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Hydrolyzed collagen

Glycine Hydroxyproline

Proline

Hydroxyproline

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Trophological status and quality of life in infants administered probiotic enterococci

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This article presents the results of a study on the effectiveness of oral administration of the probiotic *Enterococcus faecium* L3 on the trophological status of infants and their quality of life. Over 10 weeks during autumn and winter, we observed 26 children aged 2–12 months in a specialized (psychoneurological) children's orphanage. Children were randomly divided into a main group (n=15) and a comparison group (n=11). The groups were similar regarding sex (p=0.62) and trophological status (body weight, Chulitskaya index and body mass index). The average ages of the children in the main and comparison groups were 4.3±0.4 and 6.4±0.18 months, respectively (p=0.02). In addition to their regular food, children in the main group received 5 ml of a liquid probiotic form of *E. faecium* L3 10⁸ CFU/ml twice a day. Indicators of trophological status were assessed every 2 weeks, change in quality of life according to the QUALIN questionnaire at baseline and at study completion, incidence of acute respiratory infections, and completion of planned vaccinations. Children in the main group showed during the first 8 weeks of the study. Children in the main group had fewer acute respiratory infections, improved quality of life and more planned vaccinations.

Introduction

BSTRAC

The trophological status of a person describes their state of health and physical development in relation to the optimal assimilation of nutrients. In the trophological approach, nutritional values are assessed as the consumption of a particular set of essential nutrients together with the complex interaction of nutrients with the digestive system and the body

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as a whole, including metabolic parameters and adaptation reserves. Disturbance of the internal environment of human systems can have negative consequences with a decline in nutrient absorption and an increase in the production of toxic biologically active substances [1].

As children's pathological conditions are often associated with malnutrition, it is very important that malnutrition is diagnosed and treated at an early age [2]. Timely diagnosis, treatment strategy and prognosis are based on the results of dynamic assessment of trophological status [3]. Correction of malnutrition, depending on aetiology, can be achieved by various approaches. Where breastfeeding is not possible, infant formula and food for artificial feeding provide the growing body with essential nutrients [4]. Inclusion of probiotic strains into the infant formula or supplementation of their diets with probiotic bacteria optimizes metabolism and increases resistance to infection due to the actions of probiotics as biocatalysts of many vital processes in the body [5]. Differences in the effectiveness of probiotic agents used to prevent or treat infectious and somatic diseases are determined by the characteristics of the probiotic strains [6, 7]. Numerous investigations have demonstrated the therapeutic

and prophylactic effectiveness of probiotic strain *Enterococcus faecium* L3 in paediatrics [8, 9]. The aim of this study was to investigate the effect of a liquid form of the probiotic *E. faecium* L3 on trophological status and quality of life (QoL) in infants.

Materials and methods

A total of 26 children in the first year of life were observed in St. Petersburg specialized orphanage No. 16 for 10 weeks from November 2014 to February 2015. This orphanage cares for the children of socially disadvantaged parents. During pregnancy, most of the mothers consumed inappropriate drugs, alcohol and nicotine, and had various illnesses including sexually transmitted diseases (including HIV, hepatitis C and syphilis) and in some cases tuberculosis. The physical development indicators of the children at birth were characterized by low values due to the high incidence of prematurity, drug withdrawal syndrome at birth and intrauterine growth retardation. In the first months of life, these children received antibiotic treatment (prophylactic treatment for syphilis), antiretroviral prophylaxis (Viramune, Epivir, Retrovir) and pneumocystis pneumonia prophylaxis (Biseptol). During the first year of life, the physical development of children with intoxication at birth is delayed and they are underweight and stunted [10].

The criteria for enrolment of children in the study were age 2–12 months and absence of chronic diseases, serious congenital malformations and functional insufficiency of organs or systems. The children were randomly divided into two groups. The main group (n=15) included eight boys and seven girls, while the control group (n=11) consisted of seven boys and four girls. The groups did not differ significantly by sex (p=0.62), initial average body weight (p=0.07), Chulit-skaya index (used to determine the trophological status of infants) (p=0.98) or body mass index (BMI) (p=0.66) (Table 1). The mean age (±SD) of children in the main group was 4.3±0.4 months, and 6.4±0.18 months (p=0.02) in the comparison group.

Twice a day, children in the main group received 5 ml of a liquid form of the probiotic *E. faecium* L3 (No. RU. 77.99.26.009.E.002272.02.11) with a titre of bacteria of not less than 10⁸ CFU/ml. The probiotic *E. faecium* L3 was added to the infant formula. Children in the comparison group received the normal diet for their age.

The effectiveness of the addition of *E. faecium* L3 was compared in the two groups of children by assessing: (1) trophological status (evaluated at baseline and every 2 weeks for

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10 weeks): body weight, body length, arm circumference, chest circumference, hip circumference, lower leg circumference, BMI, Chulitskaya index and Erismann index; (2) QUALIN [11], a quality of life questionnaire for paediatricians (assessed at baseline and at study completion); (3) the number of cases of acute respiratory infections (ARIs) during the study (the absolute number and percentage of children affected in each group); and (4) the absolute number and percentage of vaccinated children in each group.

The trophological status of the children was based on assessment of the Chulitskaya index, Erismann index and BMI. The Chulitskaya index is traditionally used by paediatricians to evaluate the nutritional status of children in the first year of life. Normal values are in the range 20–25 with a decrease in the index indicating malnutrition [2]. The Chulitskaya index=3×arm circumference+thigh circumference+tibia circumference–body length (cm). The Erismann index was calculated using the formula: Erismann index=chest circumference–(0.5×length) (cm). BMI was determined using the formula: BMI=weight (kg)/length (m)² [12].

The QUALIN questionnaire for evaluating the quality of the first year of life in children consisted of 33 questions on: (1) behaviour and communication (13 questions); (2) ability to stay alone (5 questions); (3) family surroundings (4 questions); and (4) neuropsychological development and physical health (11 questions). Each question included six possible answers: 'Definitely not' (1 point), 'Rather no than yes' (2 points), 'Yes and no' (3 points), 'More likely than not' (4 points), 'Definitely yes' (5 points) and 'I do not know' (0 points). The average of each of these four indicators of QoL and the average value of the sum of all 33 questions (average value) were calculated. We counted the total number of points for each child and the average number of points in both groups. QUALIN also provides an 'overall assessment' of the child's QoL by assigning numbers in the range from 1 ('very bad') to 10 ('excellent'). The results of the estimations were converted to a 0-5 scale where 1 and 2 corresponded to 1 point, 3 and 4 to 2 points, 5 and 6 to 3 points, 7 and 8 to 4 points, and 9 and 10 to 5 points. The result was called the 'approximate overall assessment' and the average value was determined in both groups of children. We analysed seven QoL indicators in total.

The results were subjected to statistical analysis using Student's t-test and Pearson's χ^2 test. Differences between the results obtained in the groups under study were considered significant at *p*<0.05.

Results

Comparison of the main indicators of trophological status (weight and body length) revealed a marked increase in the weight of children throughout the study and the absence of significant differences between the groups (Table 1). The body length of the children also increased. The baseline body length in the comparison group was higher than in the main group, but this difference later disappeared, indicating accelerated growth in children in the main group. The increase in the average body length of the comparison group early in the study was slower than in the main group of children (Table 1). Erismann index values were significantly higher in children in the main group at baseline, 2 weeks and 8 weeks (Table 1). There were no significant differences in BMI or the Chulitskaya index between the groups during the study. Chulitskaya index values were below normal throughout the study, reflecting the difficulties treating malnutrition in these patients.

Average growth values were compared throughout the study. There was a reduction in BMI gain in the main group compared to the comparison group. This difference was significant at 2 weeks (-0.15 ± 0.51 kg/m²; 0.25 ± 0.38 kg/m²; t=2.13; p=0.04) but not significant at 4 weeks (-0.19 ± 0.59

Trophological status criteria	Comparison group (n=11)	Main group (n=15)	Student's t	p Value				
Baseline data								
Body mass (g)	6340±1402	5386±1168	1.89	0.07				
Length (cm)	62.2±4.7	56.8±5.1	2.78	0.01				
Body mass index (kg/m ²)	16.2±1.9	16.5±1.6	-0.44	0.66				
Chulickaya index (cm)	15.5±5.6	15.4±4.2	0.03	0.98				
Erismann index (cm)	10.2±1.5	12.2±2.1	-2.66	0.02				
At 2 weeks								
Body mass (g)	6563±1387	5635±1170	1.85	0.08				
Length (cm)	62.9±4.5	58.4±4.9	2.38	0.03				
Body mass index (kg/m ²)	16.4±1.9	16.3±1.6	0.13	0.89				
Chulickaya index (cm)	16.0±5.7 16.3± 4.6		-0.15	0.88				
Erismann index (cm)	10.2±1.5	12.0±1.7	-2.82	0.01				
At 4 weeks								
Body mass (g)	6717±1321	5874±1188	1.71	0.10				
Length (cm)	63.4±4.4	60.0±4.8	1.85	0.08				
Body mass index (kg/m ²)	16.6±1.8	16.2±1.6	0.64	0.53				
Chulickaya index (cm)	16.3±5.9	16.6±4.4	-0.16	0.87				
Erismann index (cm)	10.6±1.5	11.7±1.6	-1.64	0.11				
	At 6 weeks							
Body mass (g)	6871±1264	6094±1021	1.73	0.10				
Length (cm)	64.2±4.4	61.2±3.8	1.83	0.08				
Body mass index (kg/m ²)	16.6±1.6	16.1±1.4	0.75	0.46				
Chulickaya index (cm)	17.1±6.4	17.8±3.9	-0.35	0.73				
Erismann index (cm)	10.8±1.7	11.8±1.3	-1.67	0.11				
	At 8 weeks		1					
Body mass (g)	7072±1192	6349±1026	1.66	0.11				
Length (cm)	65.0±4.0	62.2±3.8	1.79	0.09				
Body mass index (kg/m ²)	16.6±1.4	16.3±1.4	0.59	0.56				
Chulickaya index (cm)	17.1±6.1	19.3±3.3	-1.21	0.24				
Erismann index (cm)	10.6±1.6	12.0±1.5	-2.26	0.03				
At 10 weeks								
Body mass (g)	7246±1223	6485±1055	1.70	0.10				
Length (cm)	66.0±4.0	63.3±4.0	1.75	0.09				
Body mass index (kg/m ²)	16.5±1.5	16.1±1.2	0.77	0.45				
Chulickaya index (cm)	18.2±6.5	19.7±3.1	-0.80	0.43				
Erismann index (cm)	11.0±1.5	11.9±1.7	-1.41	0.17				
Significant <i>p</i> values are shown in bold								

 Table 1 - Average trophological status data (mean±SD) in two groups of children in the first year of
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kg/m²; 0.13 ± 0.48 kg/m²; t=1.48; p=0.15), reflecting an overall increase in body length in the main group. Changes in the average increase in the Erismann index in children in the main group compared to the comparison group were characterized by their low values at 4 weeks (-0.33±1.09 cm; 0.46±0.69 cm; t=-2.11; p=0.05) and high values at weeks (0.23±0.46 cm; 8 -0.18±0.40; t=2.40; p=0.03). This indicated greater improvement in the nutritional status of children in the main group than in the comparison group. Changes in the Chulitskaya index indicated accelerated elimination of malnutrition in children in the main group as values from 2 to 8 weeks were higher in the main group than in the comparison group (Fig. 1). The average Chulitskaya index values in the main group significantly increased between the 6th and 8th weeks (1.53±1.77 cm) compared to no increase in the comparison group in the same age group (0.00±1.00 cm; t=2.58; p=0.02). The faster increase in the main group was the result of significantly higher increases in tibia cir-



Figure 1 - Chulitskaya index in children of the main and comparison groups. The observation time points are shown on the x axis and index values on the y axis



Figure 2 - Lower leg circumterence values in children in the main and comparison groups. The observation time points are shown on the x axis and circumference values (cm) on the y axis



axis and the thigh circumference values (cm) on the y axis

cumference (Fig. 2) at 4 weeks (0.40 ± 0.47 cm; 0.0 ± 0.0 cm; t=2.8; p=0.01) and 6 weeks (0.61 ± 0.42 cm; 0.23 ± 0.26 cm; t=2.67; p=0.01) and in thigh circumference (Fig. 3) at 2 weeks (0.80 ± 0.62 cm; 0.18 ± 0.25 cm; t=3.11; p=0.005), 6 weeks (0.87 ± 0.69 cm; 0.20 ± 0.33 cm; t=2.94; p=0.007) and 8 weeks (1.07 ± 0.62 cm; 0.18 ± 0.25 cm; t=4.43; p<0.0001). Similar changes were observed in chest and arm circumference values, with a higher gain seen in the main group than in the comparison group. Thus, addition of the probiotic strain *E. faecium* L3 to the diet of infants helped to improve their trophological status.

Analysis of QoL showed significantly higher values (mean±SD) for neuropsychological development and physical health (3.93±0.22; 3.41±0.50; t=3.18; p=0.04) and approximate overall assessment in the comparison group $(3.64\pm0.81; 2.60\pm0.51; t=4.02; p=0.001)$ at the beginning of the study (Table 2). After 10 weeks of observation, the values of five of the seven parameters under study were higher in the comparison group than in the main group (Table 2). However, in the comparison group at 10 weeks, only neuropsychological development and physical health demonstrated significantly higher values as compared to baseline $(3.93\pm0.22; 4.17\pm0.19; t=3.95; p=0.003)$. In the main group, significant increases were seen in the ability to stay alone (2.58±0.86; 3.28±0.78; t=3.40; p=0.004), neuropsychological development and physical health (3.41±0.50; 3.84 \pm 0.38; t=3.08; p=0.008) and approximate overall assessment (2.60±0.51; 4.00±0.00; t=10.70; p<0.001). These data demonstrated significantly better QoL indicators in children of the main group.

During the autumn–winter period, six (66.7%) cases of ARI were observed in the comparison group and only three in the main group (33.3%; p>0.05). Five (45.5%) children in the comparison group and two (13.3%) in the main group had ARIs (p>0.05). Thus, there was a lower incidence of ARI in the main group than in the comparison group.

Routine vaccination also indicated the general health of the children. Seven children (63.6%) in the control group and 11 (73.3%; p>0.05) in the main group were vaccinated during the observation period. Four (36.4%) children in the comparison group and eight (53.3%; p>0.05) in the main group received two or more vaccinations at the same time, indicating that probiotic *E. faecium* L3 improved health indicators in the main group, thus allowing more vaccinations.

Discussion

This work was a continuation of a study on the positive impact of 3-month administration of a liquid form of the probiotic *E. faecium* L3 on the health of infants [13].

The results of the present study confirm the beneficial effects of the administration of the probiotic *E. faecium* L3 on the trophological status of children during the autumn–winter period as a marked acceleration in growth and improvement in nutritional status was seen in the children in the main group (Chulitskaya index and Erismann index).

Quality of life parameters	Compared parameters	Comparison group (n=11)	Main group (n=15)	Student's t	<i>p</i> Value	
Behaviour and communication	Baseline	3.99±0.51	3.78±0.74	0.82	0.42	
	At 10 weeks	4.29±0.21	3.85±0.57	2.40	0.02	
Ability to stay alone	Baseline	3.60±0.59	3.21±0.70	1.49	0.15	
	At 10 weeks	3.62±0.57	3.04±0.70	2.25	0.03	
Family surroundings	Baseline	3.20±0.74	2.58±0.86	1.93	0.07	
	At 10 weeks	3.55±0.51	3.28±0.78	0.97	0.34	
Neuropsychological deve- lopment and physical health	Baseline	3.93±0.22	3.41±0.50	3.18	0.004	
	At 10 weeks	4.17±0.19	3.84±0.38	2.64	0.01	
Approximate overall assessment	Baseline	3.64±0.81	2.60±0.51	4.02	0.001	
	At 10 weeks	4.00±0.00	4.00±0.00	0.0	1.0	
Number of points	Baseline	125.9±9.2	113.1±19.3	2.04	0.053	
	At 10 weeks	133.9±7.9	120.7±15.4	2.60	0.02	
Average value	Baseline	3.82±0.28	3.43±0.59	2.04	0.053	
	At 10 weeks	4.06±0.24	3.66±0.47	2.61	0.02	
Significant <i>p</i> values are shown in bold						

Table 2 - Quality of life (mean±SD) parameters assessed using the Qualin questionnaire in children in their first year of life

The intestinal microbiota responds dynamically to changes in the external environment, including food and weather conditions. Probiotic bacteria can produce hormones, growth factor analogues and neurotransmitters that affect metabolism [14]. The data obtained suggest that the qualitative and quantitative composition of the intestinal microbiota was improved in children of the main group receiving the probiotic. Although the initially higher QoL indicators in the comparison group were possibly explained by the difference in the age of the children in the two groups, during 10 weeks of observation only one of the seven QoL parameters studied in the comparison group improved compared to three of the seven parameters in the main group. Thus, the improved trophological status of the children in the first year of life in the main group indicates the prophylactic value of probiotic of *E. faecium* L3. We also noted a lower incidence of ARIs, increased routine immunization and a marked increase in QoL.

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