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The Efficacy of Egg White Powder on Anthropometric Indices in Malnourished Children

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ABSTRACT

Background: White egg powder provides essential amino acids compounds. This study aims to investigate the theory that a regular consumption of white egg powder would improve weight gain and appetite in children with malnutrition. **Methods**: The present experimental study was conducted among children aged 3-6 years with mild to severe malnutrition referred to Ghadir Mother and Child Hospital affiliated with Shiraz University of Medical Sciences from April to October 2017. The malnourished children received egg white protein (1 g/kg of their current body weight) for 3 weeks. Weight loss as a primary outcome and weight-for-height Z-score (WHZ), height-for-age Z-score (HAZ), weight-for-age Z-score (WAZ), and BMI-for-age Z-score (BAZ) were measured as secondary outcomes, assessed at baseline and after six weeks of study. **Results:** Of the 23 children included, 20 finished the study. Weight increased in all children although it was not significant (P = 0.101). A lower appetite was seen at the end of the intervention, but it was not significant (P = 0.575). Malnutrition based on WHZ and BAZ decreased compared to the baseline measurement, while the changes were not significant. Regarding other markers, no statistically significant changes were found compared to the baseline measurement. **Conclusion**: The addition of white egg powder to complementary nutrition could not improve weight gain and appetite in malnourished children. Further research with a larger study population and longer intervention time is needed to demonstrate the clear effect of egg white on improving malnutrition in children.

Keywords: *White egg powder, Malnutrition, Children, Weight gain*

Introduction

Malnutrition is a condition in which the body does not receive enough nutrients, leading to acute or chronic deficiencies in protein, other nutrients, and energy in children that can cause half of the deaths among them (Kemenkes, 2011). Malnutrition can lead to cognitive impairment and growth retardation and is also related to a higher vulnerability to different types of morbidity and

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mortality in children (Black *et al.*, 2008). The prevalence of malnutrition in developing countries is due to economic and social problems, which increase the risk factor of physical complications and mortalities in children (Fenton and Silverman, 2004). About 26.9 million children have severe malnutrition in southern Asia (Unicef *et al.*, 2012). According to recent studies, 6 percent of the under-five children in Iran are underweight (Kia *et al.*, 2017). Imbalance between nutrient consumption and metabolic requirements causes symptoms of malnutrition, which, as a consequence, leads to a variety of clinical illnesses (Norman *et al.*, 2008). Adequate and balanced nutrition plays a key role in children's physical and mental growth (World Health Organization, 2006). Research has mainly employed supplements, but inadequate evidence exists for nutrients. Eggs may improve the immune systems of malnourished children (Iannotti *et al.*, 2014). Eggs are rich in choline, betaine, and vitamin B12, and provide all the essential amino acids for a baby's growth (Iannotti *et al.*, 2014). Adequate and high-quality protein in the diet is essential for building and preventing muscle atrophy and also provides adequate energy supply and growth (Leidy *et al.*, 2007). In a malnourished child, branched-chain amino acids affect compensatory growth, protein synthesis, and weight gain (Hsu *et al.*, 2014).

A study showed that the frequency of supplements increased nutrition and weight gain in the intervention group compared to the control group (Roy *et al.*, 2007). In addition, in a clinical trial study, egg consumption in malnourished children resulted in a 9-fold weight gain compared to the control group (Setyaningsih, 2016). The Lulun project aimed to determine the effectiveness of eggs on biomarkers of early childhood nutrition and growth. The results of this study showed that eggs reduced short stature and increased linear growth with a length z score for age (Iannotti *et al.*, 2017) . Egg whites improve children's growth, but there are no comprehensive and appropriate studies in this field. Therefore, given the importance of children's development and the importance of time in the treatment of their malnutrition, this clinical experimental study aimed to assess the efficacy of egg white powder as a supplementary food on the anthropometric status of children with mild to moderate malnutrition.

Materials and Methods

Study design and participants: This 6-week experimental study was conducted on children with mild to severe malnutrition at Ghadir Mother and Child Hospital, affiliated with Shiraz University of Medical Sciences from April to October 2017. The children referred to a pediatrician due to their short stature and low weight and after the doctor's diagnosis, those without underlying disorders were included in the study. Children aged 3-6 years with mild to severe malnutrition and a history of using growth drugs or supplements during the study met eligible criteria. The exclusion criteria included patients who were sick, dying, taking any kind of medicine or supplement, and did not consume egg white protein powder based on the required amount. A sample size of 20 participants was designed based on weight: X1: 6.4, X2: 7.2, SD1: 0.9, and an alpha error probability of 0.05, power = 0.80, according to a similar study (Setyaningsih, 2016). In this experimental study, 23 children were selected from the group as the final sample size. Dietary adherence was measured through subjective methods (self-reported adherence rate, which ranged from 70% to 90%).

Based on the evidence, the Dietary Reference Intakes for protein indicate that children aged 1–3 years and 4–8 years require 1.1 and 0.95 g/kg/day, respectively, based on the classic nitrogen balance technique (Paula *et al.*, 2002). Therefore, the authors believed that the amount of egg white protein required by each child was calculated based on their current weight (1 g/kg of body weight), and parents were given a packet of egg white protein powder (300 g) for three weeks. Parents were asked to add two or three servings of egg white protein powder to yogurt, stews, soups, or other watery foods daily (they were not too hot), and they were asked not to let the children notice.

In addition, the parents were counseled by the dietitian, and they were then trained in

healthy balanced diets and different techniques of decorating baby food to stimulate appetite, as well as a booklet. A daily registration form was given to the parents to record the amount of protein white egg powder consumed by their children, and they were asked to complete it daily for a more accurate assessment of supplement consumption. The package was given to the parents at the beginning of the study and again in the third week. Parents were asked to give back the empty package in the follow-up meetings (at weeks 3 and 6 of the intervention).

Furthermore, researcher reminded the participants to consume egg powder once a week. Their parents were requested not to change the common powder consumption of their children through the experimental study.

Measurements: The weight and height of the participants were evaluated from the beginning to the end of the study based on standard methods (de Onis *et al.*, 2004). Height was measured by a standard tape measure, barefoot, with the child close to the wall and looking straight ahead, with an error of about one-tenth of a centimeter (Seca 220, Hamburg, Germany). Weight was measured using Seca hand scales, with a minimum wear and error of nearly 100 grams (Seca 755, Hamburg, Germany).

The Z-score was used to determine the difference between normal status and malnutrition in children, which was calculated by diagram. Also, demographic questions (name, surname, age, current height, and weight, history of illness or medications taken, and appetite status) were asked from the beginning of the study.

Ethical considerations: The study was conducted in accordance with the Declaration of Helsinki and Good Clinical Practice guidelines and was accepted by the Ethics Committee of Shiraz University of Medical Sciences (IR.SUMS.REC.1396.162). This clinical experimental study was registered in the Iranian Registry of Controlled Experimental Studies (IRCT) (IRCT20100223003408N9). Consent form was obtained from the children's parents.

Data analysis: The data were analyzed using the SPSS statistical software. The normal distribution of the data was checked by the Kolmogorov-Smirnov test. A paired t-test was used to assess changes in each group and compare them within groups. ANOVA was performed to assess differences in total weight between the growth indicators. The association between weight and growth indicators was analyzed using linear regression model. The significance level was set at P-value≤0.05. The categorical variable was described by frequencies and percentages.

Results

Of the 25 children evaluated for eligibility, 2 children were not eligible to enter the study and 3 left the study (**Figure 1**). Except for one case of nausea after taking the powder on the first day, no side effects or problems were reported due to taking the powder. Baseline demographic and clinical parameters are shown in **Table 1**.

Table 1. General children's characteristics at baseline.

Variables	
Gender	
Male	14(61.0)
Female	9(39.0)
Mother's education	
High school	2(8.7)
Associate degree	17(73.9)
Bachelor's degree	3(13.0)
Master's degree	1(4.3)
Place of residence	
Urban	20(87.0)
Rural	3(13.0)
Constipation	5(21.7)
Vomiting	1(4.3)
Anemia	14(60.9)
Low appetite	17(79.3)
Duration of breast feeding (month)	16.26±9.49
Birth weight (kg)	3.03±0.86
Height (cm)	99.40±7.74
Age(month)	48.78±10.56

Values are presented as mean ± SD or n (%).

The prevalence of anemia and anorexia was high in participants at the beginning of the study (**Table 1**). Changes in clinical outcomes during the treatment phase of this study are demonstrated in **Table 2**. The increment in WHZ and BAZ levels in

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participants could have some clinical values. It might be indicative of practical effects of white egg powder in patients although these changes were not significant during the study (*P*=0.168 and *P*=0.089, respectively). Appetite levels decreased during the study, but it was not significant. There were no significant differences in HAZ and other parameters at the beginning and end of the intervention (**Table 2**).

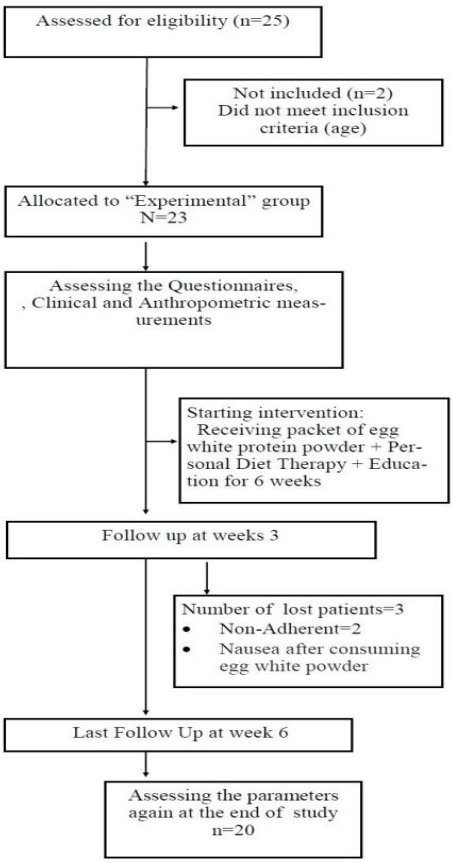

Figure 1. Flow diagram of the experimental study.

Table 2. Changes in growth indicators after 6-week supplementation with white egg powder.

Parameters	Before	After	Changes (CI)	P-value[a]
Weight (kg)	15.18±2.43[b]	15.27±2.45	0.086±0.24 (-0.18 to 0.19)	0.10
WHZ	-0.32±0.72	-0.26±0.72	0.062±0.19 (-0.28 to 0.15)	0.16
HAZ	-0.62±1.04	-0.62±1.04	0	1
WAZ	-0.54±0.63	-0.53±0.67	0.013±0.13 (-0.40 to 0.70)	0.61
BAZ	-0.27±0.76	-0.19±0.75	0.08±0.2 (-0.01 to 0.17)	0.08
Appetite score	0.74±0.44	0.65±0.48	-0.087±0.73 (-0.40 to 0.23)	0.57

BMI: Body mass index (kg/m2); BAZ: Body mass index z score; HAZ: Height-for-age z score; WAZ: Weight-for-age z score; WHZ: Weight-for-height z score; CI: Confidence interval; [a]: Paired t-test; [b]: Mean± SD

Discussion

The data indicated that supplementation with the weighted egg powder improves growth indicators, including weight, but no statistically significant difference was found during the study.

Children with malnutrition need to improve their health. They need protein, fat, minerals, and vitamins (Hossain *et al.*, 2020). In a study in this

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field, complete milk protein supplementation in school-age children was reported to significantly increase weight and height compared to control group who followed a routine school diet without receiving extra protein from milk (Lampl *et al.*, 1978). A meta-analysis study by Laura Pimpin *et al.* showed that animal protein generally causes weight gain in children (Pimpin *et al.*, 2019). The WHO has considered animal protein as a complementary food in the management of malnutrition in children and states that animal food improves the condition of children by providing amino acids and other nutrient needs (Skau *et al.*, 2015). Consistent with the present study, protein supplements during pregnancy had no benefit in improving malnutrition status or birth outcomes (Tang and Krebs, 2014). Therefore, significant changes may be observed compared to the present results if higher doses of egg white powder were consumed by children with malnutrition for a longer period of time. This increase in weight can have clinical values. It may indicate the effects of egg white consumption on malnourished children. No significant increase in the WHZ of participants was observed after the intervention. Lulun project had a significant effect on increasing weight-for-age z score by 0.61 (95% CI, 0.45–0.77) (Iannotti *et al.*, 2017) . However, we did not observe any significant change in the WHZ after the intervention which could be the due to the short duration of this study

Also, in children with malnutrition, a slight improvement in the mean z-scores for the two anthropometric indices, including BAZ, was observed after consumption of egg white powder compared to the beginning of the study, but these changes were not significant. In Lulun project, BAZ also increased significantly in the treatment group compared to the control group after consuming eggs in children for 6 months (Iannotti *et al.*, 2017) . This difference is probably due to the larger sample size compared to the present study. An observational study in India reported a significant direct association between low egg consumption and stunted growth in children (Aguayo *et al.*, 2016).

It was hypothesized that eggs, as a high-quality food, would be effective in the compensatory development of malnourished children. Eggs contain a lot of choline, a substance that has been shown to increase growth in animal models (Zeisel and Da Costa, 2009).

The effectiveness of animal-source proteins on children's growth has been confirmed (Eaton *et al.*, 2019, Kaimila *et al.*, 2019). Branched-chain amino acids are essential for the growth of children (Nuss and Tanumihardjo, 2011, Pillai and Kurpad, 2012). Observational studies have revealed that consuming fewer eggs resulted in malnutrition in children (Aguayo *et al.*, 2016). Eggs are rich in amino acids and other nutrients that are effective in child growth (Zeisel and Da Costa, 2009). Therefore, high-quality diets like eggs could provide calories and protein and also improve appetite in young children. Consistent with the present study, in a study in rural Malawi, growth was not improved by consuming one egg per day (Iannotti *et al.*, 2017).

The lack of change in anthropometric indicators in the current study could be due to the short duration of intervention and also different health and socioeconomic conditions. Increasing height was found to be related to income status (McGovern *et al.*, 2017). In low-income environments, getting the essential amino acids is not enough (Kampman-van de Hoek *et al.*, 2016). Like many low- and middle-income countries in the world, Iran is one of the countries in short supply (Kia *et al.*, 2017). The critical lack of living facilities, poverty, and unfavorable food for kids might be the reasons why there is malnutrition in children in Iran (Sharifzadeh *et al.*, 2010). Eggs are a complete, accessible and safe food in poor populations compared to fortified complementary food (Iannotti *et al.*, 2014).

The present study closely monitored allergic reactions to eggs during the study and unfortunately one participant was excluded from the study due to allergies. Egg allergy is one of the most common immunoglobulin-mediated food allergies in children although few studies have been conducted in impoverished populations

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(Boye, 2012). According to the American Academy of Sciences, supplemental feeding with eggs is considered without the risk of increasing the incidence of allergies (Greer *et al.*, 2008).

In this study, the effect of egg white powder on weight gain and other anthropometric indices in malnourished children was tested for the first time. This experimental study has some limitations. The possibility of no intervention for malnourished children is not scientifically and morally acceptable. This study was designed and conducted without a control group. It would be preferable to look for other inflammatory agents. Feeding was indirectly checked by telephone, so there was uncertainty about the amount of white egg powder consumed by the studied children. With significant protein and micronutrients found in egg whites, it was expected that the white egg powder would improve growth and appetite in children with malnutrition. Studies with longer intervention time appear to be more effective. Another limitation of the study is the low sample size and short duration. Six weeks is too short to observe the changes in primary and secondary outcomes, especially in terms of anthropometric indicators. It is suggested that egg powder with desirable flavors with better reception by children be evaluated in future studies. It was also better to use appetite tests to accurately assess children's appetite.

Conclusions

This experimental study showed that 1 g/kg white egg powder per day in 3-6-year-old children with malnutrition for 6 weeks can affect the WHZ and BAZ parameters to some extent, but these changes were not significant. Egg allergy was also observed in one participant. Further studies with larger sample sizes and lengths of studies are needed to evaluate the effectiveness of egg whites in the development of malnourished children. Since malnutrition is a multifaceted condition, it will definitely necessitate complicated involvement to improve it.

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Conflict of interest

None

Authors' contributions

Research idea and study design: Ekramzadeh M, Ahmadi A, Dehzad MJ, Dehghani MR; data acquisition: Dehzad MJ, Dehghani MR; data analysis/interpretation: Hamidianshirazi M, Ekramzadeh M, Nouri M; statistical analysis: Hamidianshirazi M, Ahmadi A, Nouri M; supervision or mentorship: Ekramzadeh M, AH. Each author contributed to the important intellectual content during manuscript drafting or revision.

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