Nutritional status based on mid upper arm circumference and head circumference: a cross sectional study among the children in Jaffna District

K Kandeepan, S Balakumar and V Arasaratnam
Department of Biochemistry, Faculty of Medicine, University of Jaffna, Jaffna, Sri Lanka
#kande_karthigesu@yahoo.com

Abstract— *Most studies specify nutritional status based on weight and height. However, under nutrition based on weight and height are less able to interpret biochemical alterations and protein energy malnutrition. Therefore, a study was carried out to determine the nutritional status based on MUAC and HC among children aged 1-5 years in Jaffna district. Multistage cluster sampling was used and 846 children were selected. Their HC, MUAC, weight and height and the selected biochemical parameters were obtained. Undernutrition was defined based on age-and sex-specific MUAC and HC z-score values according to the World Health Organization recommendations. Among children, 414 (48.9%) were boys and the mean age was 34.7 (±13.1) in months. Mean (±SD) HC and MUAC of the children was 48.01 (±1.65)cm (range- 39 to 59.50 cm) and 14.38 (±1.12)cm (range- 10.5 to 18.50cm) respectively. Mean HC and MUAC among boys were higher than girls at all ages. However the significant sex differences were not observed in MUAC. Prevalence of undernutrition based on MUAC and HC was 11.5 and 8.6% respectively. However, the overall prevalence of wasting, underweight and stunting were 21.6, 33.1 and 26.4% respectively. The mean (±SD) serum albumin concentration of the children with low MUAC was 3.4 (±0.52) g/dL. A higher percentage of anemia (52%), low albumin level (61%) and iodine deficiency (18%) were observed among the low MUAC-for-aged children. Consumption of protein [(21.4 (±7.09)g] was observed to be low among MUAC-for-aged children when compare with normal children [24.51(±8.6g)]. MUAC was significantly correlated with serum albumin concentration (p=0.001: Pearson's correlation coefficient=0.263). This study revealed that the overall prevalence of undernutrition among these children was very high. However prevalence of undernutrition was observed to be low based on the MUAC and HC.*

Keywords— *Mid Upper Arm Circumference, Head Circumference (HC), and Under Nutrition*

I. INTRODUCTION

Despite remarkable achievements in the health sector, malnutrition has been a persistent health challenge in Sri Lanka. More than 1 in 5 under-five year olds are underweight in the country. Nearly 1 in 6 babies born are of low birth weight. Moreover, children in the rural sector are twice as likely to be underweight than children in the urban sector. Despite countless initiatives to alleviate malnutrition over the years, child nutritional levels have improved only marginally in the country and it is a serious health issues in Sri Lanka (DHS, 2009). Even though, assessments of nutritional status have been carried out periodically as a part of the Demographic and Health survey (DHS) conducted by the Department of Census and Statistics and through Regional Directorate of Health Services (RDHS), prevalence of stunting and underweight has been brought down considerably within recent decades and wasting remains at a level which has been relatively unchanged for the last 30 years. According to the most recent research carried out in 2015 showed that, the prevalence of stunting, wasting and underweight were 16.8, 21.5 and 27.2% among the children aged 6-36 months, in the Eastern Province of Sri Lanka respectively (Sujendran, et al., 2015).

To eradicate this chronic issue, anthropometric measurements are used as the main criteria for assessing the adequacy of diet and growth of children (WHO, 1995). Moreover, anthropometry is the single most universally applicable, inexpensive and non-invasive method available to assess the size, proportions, and composition of the human body (WHO, 1995). It is used to gauge the health and nutritional status of individuals or populations (de Onis and Habicht 1996; FANTA, 2003). Anthropometric indices are used to screen children at risk of malnutrition over the short term, as well as to assess population changes over the long term (FANTA, 2003). However, the most frequently used anthropometric measurements are height-for-age (stunting/ chronic malnutrition), weight-for-age (underweight) and weight-for-height (wasting/ acute malnutrition). Head Circumference-for- age (Low Head Circumference-for-age), Mid-Upper Arm Circumference-for-age (Low Mid-Upper Arm Circumference-for-age) and other specific anthropometric measurements are rarely used in the population based studies (Allen and Gillespie, 2001; WHO 1995). Mid-upper arm circumference (MUAC) is a valuable anthropometric indicator to predict immediate mortality risk in under-five year old children (FANTA 2003). However, MUAC would be used to detect protein malnutrition in the population.

According to de Onis (2001), growth assessment is the single best measurement for evaluating child health and nutritional status, and it provides an indirect measurement of the quality of life of an entire population. Undernutrition during infancy and childhood substantially raises vulnerability to infection and disease and increases the risk of premature death (Biswas, et al., 2009). Malnutrition during childhood can also affect the growth potential and the risk of morbidity and mortality in later years of life (Alderman, et al., 2003).

The under nutrition based on the height and weight are less representative of the biochemical alteration specially loss of muscle mass. Even in the child with altered anthropometric measurements, the biochemical parameters would be normal (The Mother and Child Health and Education Trust, 2015). In community based studies, mid-upper arm circumference (MUAC) appears to be a superior predictor of childhood under nutrition than many other anthropometric indicators (WHO, 1995). Measurements of MUAC are simple and cheap. It can be used in the community level at different contact points without greatly increasing their workload and it can be effectively used by community surveys for active case finding. MUAC is a better indicator of mortality risk associated with malnutrition than Weight-for-Height. It is therefore a better measure to identify children most in need of treatment. Comparative studies have shown that MUAC is subject to fewer errors than Weight-for-Height (Myatt et al., 2006).

The MUAC is a relatively simple measurement /index, but with a fixed cutoff, it ignores age-related changes. Compared with weight-for-height, MUAC has a sensitivity of 24.6% and a specificity of 94.8% (Joseph, et al., 2002) with fixed cut-off values and appears to be a better predictor of childhood mortality than weight-for-height. In addition to that, a measurement of MUAC is good indicators of protein energy malnutrition in both survey and screening programs (Singh, el al, 2005). Routine measurement of HC (the frontal occipital circumference) is a component of the nutritional assessment in children up to age three and longer in children who are at high nutritional risk. In addition to that, Jaffna District in the Northern Province had been affected by conflict for three decades (nearly 30 years) and many humanitarian crisis such as internal migration, immigration to other countries and destruction of infrastructure facilities. Beyond the war, time to time Jaffna District was affected by natural disasters such as 'Tsunami'; 'Nisha', 'Lyla' and 'Neelam' cyclones and flood. As a consequence, fishery and agriculture sectors have been affected and accordingly severe food and economic crisis has been raised among households. Hence the nutritional indicators of Jaffna population especially children were affected compared to other parts of the country in Sri Lanka. Thus this study was aimed to determine malnutrition based on the MUAC and HC.

II. METHODOLOGY

A. *Study area and population*

The study was conducted in children aged 1 to 5 years in Jaffna district. The study population was the children aged one to five years old children in the Jaffna District.

B. *Study design*

A population based multistage cluster sampling method was used to identify the sample of children.

C. *Sample size*

To find out the minimum number of subjects to be recruited to demonstrate a statistically significant association of a predictor of malnutrition, formula of $[z^2p(1\text{-}p)/d^2]$ was used, where p is the highest proportion of underweight from the previous studies (Fernando, 1994). With a z value of 1.96 (at 95% confidence level with type 1 error=0.05), margin of error of 5%, and design effect of 2, minimum required sample size was derived. The numbers of non-respondents were 100 (13% of the calculated sample size). 'n' after correction for non-responders was 856. Among 856, 10 (1.2 %) of the children were non-despondence and the final sample size was 846.

D. *Sampling technique*

In this multi-stage cluster sampling, the Primary Sampling Unit (PSU) was MOH area. From the primary Sampling Unit, required numbers of clusters were selected based on the population size and those clusters are called as Secondary Sampling Units (SSU). Selected number of clusters includes PSU and SSU are given with serial number (ID number of the samples). From a SSU, 10 households were selected randomly. Thus Eighty five clusters were used to derive a total of 856 samples.

In the first stage, required numbers of clusters (SSU) from particular MOH divisions were selected by using the following equation.

$$\text{Required numbers of SSU} = \frac{\text{Total Population}_{MOH}}{\text{Total Population}_{Jfn}/\text{N}_{Clu}}$$

Where, "Total Population MOH" is total population of children in a MOH division and "Total Population Jfn" is total population of children aged one to five years in Jaffna District. "NClu" is selected number of clusters in Jaffna District for this study and that is 85. In 2nd stage of sampling method, initially the details (include name and address) of the children were collected from selected PHM areas and arranged based on the birth order. Separate list for children (sampling frame) to each PHM areas was prepared. From each list, one child was selected randomly. That child was visited by our research team and recruited for this study. From that child's home, other children were selected by using 'Spin-a-pen random walk method' (Osei, et al., 2010).

If more than one child of 1 to 5 year of age lives in a house, child who has completed his or her birthday recently at the date of data collection was selected for this study.

E. Study instruments

Pretested interviewer administered questionnaire was used to get the information of socio demographic factors and socio-economical factors. Information on the age and sex of the child were derived from the Child Health Development Records (CHDR) book and recorded. Age of the child was defined as the completed months by the date of data collection. Data record sheet was used to record the height, weight, MUAC and HC.

Blood (5mL) was used to derive the haemoglobin concentration and serum was used for albumin concentration. Early morning urine specimen was used to obtain iodine concentration. Anemia was defined if haemoglobin concentration was less than 11g/dL (WHO, 2011). Normal reference range of serum albumin is 3.5-5.0 g/dL (Spencer and Price, 1977) and low albumin levels was identified based on the albumin concentration less than 3.5 g/dL (Spencer and Price, 1977). Iodine deficiency is defined by the International Council for the Control of Iodine Deficiency Disorders (ICCIDD), World Health Organization (WHO) and UNICEF as a population median urinary iodine concentration (UIC) that falls below 100 μg/L (0.78μmol/L) (WHO/UNICEF/ICCIDD, 2007).

F. Data analysis

The selected children were weighed with light cloth by using an electronic scale (SECA 811) with accuracy of ±100g. The height of the children was measured with a portable stadiometer (SECA 213) with accuracy of ±0.5cm. All anthropometric assessments were performed according to standard WHO procedures (WHO, 1995). The weights and height of the children were used to compute age and sex specific z-scores for weight-for-age (WAZ), weight-for-height (WHZ), and height-for-age (HAZ) using WHO Anthro software (version 3, 2009) to detect underweight, wasting, and stunting which were defined as WAZ, WHZ, and HAZ less than -2 SD below the 2006 WHO growth standards, respectively and its severe forms were defined as the z-score value less than -3SD (WHO, 2006). Mid-upper arm circumferences (MUAC) were recorded to its nearest 0.1 cm using a non-stretchable measuring tape. HC was measured (cm) using a flexible, non stretch tape according to standard method (WHO, 1995). The measurement was recorded to the nearest 0.1 cm. Nutritional assessment of the children was evaluated using the World Health Organization (WHO) 2009 recommended age specific z-scores cut-off value.

Data were analyzed in Statistical Package for the Social Sciences (SPSS) version 21.0-IBM for window. All statistical tests were carried out at the 5% significance level.

G. Ethics

Permission to conduct the study was obtained from Director, Regional Directorate of Health Office (RDHS), Jaffna. Informed written consent was obtained from mothers to include their children in the study. Ethical clearance was obtained from Ethical Review Committee, Faculty of Medicine, University of Jaffna to conduct the study.

III. RESULTS

Among the total of 846 children, 414 (48.9%) were males. The mean age of the children was 34.73 (±13.1) months with minimum and maximum of 12 and 59 respectively. Baseline characteristics of the population are given in the table 1. In this study population 75.8 % of children were from rural areas. Only one fourth of the families were getting more than 30000.00 Sri Lankan rupees as monthly income.

Mean (±SD) weight of the total population (n846) was 11.97 (±2.28) kg with the range of 6.8 to 23.4 kg. Mean (±SD) height (n846) was 89.87 (±8.69) with the range of 68 to 111.50 cm. Weight and height of the children with age is given in the table 2.

Mean weight and height of the children were significantly increased with age (Chi-squred trend was applied and it was significant at P=0.05). The mean weight and height was lower in this children when compared with WHO reference population ant that was not significantly differed (p>0.05).

Table 1. Distribution of the participants based on sociodemographic factors.

	No.	%
Gender		
Male	414	48.9
Female	432	51.1
Category of age (Months)		
12-23	209	24.7
24-35	239	28.3
36-47	221	26.1
48-59	177	20.9
Sector		
Urban	205	24.2
Rural	641	75.8
Type of family		
Nucleated Family	500	59.1
Extended Family	346	40.9
Total Household members		
3	66	7.8
4	168	19.9
5	238	28.1
6	182	21.5
7	131	15.5
>7	61	7.2
Total income (Rs/Month)		
<14000	158	18.7
14000-16499	169	20.0
16500-20699	173	20.4
20700-29999	131	15.5
>30000	215	25.4
Educational levels of the father		
No Education	17	2.0
Primary Education	95	11.2
Secondary Education	656	77.5
Tertiary education	78	9.2
Educational levels of the mother		
No Education	4	0.5
Primary Education	78	9.2
Secondary Education	722	85.3
Tertiary education	42	5.0

Mean (±SD) head circumference was 48.01 (±1.65) cm with the range of 39 to 59.50 cm. Mean (±SD) Mid Upper Arm Circumference was 14.38 (±1.12) with the range of 10.5 to 18.50 cm. Mean weight, height and MUAC did not significantly differ between the male and female children while the HC significantly differed between male and female children (p=0.001).

Mean HC and MUAC with sex and age groups are given in the Tables 3 and 4 respectively. The overall prevalence of wasting, underweight, stunting and overweight were 21.6 (*n*184), 33.1 (*n*282), 26.4 (*n*223) and 3.4 % (*n*27) respectively. Among the children, 8.6 and 11.5% had less HC-for-age and less MUAC-for-age respectively.

Mean albumin concentration of the total population was 3.9g/dL (95% CI: 3.8, 4.0). The range of albumin concentration was from 2.40 to 6.00g/dL. MUAC was significantly correlated with serum albumin concentration (p=0.001: pearson's correlation coefficient=0.263). Children with low MUAC-for- age (<-2SD for age) were highly affected with anemia, protein deficiency and iodine deficiency when compare to the children with normal MUAC-for-age (Table 5).

In this study, the MUAC was significantly associated with stunting and wasting (P<0.05). Among the children with low HC-for-age (<-2SD for age), 25, 35 and 29% of the children were affected with wasting, underweight and stunting respectively.

Table 2: Mean weight and height of the children.

Ages (months)	Weight (kg)			Height (cm)		
	Boys Mean (±SD)	Girls Mean (±SD)	Total	Boys Mean (±SD)	Girls Mean (±SD)	Total
12-23	9.9 (±1.9)	10.1 (±1.9)	10.0 (±1.9)	79.2 (±5.1)	80.4 (±5.8)	79.8 (±5.5)
24-35	11.9 (±1.8)	11.4 (±2.0)	11.6 (±1.9)	88.2 (±5.2)	87.4 (±4.6)	87.8 (±4.9)
36-47	12.9 (±1.6)	12.7 (±1.5)	12.8 (±1.5)	93.6 (±9.6)	94 (±4.8)	93.8 (±7.4)
47-59	13.7 (±1.7)	13.7 (±2.2)	13.7(±2.0)	99.4 (±4.5)	99.1 (±6.0)	99.2 (±5.3)

Table 3. Mean Head Circumference (HC) based on the age and sex specific distribution of the children.

Ages (months)	Boys Mean (±SD)	Girls Mean (±SD)	t-value	p-value	Total
12-23	47.1 (±1.4)	46.8 (±1.5)	1.82	0.07	47.0 (±1.5)
24-35	48.2 (±1.4)	47.4 (±1.6)	3.6	0.001	47.8 (±1.5)
36-47	48.6 (±1.5)	48.3 (±1.7)	1.22	0.207	48.5 (±1.6)
47-59	49.2 (±1.1)	48.8 (±1.3)	2.05	0.041	49.0 (±1.2)

Table 4. Mean Mid Upper Arm Circumference (MUAC) based on the age and sex specific distribution of the children.

Ages (months)	Boys Mean (±SD)	Girls Mean (±SD)	t-value	p-value	Total
12-23	14.0 (±1.3)	13.8 (±0.9)	1.577	0.116	13.9 (±1.1)
24-35	14.3 (±1.1)	14.1 (±1.0)	1.218	0.224	14.2 (±1.1)
36-47	14.7 (±1.0)	14.6 (±1.1)	0.639	0.412	14.7 (±1.0)
47-59	14.7 (±1.0)	14.9 (±1.1)	0.286	0.362	14.8 (±1.0)

Table 5. Selected biochemical parameters and dietary protein consumption among low MUAC group and Normal group.

Parameters	Low MUAC-for-age group (n=93)	Normal group (n=753)	p-value
Albumin	3.4 (±0.52)	4.0 (±0.62)	0.001**
Haemoglobin	11.1(±1.9)	11.8(±1.8)	0.001**
Serum ferritin	28.15 (±30.50)	37.51 (±35.69)	0.018*
Urinary Iodine excretion	141.2 (±45.01)	150.86 (±54.18)	0.099
Protein consumption (g)	21.4 (±7.09)	24.51(±8.6)	0.001**

**p<0.05, **p<0.001 significant level between Low MUAC-for-age group and Normal group.*

IV. DISCUSSION

The prevalence of malnutrition among the children of Jaffna district such as height-for-age (stunting), weight-for-height (wasting), and weight–for–age (underweight) are seen higher than the prevalence of the country. A study done by Sujendran, et al, 2015, there are higher prevalence rates of stunting, wasting, and underweight among children aged 6-36 months, in the eastern province of Sri Lanka.

MUAC is the circumference of the left upper arm, measured at the mid-point between the tip of the shoulder and the tip of the elbow (olecranon process and the acromium). In children, MUAC is useful for the assessment of nutritional status WHO (1986).

The MUAC measurement requires little equipment and is easy to perform even on the most weakened individuals. Although it is important to give training to the data collectors in how to take the measurement in order to reduce inter- and intra- observer error, the technique was done properly. The use of MUAC in emergencies is, however, still controversial, and disagreement over the preferential selection of younger children, the levels of cut-off points used, the measurement is continued. Hence, in this study we used the Z-Score values to detect the low MUAC rather than using fixed cutoff values to minimize the age and sex related variation.

At present during emergencies, MUAC is only recommended for use with children between one and five years of age. It is, however, increasingly being used to assess adult undernutrition during famine. Measurements of MUAC have long been known to reflect changes in adult body weight, and the major determinants of MUAC, arm muscle and sub-cutaneous fat, are both important determinants of survival in starvation. As MUAC is less affected than BMI by the localised accumulation of excess fluid (pedal oedema, periorbital oedema, ascites), it is likely to prove to be a more sensitive index of tissue atrophy than low body weight. It is also relatively independent of height.

Ferro-Luzzi and James have proposed MUAC cut-off points for use in screening acute undernutrition. They base these on extrapolation from more normally nourished populations in developing countries, without reference to data from acutely undernourished. Although there is some evidence that the undernourished category may be associated with increased morbidity in chronically undernourished populations.

The relationship between MUAC and BMI is not constant during undernutrition and that an accelerated loss of peripheral tissue during acute undernutrition has a relatively greater depressing effect on MUAC than upon BMI. These data also suggest that during acute undernutrition the differences in MUAC between boy and girl become less pronounced, a finding supported by previous observations in more normally nourished populations.

It is likely, therefore, that in populations suffering from famine, MUAC cut-off points denoting moderate to severe undernutrition should be adjusted.

The indicator is useful for both screening undernutrition and for estimating prevalence of undernutrition at a population level. However, the children with normal MUAC might be affected with undernutrition in terms of wasting, stunting and undernutrition. But their biochemical parameters could be minimally altered.

Even though, the prevalence of wasting, stunting and underweight was high in this study based on the height and weight measurements, the prevalence of undernutrition based on the HC and MUAC were low. Even though, the prevalence of under nutrition based on the MUAC was low, the biochemical parameters were highly altered. In this study, the mean serum albumin concentration was significantly low in the children who had low MUAC than that of normal children. MUAC was significantly correlated with serum albumin concentration (p=0.001: pearson's correlation coefficient=0.263). Higher percentage of Anemia (52%), low albumin level (61%) and iodine deficiency (18%) were observed among the low MUAC-for-age children than that in normal children.

A study done by Biswas, et al., 2010 in India, the age-combined rates of overall (moderate and severe) undernutrition among boys (38.49%) was higher than among girls (32.22%). The age-combined rates of moderate undernutrition were 36.34% and 31.03% among boys and girls, respectively. The rates of severe undernutrition were 2.15% and 1.20% among boys and girls respectively. In general, there was an increasing trend in the rates of overall undernutrition in both sexes (Biswas, et al., 2010). Available evidence shows that MUAC is the best (i.e. in terms of age independence, precision, accuracy, sensitivity and specificity) case detection method for severe and moderate malnutrition and that it is also simple, cheap and acceptable. Consistently high case fatality rates in hospitalized Kenyan children of all ages between 12 – 59 months with low MUAC values, (≤ 11.5 cm) has been reported, In Guatemala, younger children tended to become upset and agitated during both height and weight measurements and that no such behavior was observed during the measurement of MUAC and HC. There are several practical and theoretical advantages of using MUAC rather than weight-for-height for the determination of nutritional status (Myatt, et al., 2006). The prevalence of undernutrition had a higher rate in this study. As well as the measurements of MUAC and head circumference (HC) are good indicators of marginal cases of protein energy malnutrition in both survey and screening programs (Singh, el al, 2005).

V. CONCLUSION

This study revealed that, the overall prevalence of undernutrition among these children was higher than that of the national data of Sri Lanka. Even though prevalence of undernutrition was observed to be low based on the MUAC and HC, the children with low MUAC were highly affected with biochemical parameters. Thus, MUAC could be the best screening assessment to detect the anthropometric as well as biochemical alteration among the children. In addition to that, HC was not associated with malnutrition. A quick screening program should be initiated to make a best integrated method in this region for the development of normal physical and mental growth of children as well as for health in later life.

REFERENCES

Alderman H, Hentschel J, Sabates R, 2003. With the help of one's neighbors: externalities in the production of nutrition in *Peru. Soc Sci and Med*; 56(10):2019-31.

Allen LH, Gillespie SR, 2001. Improving child growth: What Works? A Review of the Efficacy and Effectiveness of Nutrition Interventions, United Nations Administrative Committee on Coordination Sub-Committee on Nutrition ACC/SCN: Geneva in collaboration with the Asian Development Bank, Manila:1-123.

Biswas S, Bose K, Mukhopadhyay A, et al. 2010. Mid-upper Arm Circumference Based Undernutrition among Bengalee Children of Chapra, West Bengal, India. *Iran J Pediatr;*20(1):63-68.

de Onis M, Habicht JP, 1996. Anthropometric reference data for international use: recommendations from a World Health Organization Expert Committee. *Am. J. Clin. Nutr.*; 64:650–658.

de Onis M, 2001. Child growth and development. In: Semba RD, Bloem MW, editors. Nutrition and Health in Developing Countries. Totana, N.J: Humana Press Inc;.

de Onis M, Blössner M, 2003. The World Health Organization Global database on child growth and malnutrition: methodology and applications. *Int J Epidemiol*;32:518-26.

DHS, 2009. Demographic Health Survey: Department of Census and Statistics, Sri Lanka 2006/2007.

FANTA, 2003. Food and Nutrition Technical Assistance; Nutritional status of a population.

Fernando DAL, 1994. Prevalence and some factors influencing growth retardation of children of 6 months to 3 years in low income families in Kotte area. *Dissertation (MSc).* Colombo: University of Colombo.

Ferro-Luzzi A, James WPT, 1996. Adult malnutrition: simple assessment techniques for use in emergencies. *Br. J. Nutr.;* 75:3-10.

Joseph B, Rebello A, Kullu P, et al., 2002. Prevalence of malnutrition in rural Karnataka, South India: a comparison of anthropometric indicators. *J Health Popul Nutr.;*20(3):239-44.

Myatt M, Khara T, Collins S, 2006. A review of methods to detect cases of severely malnourished children in the community for their admission into community– best therapeutic care programs. *Food and Nutr Bull;* 27(Suppl3): S7-S23.

Osei A, Pandey P, piro D, et al, 2010. Household food insecurity and nutritional status of children aged 6 to 23 months in Kailali District of Nepal. *Food and Nutr Bull.* 31(4):483-494.

Singh S, Bisnoi I, 2005. Trend of growth in mid-arm circumference and head circumference of preschool female children of Faizabad District, U.P. *Indian J Prev Soc Med*.;36:143–6.

Spencer K, Price CP, 1977. Influence of Reagent Quality and Reaction Conditions on the Determination of Serum Albumin by the Bromcresol Green Dye-Binding Method. *Ann. Clin. Biochem.;* 14:105-115.

Sujendran S, Senarath U and Joseph J, 2015. Prevalence of Stunting among Children Aged 6 to 36 Months, in the Eastern Province of Sri Lanka, *J Nutr Disorders Ther*, 5:1.

The Mother and Child Health and Education Trust, 2015. http://www.motherchildtrust.org/

WHO, 1995. Physical status: The use and interpretation of anthropometry: Technical report series. Geneva: World Health Organization; WHO. Report No.:854.

WHO, 2006. Guidelines on Standard Operating Procedures for urinary tract infection. Guidelines on Standard Operating Procedures for Microbiology; Urinary Tract Infection. Blood Safety and Clinical Technology, April.

WHO, 2009. Methods and Development. Geneva: World Health Organization. WHO Child Growth Standards: Head circumferencefor-age, arm circumference-for-age, triceps skin fold for-age and subscapular skin fold-for-age.

WHO, 2011. Serum ferritin concentrations for the assessment of iron status and iron deficiency in populations. Vitamin and Mineral Nutrition Information System. Geneva, World Health Organization (WHO/NMH/NHD/MNM/11.2).

WHO, 1986. Use an interpretation of anthropometric indicators of nutritional status. *Bulletin of the World Health Organization* 64(6):929-941.

WHO/UNICEF/ICCIDD, 2007. Assessment of iodine deficiency disorders and monitoring their elimination: A guide for programme managers Geneva: WHO 2007. Report No.: 978 92 4 159582 7.

ACKNOWLEDGEMENTS

We would like to acknowledge all the mothers' and child who graciously agreed to participate in this study. The research assistants exhibited a high level of commitment to their work. The technical support from Department of Biochemistry, Medicine, University of Jaffna was most appreciated. This study was funded by Fonterra Brands Lanka (Pvt.) Ltd., Biyagama, Colombo, and National Research Grant, Sri Lanka 13-121).

BIOGRAPHY OF AUTHORS

Dr. K. Kandeepan is a lecturer in Biochemistry at the Faculty of Medicine, University of Jaffna, Sri Lanka. His research interests include body composition of children and adolescents, micronutrient deficiencies, nutritional intervention through dietary modification and clinical nutrition.

Dr. S. Balakumar is a senior lecturer in Biochemistry at the Faculty of Medicine, University of Jaffna, Sri Lanka. His research interests include insulin resistance, diabetes mellitus, oxidative stress and glycaemic index. He has produced many international publications to his credit. He is currently the Head of Department.

Prof. (Ms.) V. Arasaratnam is a senior professor of Biochemistry at the Faculty of Medicine, University of Jaffna, Sri Lanka. Her research interests are diabetes, glycemic index, drug addiction, nutrition, etc., She has published many international publications to her credit. She is currently the Vice-Chancellor of the University of Jaffna.