Spirulina Supplementation as a Means to Combat Malnutrition in CLHIV
Study Report

Meghan O'Hearn
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Sneha Care Home, Bangalore, India

Introduction

Malnutrition, pathological micronutrient deficiency due to the long-term consumption of food inadequate for good health, is epidemic in many developing countries. 852 million people globally are affected by malnutrition in a drastic way. Malnutrition's impact on a child's life is far reaching- affecting their cognitive and physical development, motor skills, immune function, and ability to live a normal life. Malnutrition is particularly prevalent in India. According to UNICEF, a shocking 43 percent of Indian children under five are categorized as moderately or severely underweight, 16 percent are categorized as moderately or severely stunting, and 20 percent are categorized as moderately or severely wasting. Underweight, stunting, and wasting are all characteristic of malnutrition in children. Recent statistics released in India revealed that 3000 children are dying daily due to illnesses related to poor diets, a national outrage given the economic growth India has seen over the past 20 years.

According to the WHO, there is significant overlap in the presentations of severe malnutrition and HIV infection in children, particularly in poorer areas. Not only can HIV infection lead to malnutrition, but poor diet can also speed up the infection's progress. People living with HIV have been shown to require far more energy than the average individual. For instance, in HIV-positive children, energy intake needs to be increased by 50-100 percent over normal requirements in children. Likewise, HIV-infected individuals oftentimes suffer from malabsorption, the ability to successfully absorb nutrients from food, because of the HIV's destruction of the gut lining. People living with HIV/AIDS have shown to present significant micronutrient deficiencies, namely low levels of vitamin A, vitamin B12, vitamin C, vitamin D, carotenoids, selenium, zinc and iron in the blood.

Spirulina, dried algae of the species *Arthrospira planensis*, is a photosynthetic bacterium found worldwide in fresh and marine waters. It has been used for centuries as a diet staple because of its high protein and micronutrient content. Spirulina offers tremendous potential for individuals fighting malnutrition. It has immunostimulatory and antiviral properties that are of great interest in the fight against malnutrition, particularly for children living with HIV/AIDS (CLHIV), because of these children's weakened immune defenses. The protein content of spirulina varies between 60-70 percent of its

dry weight. It also contains GLA fatty acids and sulfolipids, both of which are involved in inflammation and immune reactions. Spirulina is rich in beta-carotene, a compound that can overcome eye problems cause by vitamin A deficiency. Spirulina is also the most easily digestible protein-rich food, which is especially critical for patients suffering from problems of malabsorption. Beyond its various nutritional benefits, spirulina requires less energy and water input per kilogram than other protein sources and does not require fertile land for cultivation.

There have been several studies and clinical trials done to date on the effectiveness of spirulina in treating malnutrition, particularly with children and HIV positive populations. Pioneering studies conducted in the Central African Republic as early as 1993 revealed the benefits of spirulina in tackling malnutrition problems. Children in the study showed significant improvement in weight gain and speed of recovery. A study on the impact of a small intake of spirulina on nutrition and intellectual performance was conducted in India in 2004. The research invesigators recommended Indian government agencies supply free spirulina in schools, particularly in economically depressed regions. A study conducted in 2010 on HIV-positive patients supplemented half of the patients with soya beans and half with spirulina. Although the results indicated comparable efficacy with regards to weight gain, those who received spirulina treatment showed a significant increase in immunological markers.

Today, spirulina is mainly used by NGOs and local health institutions as a complementary strategy to addressing malnutrition. Intergovernmental agencies such as the WHO, WFP and UNICEF have neither promoted nor recommended its use due to the lack of scientific evidence.

Based on several recommendations from outside sources, two severely malnourished CLHIV at Sneha Care Home were given a daily DXN ganocelium and spirulina cocktail for three months in 2011. Over this three-month period, there was improvement in both child's weight, height, and overall health status. While the ganocelium and spirulina cocktail proved to be effective for these two children, the combination was too expensive to employ for a larger-scale study. Thus, it was

determined that a study on the effectiveness of spirulina in underweight CLHIV would be conducted at Sneha Care Home.

Methods

After evaluating each resident child's general health, weight and respective height, the resident nutritionist and nurse at Sneha Care Home selected 30 children as underweight and enrolled them in this spirulina study. Children enrolled in the study received 2 tablets on an empty stomach before breakfast everyday for six months. Although some participants experienced vomiting during the first two days of the study, the majority of participants experienced little to no side effects from the spirulina supplementation. Each child's weight and height was recorded monthly. Their CD4 count was measured once every six months. Data for the thirty participants in the spirulina study (treatment data) was compared to data from thirty additional children chosen at random from Sneha Care Home's records (control data). Data points before and after the study (November 2011 and August 2012, respectively) have also been included for more thorough analysis. Data was qualitatively analyzed to determine the efficacy of spirulina in fighting malnutrition in CLHIV.

Results and Discussion

When discussing the efficacy of nutritional supplements for combating malnutrition, weight gain and weight for height are two of the most revealing statistics. Analysis of weight data revealed that twenty-six of the thirty underweight participants (86.7%) in the spirulina study exhibited weight gain. Average weight gain per month among the thirty participants was 0.258 kg/month. Despite these positive statistics, twenty-nine of the thirty control subjects (96.7%) exhibited weight gain with an average weight gain of 0.417 kg/month. Six of the children in the treatment group showed significant weight gain-- greater than 2.2 kg increase between November 2011 and August 2012. This included Manjanuth (2.3 kg increase), Rahul (2.5 kg increase),

Priyanka K (2.5 kg), Tharun (2.7 kg increase), Sunil (3.1 kg increase), and Chandrakanth (4.1 kg increase).

Height data can also be useful in analyzing the efficacy of nutritional supplements. All children in both the treatment and control groups showed height increases over the study period. Children given spirulina showed an average height increase of 0.645 cm/month whereas control children showed an average height increase of 0.928 cm/month. Twelve of the children exhibited a height increase of greater than 3 centimeters during the study period. This included Yogesh (3.5 cm increase), Sukesh (3.5 cm increase), Vidyasaree (4 cm increase), Ambika N (4 cm increase), Chandrakanth (4 cm increase), Shravani (4.5 cm increase), Bagyasree (4.5 cm increase), Rahul (4.5 cm increase), Nagaraju (4.5 cm increase), Nandini (5.5 cm increase), and Priyanaka K (6.5 cm increase).

Table 1. Summary of treatment and control data for children's weight and height.

	Treatment (n = 30)	**Control (n= 30)**
Children who increased in weight (kg)	26 (86.7%)	29 (96.7%)
Children who increased in height (cm)	30 (100%)	30 (100%)
Average weight change/month (kg/month)	0.258	0.417
Average height change/month (cm/month)	0.645	0.928

Although only two data points for CD4 count were available for some study participants (CD4 count is measured by clinic staff once every 6 months), analysis revealed that nine participants showed an increase in CD4 count while twelve showed a decrease in CD4 count. Although clinical studies indicate spirulina's immunostimulatory properties and field studies have shown increased immunological markers in patients taking spirulina, our incomplete data set prevents any conclusions to be drawn. Further analysis of immunological markers and more vigilant CD4 counts would be necessary for significant insight into spirulina's immunological properties in the field.

Children in the study reported medical complaints similar to those of children not enrolled in the study. The most common complaints were opportunistic infections including cough and cold, inflammation (fever, lymph node enlargement), and ear

infections. Again, no significant difference was noted between children on spirulina supplementation and those not in the study.

It is important to note that during the spirulina study, students went home for summer holiday during June 2012. Participants were given enough tablets for their home-stay and were asked to continue with the treatment daily. Participants likely had good adherence rates to the treatment regimen given they were taking spirulina in correlation with their antiretroviral therapy. Seventeen of the thirty study children (56.7%) and ten of the thirty control children (33.3%) exhibited weight loss during the month of June. While this weight drop seems significant, it is probably indicative of the children's home conditions. All of the children come from families burdened with health issues, low income, poor nutrition, and socioeconomic problems. Thus this weight drop is not indicative of the spirulina but rather the home environment and food intake during that month. Greater analysis of each child's home environment in correlation with their nutrition status would be necessary to draw any significant conclusions.

Conclusion and Strategies Moving Forward

Based on data analysis and qualitative observations of study participants' general health and well-being throughout the duration of the study, spirulina doesn't seem to be an effective strategy for addressing the malnutrition problems at Sneha Care Home. The impact of spirulina supplementation on weight gain was only substantial for two to three participants. Children uninvolved in the spirulina study likely exhibited greater weight and height gain because their base weight and height were more stable. While these control children were exhibiting normal growth patterns, the children enrolled in the study were malnourished and thus required a much greater increase in food and nutrient intake to see significant changes. The addition of more, higher-quality nutritious foods would be as effective if not more effective at addressing malnutrition in these CLHIV.

Thus, Sneha Care Home has made the strategic decision to go forward with a healthy diet and additional food intake rather than spirulina supplements to address malnutrition among its children. Additional healthy foods would be a more cost-

effective, sustainable solution to malnutrition than nutritional supplements like spirulina and would likely be beneficial to all children at Sneha Care Home. Micronutrient deficiencies will be addressed with addition of a variety of vegetables and fruits, especially green, leafy vegetables. Protein and energy deficiencies will be addressed with additional meats, eggs, and new protein sources such as groundnuts, nut butter, and soya products. Sneha Care Home will consult with a nutritionist from St. John's Hospital, Bangalore to determine the nutritional priorities for undernourished children at Sneha Care Home, alterations to the current diet, and additional local, low-cost protein sources. Based on the nutritionist's guidance and input from the director, cooks, and nurse at Sneha Care Home, a proposal detailing allocation of funding for improved nutrition as well as a proposal for the continuation of the malnutrition study will be developed.

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Appendices:

Appendix I. Treatment Data (weight in kilograms)

Si. No	NAME OF CHILD	November	February	March	April	June	July
1	Savitha	21	22.5	22	22	21.9	22
2	Vanitha	29	30	30.7	30	31.3	31.3
3	Sunil	21	23.5	22.8	23	22.8	24.1
4	Abhishek an narao	25	25.7	27.4	27	26.8	27.2
5	Mallikarjun	14.5	14	15	15.4	15.2	15.6
6	Vidyasree	19	18.3	19.2	19	19.6	19.4
7	Manjunath	21	21.7	22	22	22.8	23.3
8	Lakshmi	16	15.2	16	16.2	15.4	16
9	Priyanka.K	18	20	19.7	20	19.2	21
10	Yogesh	15.5	15.9	15.3	15.3	15	16
11	Chaithra	17.5	17.3	18	18.2	17.5	19
12	Shravani	16	16	16	16.4	16.7	16.7
13	Bagyasree	15.5	15.5	16.3	16.2	15	17.1
14	Ambika.N	15	14	15	15.4	15	15.4
15	Premkumar	18	18.3	19	19.2	19.2	18.8
16	Chetan.L	19	19.3	19.6	19.6	19.7	20.9
17	Ranjan	15	16.4	16	16.2	15.3	16.2
18	Nithin	22	22.5	22.6	22.4	24	23.8
19	Darshan	21.5	21.9	21	21.2	21	20.9
20	Tharun	15	16	16	16.2	16.7	17.7
21	Megana[small]	18	19.5	19	19.5	19.3	19.8
22	Rahul	19.5	20.2	20	20.3	20.7	22.4
23	Sukesh	27.5	28.8	28.3	28.5	30.3	29.3
24	Chandrakanth	21	21.6	23	23.5	24	25.1
25	Nagaraju	22	21	22.5	22.6	21.6	23
26	Ravi	16.5	18.2	18	18.2	18.4	18.3
27	Sanjay	23	23.5	23	23.5	23	22.8
28	Monika	25	26	26.8	26.2	25.9	27.4
29	Nandini	17	17.3	18	18.2	18.7	18.9
30	Suhasini	19	17	19	19.5	18	19.4

Appendix II. Treatment Data (height in centimeters)

Sl.No	NAME OF CHILD	November	February	March	April	June	July
1	Savitha	124	124	125	125	126	127
2	Vanitha	138	139	139	139	139	139.5
3	Sunil	124	125	125	125	127	127.5
4	Abhishek an narao	130	131	131.5	131.5	132	133
5	Mallikarjun	99	100	101.5	101.5	103	103

6	Vidyasree	105	106	107	107	109	109
7	Manjunath	122	123	123	123	123.5	123.5
8	Lakshmi	105	105.5	106	106	107	107.5
9	Priyanka.K	106.5	108	110	110	112	113
10	Yogesh	109	109	110	110	112	112.5
11	Chaithra	113	114	114	114	115.5	116
12	Shravani	109	110.5	110.5	111	112.5	113.5
13	Bagyasree	106.5	108	109	109	109.5	111
14	Ambika.N	107	108	108.5	109	110.5	111
15	Premkumar	109.5	111	112	112	112	112.5
16	Chetan.L	116	117	117.5	117.5	118	119
17	Ranjan	101	102	103	103	105	105.5
18	Nithin	126	126	127	127	128.5	129
19	Darshan	116	117	117.5	117.5	118.5	118.5
20	Tharun	110	110.5	110.5	111	111.5	112
21	Megana[small]	111	112.5	112.5	113	113	114
22	Rahul	115	115.5	117	117	119	119.5
23	Sukesh	133.5	134	135	135	135	137
24	Chandrakanth	113	114.5	114.5	116.5	116.5	117
25	Nagaraju	121	122	122	122	125.5	125.5
26	Ravi	111.5	111.5	112	113	113.5	114
27	Sanjay	123	123	123	124	124	124
28	Monika	119	119.5	120	120	121	122
29	Nandini	109.5	110	112.5	113	115	115
30	Suhasini	118	118	118	119	120	120

Appendix III. Control Data (weight in kilograms)

Si No	NAME OF CHILD	November	January	March	June	August
1	Akash	18	18.7	19	18.8	19.8
2	Alwin	22	22.7	23	22.6	23.2
3	Anil	18	19	19.6	20.3	20.5
4	Anjappa	20	21.5	22	20.6	23
5	Ambika R	29	30.2	30	32.1	32.9
6	Ashwini M	21	21	22	22.4	22
7	Amar	19	19	19.2	19.5	19.7
8	Anu	22	21.8	21.5	21.7	22.1
9	Babu	24	25.8	25.8	26.3	26
10	Danush	21	21.8	21.6	23	23
11	Divya	17	17	16.6	17.3	17.5
12	Jyothi	28	28.2	27.8	28	28.6
13	Kalesh	27	29	28.5	29.9	28.6
14	Karthik	24	25.8	26	25.2	25.8

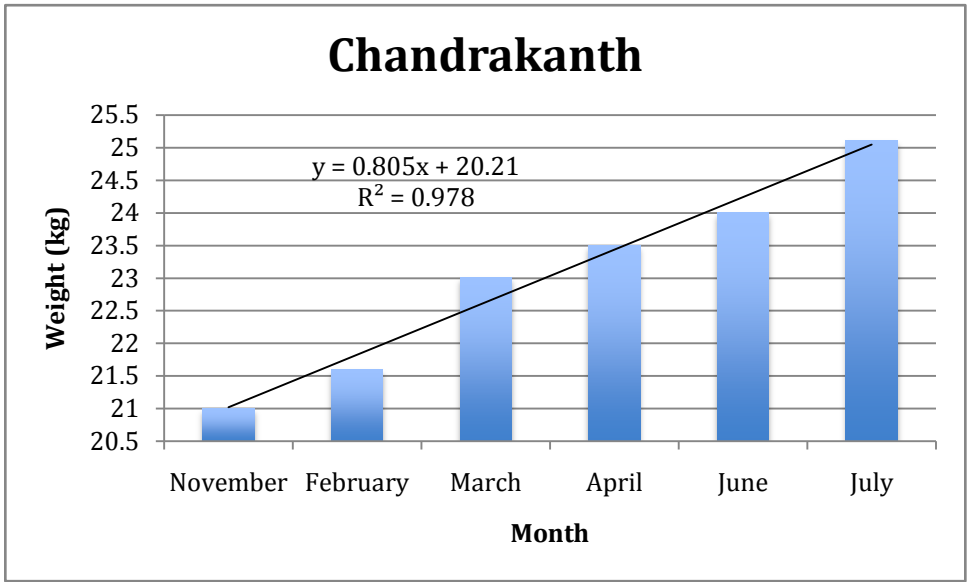
15	Lakshmikanth	25	25.6	25	25.7	26
16	Mallamma	37	38.2	38.8	37.8	39.4
17	Mallava	17	15.8	16	16	16.8
18	Manoj	14.5	15.7	16	16.8	17.7
19	Meena	33	33.5	33.5	34.4	35.5
20	Megha BR	32	32.3	33.5	34.6	35.1
21	Pooja	24.5	24.3	24.3	25.2	25.3
22	Prathap	22	22.7	23.5	22.9	23.6
23	Sachin	24	24.8	24.5	24.3	25.3
24	Sonika	35	36	38.2	35.6	37.4
25	Suhas	18	19.8	20.3	20.3	21.3
26	Shruthi	34	35.9	37.2	37.4	38.6
27	Thirumal	15.5	17	17	16.5	17.2
28	Umesh	18	19.3	20	20.6	20.4
29	Vasu	21	21	21.6	21.2	21.8
30	Vishal	20	22.4	22.5	21.9	22.5

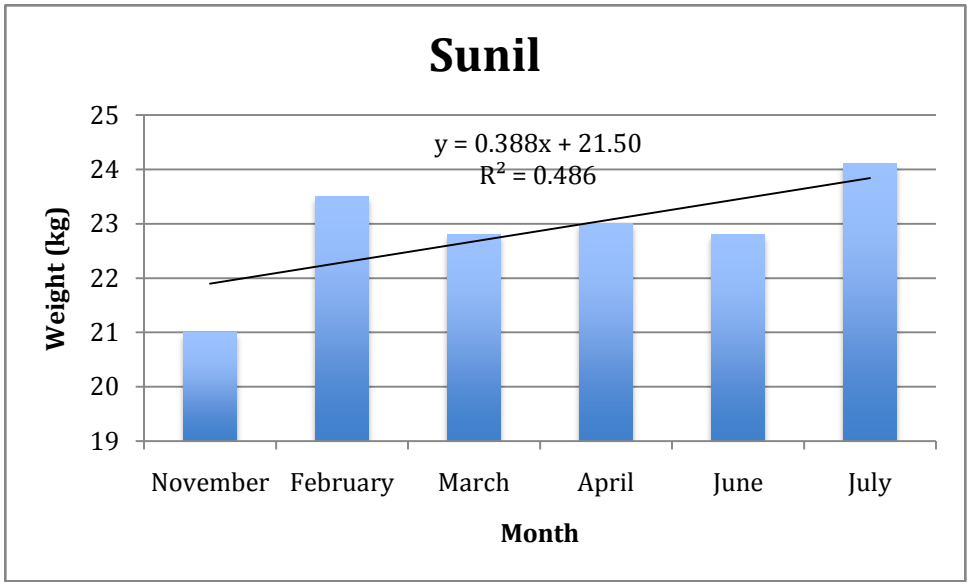
Appendix IV. Control Data (height in centimeters)

Si. NO	NAME OF CHILD	November	January	March	June	August
1	Akesh	119.5	120.5	121	123	124
2	Alwin	120.5	121	121	122	122.5
3	Anil	112.5	113	114.5	116.5	116.5
4	Anjappa	119.5	120.5	121	122.5	123.5
5	Ambika R	135	135.5	137	139	141
6	Ashwini M	119	119.5	119.5	122	123.5
7	Amar	121	121	121	123	123
8	Anu	118	118.5	119	120	121
9	Babu	127	128.5	128.5	128.5	130
10	Danush	121.5	121.5	121.5	122.5	122.5
11	Divya	106.5	107.5	107	109	109.5
12	Jyothi	132	132	132.5	132	134
13	Kalesh	137	137	139	140	140.5
14	Karthik	119	119	120	122	122.5
15	Lakshmikanth	133	134	134.5	135.5	136.5
16	Mallamma	141	142.5	144	145	146.5
17	Mallava	108	109	109	110.5	112
18	Manoj	104	106.5	108	109.5	111
19	Meena	134.5	135.5	135.5	136.5	138
20	Megha BR	130.5	131	131	132.5	134
21	Pooja	123.5	124	124	125	126.5
22	Prathap	120.5	121	122	124	124.5

23	Sachin	124	124.5	125	126.5	127.5
24	Sonika	145	145	147	147	148.5
25	Suhas	115	115.5	117	118	118
26	Shruthi	142	143.5	145	145.5	148
27	Thirumal	104	105	105.5	107	108
28	Umesh	116	116.5	117.5	119.5	121
29	Vasu	119	119	120	120.5	122
30	Vishal	118	118.5	119	119	120.5

Appendix V. Treatment Children with Significant Weight Gain





Appendix VI. Treatment Children with Significant Height Increase