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EFFECT OF YOGA PRACTICES ON MICRONUTRIENT ABSORPTION AND PHYSICAL FITNESS IN RURAL RESIDENTIAL SCHOOL CHILDREN: A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT
Micronutrients are extremely important in preschool and adolescent children due to the rapid physical and mental growth. Impaired absorption of micronutrients may lead to poor physical and mental health. Therefore, this study was conducted to examine the effect of yoga practices on selected micronutrient absorption and physical fitness variables among rural residential school children. Eighty two male students, aged 11-15 years, were randomly divided into experimental (n = 41) and control (n = 41) groups. Micronutrient status and physical fitness variables were evaluated at the baseline and at the end of 12 weeks of yoga training in both groups. During the experimental study, all the students continued with their normal vegetarian diet available at the hostel mess and no external nutritional supplements were provided. Data were analysed using paired 't' tests and independent 't' test. Micronutrients and physical fitness were measured at the beginning and at the end of 12 weeks. The results of comparisons between groups revealed significant improvement in Cu and Mg ($p < 0.001$; $p < 0.01$) in yoga group as compared to control group. There was no significant change in Hb, Zn, Fe and physical fitness variables ($p > 0.05$). However, results of within group showed no significant increase in Mg, Fe, and Cu ($p < 0.001$) as well as haemoglobin and Zinc ($p > 0.05$) in yoga group, whereas control group showed significant increase in Cu ($p < 0.001$) and no statistically significant change was observed in Haemoglobin and Zn ($p > 0.05$). The significant increase in flexibility, grip strength and abdominal strength was evident after yoga practice ($p < 0.001$). Micronutrient absorption and physical fitness can be improved after 12 weeks of yoga training in adolescent rural residential school children.
Keywords: Micronutrient absorption, Yoga, Physical fitness, School children.

INTRODUCTION

Micronutrient deficiency is a contributing factor in many child deaths in India.[1] Micronutrient deficiency is often ignored as it does not lead to child deaths directly, and is, therefore, often referred to as "hidden hunger".[2] Micronutrient deficiency leads to impaired physical and mental health, primarily in children.[3,4] Nutritional status is extremely important during crucial periods of development i.e. early infancy (0-6 months) and late infancy/early childhood (6-24 months) and teenage years (12-18 years).[5] However, in the recent past, the problem of micronutrient deficiency has received a special attention.[6] Micronutrients are extremely important in preschool and adolescent children due to the rapid physical and mental growth during this period.[7,8] Deficiency of micronutrients such as Iron,[9] Zinc,[10,11] Iodine,[12] Copper,[12,13] Magnesium[14] and Vitamin A[12] leads to mental[15] and physical growth retardation in children of all ages.[16] Earlier research findings suggest that micronutrient deficiency occur due to low socioeconomic status,[17-19] poverty,[20,21] lack of maternal warmth, poor maternal education[22] and low Intelligence Quotient, increasingly absent fathers, low birth weight (< 2.5 kg), and early weaning,[23,24] worm infection,[25,26] and food insecurity.[27] Therefore, Indian government has started mid-day meal programs in primary schools to provide nutritious food to growing children.[28-30] In fact, mid-day meal program for primary school children in India showed positive,[31] but only limited beneficial effect on nutrition, enrolment, attendance, and scholastic performance.[28,29] Malnutrition in childhood might have long-term ill effects on health as the immune system is immature at birth.[32] According to Lozoff *et al*., even if anaemia is treated with iron supplements, the child's mental health is irreversibly affected.[23,24] The United Nations Administrative Committee on Nutrition recommends that the dietary sources alone cannot provide 100 % recommended dietary allowance of micronutrients. Thus, nutritional supplements are extremely essential for proper physical and mental growth of children. However, nutritional supplements alone might not be helpful but the extent of absorption is also important in improving overall health.[33] During the past years, health initiatives such as Mid-day meal, micronutrient supplementation[34,35] and de-worming programs[36] were given high priority by the government, but still the improvement in the physical and mental health of children was found inadequate.[28,29] There is a possibility that problem lies in mal-absorption of nutrients from the supplements or diets provided to the underprivileged young, as well as, adolescent children. Absorption of nutrients is affected by several factors such as worm infections, prolonged illnesses, medication, unhygienic surroundings, lack of exercise, and ignorance. If these fundamental factors are taken into account, possibly the problem of malnutrition can be minimized to a greater extent. In this context, Indian traditional practices like Yoga might help in improving the digestive system and hence absorption of nutrients. The Sanskrit

term Yoga means "the union or yoke meaning thereby a complete integration of mind-body-intellect complex. Patanjali defines yoga as the 'canalization and transcendence of the modifications of mind'. Yoga has multiple physical, mental and spiritual benefits. Hatha Yoga holds that the mind and the body have mutually interdependent effects.[37] There are scientific evidence that yoga improves physical[38, 39] and mental health[40] in children, as well as, adults. However, there are scant scientific evidences that yoga improves absorption of micronutrients, especially in children. Therefore, it would be worthwhile to study the effect of yoga practices in micronutrient absorption. Therefore, this study was carried out in rural residential school children for investigating the effect of yoga on micronutrient absorption and selected physical fitness variables.

MATERIALS AND METHODS

Subjects

Eighty two school children, aged 11 to 15 years (13.02 ± 1.24) studying in 5th to 9th grade at a rural residential school, participated in this study. All the students were from different rural areas of Maharashtra. They were chosen as subjects because their dietary intakes were uniform and well regulated. Food was prepared in the hostel kitchen and was common for both the groups i.e. experimental and control group. After approval of experimental procedures by the Institutional Ethical Committee, informed consent was obtained from the guardian of the students. Oral consent of the children was taken concerning the procedure and benefits of the study, at the outset. Medical examination was conducted by medical doctors appointed by Kaivalyadhama Yoga Institute, Lonavla, to assess general health conditions of the participating students, prior to the start of yoga training. There were 41 students in each group at the baseline testing. However, at the end of 12 weeks, there were 37 students in experimental group and 34 students in control group because of 11 drop-outs. Drop-outs were due to various reasons, mainly disinterest, academic pressure, illness and absence during either pretesting or post testing. All the students who participated in the research study were in apparent good health. Girls were excluded from the study because in initial adolescent years, they may be going through hormonal changes leading to menarche.[41] Also, puberty increases the risk of being anaemic in girls, therefore data is required to be reported separately.[42] Figure 1 provides a flow diagram of enrolment and attrition. The Institutional Ethical Clearance number is: kdham/SRD/IEC-05/2010.

Research Design

Quasi experimental pre post design was used for conducting this research study. The purposive sample was randomly assigned into experimental group (n = 41 boys) and control (n = 41 boys) group by Chit method for random selection. Both experimental and control group were assessed on the first day and after 12 weeks of the interventions. The subjects of experimental group then underwent a training of yoga practices, under the supervision of a yoga expert, for one hour in the morning, excluding Saturdays, Sundays and holidays for a total period of 12 weeks. The control group did not undergo any yoga training during this period. However, both the groups continued to participate in their regular extracurricular activities during school hours.

Biochemical testing

Four micronutrients i.e. Fe (Iron), Zn (Zinc), Mg (Magnesium), and Cu (Copper) were measured at the baseline and at the end of 12 weeks. Serum Fe, Zn, Mg, and Cu were measured by using Minias Globe Diagnostic SRL (Italy) diagnostic kit on Statfax-2000 analyzer (Awareness technology, USA). For the estimation of haemoglobin, blood was collected in EDTA vaccutainer. Cyanmethemoglobin method was followed for the assessment of haemoglobin concentration.[43] Blood samples were collected in the hostel premises hall provided by the school authorities. Non-fasting blood samples were collected from median incubital vein by venipuncture using 5 ml sterile disposable syringe and needle. Blood was allowed to clot at room temperature for 30 minutes. After that Serum samples were separated from the collected blood by using vaccutainer blood collection tubes (Becton Dickinson) with the centrifugation at 1000 g for 10 minutes.

Physical fitness tests

Anthropometric measurements

Height and weight were measured at the baseline and at the end of 12 weeks using standardized scales. Height was measured using a measuring tape (height to the nearest 1 mm) and weight was measured using a digital weighing machine TANITA (HD 318) (weight to the nearest 0.1 kg). BMI was calculated as weight (kg) divided by the square of height (m^2). Students were barefooted and wore school uniform during the measurements. Physical fitness variables i.e. flexibility, grip strength, and abdominal strength were measured using Cureton's Sit and Reach scale,[44] Hand Grip Dynamometer (Anand Agencies, Pune, India)[45] and sit-ups respectively. Grip strength was tested in 6 trials, 3 for each hand alternately with 10 seconds gap between two trials. Subjects were asked to keep their arms straight at the shoulder level, horizontal to the ground. Average value was taken as the final value for further analysis. Similarly, 3 trials were taken during flexibility tests and average value was calculated for further statistical analysis.

Intervention

Yoga module was prepared by a senior Yoga expert from Kaivalyadhama Yoga Institute, Lonavla, Pune, Maharashtra, India. Each Yoga session was conducted for 45 minutes, 5 days a week, for 12 weeks in the school premises. Each Yoga session was started with Om chanting and a prayer, and was concluded with Shanti Path. The experimental group practiced Yoga asanas (postures) and Pranayama (breathing techniques). Each asana pose was held for 15-30 sec initially, and for 1 minute in the later stages. Duration of Pranayama was 2-3 minutes initially and was gradually increased to 5 minutes. The supine position asanas included Ardh-halasana (half plough pose), Ekpaduttanpadasana (Single leg raise pose), Uttanpadasana (leg raise pose),

Ardhapavanmuktasana (half wind release pose), Pavanmuktasana (wind release pose), Naukasana (boat pose), Viparitakarani (inverted pose), Matsyasana (fish pose), Setubandhasana (bridge pose) and Shavasana (dead pose). The prone position asanas include Bhujangasana (cobra pose), Sarpasana (snake pose), Ardhashalabhasana (half locust pose), Shalabhasana (locust pose), Dhanurasana (bow pose) and Makarasana (crocodile pose). The sitting position asanas included Vakrasana (twisted pose), Ardhamatsyendrasana, Gomukhasana (cow face pose), Paschimatanasana (posterior stretching pose), Ardhaushtrasana (half camel pose), Ushtrasana (camel pose), Mayurasana (peacock pose), Vajrasana (pelvic pose), Padmasana (lotus pose), Yog mudra (yoga pose) and Brahma mudra (Brahma pose). The standing position asanas were Tadasana (mountain pose), Chakrasana (wheel pose), Trikonasana (triangle pose), Vrikshasana (tree pose), and Utkatasana (chair pose). The pranayama practices for this experiment were Anulomvilom, Ujjayi, and Bhramari.[46] Control group continued with their regular schedule of physical training sessions throughout the study period. During the experimental study, all the students continued with their normal vegetarian diet available at the hostel mess. No external nutritional supplements were provided during the study. The students were provided breakfast, lunch, evening snacks and dinner.

Statistical Analysis

Standard methods were followed for the data extraction for each of the variables. Data analysis was done using statistical software (SPSS, Statistical Package for the Social Sciences, Version 16.0). Data was analyzed using paired 't' tests, independent 't' test and descriptive statistical method. The mean values ± SD of pre and post variables are presented in Table 1.

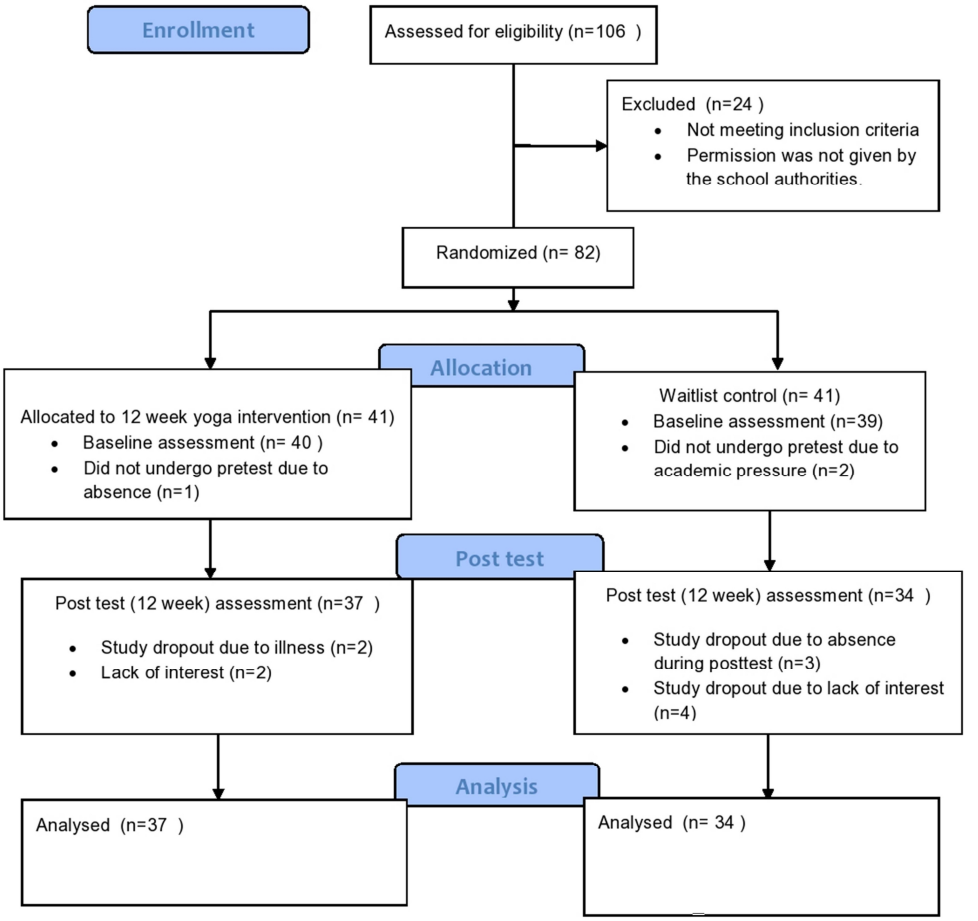
RESULTS

The result of within group comparison revealed that the experimental Group showed highly significant increase in biochemical variables i.e. serum Mg, Fe, and Cu ($t = -3.49$, $p < 0.001$; $t = -3.25$, $p < 0.001$; $t = -6.73$, $p < 0.000$) (Table 1), whereas the control group revealed no change in serum Mg and Fe ($t = 0.057$, $p > 0.05$; $t = -0.67$, $p > 0.05$) respectively, however Copper (Cu) status improved in control group ($t = -3.33$, $p < 0.001$). There was no statistically significant change observed in Haemoglobin (Hb) status and Zinc (Zn) status in both experimental ($t = -1.43$, $p > 0.05$; $t = -1.05$, $p > 0.3$) and control group ($t = 0.29$, $p > 0.05$; $t = 1.86$, $p > 0.05$). The results of within group comparison of physical fitness variables of experimental group showed highly significant increase in flexibility, grip strength (left) ($t = -3.49$, $p < 0.001$; $t = -5.43$, $p < 0.001$) and significant increase in grip strength (right) and abdominal strength (sit ups) ($t = -2.65$, $p < 0.01$; $t = -2.5$, $p < 0.01$) (Table 1). However, the control group also showed highly significant improvement in grip strength (right) and grip strength (left) ($t = -3.6$, $p < 0.001$; $t = -5.6$, $p < 0.001$) and significant improvement in abdominal strength (sit ups) ($t = -2.1$, $p < 0.05$). Further, the result of between group comparison revealed that experimental group had highly significant improvement in Cu status ($t = -3.5$, $p < 0.001$) and significant improvement in Mg status ($t = -2.6$, $p < 0.01$). However, no statistically significant difference was evident in Haemoglobin (Hb), Zn, and Fe status ($t = -1.6$, $p > 0.05$; $t = -1.7$, $p > 0.05$; $t = -1.5$, $p > 0.05$) respectively. But, a positive shift was observed in haemoglobin and zinc status in the experimental group, whereas no such shift was observed in haemoglobin and zinc status in control group. A positive shift in Iron (Fe) status was observed in both experimental and control group, although statistically non-significant. The results of comparison between groups of physical fitness variables i.e. BMI, flexibility, grip strength (right), grip strength (left), and sit ups (abdominal strength) showed a positive shift in both experimental and control group, however no statistically significant difference was evident between these groups ($t = 1.55$, $p > 0.05$; $t = -0.61$, $p > 0.05$; $t = 0.61$; $p > 0.05$; $t = 0.51$, $p > 0.05$; $t = 0.07$, $p > 0.05$) respectively (Table 1). However, BMI of experimental group ($t = -1.1$, $p > 0.05$) and control group ($t = -1.2$, $p > 0.05$) showed no statistically significant increase. BMI of experimental group remained unchanged while BMI of control group showed statistically non-significant increase. These results indicate that yoga practices may improve micronutrient absorption in adolescent rural residential school children. Yoga practices are also, plausibly, helpful in improving overall physical fitness of these children.

Table 1: Pre test and post test values of selected variables after 12 weeks of yoga training

Variable	Exp Group			Control Group			Exp Vs Control (p-value)
	Baseline (M ± SD)	Final (M ± SD)	p-value	Baseline (M ± SD)	Final (M ± SD)	p-value	
Hb	13.47 ± 1.00	13.60 ± 1.04	-1.43	13.27 ± 1.14	13.24 ± 0.80	0.29	-1.634
Zn	95.07 ± 4.43	97.77 ± 14.36	-1.05	95.32 ± 16.19	91.10 ± 17.76	1.86	-1.745
Mg	1.92 ± 0.28	2.10 ± 0.25	-3.49***	1.94 ± 0.29	1.93 ± 0.27	0.05	-2.623**
Fe	71.10 ± 20.76	78.73 ± 21.16	-3.25***	70.42 ± 19.92	71.57 ± 16.73	-0.67	-1.573
Cu	99.13 ± 12.31	112.58 ± 12.59	-6.73***	97.68 ± 12.63	101.81 ± 13.17	-3.33***	-3.525***
BMI	1.64 ± 1.75	1.65 ± 1.90	-1.19	1.69 ± 3.01	1.76 ± 3.78	-1.20	1.552
Flexibility	-3.39 ± 5.91	-3.28 ± 5.71	-3.49***	-2.54 ± 5.73	-1.20 ± 6.01	-1.62	-0.613
Grip right	1.99 ± 6.50	2.12 ± 6.46	-2.65**	2.05 ± 6.09	2.22 ± 6.69	-3.68***	0.619
Grip left	1.86 ± 5.97	2.07 ± 6.27	-5.43***	1.90 ± 6.08	2.15 ± 6.21	-5.69***	0.510
Sit ups	18.57 ± 8.96	21.26 ± 8.57	-2.55**	18.64 ± 8.98	21.42 ± 9.52	-2.13*	0.076

*p < 0.05, **p < 0.01, ***p < 0.001



Flow diagram of subject enrolment and attrition

DISCUSSION

The findings of this 12 week research study suggests, amply, the effectiveness of yoga training in improving micronutrient absorption and in enhancing physical fitness level of adolescent rural residential school children. Micronutrient deficiency often goes undetected and is a widespread problem among rural adolescent children.[47] There is disproportionate burden on the poor, in spite of different governmental policies for children.[48] In rural area for children, family environment, physical growth, dietary patterns, school performance and nutrient intakes are poorer as compared to the urban children.[19,27] Micronutrient deficiency in adolescent children is significantly related to poor socio-economic status and impaired brain development,[49,50] poor cognitive development,[9,51] growth retardation,[3] depression, anxiety, learning, memory deficits,[52,53] and scholastic achievement. The effect of micronutrient deficiency could be long-term, irreversible and detrimental to the health of adolescent children.[23,24] In the present study, highly significant increase in Mg, Fe and Cu was observed in experimental Group due to yoga, whereas, control group showed no improvement in micronutrient absorption except highly significant increase in Cu status (Within Group Comparison). However, there was no statistically significant improvement in Haemoglobin and Zinc status but a definite positive shift was evident in experimental Group, whereas there was no improvement observed in control group. However, highly significant increase in Cu status within control Group can be attributed to the use of copper utensils in the hostel mess for storage of water. Also, low serum Zinc levels in experimental group could be attributed to the fact that zinc and iron when present together, compete for absorptive pathways as they have chemically similar absorption and transport mechanisms.[54,55] Improvement in Mg, Fe, and Cu status of experimental group can be attributed to 12 week Yoga training. Yoga might have improved an overall state of well being and relaxation in experimental group children. Physical fitness variables i.e. flexibility, grip strength, and abdominal strength increased significantly in experimental group. However, control group also showed highly significant increase in grip strength and abdominal strength but there was no change in flexibility. Physical exercise might have helped to build muscular strength of arms and legs but not flexibility when compared to that of Yogic poses.[46] experimental group practiced different yogic postures which might have improved flexibility, grip strength, and abdominal strength, whereas control group had continued with their regular physical training sessions throughout the study period of 12 weeks. Therefore, it can be inferred that the practice of Yoga for

12 weeks improved micronutrient absorption and physical fitness in adolescent rural residential school children. Yoga helps in gentle and automatic massaging of internal organs and thus helps in enhancing functioning of digestive system, circulatory system, respiratory system, endocrine system, nervous system, and excretory system.[38] Also, studies have been conducted in the past which suggest that yoga practices are helpful in improving digestion and gastrointestinal problems.[56,57] Subjects were on normal daily diet provided by their institution. No external micronutrient supplementation was given. So, also, no food fortification was suggested by the researchers. Therefore, it was ensured that the change in micronutrient absorption was solely due to yoga training. Compliance to yoga training was ensured by the researcher by being physically present during each yoga session. Although, the results of this study being encouraging, there are some limitations in this study. Worm infestation, being one of the major causes of micronutrient deficiency,[26,36] was not confirmed by any pathological tests. However, as per the information given by school authorities, children were de-wormed three months prior to the study. The study duration was shorter i.e. 12 weeks only, but present results provide us with ample evidence to conduct this study for a longer period in future. Future research is required on a larger population to study the effect of yoga on micronutrient absorption, with a proper de-worming. This research can also be conducted by providing external micronutrient supplements along with yoga training, for which appropriate study design would be required. Also, effect of yoga practices on micronutrient absorption in urban school children can be studied in near future due to their excessive junk food intake which is, generally, bereft of essential vitamins, minerals and micronutrients.

CONCLUSION

The present study has demonstrated that yoga training improved micronutrient absorption in adolescent rural residential school children. Yoga also improves physical fitness status in children. It is worthwhile mentioning that micronutrient absorption might have been enhanced due to yoga training, even when no external micronutrient supplements were provided to the participants. Yoga, being a simple and inexpensive health regimen, can be incorporated as an effective adjuvant therapy to governmental child health initiatives in school curriculum, and thus, ensures a bright future for our children. Further studies on a larger scale and longer time period would be required to substantiate these findings.

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