Nutritional Status of some Children and Adolescents with Down syndrome in Jeddah

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Abstract: ***Background:*** Physical growth is one of the most important aspects of child and adolescent growth. Measurements of weight and height as well as nutritional intake for each population, including Down syndrome are needed to assess their nutritional status and growth. ***Objective*:** this study was conducted to assess nutritional status of some children and adolescents with Down syndrome in Jeddah based on nutrient intake and anthropometrical characteristics. And to establish baseline data of their nutritional status in order to make their needs addressed by the society to enhance their quality of life, increase their life expectancy, realize their life aspirations and make them valued and productive members of a welcoming community. ***Study design***: Case/control study, included 30 Down syndrome cases 6-18 years. The sample was divided into two age groups, 6-<12 years and 12–18 years old. And 30 cross matched healthy control individuals. Anthropometric measures of body weight, height and calculated BMI for each Participant. And 24 hours recall method was conducted to evaluate daily dietary intake. Computer software package was used for diet analysis and compared to RDA. Statistical analysis was done by using computer software SPSS version 13. ***Results:*** Short stature was reported significantly for the majority (87%) of Down syndrome individuals compared to normal controls. While 53% of them were either overweight or obese compared to 43% of controls with no significant difference. There was significant higher consumption of macronutrients especially from carbohydrates and fats by Down syndrome cases compared to normal controls. ***Conclusions*:** Malnutrition as revealed by anthropometric variables and micronutrient deficiency is highly prevalent among children and adolescents with Down syndrome compared to normal controls. Nutrition educational programs to the children and adolescents with Down syndrome, parents and caregivers is recommended and considering physical activity adapted to the individuals age and ability.

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Introduction

Growth is one of the important tools to find out the health status of an individual. Various factors affect the growth of an individual, among them; genetic factors have a major role. Wide varieties of chromosomal instability syndromes affect the process of growth. The commonest viable autosomal aneuploidal condition, the Down syndrome (trisomy 21) seems to have a diverse degree of growth disturbances in the early infancy to adolescence period of life and also with reference to gender **(1).**

Down syndrome is a genetic condition in which there are three 21st chromosomes instead of the usual two. Most people have 46 chromosomes per cell originating from the 23 chromosomes in the mother's egg and 23 in the father's sperm. Not all people with Down syndrome have the same chromosomal arrangement, however. Ninety-five percent of people with Down syndrome (trisomy 21) have 47 chromosomes per cell (they have an extra 21 chromosome). This common type of trisomy 21 is called *non-disjunction*. Three to four percent of people with Down syndrome have *Robertsonian Translocation*, where the number of chromosomes is normal, but the extra chromosome 21 material is attached with chromosome 14. The remainders have a rare type of Down syndrome in which some of their cells have 46 chromosomes and some have 47 chromosomes. This is called *mosaicism* **(2,3).**

Down syndrome (DS) has been estimated to occur in 1 in 732 infants in the United States, with evidence that variability in prevalence of estimates exist among racial/ethnic groups **(4).**Malnutrition as revealed by anthropometric variables and micronutrient deficiency occurs with a high prevalence among mentally disabled children and almost increases with age and low socioeconomic level. Disabled people are often assumed to have poorer nutrition than their non-disabled counterparts, and they are vulnerable to poor nutritional care. This is the situation in developed

countries. In contrast, far less information is available on the nutritional status of disabled children in developing countries, where the situation is further complicated by widespread malnutrition among the general population **(5).**

Physical growth is one of the most important aspects of child and adolescent
growth. Measurements of weight and height for each population are needed to adequately monitor growth. A lower peak growth velocity in subjects with DS, resulting in lower height gains (cm/year) during puberty and in a lower final height compared to the typical population. **Cronk et al, (6)** also found that the increase in body weight exceeds height gain, resulting in an elevated body mass index. This fact may explain the high incidence of overweight and obesity among subjects with DS **(7).**

Down syndrome children were found to consume more nutrients than mentally retarded and autistic subjects. Although children with DS are born with a genetic predisposition to become overweight, obesity is actually nurtured throughout childhood when they develop food choices and become more independent **(8).**Also, Children with Down syndrome are significantly shorter than healthy children when height is expressed as percentile of National Center for Health Statistics (NCHS) growth charts **(9).**

One of the factors that possibly influence the growth retardation of subjects with DS is a deficiency in insulin-like growth factor 1 (IGF-1), the main factor responsible for the actions of growth hormone (GH). IGF-1 is mainly produced by the liver and stimulates cell proliferation and somatic growth **(10).** Zinc deficiency is another factor that may influence the growth and development of children with DS since this nutrient plays an important role in child development and growth. According to **Wilke (11),** zinc supplementation in children with mild deficiency increases appetite, growth velocity and GH, somatomedin and IGF-1 levels, and improves immunity.

Down syndrome individuals may have lower levels of vitamin A, thiamin, folate, vitamin B12, vitamin C, magnesium, manganese, selenium, zinc, carnitine, carnosine and choline; excesses of cupper, cystein, phenylalanine and superoxide dismutase are sometimes encountered **(12).** The altered zinc nutritional status of individuals with Down syndrome contributes to clinical disturbances that usually appear with aging in these patients **(13).** Health maintenance and avoidance of complications can be promoted by timely and cost-effective nutrition interventions **(14).**One of the most important components of early intervention is attaining and maintaining an optimal nutritional status of those people since early childhood. Developmental and physical limitations along with feeding difficulties can predispose children and adolescents with Down syndrome to inappropriate energy and nutrient intakes, absorption and metabolism.

This study was carried out to assess the nutritional status of Down syndrome children and adolescents in Jeddah, and to establish baseline data about their nutritional status in order to make their needs addressed by the society to enhance their quality of life, increase their life expectancy, realize their life aspirations and make them valued and productive members of a welcoming community.

2.Subject and Methods

This Case control study was approved from the student research ethical committee of applied medical sciences faculty at King Abdul-Aziz University in Jeddah, kingdom of Saudi Arabia. The study was conducted on Thirty child and adolescent (6 to 18 years' old), with Down syndrome 14 boys and 16 girls. They were recruited from the Help Center in Jeddah. And cross matched healthy control individuals from the Majestic Nursery for primary school, and relatives of the clinical nutrition department students in king Abdul-Aziz University, 15 girls and 15 boys.

Individuals with mental disabilities other than Down syndrome and Down syndrome cases combined with other disabilities were excluded from the study. Only, Children and adolescents with Down syndrome, between 6-18 years old were included in the study. After taking the parents consent. All the studied individuals were subjected to the following:

Anthropometric measurements:

1) Weight and height were measured with the subject wearing light clothing, without shoes and were recorded to the nearest 0.1kg and 0.1cm, respectively according to **Lee and Nieman, (15).**

Height-for-Age and Weight-for-Age percentiles was calculated and referred to the centres for disease control and prevention (CDC) 2000 **(16)**.

2) Body mass index (BMI) was calculated and BMI percentiles for age and sex were determined based on established centres for disease control normative curves **(16)** BMI was Categorised into the following

Criteria for body mass index:

BMI categories

Underweight = < 5^{th} Percentile

Normal weight= >5^{th} and <85^{th} Percentile

Dietary intake assessment:

Data was collected using especially designed questionnaire to cover required information on;

Daily dietary intake recorded using 24-hour recalls method **(15).**

The energy and nutrient content of the 24hour intake was quantitatively computed through the Arabian Program for Food Analysis.

The consumed nutrients were compared to the recommended dietary allowance (RDA) of protein, vitamins, minerals **(17).** Energy was compared to RDA **(18)**

Statistical analysis was done by using computer software SPSS version 13 and the Arabian Program for Food Analysis.

Data was presented as frequency distribution percent, means and standard deviation. Independent t-test & Chi-square was applied as test of significance and 0.05was used as cut-off point for significant results (significance at $p < 0.05$)

3. Results

A total of sixty participants were included in the study. They comprised thirty child and adolescent (6 to 18 years) with Down syndrome 14 boys and 16 girls. They were recruited from the Help Center in Jeddah. And cross matched healthy control thirty individuals from the Majestic Nursery for primary school, and relatives of the clinical nutrition department students in king Abdul-Aziz University, 15 girls and 15 boys.

Table (1): shows the mean weight / age percentile of the studied population regarding age and sex. Weight was significantly decreased in participant with Down syndrome compared to the controls in both sexes, 34.9±33.1 versus 66.2±32.5 respectively ($p< 0.01$). This significance was particularly seen in the age group of 6-12 years, 31.1±34.3 versus 66.8±32.2 respectively ($p<0.001$) (Table1).

Table (2): shows the mean height / age percentile of the studied population regarding age and sex. Height was highly significant decreased in Down syndrome individuals compared to the controls, 4.1±10.0 versus 56.2±31 respectively ($p< 0.000$). This was observed in all age groups of both sexes included in our study. (Table2).

Table (3): illustrate Body Mass Index as (Mean ± SD) of the studied population regarding age and sex. Calculated body mass index in Down syndrome individuals was not different statistically from controls in all age groups of both sexes included in the study. (Table6).

Table (4): percentile based anthropometric parameters (WT/age, HT/age, and BMI).

Underweight was significantly more prevalent among Down syndrome cases compared to controls ((36.7% versus 6.7% respectively) in relation to their age ($p<0.005$) (Table 7).

High prevalence of short stature was significantly observed in Down syndrome individuals (86.7%) compared to controls (none) ($p<0.000$).

There was high prevalence of overweight/obesity in Down syndrome cases (53.3%) compared to controls (43.3%) in relation to their height, with no statistically significant difference (Table 7).

Table (5): Mean and standard deviation of daily dietary intake for the total studied groups

The mean daily energy intake was significantly higher in Down syndrome participants compared to controls (2614±513 versus 1450±426 respectively) ($P<0.000$) (Table 5).

Macronutrient content of the diets (protein, carbohydrates and total fats) was significantly high in Down syndrome cases compared to controls, for protein was 68.0±20.0 vs 55±20.0 respectively, for carbohydrates was 296±66 versus 194±68 respectively and for total fats was 128±29 versus 51±18 respectively and for all macronutrient, significant level was $P<0.01$, 0.000, and 0.000 respectively (Table 5)

The daily intake of fibers was significantly high in Down syndrome cases compared to controls (13±4 versus 6±3 respectively) ($P<0.000$)

Compared with the control group, the Down syndrome subjects had lower intake of the different micronutrients, and the difference was not significant except for folate intake (11±13 versus 15±14 respectively) ($p < 0.03$).

Table (6): The distribution of the studied population according to their dietary adequacy of Kilocalories, total protein, and micronutrients compared to the recommended daily allowance (RDA)

The reported energy intake expressed as percentage of the recommended daily allowance (RDA), of the Down syndrome subjects was significantly more than that of the controls (76.7% versus 3.4% respectively), ($p<0.000$).

The reported adequacy of protein intake expressed as percentage of the RDA, of the Down syndrome group was significantly more than that of the controls. The majority of the Down syndrome subjects consumed ≥ 100% of the RDA (86.8% versus 76.7% respectively ($P<0.032$).

Both group, however consumed less than the RDA of dietary fibers, as all individuals in the study consumed less than 75% of the RDA of fibers (1g/100Kcal, Luke,1996).

The micronutrient consumption was inadequate in all studied individuals as compared to the RDA; lower calcium consumption was significantly prevalent ($p= 0.039$) in Down syndrome (83.3%) compared to controls (56.6%). However, prevalence of vitamin c consumption was significantly more in Down syndrome (56.6%) compared to controls (36.8%) (Significance level= 0.000). For vitamin A, zinc and iron, the daily intake was inadequate in relation to the RDA for the Down syndrome and control group (63% versus 60%, 100% versus 100% and 50% versus 57%) respectively (table 6).

Table (1): Mean weight / age percentile of the studied population regarding age and sex

Age group (year)	Down syndrome (n) mean ± SD	Controls (n) mean ± SD	P –value
6- <12 yrs	19 31.1±34.3	23 66.8±32.2	0.000*
12 – 18 yrs	11 41.7±31	7 66.2±36.0	NS
Sex			
Males	13 37.9±37.2	15 72.0±33.7	0.01*
Females	17 32.8±30.7	15 60.4±31.2	0.01*
Total	30 34.9±33.1	30 66.2±32.5	0.001**

P statistically significant P<0.05, P** statistically highly significant P<0.001*
NS= not significant

Table (2): Mean height / age percentile of the studied population regarding age and sex

Age group (year)	Down syndrome (n) mean ± SD	Controls (n) mean ± SD	P value
6- <12 yrs	19 4.1±8.3	23 53.8±32.6	0.000*
12 – 18 yrs	11 4.2±12.8	7 63.8±26.0	0.000*
Sex			
Males	13 8.8±14.2	15 59.6±26.6	0.000*
Females	17 0.62±0.9	15 60.4 ±31.2	0.000*
Total	30 4.1±10.0	30 56.2±31.1	0.000*

P statistically highly significant P<0.001*

Table (3): Body Mass Index (Mean ± SD) of the studied population regarding age and sex

Age group (year)	Down syndrome (n) mean ± SD	Controls (n) mean ± SD	P value
6- <12 yrs	19 18.3±4.9	23 18.3±3.9	NS
12 – 18 yrs	11 23.7±4.5	7 24.2±9.1	NS
Sex			
Males	13 19.9±4.7	15 21.96±7.0	NS
Females	17 20.6±5.9	15 17.4±3.5	NS
Total	30 20.3±5.4	30 19.7±5.9	NS

NS= non significant

Table (4): percentile based anthropometric parameters (WT/age, HT/age, and BMI).

Anthropometric category	Case(n=30) NO. %	Controls(n=30) NO. %	P- value
Under weight (< 5thcentile)	11 36.7%	2 6.7%	0.005**
Short stature (< 5thcentile)	26 86.7%	0.0 0.00	0.000**
Over weight (85-95th)/ Obese (>= 95thcentile)	16 53.3%	13 43.3%	NS

P statistically significant P<0.05, P** statistically highly significant P<0.001*
NS= not significant

Table (5): Mean and standard deviation of daily dietary intake for the total studied groups

Dietary Category	DS Cases(n=30) Mean ± SD	Normal Controls(n=30) Mean ± SD	P- value
Total calories(kcal)	**2614 ± 513**	**1450 ± 426**	**0.000****
Total protein(gm)	**68 ± 20**	**55 ± 20**	**0.013***
Carbohydrates(gm)	**297 ± 66**	**194 ± 68.0**	**0.000****
Total Fats(gm)	**128 ± 29.0**	**51 ± 18.0**	**0.000****

Fibers(gm)	**13 ±4.0**	**6.0 ±3.0**	**0.000****
Vitamin A(ug)	**359 ± 216**	**457 ± 343**	**NS**
Vitamin C(mg)	**49 ± 26**	**54 ± 38**	**NS**
Calcium(mg)	**585 ±258**	**646 ±387**	**NS**
Zinc(mg)	**1.0 ± 1.0**	**1.0 ±1.0**	**NS**
Iron(mg)	**13 ±5.0**	**15 ±10**	**NS**
Folate(ug)	**11 ±13**	**15 ±14**	**0.03**

P statistically significant P<0.05, P** statistically highly significant P<0.001*
NS= not significant.

Table (6): **The distribution of the studied population according to their dietary adequacy of Kilocalories, total protein, and micronutrients compared to the recommended daily allowance (RDA)**

Nutrient % RDA	Down Syndrome (30) No	%	Normal controls (30) No	%	P- value
Macronutrients					
Daily Caloric intake:					
< 75%	2	6.6	25	83.3	
-100%	5	16.7	4	13.3	0.000**
>100%	23	76.7	1	3.4	
Total Protein					
< 75%	2	6.6	3	10	
-100%	2	6.6	4	13.3	0.032*
>100%	26	86.8	23	76.7	
Micronutrients					
Vitamin A					
< 75%	19	63.4	18	60	
-100%	7	23.3	6	20	NS
>100%	4	13.3	6	20	
Vitamin C					
< 75%	1	3.4	17	56.6	
-100%	12	40	2	6.6	0.000**
>100%	17	56.6	11	36.8	
Calcium					
< 75%	25	83.3	17	56.6	
-100%	4	13.3	5	16.7	0.039*
>100%	1	3.4	8	26.7	
Zinc					
< 75%	30	100	30	100	
-100%	0		0		NS
>100%	0		0		
Iron					
< 75%	15	50	17	56.6	
-100%	9	30	2	6.6	NS
>100%	6	20	11	36.8	

P statistically significant P<0.05, P** statistically highly significant P<0.001*
NS= not significant

4. Discussion

Down's syndrome (Trisomy 21) is the most common autosomal aneuploidy among the well established conditions of chromosomal abnormalities. It is the most frequent and most recognizable form of mental retardation. As development is influenced / linked with growth, the growth patterns exhibit wide varieties of variations. Earlier workers have observed markedly deviated growth pattern in individuals with Trisomy-21 from that of normal, exhibiting a deficient growth rate throughout the growing phase, **(1, 19).**

Children with mental disabilities other than Down syndrome and Down syndrome(DS) cases combined with other disabilities were excluded from the study.

This study was done to assess the nutritional status of those people on the basis of anthropometric parameters and dietary intake, in order to establish baseline data about their nutritional status, and to provide insight on their nutritional needs. To our knowledge studies focusing on the nutritional status of children and adolescents with Down syndrome (DS) In Saudi Arabia, are scarce.

Regarding anthropometric parameters, in the present study, Weight for age was significantly decreased in participant with Down syndrome compared to the controls in both sexes and particularly in the younger age group (table,1) This was reflected by the higher prevalence of underweight among Down syndrome compared to controls (table,4). This may be due to decreased growth potential. Our results are in agreement with the results of **Raja et al, (1).** And also with the finding of **Clementi et al, (20)** who noted decreased weight gain in the Down syndrome group compared to controls in younger age. The Down's syndrome seems to have a diverse degree of growth disturbances up to adolescence period of life and also with reference to gender **(6).**

With respect to growth, there is consensus in the literatures that children and adolescents with DS present a height deficit when compared to the typical population **(7).**

The prevalence of short stature was higher among Down syndrome group compared to normal controls (Table,4). The individuals with Down syndrome were significantly shorter than the controls with respect to sex and age variables (Table, 2). This finding is in agreement with **Luke et al, (9).**

Short stature is a recognised characteristic of most individuals with Down syndrome. They tend to have retarded linear growth relative to children without DS. Average height at most ages is around the 2nd centile for the general population. For the majority the cause of growth retardation is not known. Some conditions leading to poor growth like nutritional inadequacy caused by feeding problems occurs more frequently among those with the syndrome **(21).** Also, it is thought to be due to factors associated with the chromosomal abnormalities and possibly, due to defects in growth hormone and insulin-like growth factor rather than nutritional deficits **(22).**

In relation to their height (BMI), Down syndrome subjects in our study were not significantly differing from controls of different age groups and of both sexes (table 3). Also prevalence of overweight/obesity was higher among Down syndrome compared to controls (table 4). Our results are going with results of **Chumlea and Cronk, (23) and Marques et al, (24).**

Individuals with DS may have an inherent metabolic risk factor for expending less total energy because of their lower resting metabolic rate, which places them at risk for developing obesity. Although children with DS are born with a genetic predisposition to become overweight, obesity is actually nurtured throughout childhood when they develop food choices and become more independent **(8).** Inactivity is a known risk factor for obesity in all people, and an emphasis on physical fitness in childhood is a recognized treatment measure **(25).**
The Down syndrome patients were less active than their siblings and spent significantly more time indoors & showing a preference for indoor activities **(26, 27).** Unfortunately, developmental and physical limitations place children with Down syndrome at greater risk for inactivity than the average child **(28, 29).**

Children with DS present growth and metabolism slower than non-DS children since these aspects contribute to a decrease in daily energy requirements. Caloric intake calculated as percentage of recommended allowance for height was somewhat less in the Down syndrome children--88.7%, compared with 95% in the siblings--but not significantly so. It is postulated that even though Down syndrome patients have been shown to be at risk for obesity, familial and other environmental factors, such as dietary control and involvement in physical activity, have an influence **(26).**

However, people with Down syndrome are not necessarily overweight in relation to their height. As with the general population, weight is influenced by environmental as well as biological factors and for most, preventive measures are both feasible and effective **(21).**

Concerning dietary intake, the Down syndrome subjects reported significantly higher daily intake of energy than that of the normal controls. This was contrary to the findings of **Luke et al, (9).** As mentioned earlier this is an additional risk factor for developing obesity in DS individuals, since they have a lower resting metabolic rate than normal people.

There are no known nutritional requirements specific to Down syndrome. Eating a healthy and balanced diet is as important for people with Down syndrome as it is for all people.

Health guidelines for individuals with Down syndrome recommended that total caloric intake should be below the recommended daily allowance for other children of similar height and age, and that physical recreation activities should be established early. Importantly, individuals with Down syndrome still need as many nutrients as everyone else, which means that food choices are very important to maintain a delicate balance of nutritional requirements

and weight management. It is important that all the calories consumed also contribute important nutrients, otherwise by limiting calorie intake there is a risk of deficiency of some important nutrients. The food guide pyramid is a good basis to guide food selection for a healthy diet **(30).**

In light of concern about macronutrient intake, our study revealed that the overall daily protein, carbohydrate and total fat intake of Down syndrome participants was significantly higher than that of the normal controls. This was confirmed by the higher prevalence of over consumption of total calories and protein among Down syndrome individuals compared to controls. Our results are in agreement with **Hopman et al, (31) and Clvert et al (32)** who also found higher intakes than recommended in Down syndrome age 1-12 years.

Although fiber intake was significantly higher in the DS cases both studied subjects consumed inadequate intake of the RDA of fiber. An increase of fiber intake is needed for almost all of the subjects and in particular for Down syndrome as they are susceptible for constipation because of overall low tone followed by lack of fiber and fluid in the diet **(30).**

Individuals with DS have significantly lower reported intakes of several micronutrients than normal ones, levels that may put them at risk for vitamin or mineral deficiencies **(9).**

In our study, Vitamin and mineral intakes were lower overall in subjects with Down syndrome than in the control subjects, except for vitamin C. This finding may be related to the feeding difficulties in patient with Down syndrome making them unable to consume adequately the fresh natural sources.

For vitamin A, our results showed unsafe consumption by more than 50% of individuals. While**, Baer et al, (33)** concluded, "Serum vitamin A levels have been reported to be lower in individuals with Down syndrome" this is possibly due to malabsorption.

For vitamin C, Down syndrome individuals significantly consumed more vitamin C than the recommended daily allowance compared to the normal controls; the same result was reported for study on institutionalized children with Down syndrome **Pruess et al, (34).** However, some studies found that many children with Down syndrome had a deficiency of vitamin C according to serum tests which correlated to dietary intakes **Van Dyke et al, (35) and Thiel (36).**

Consumption of calcium in our study was significantly unsafe among Down syndrome subjects compared to controls. On the contrary, a small study found that children with Down syndrome tended to consume more calcium than the recommended daily allowance **(34). Turkel and Nusbaum, (37)** speculated that those with Down syndrome often have disorders of calcium metabolism.

Zinc intake was deficient among all studied subjects (Table 5) and this is confirmed by the prevalence of unsafe consumption among all(100%) studied individuals(Table 6). Zinc deficiency is one factor that may influence the growth and development of children with DS since this nutrient plays an important role in child development and growth. According to **Wilke (11),** zinc supplementation in children with mild deficiency increases appetite, growth velocity and GH, somatomedin and IGF-1 levels, and improves immunity.

About 50% of the studied Down syndrome individuals was consuming inadequate iron compared to the RDA and needs further improvement. **Luke et al, (9)** observed a similar finding and a small study found that children with Down syndrome tended to consume less iron than the recommended daily allowance **(36).**

The daily folate intake of Down syndrome cases in our study was significantly lower than that of the normal controls. However both groups were consuming inadequate folate when compared to the RDA.

Children with Down syndrome often have below normal levels of folate. Erythrocyte macrocytosis is more common in children and adults with Down syndrome and may be due to an alteration of the folate remethylation pathway. As those with Down syndrome age, further declines in folate levels seem to occur **(38).**

Conclusion

Malnutrition as revealed by anthropometric variables and micronutrient deficiency is highly prevalent among children and adolescents with Down syndrome compared to normal controls. Nutrition educational programs to the children and adolescents with Down syndrome, parents and caregivers is recommended and considering physical activity adapted to the individuals age and ability. Especially involving food nutrients, immune enhancing macro and micronutrient is a logical therapy to consider when Down syndrome is present. Therefore, public health care policies should take into consideration the particularities of the DS population. In addition, new international growth curves must be constructed and consider the comorbidities associated with this population.

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