 children, 37,493 measurements) recruited between 1999 and 2018 in Germany, E. Kempf et al. [26] compared growth and endocrine parameters between normal weight and obese children (0–20 years). Based on an independent German registry, CrescNet (12,703 children), it was also demonstrated that obese children were significantly taller than their normal-weight peers, with a maximum difference of 7.6 cm (height 1.4, standard deviation, or SDS) at ages 6–8 years. Already at birth, obese children were slightly taller, and then their growth rate increased to 1.2 cm/year. This growth spurt was unrelated to parental growth, but was accompanied by increased levels of insulin-like growth factor-1 (IGF-1), insulin, and leptin. During puberty, children with obesity showed a decrease in SDS growth.

Excess body weight

The effective result of non-pharmacological treatment was observed more often in children with BMI<99 percentiles at the initial visit to the

doctor (RR=1.61; PC=2.1), while an increase in BMI≥99 percentiles at the initial visit to the doctor was characterized by a significant decrease in the effect of treatment (RR=0.9; PC= –0.7).

Excess body fat mass and type of its distribution

Among children with an effective WMP outcome, the relative amount of body fat did not exceed the 90th percentile (RR=2.1; PC=3.2), whereas among children with an ineffective WMP outcome, the relative amount of body fat exceeded the 90th percentile (RR= 1.61; PC = –9.3). Abdominal type of adipose tissue distribution in a child was associated with an ineffective outcome of WMP (RR=0.7; PC= –1.9), while the presence of a waist circumference indicator in a child less than the 90th percentile for age and sex was characterized by an effective prognosis (RR=5.2; PC= 7.2). Unlike previous studies [27] effectiveness of a childhood obesity treatment program that focused on weight control and metabolic disorders, our work only included stratified anthropometric and metabolic measures expressed as percentiles.

Physiological parameters according to manometry data

The effective result of non-pharmacological treatment was observed more often in children with SBP in the range of 40-59 percentiles (RR=2.9; PC=4.6), with a gradual decrease in the positive effect at the SBP level in the range of 60-79 percentiles (RR=1; PC= 1.4) and the absence of an effect at a SBP level within the 80-99 percentiles (RR=0.5; PC= –3.6).

The effective result of non-pharmacological treatment was noted more often in children with a blood pressure index in the range of 40-59 percentiles (RR=2.12; PC=3.4), with a gradual decrease in the positive effect at a SBP level in the range of 60-79 percentiles (RR=2; PC=3.1) and the lack of effect at the SBP level within the 80-99 percentiles (RR=0.5; PC= –3.6), Table 2.

Table 2

WMP effective outcome prediction model

Parameter	Gradation	PC	I	Rank
History of physical activity (over the last month) — physical activity of high intensity, minutes/day	≤120	-3.2	**2.00**	3
	≥240	+6.6		
Abdominal type of obesity according to WC, percentiles	<90	+7.2	**1.00**	5
	≥90	-1.9		
Positive food history is the frequency of weekly consumption of fresh vegetables and fruits	Daily	+4.6	**1.90**	4
	Less than once a week	-6.1		
Negative food history according to the HFSS is the frequency of consumption of high-calorie foods per week	Daily	-5.7	**0.64**	10
	Less than once a week	+4.2		
Average duration of meals, minutes	<10	-4.5	**0.62**	11
	10 - 20	+0.6		
	>20	+6.9		
Time spent watching TV, computer, phone, minutes/day	<180	+5.8	**2.50**	2
	180-360	-3.8		
	>360	-9.7		
Child's age, years	6-9	+2,8	**3.00**	1
	10-13	-1.3		
	14-18	-1.5		
BMI, percentiles	<99	+2.1	**0.80**	8
	≥99	-0.7		
Child's height, percentiles	4-69	+2.8	**0.70**	9
	>70	-3		

Table 2

Sex	Women'	+0.5	**0.50**	13
	Male	-0.5		
SBP in percentiles	40-59	+4.6	**0.60**	12
	60-79	+1.4		
	80-99	-3.6		
DBP in percentiles	40-59	+3.4	**0.90**	7
	60-79	+3.1		
	80-99	-3.6		
FMI in percentiles	<90	+3.2	**0.95**	6
	≥90	-9.3		

The selection of diagnostic thresholds (sums of diagnostic coefficients) that make it possible to predict the appearance of pathology is carried out using errors of the 1st and 2nd type, and in order to achieve a 95% probability of an error-free forecast, they focus on the range∑PC≥13.0 – the presence of an effective WMP result is predicted, or∑PC≤-13.0 – прогнозується відсутність ефективного результату WMP. Accordingly, to achieve a 99% probability of an error-free forecast, focus on the range ∑PC≥20.0 and ∑PC≤-20.0, respectively. If the amount was in the range between the defined diagnostic thresholds, it is concluded that the available information is insufficient to make a decision with a given level of errors.

You can use the developed prediction table according to the above principle of operation, which is considered a classic approach.

To demonstrate the use of the model for predicting metabolically unhealthy obesity, here is a clinical case:

The parents of a girl, Maria K., 6 years and 7 months old, turned to a pediatrician with complaints about the child's excess body weight.

During the subjective examination of the girl Maria K., 6 years and 7 months old, whose parents contacted her about the child's excess body weight against the background of regular swimming training at the «Olympic Reserve School» (seven times a week for more than 240 minutes/day). The viewing time of only educational TV programs under the control of parents is no more than 120 minutes/day. When analyzing the food diary and the FBPQ questionnaire, it was found that the girl daily consumes fresh vegetables and fruits and toast with margarine, the average duration of meals is 22 minutes.During an objective examination of the child, it was found that the body weight is 42.1 kg, height - 1.34 m (95th percentile), BMI = 23.39 (98th percentile, or obesity level 113% over the 95th percentile), WC – 0.61 m (95th percentile), BMI – 19 kg (85th percentile), SBP – 90 mm Hg. Art. (45th percentile), DBP - 60 mm Hg. Art. (50th percentile).

The model for forecasting the effective result for this child is presented in Table 3.

Table 3

A model for forecasting the effective result of the WMP

Parameter	Gradation	PC	Indicators	Score in points
History of physical activity (over the last month) — physical activity of high intensity, minutes/day	≤120	-3.2	240	+6.6
	≥240	+6.6		
Abdominal type of obesity according to WC, percentiles	<90	+7.2	**95**	-1.9
	≥90	-1.9		
Positive food history is the frequency of weekly consumption of fresh vegetables and fruits	Daily	+4.6	**Daily**	+4.6
	Less than once a week	-6.1		

Table 3

Negative food history according to the HFSS is the frequency of consumption of high-calorie foods per week	Daily	-5.7	**Daily**	-5.7
	Less than once a week	+4.2		
Average duration of meals, minutes	<10	-4.5	**22**	+6.9
	10-20	+0.6		
	>20	+6.9		
Time spent watching TV, computer, phone, minutes/ day	<180	+5.8	**120**	+5.8
	180-360	-3.8		
	>360	-9.7		
Child's age, years	6-9	+2,8	**6 years and 7 months**	+2,8
	10-13	-1.3		
	14-18	-1.5		
BMI, percentiles	<99	+2.1	**98**	+2.1
	≥99	-0,7		
Child's height, percentiles	4-69	+2.8	95	-3
	>70	-3		
Sex	Women's	+0.5	**Women's**	+0.5
	Male	-0.5		
SBP in percentiles	40-59	+4.6	**45**	+4.6
	60-79	+1.4		
	80-99	-3.6		
DBP in percentiles	40-59	+3.4	**60**	+3.1
	60-79	+3.1		
	80-99	-3.6		
FMI in percentiles	<90	+3.2	**85**	+3.2
	≥90	-9.3		
Result	ΣPC=29.6 The probability of an effective WMP result is very high			

Having chosen diagnostically significant indicators for the girl Maria K., 6 years and 7 months old (Table 3), we obtained a total diagnostic value of 28.39 points, which corresponds to a very high probability of an effective result of non-drug treatment of obesity.

During further laboratory screening of metabolic disorders, which was prescribed by an endocrinologist, the following clinical and statistical parameters associated with a favorable outcome of treatment were determined for the girl: basal glycemia 4.18 mmol/l (I=0.95; RR=1.2; PC=0.6); basal insulin 12.63 μU/ml (I=0.5; RR=1; PC=0.6); HOMA index 2.35 (I=0.5; RR=3.22; PC=5.1); leptin 6.68 ng/ml (I=0.95; RR=2.06; PC=3.14); adiponectin 14 μg/ml (I=2.25; RR=4.02; PC=6); HDL-C 1.28 mmol/l (30th percentile), I=1.2; RR=1.8; PC=2.6; TG 0.56 mmol/l (60th percentile) with I=0.52; RR=2 and PC=2.91.

The presence of an effective result of non-pharmacological treatment of obesity was confirmed by a decrease in BMI by 5% already after 1 month of follow-up (I=2.6; RR=2.73; PC=4.4) with the transition to the category of children with excess body weight and the absence of metabolic disorders during secondary laboratory screening according to such indicators of metabolically unhealthy obesity as fasting hyperglycemia, insulin resistance, dyslipidemia gave us the opportunity to determine the girl's metabolically healthy obesity (I=2; RR=3.34;

PC=5.9) and obtain an effective result of non-drug treatment after 6 months of observation and the final loss of excess weight body mass of 13% with transition to the category of children with physiological body weight.

The performance indicators of the mathematical forecasting model proposed by us, when used with the involvement of 350 patients, were: negative result prediction test - 88.1%. The share of correct prediction of the patient's actual belonging to one or another group (has an effective prognosis of non-drug treatment or not) was 87.9%, which indicates a high agreement between the real distribution of observations based on the presence of an effective WMP result and the distribution based on the predictive model.

Conclusions

The effectiveness of the outcome of the treatment of children with metabolically healthy obesity at the outpatient stage according to our proposed prediction model is highly related to non-pharmacological methods: 1) physical activity of medium intensity according to the aerobic type (more than 240 minutes/day or 28 MET hours/week) and 2) adherence to the diet. One of the conditions for the high efficiency of non-drug treatment of children is the presence of metabolically healthy obesity. Factors that reduce the effectiveness of treatment are children's daily consumption of excessive amounts of sugar, unsaturated fats, dietary salt and processed food products, which lead to the redistribution of adipose tissue and the development of abdominal obesity. It should be noted that as children grow older, especially during the transition period between childhood and adolescence, the negative contribution of disordered eating patterns increases.

To prevent repeated weight gain in children with a genetic predisposition to obesity without metabolic disorders, only non-pharmacological methods of treatment, such as dosed physical activity and rational nutrition, are recommended. At the same time, it is necessary to consider the expediency of prescribing pharmacotherapy in children with obesity, which is accompanied by metabolic disorders.

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