Sudan University of Sciences and Technology

College of Graduate studies

Assessment of Plasma Levels of Sodium and Potassium among Sudanese Malnourished Children in Khartoum State

تقييم مستويات الصوديوم والبوتاسيوم في البلازما لدى الاطفال السودانيين المصابين بسوء التغذية في ولاية الخرطوم

A dissertation submitted for the partial fulfillment for the requirement of M.Sc. degree in Medical Laboratory Sciences- Clinical Chemistry

By:

Nasr Eldeen Hassan Hussein Hassan

B.Sc. in medical laboratory sciences -clinical chemistry

Omdurman Islamic University

2014

Supervisor:

Dr. Nuha Eljaili Abubker

Assistant professor of Clinical Chemistry

May-2017

الآيـــــة

قال تعالى:

(وَيَسْأَلُونَكَ عَنِ الرُّوحِ قُلِ الرُّوحُ مِنْ أَمْرِ رَبِّي وَمَا أُوتِيتُمْ مِنَ الْعِلْمِ إِلَّا قَلِيلًا) .

صدق الله العظيم

سورة الاسراء (الاية رقم٨٥)

Dedication

To..................

My father ,sisters and brothers

To...................

Whom may god bless me because of her prayers...my mother

To ....

The compassionate souls which make my dreams come to

Reality .... My father

To......................

The person who denoted her time and energy helping us to

Achieving this study.......my respectful supervisor

Assistant professor : Nuha EL-jaili Abubker

To……………..

The peoples ,whom I love ,respect and appreciate

To...................

All these dedicated my study.

Acknowledgements

Thanks are first and last to Allah who enabled me to conduct this Study by the grace of him and denoted strength and patience.

Am thanking everybody who contributed to the success of this work. In particular am grateful to my supervisor: **Nuha ELjaili Abubker** for her skilful Guidance, Wisdom, enthusiastic and encouragement through the progress of this research.

To my family for their patience, encouragement and morel support during this research.

Sincere gratitude extending to my friends, colleagues and relatives who assisted me in one way or another.

Finally I thanks management and clinical laboratory staff of Mohammed AL Amin Hamid Hospital for pediatric to help me in samples collection and analysis.

Abstract

The term 'malnutrition' usually means the inappropriate intake of one or more of the nutrients essential for normal growth and development of the body.

This study was carried out to measure plasma levels of sodium and potassium in malnourished children. Sixty samples were collected from malnourished children in period between January to March 2017, chosen randomly from Mohammed AL Amin Hamid for pediatric hospital in Khartoum State, and Sixty apparently healthy individuals as control group, to assess the effect of malnutrition on plasma levels of sodium and potassium.

plasma sodium and potassium ware measure by using Easylyte electrolyte analyzer system, and results were analyzed using statistical package for social science (SPSS), computer program.

The study showed that, the plasma levels of sodium and potassium was significantly decreased in Sudanese malnourished children. Mean ± SD for cases versus control For sodium :(133.29± 5.1 versus 139.6 ±2.6 mmoL/L , p-value =0.000) and For potassium: (3.53± 0.4 versus 4.03 ± 0.38mmoL/L , p-value =0.000) . Also the finding of this study showed that, there was significantly decreased in the mean of BM I in malnourished children group compared to contra group. Mean BMI± SD for case versus control (15.28 ± 2.28 kg/m2 versus 19.25 ± 2.48 kg/m2).

The result of this study showed that malnutrition most common among age between (6-9) years (85%), and malnutrition most abundant in females (56 .7%) than males (43.3%).

Person correlation showed that, there was no correlation between age of malnourished children and the level of Sodium (r= 0.22, p-value= 0.869), and there was insignificant weak positive correlation between age and levels of potassium(r= 0.186, p-value= 0.154).

There were significant moderate negative correlation between the levels of sodium, potassium and the duration of malnourished children (r = - 0.493, p-value = 0. 000), (r = - 0. 589, p-value =0.000) respectively.

It is concluded that: the plasma levels of sodium and potassium were significantly decreased in Sudanese malnourished children.

مستخلص الدراسة

مصطلح سوء التغذية عادة يعني تناول كمية غير مناسبة من واحد أو أكثر من العناصر الغذائية الضرورية للنمو الطبيعي للجسم .

أجريت هذه الدراسة لقياس مستويات الصوديوم والبوتاسيوم في البلازما لدى الأطفال الذين يعانون من سوء التغذية. تم جمع ستين عينة من الأطفال الذين يعانون من سوء التغذية خلال الفترة من يناير إلى مارس 2017، تم اختيارهم عشوائيا من مستشفى محمد الامين حامد للاطفال في ولاية الخرطوم و 60 من الأفراد الأصحاء كمجموعة ضابطة، لتقييم تأثير سوء التغذية على مستويات الصوديوم والبوتاسيوم في البلازما.

تم قياس مستويات الصوديوم والبوتاسيوم باستخدام جهاز ايزي لايت ، وتم تحليل النتائج باستخدام الحزمة الإحصائية للعلوم الاجتماعية (SPSS)، برنامج الكمبيوتر.

وأظهرت الدراسة أن مستويات البلازما من الصوديوم والبوتاسيوم انخفضت بشكل ملحوظ في الأطفال السودانيين الذين يعانون من سوء التغذية. " المتوسط ± الإنحراف المعياري للمرضى مقارنة بمجموعة التحكم ". بالنسبة للصوديوم: (133.29 ± 5.1 مقابل 139.6 ± 2.6 ملي مول / لتر،وكان الاحتمال الاحصائي للمقارنة 0.000). و للبوتاسيوم: (3.53 ± 0.4 مقابل 4.03 ± 0.38ملي مول/ لتر ، وكان الاحتمال الاحصائي للمقارنة 0.000).

كما أظهرت نتائج الدراسة أن هناك انخفاض معنوي في مؤشر كتلة الجسم لدى الأطفال الذين يعانون من سوء التغذية مقارنة بمجموعة التحكم. متوسط مؤشر كتلة الجسم ± الإنحراف المعياري للمرضى مقارنة بمجموعة التحكم (15.28 ± 2.28 كجم / م 2

وأظهرت نتائج الدراسة أن معدل الإصابة بمرض سوء التغزية اكثر شيوعا بين سن (6-9) سنوات (85%)، وسوء التغذية اكثر شيوعاً لدى الإناث (56.7٪) مقارنة بالذكور (43.3٪). كما أظهر مستوى المعنوية ليس هناك علاقة معنوية بين عمر الأطفال الذين يعانون من سوء التغذية ومستويات الصوديوم (معامل بيرسون للإرتباط=0.22،مستوى المعنوية=0.869)، واوجد هنالك علاقة غير معنوية ايجابية ضعيفة بين عمر الأطفال الذين يعانون من سوء التغذية ومستويات البوتاسيوم (معامل بيرسون للإتباط=0.186،مستوى المعنوية=0.154). كان هناك ارتباط معنوي متوسط سالب بين مستوى الصوديوم و البوتاسيوم ومدة إصابة الأطفال بمرض سوء التغذية (معامل بيرسون للإتباط=-0.493،مستوى المعنوية=0.000)،(معامل بيرسون للإتباط=-0.589،مستوى المعنوية=0.000) علي التوالي.

وخلصت الدراسة إلى أن مستويات البلازما من الصوديوم والبوتاسيوم انخفضت بشكل ملحوظ لدى الأطفال السودانيين الذين يعانون من سوء التغذية.

List of contents

List of table

List of figures

List of abbreviation

BMI	Body mass index
CNS	Central nervous system
FFMI	Fat Free mass index
ISE	Ion selective electrode
K +	Potassium
Na+	Sodium
mmol/L	Milimole per liter
WHO	World Health Organization

Chapter one

Introduction

1.1. Introduction:

Malnutrition is generally a nutritional problem that results from varying proportion of protein and calories deficiency in infant and young children and is a complicating factor for other illnesses in developing countries. Malnourished children have more severe diarrhea, which lasts longer. The prevalence of diarrhea is 5-7 times more in malnourished as compared to normal children and its severity is 3 to 4 times greater in malnourished children as compared to normal children (Mubarak *teal*., 2003).

In malnutrition various abnormalities occur in body electrolytes, which become more marked if accompanied by diarrhea diseases. Electrolytes are ionized molecules found through out the blood, tissues and cells of the body. Their mole is either positive or negative and they conduct an electric current and help to balance pH and acid base level in the body. They also facilitate the passage of fluid between and within cells through process of osmosis and play a part in regulating the function of neuromuscular, endocrine and excretory systems.

The main plasma electrolytes are sodium and potassium. Sodium, is helps to balance fluid level in the body and facilitate neuron functioning. Potassium is the main component of cellular fluid and helps to regulate neuromuscular function and osmotic pressure. Both malnutrition and electrolyte disturbances are considered to be risk factors for death among children with diarrhea (Uysal *etal*. 2000).

1.2. Rationale:

Malnutrition is a major problem globally (Mesham and chatterjee ,1999). It interacts with diarrhea in a vicious circle leading to high morbidity and mortality in children in developing countries, Sudan being one of developing countries and malnutrition is widely distributed among children.

Malnutrition is an important public health problem, however little information is available on assessment for severe acute malnutrition so it is very important to evaluate essential parameters of electrolytes.

To my knowledge there are few published studies about this in Sudan, so this study may help to provide the monitoring of sodium and potassium in malnourished children.

1.3. Objectives:

1.3.1- General objective:

To assess plasma levels of sodium and potassium in Sudanese malnourished children in Khartoum state.

1.3.2- Specific objective:

1- To measure plasma levels of sodium and potassium in malnourished children and control group.

2- To compare mean concentration of sodium, potassium and BMI in both study groups.

3-To correlate between sodium and potassium and study variables (age and duration).

Chapter Tow

Literature review

2. Literature review

2.1. Malnutrition:

Malnutrition is a broad term that can be used to describe any imbalance in nutrition; from over-nutrition often seen in the developed world, to under-nutrition seen in many level hoping countries, but also in hospitals and residential care facilities in developed nations. Malnutrition can develop as a consequence of deficiency in dietary intake, increased requirements Associated with a disease state, from complications of an underlying illness such as poor absorption and excessive nutrient losses, or from a combination of these aforementioned factors (Soetrs *etal* ., 2008).

2.1.1. Protein energy malnutrition:

Protein Energy Malnutrition (PEM) results when the body's need for protein, energy or both cannot be satisfied by the diet. It includes a wide spectrum of clinical manifestations conditioned by:

i) The relative severity of protein or energy deficit

ii) The severity and duration of the deficiencies.

iii) The age of the host

iv) The cause of the deficiency

v) The association of the deficiency with other physiological problems such as infectious diseases and pregnancy (Torun and Chew, 1994).

Protein Energy Malnutrition (PEM) or protein calorie malnutrition (PCM) generally referred to simply as malnutrition is an imbalance between the supply of protein and energy and the body's demand for them to ensure optimal growth and function (WHO, 1997).

The World Health Organization (WHO) defines Protein Energy Malnutrition as "the cellular imbalance between the supply of nutrient and energy and the body's demand for them to ensure growth, maintenance and specific function (Pauline, 2008). Protein Energy Malnutrition (PEM) or Protein calorie malnutrition is also a deficiency syndrome caused by inadequate intake of macro-nutrients as well as micro-nutrients (Pauline, 2008). It is a syndrome that represents one of the various levels of inadequate protein and or energy intake between starvation (no food intake) and adequate nourishment.

2.1.1.1. Types of Protein Energy Malnutrition:

Clinically PEM has four forms. These forms depend on the balance of non-protein and protein sources of energy. The origin of these three forms can be primary, when it is the result of inadequate food intake or secondary, when it is the result of other diseases that lead to low food ingestion, inadequate nutritional absorption or utilization and or increased nutrient losses. Also these forms of PEM can be graded as mild, moderate or severe (Pauline, 2008).

A-Under nutrition:

Under nutrition is a consequence of consuming little energy and other essential nutrients or using or excreting more rapidly than they can be replaced. This state of malnutrition is often characterized by infectious and diseased children who are already under nourished can suffer from protein energy malnutrition who rapid growth , infectious or disease increases the need for protein and essential nutrients (Pauline, 2008).

B - Marasmus :

This is the dry, thin desiccated form of PEM. It results from near starvation with deficiency of energy, protein and non protein nutrients. The marasmic individual consumes very little food. In children it is often because the mother is unable to breastfeed. Marasmus is characterized by stunted growth. Usually the children are thin from loss of muscle and body fat. It develops in children between 6-12 months who have been weaned from breast milk or who are suffering from weakening conditions like chronic diarrhea (Pauline, 2008).

C- Kwashiorkor:

This is the wet edematous and swollen form. "Kwashiorkor" is a Ghanaian word meaning "first child-second child". It refers to the observation that this is a disease the first child develops when the second child is born and replaces the first child at the breast. This is because the weaned child is fed with a thin gruel of poor nutritional quantity compared with breast milk and as a consequence the child fails to thrive. This condition is marked with protein deficiency more marked than energy deficiency, and Oedema results. Children with Kwashiorkor tend to be older than those with marasmus and tend to develop the disease after weaning. Adults develop kwashiorkor as a result of under-nutrition from diets rich in carbohydrate than protein. This may be as a result of poverty, wars, famine etc. Kwashiorkor is characterized by fluid retention, oedema, dry peeling skin, hair discolorations, etc (Pauline, 2008).

D- Marasmic Kwashiorkor :

This is the combined form of the Protein Energy Malnutrition. It is a combination of chronic energy deficit and chronic or acute protein deficiency. Children with this form of PEM have some oedema and or body fat than those with maramus . The clinical manifestation is a combination of maramus and kwashiorkor (Stanfield *et al.* ,1978).

2.1.1.2. Classification of Protein Energy Malnutrition :

The classification scheme for PEM is useful for diagnosis and treatment as well as the application and evaluation of public health measures. Several methods have been suggested for the classification of PEM. The choice of classification depends on the purpose for which it is used, e.g. clinical studies or community surveys.

There are three main classifications of PEM based on clinical and anthropometric assessments.

a) The welcome classification

b) The water-low classification

c) The Gomez classification

In order to understand these classifications, it is necessary to have a knowledge of the central chart system on which they are based **(**Stanfield *etal*.,1978) .

A- Welcome Classification :

This was proposed by the Welcome Working Party. In this classification reduction in body weight below 80 percent of the Harvard Standard (50th Centile) is considered malnutrition. There is also the presence and absence of oedema as well as deficit in body weight. Therefore children with oedema with weight 60-80 percent of the expected weight for age are classified as suffering from kwashiorkor (Welcome , 1970). Those without oedema and who weigh less than 60 percent of the standard are considered as marasmic. Those with oedema and body weight less than 60 percent of the standard are diagnosed marasmic kwashiokor. However, children without oedema weighing 60-80 percent of the standard weight are classified as underweight. The Welcome classification is the most generally accepted and widely used for clinical purposes (See Table 2.1).

Table (2.1): Welcome Classification of Malnutrition :

MALNUTRITION	**BODY WEIGHT % OF STANDARD**	**OEDEMA**
Underweight	80-60	-
Marasmus	<60	-
Kwashiorkor	80-60	+
Marasmic kwashiorkor	<60	+

50th Centile of Harvard Standard (Welcome , 1970).

B - Gomez Classification:

The Gomez classification is based on the deficit in weight for age and the 90 percent of the Harvard Standard is used as cut-off point from normal to malnourished. Malnutrition is subdivided into three degrees, first, second and third degree malnutrition(Gomez, 1956).

First degree malnutrition is defined as 75-90 percent; second degree is defined as 60-75% while third degree is defined as less than 60% of expected weight as illustrated Table 2.2. All cases of oedema are included in third degree malnutrition regardless of body weight.

The Gomez classification is useful for community surveys and helps to access the magnitude of the problem in a community. However it does not indicate the duration or types of malnutrition (Table 2.2).

Table (2.2): Gomez Classification of Malnutrition (Gomez, 1956).

MALNUTRITION	BODY WEIGHT (% of standard)
First degree	75-90
Second degree	60-75
Third degree	<60

C-Water Low Classification:

Water low described a classification of malnutrition using both weight and height for age. This classification is useful in that it distinguishes those children with acute malnutrition (wasting) from those with chronic under-nutrition who are stunted. It also assesses the relationship between weight and height in early childhood which is reasonably constant as indicated in (Table 2-3). Water low suggested the terms “wasting” for a deficit in weight and “stunting” for a deficit in height for age **(**Stanfield *etal* .,1978).

Therefore patients fall into four categories:

1) Normal

2) Wasted but not stunted (suffering from acute PEM)

3) Wasted and stunted (suffering from acute and chronic PEM)

4) Stunted but not wasted (nutritional dwarfs with past PEM with present adequate nutrition)

The disadvantage of this method is that, although height is a far more accurate reflection of growth in the long term, it is often difficult to measure accurately in community surveys. There is also the tendency to place the genetically or constitutionally small child or premature infants into the category of malnutrition **(**Stanfield *etal*.,1978) .

Table(2.3): Water low Classification of Malnutrition (Stanfield *etal*.,1978).

Height for age >80%		**Weight for Age** <80%
>90%	Normal	Wasted
<90%	Stunted	Stunted and wasted

2.1.1.3. Causes :

Inadequate food intake, infections, psychosocial deprivation, the environment (lack of sanitation and hygiene),social inequality and perhaps genetics contribute to childhood malnutrition(Pauline, 2008).

2.1.1.4. Clinical signs and symptoms of protein-energy malnutrition (PEM):

A- Main symptom:

The main symptom of malnutrition (under nutrition) is unintended weight loss, although this isn't always obvious (Pauline, 2008).

Most people who are malnourished will lose weight, but it is possible to be a healthy weight or even overweight and still be malnourished.

Someone could be malnourished if:

They unintentionally lose 5-10% of their body weight within three to six months their body mass index (BMI) is under 18.5 (although a person with a
Under 20 could also be at risk) (Pauline, 2008).

B- Other symptoms:

* reduced appetite.
* Lack of interest in food and drinks.
* Feeling tired all the time.
* feeling weaker.
* getting ill often and taking a long time to recover.
* wounds taking a long time to heal .
* Poor concentration.
* feeling cold most of the time.
*low mood or depression (Pauline, 2008).

C-Symptoms in children:

Symptoms of malnutrition in a child can include:

* not growing at the expected rate or not putting on weight as would normally be expected (faltering growth).
* changes in behavior, such as being unusually irritable, slow or anxious .
* low energy levels and tiring more easily than other children .

Clinical signs and symptoms of micronutrient deficiencies: Some of the clinical signs and symptoms of specific micronutrient deficiencies may closely resemble those observed in PEM. Deficiencies of micronutrients, including vitamins, minerals, and trace elements have been well described. The most common and clinically significant deficiencies include the following:

- Iron - Fatigue, anemia, decreased cognitive function, headache, glossitis , and nail changes.
- Iodine - Goiter, developmental delay, and mental retardation.
- Vitamin D - Poor growth, rickets , and hypocalcaemia
- Vitamin A - Night blindness, xerophthalmia, poor growth, and hair changes
- Folate - Glossitis, anemia (megaloblastic), and neural tube defects (in fetuses of women without folate supplementation)
- Zinc - Anemia, dwarfism, hepatosplenomegaly, hyper pigmentation and hypogonadism , acrodermatitis enteropathica , diminished immune response, poor wound healing(Pauline, 2008).

2.1.1.5. Diagnosis of malnutrition:

A- Weight loss:

Weight loss trajectories differ with clinical condition. Nevertheless, involuntary weight loss is a strong predictor of negative (Who ,1995)
outcomes irrespective of magnitude, speed and underlying cause.
Naturally, a massive and fast weight loss due to an aggressive cancer disease imposes a higher risk than a smaller and slower weight loss due to ageing.
Thus, consensus was reached to propose two optional cut-offs for unintentional weight loss; i.e. either >5% over the last 3 months to cover for acute illnesses, or >10% of habitual weight indefinite of time to be relevant for chronic conditions (Who ,1995).

B- Body mass index [BMI] :

WHO advocates BMI <18.5 kg/m2 as a general cut-off for underweight.

This cut-off is justified at a public health population Level l (Who,1995) ,whereas its relevance for clinical and care settings may be questioned. As already mentioned the trend of increasing BMI in all populations world-wide make this acknowledged BMI cut-off value difficult to use for the purpose of defining malnutrition. Patients struck with highly catabolic diseases may in 3e6 months lose substantially more than 10% of their weight and still have BMI values well above “normal” ranges. Another issue to consider is that epidemiological evidence indicates that older populations display higher optimal BMI intervals (e.g. for survival) than younger people (Who,1995) .

Partly due to the strong global acceptance of the WHO cut-off of 18.5 kg/m2 it was decided unanimously to accept the WHO recommended cut-off of as a criterion that in its own right will be enough to diagnose malnutrition.

With this latter decision it was easy to come to consensus for a complementary suggestion for relevant BMI cut-off values; namely <20 kg/m2 for subjects <70 years of age, and <22 kg/m2 for subjects 70 years and older, remembering the fact that these BMI levels need to be linked to weight loss as defined above. The choices of 20 and 22 kg/m2, respectively, were based on consensus in the group. Ethnic and regional variability in BMI may need to be considered (Who,1995) .

C- Fat Free mass index [FFMI]:

Cut-offs for FFMI need to be linked to the decided cut-offs for BMI on one hand, and to the fact that women have lower FFMI (and higher FMI) than men on the other hand. Based on Swiss reference material (Schutz , *etal* ., 2002) .

it was decided to suggest FFMI <15 and <17 kg/m2 in women and men, respectively. It has to be emphasized that reference values, like for BMI, should be relevant for the specific ethnic and cultural context that is at hand (Schutz, *etal* ., 2002) .

D- Biochemical Methods:

Serum biochemical markers are primarily and non proteins used in establishing the nutritional status of patients. They are used to determine whether they are at risk of complications and also in monitoring their nutritional treatment (Heymsfield *etal*., 1994).

2.1.1.6. Prevention of Malnutrition:

Poverty, Ignorance, frequent infection, cultural norms/customs, severe cyclic climatic conditions, natural and man made disasters are among the main causes of PEM. Therefore, its control and prevention require multi-sectoral approaches that include food production and distribution, preventive medicine, education, social development and economic improvement. At a national or regional level, control and prevention can only be achieved through short-term 41 and long-term political commitments and effective actions to enforce the measure to eradicate the underlying causes of malnutrition(Who,1995).

The most likely victims of PEM are children and women, especially those within child- bearing age from low socioeconomic strata. Children whose parents have misconceptions concerning the use of food, who come from broken or unstable families, whose families have a high violence, alcoholism and drug abuse, who live under poor sanitary conditions in urban slums or in rural areas frequently subject to droughts or floods, whose societal beliefs prohibit the use of nutritious foods. Special attention must be given to the following for the prevention of PEM (Who, 1995) .

2.2. Sodium:

Sodium is the most abundant cation in the extra cellular fluid representing 90% of all extra cellular cations and largely determined the osmolality of The plasma . Plasma sodium concentration depends greatly on the intake and execration of water and to a lesser degree renal regulation of sodium(Nasir, 2003).

Three processes are of primary importance in regulation of sodium Concentration:

-The intake of water in response to thirst stimulated or suppressed by plasma osmolality.

- The excretion of water, largely affected by anti diuretic hormone release in response to change in either blood volume or osmolality.

- Blood volume status which affects sodium excretion through aldosterone, angiotensin II and antindiureticprotein. The kidney has the ability to conserve or excrete large amount of sodium depending on sodium contents of the extra cellular fluid and the blood volume.

Normally 60%-75% of filtrated sodium is reabsorbed in proximal tubule, electro neutrality is maintained by either Cl-reabsorption or H+ ion secretion .Some sodium is also reabsorbed in the loop of henle and distal tubules and under control of aldosterone is exchanged for potassium in the connecting segment and cortical collecting tubules (Nasir, 2003).

2.2.1. Hypernatremia:

Increase plasma sodium concentration (> 150mmol/L) occurs whenever there is an excess sodium in relation to water. Always reflect hyperosmolarity, with the danger of cellular dehydration .There are numerous causes of hypernatremia. (Nasir, 2003) .

Hypernatremia is caused by:

- Increased sodium intake.

*Increase dietary intake: if sodium usually in the form of salt it ingested at high quantities without adequate free water, hypernateremia will occur.

*Excessive sodium in intravenous fluids: the normal kidney can excrete about 450-500 mEq of sodium per day if intake of sodium exceeds that amount in apatient without ongoing losses or aprior sodium deficit.

Sodium level can be expected to rise (Nasir, 2003).

Decreased sodium loss:

* Cushing syndrome: corticosteroids have an aldosterone like effect.

*Hyperaldosteronism: aldosterone stimulates the kidney to absorb sodium at the level of sodium tubules.

Excessive free body water loss:

*Gastrointestinal loss (without rehydration): if free water is lost residual sodium becomes more concentrated.

*Excessive sweating: Although sweat contains some sodium most is free water, this cause the serum sodium to become more concentrated. If the water loss is replaced without any sodium, the sodium dilution and hypernatremia can occur.

*Diabetes insipidus: deficiency of antidiuretic hormone and the inability of the kidney to respond to antidiuretic hormone cause large free water loss and sodium become concentrated. (Carl and Burtis ,2002)

- In certain stage of pregnancy steroid hormone causes sodium retention as well as water which result in gain in weight. (A C DEB,2008)

In those situations sodium level increases, if however free water is therapeutically provided, sodium levels may become diluted and hypernatremia may occur. (Mosby□s,2006) .

2.2.1.1. Symptoms of hypernatremia:

Symptoms of hypernatremia involve: the CNS due to hyperosmolar state, these symptoms include: altered mental status, lethargy, irritability restlessness, seizures, muscle twitching, hyper reflexes, fever, nausea or vomiting and increased thirst. Serum sodium more than 160 mmol / L is associated with increased mortality by 60%to 75%(Bishop, 2000).

2.2.2. Decreased level of sodium (hyponatremia):

A decreased plasma sodium concentration (<136 mmol/L) can occur when there is a loss of both sodium and water. This happens with some diseases of the liver and kidney, in patient with congestive heart failure, in burn victims (Nasir, 2003).

2.2.2.1. Causes of hypornatremia :

-Decreased sodium intake

* Deficient dietary intake: sodium intestinal absorption is highly efficient, deficiency of salt is rare.

- Increased sodium loss:

*Addison's disease: caused by inadequate level of aldosterone and corticosteroid hormones, sodium is not reabsorbed by the kidney and is lost in the urine.

* Diarrhea, vomiting or nasogastric aspiration: sodium in the gastro intestinal content I lost with the fluid, hyponateremia magnified if intravascular fluid replacement does not contain adequate amount of Sodium .

* Diuretic administration: many diuretics work by inhibiting sodium reabsorption by the kidney, and level can be diminished or decreased.

* Chronic renal insufficiency: if the kidney losesitreabsorptive capability, large quantities of sodium will be lost with urine.

* Large volume aspiration of pleural or peritoneal fluid: sodium concentration is the same in body fluid, in these fluids, the aspiration of these fluids is compensated by secretion of anti diuretic hormone, which acts to increase renal reabsorption of free water and sodium will become diluted(Carl and Burtis,2002).

Increase free body water :

* Excessive oral water intake.

* Hyperglycemia: each 60mg/100ml increase of glucose above normal decreases sodium by 1mEq /L, since osmotic effect of glucose pulls free water from the extracellular space and dilute sodium.

* Excessive intravenous water intake: when intravenous therapy provides less sodium than normal range or volume and ongoing losses, sodium will be diluted.

* Congestive heart failure.

*preipheral edema: the condition are associated with increase free water retention, sodium is diluted.

*Ascitis.

* Pleural effusions.

* Intraluminal bowel loss (Carl and Burtis,2002).

- Adrenocortical steroids which regulate the metabolism of sodium .In the insufficiency of adrenocortical steroids, the serum sodium level is decreased with an increase in sodium excretion (A cdeb, 2008).

Syndrome of inappropriate or ectopic secretion of antidiuretic hormone, over secretion of antidiuretic hormone stimulates the kidney to reabsorb free water. Sodium is diluted(Mosby□s,2006).

2.2.2.2.Symptoms of hyponatremia:

Depending on the serum level, between 125mmol/l and 130 mmol/l, symptoms are primarily gastrointestinal; below 125 mmol/l more severe neuropsychiatric symptoms are seen. In general, symptoms include nausea, vomiting, muscular weakness, headachy, lethargy and ataxia. More severe symptoms include seizures, coma and respiratory depression (Bishop, 2000) .

2.3. Potassium (K +) :

Potassium is the most major cation within the cell. the intracellular potassium concentration is approximately 150 mmol/L , where the normal serum concentration approximately 4 mmol/L , this ratio is most important determinant in maintaining membrane electrical potential , specifically in neuromuscular tissue , because serum concentration of potassium is so small , minor changes in concentration have significant consequences (Carl , 2002) . Potassium is excreted by kidney, there is no reapportion of potassium from the kidneys, therefore if potassium is not adequately supplied in the diet or by intravenous administration, in a patient who is unable to eat ,serum potassium level can drop rapidly Potassium is an important part of protein synthesis and maintenance of normal oncotic pressure.

It contribute to the metabolic portion of acid -base balance in that the kidneys can shift potassium for hydrogen ions to maintain a physiologic ph. serum potassium concentration depending in many factors:

-Aldosterone (and to a lesser extent glucocorticosteriods) this hormone tends to increase renal loss of potassium.

- acid- base balance: alkalotic states tend to lower serum potassium level by causing a shift of potassium into the cell, acidotic state tends to raise serum potassium levels by reversing that shift.

-Sodium reabsorption: as sodium is reabsorbed, potassium is los (Carl , 2002).

2.3.1. Hyperkalemia:

Increase plasma potassium concentration (>5mmol/l) is a result of redistribution, increase intake, or increased retention. In addition, preanalytical condition such as: hemolysis, thrompocytosis (>106 /µL) and leuokocytosis (>105 /µL) (Carl , 2002).

2.3.1.1. causes of hyperkalemia:

- Excessive dietary intake.
- Excessive intravenous intake.

Because the amount of potassium in the serum is so small minimal but ignificant increase in potassium intake cause elevation in serum level.

-Acute or chronic renal failure: this is the most common cause of hyperkalemia, otassium excretion is diminished and potassium level rise(Carl , 2002).

- Addison disease.
- Hypoaldosteronism.
- Aldosteron _inhibiting diuretics (spironolactone)
- Crush injury to tissue.

-Hemolysis

-Transfusion of hemolyzed blood.

-Infection: potassium exists in high level in the cell with cellular injury and lyses the potassium within the cell is released into the blood stream.

- Acidosis

-Dehydration: potassium becomes more concentrated in dehydrated patients and serum level appears elevated, when the patient is rehydrated potassium levels may in fact be reduced (Carl , 2002).

2.3.2. Hypokalemia :

Decrease plasma potassium concentration (<3.5mmol/l).

2.3.2.1. Causes of hypokalemia:

-Deficient dietary intake

- Deficient intravenous intake.

The kidneys cannot reabsorb potassium to compensate for the reduced potassium intake and potassium level declines.

-Gastrointestinal disorders (e.g.: diarrhea, vomiting)

- Diuretics: this medication act to increase renal excretion of potassium.

-Hyperaldesteronism : aldosterone imbalance potassium excretion.

-Cushing's syndrome: glucocorticosteroid have an aldosterone like effect.

- Renal tubule acidosis: renal excretion increased.

- Licorice ingestion: licorice has an aldosterone like effect.

-Alkalosis: to maintain physiological pH during alkalosis, Hare driven
out of the cell and into blood (Carl, 2002).

-Insulin administration: in patient with hyperglycemia, if insulin administrated, glucose and potassium will be driven into the cell, and potassium level drops (Carl, 2002).

2.4 .Relationship between plasma electrolytes (sodium and potassium) and malnutrition

Electrolyte changes were commonly seen in grade II and III
malnourished patients particularly who presented with diarrhoeal episode of variable duration. If these changes are diagnosed in time and treated appropriately the morbidity and mortality could be decreased (Yasmeen *etal* ., 2007).

serum electrolytes disturbances in malnourished children are obvious during diarrheal illness particularly in those patients with Grade III Malnutrition irrespective of Age and duration of Diarrhea. Measurement of these Serum electrolytes is helpful for immediate therapy to avoid serious life threatening situations (Arif *etal* . ,2015).

Chapter Three

Materials and methods

3. Materials and Methods

3.1. Materials:

3.1.1. Study approach:

A quantitative methods were used to estimate sodium and potassium levels in Sudanese malnourished children in Khartoum state during the period from January to may 2017.

3.1.2. Study design:

This is a cross sectional hospital base case control study.

3.1.3. Study area:

This study was conducted in Mohammed AL Amin Hamid for pediatric hospital in Khartoum State.

3.1.4. Target population:

The study was included malnourished children (males and females).

3.1.5. Sample size:

A total of 120 samples were included in this study, 60 malnourished children as cases and 60 apparently healthy subjects serve as control (age and sex match with test group).

3.1.6. Inclusion criteria:

Sudanese Malnourished children aged from 6 - 17 year old, with or without diarrhea and apparently healthy children serve as control were included in this study.

3.1.7. Exclusion criteria:

Malnourished children under 6 year or older than 17 year and Patients with liver disease, diabetes, vomiting, bone disease and how take cancer treatment were excluded.

3.1.8. Ethical consideration:

Oral Consent was taken from parents of children to participate in the study and reassurance of confidentiality. Before the sample was collected, the donors knew that this specimen for research and the purpose of the research was explained to each patient.

3.1.9. Data collection:

The clinical data were obtained from history. Clinical examinations and hospital follow up records and were recorded on a questionnaire sheet.

3.1.10. Sample collection and processing:

About 4 ml of venous blood were collected from each participant (both cases and control). The samples collected under aseptic conditions and placed in sterile heparin containers and after mixing centrifuged for 5 minutes at 3000 rpm to obtain plasma, then the plasma were kept at $^{-}20^{o}C$ till the time of analysis.

3.2. Methods:

3.2.1. Estimation of Na+ and K+ levels:

3.2.1.1. Principle of method (ISE):

An Ion selective electrode consists of a detector electrode and an Electrically conductive membrane which separates the sample solution of Unknown activity from a solution of fixed ion activity which fills the Electrode. A difference in ionic composition of the two solutions causes an Electrical potential difference to develop across the membrane, change in Potential across the selective membrane are measured with respect to a Reference electrode. The potential of which is constant. The change in Potential difference between the reference electrode and the ion selective Electrode for the sample is proportional with the potential difference for a Calibration solution of known composition (Tietz, 1987).

3.2.1.2. Procedure of Na+ and K+ measurement. (Appendix II)

3.2.1.3. Calculation of analyte concentration:

The analyzer automatically calculate the analyte concentration voltmeter This measure the potential developed, sodium and potassium result Were appear in the screen as digital number.

3.3. Quality control:

The precision and accuracy of all methods used in this study were checked by commercially prepared control sample before its application for the measurement of test and control samples .

3.4. Data analysis:

Data was analyzed to obtain means standard deviation and correlation of the sampling using statistical package for social science (SPSS) computer

Programmed version 11.5, t test and person correlation were used for comparison and correlation **.**

Chapter Four

Results

4. Results

The results of biochemical parameters of plasma sodium and potassium in malnourished children are given in tables and Figures:

Table (4-1): Show age distribution in case group , (85%) of patient between (6-9) years ,(8%) between (10-13) and (7%) between (14-17) years and gender distribution in case group , (56.7%) of patients were females while (43 .3%) were males.

Table (4-2) : illustrate mean concentration of sodium and potassium in patients and control groups. The levels of sodium and potassium were significantly decreased in malnourished children compared to control group.(mean ± SD: 133.29± 5.1 versus 139.6 ±2.6 mmoL/L: 3.53± 0.4 versus 4.03 ± 0.38mmol/L respectively.) p .value <0.05.

Table (4-3) : Mean of BMI in malnourished children compared to control group, there was significantly decreased in BMI in patients compared to control group. (Mean ± SD: 15.28 ± 2.28 kg/m2 versus 19.25 ± 2.48 kg/m2) .

Figure (4-1): Show correlation between the level of sodium and age of malnourished children, there was no correlation (r= 0.22, p-value= 0.869).

Figure (4-2): Show correlation between the level of potassium and age of malnourished children, there was insignificant weak positive correlation (r= 0.186, p-value= 0.154).

Figure (4-3): Show correlation between the sodium level and duration of malnourished children, there was moderate negative correlation. (r = - 0.493, p-value = 0. 000).

Figure (4-4): Show correlation between the potassium level and duration of malnourished children, there was moderate negative correlation. (r = - 0. 589, p-value =0.000) .

Table (4-1): Age and gender distribution in case group.

Variables	Number	Percent%
Age 6-9	51	85%
Age 10-13	5	8%
Age 14-17	4	7%
Males	26	56.7%
Females	34	43.3%

Table (4-2):Mean of plasma levels of sodium and potassium in malnourished children and control group.

Variable	Patients N=60 Mean ± SD	Controls N=60 Mean ± SD	p. value
Sodium(mmoL/L)	133.29 ± 5.1	139.6 ± 2.6	0.000
Potassium(mmoL/L)	3.53 ± 0.41	4.03 ± 0.38	0.000

*Result given in mean ± SD.

* P-value ≤ 0.05 Consider significant.

Table (4-3): Mean of Body mass index (BMI) in malnourished children and control group.

Variables	Patients N=60 Mean ± SD	Control N=60 Mean ± SD	p-value
BMI (Kg/m2)	15.28 ± 2.28	19.25 ± 2.48	0.000

* Result given in mean ± SD, P.value ≤ 0.05 consider significant .

* Independent sample T test was used for comparison

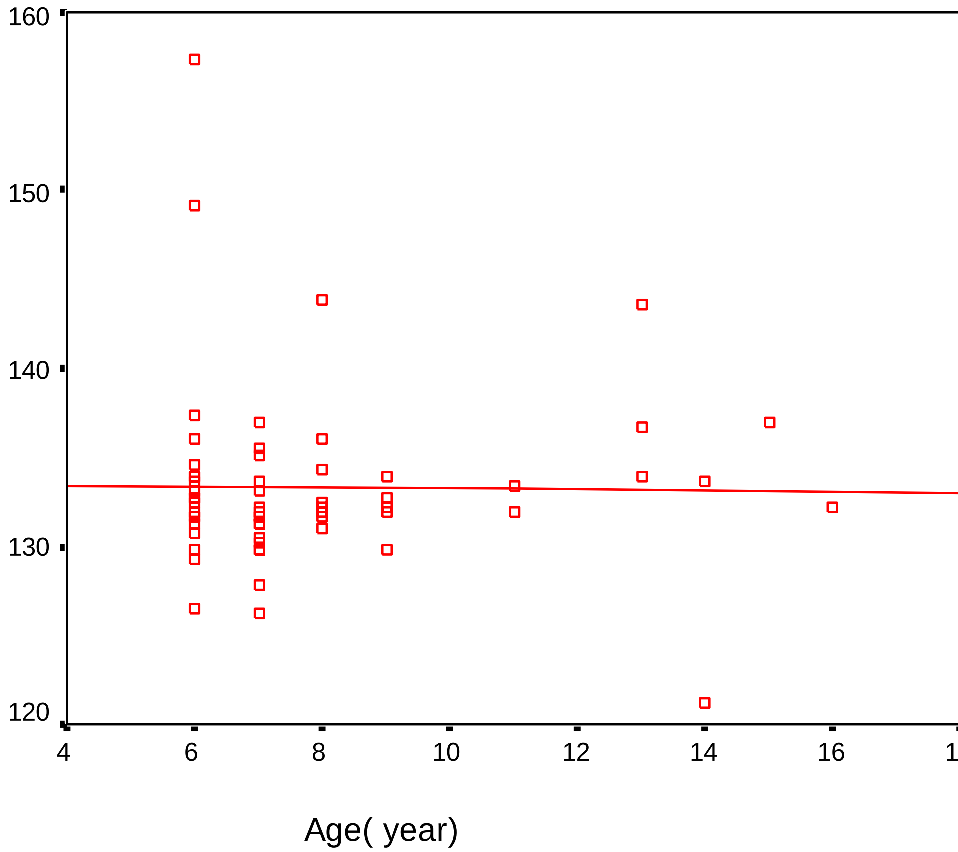

Figure (4.1): Correlation between sodium level and age of malnourished children (r=- 0.015, p-value= 0.907).

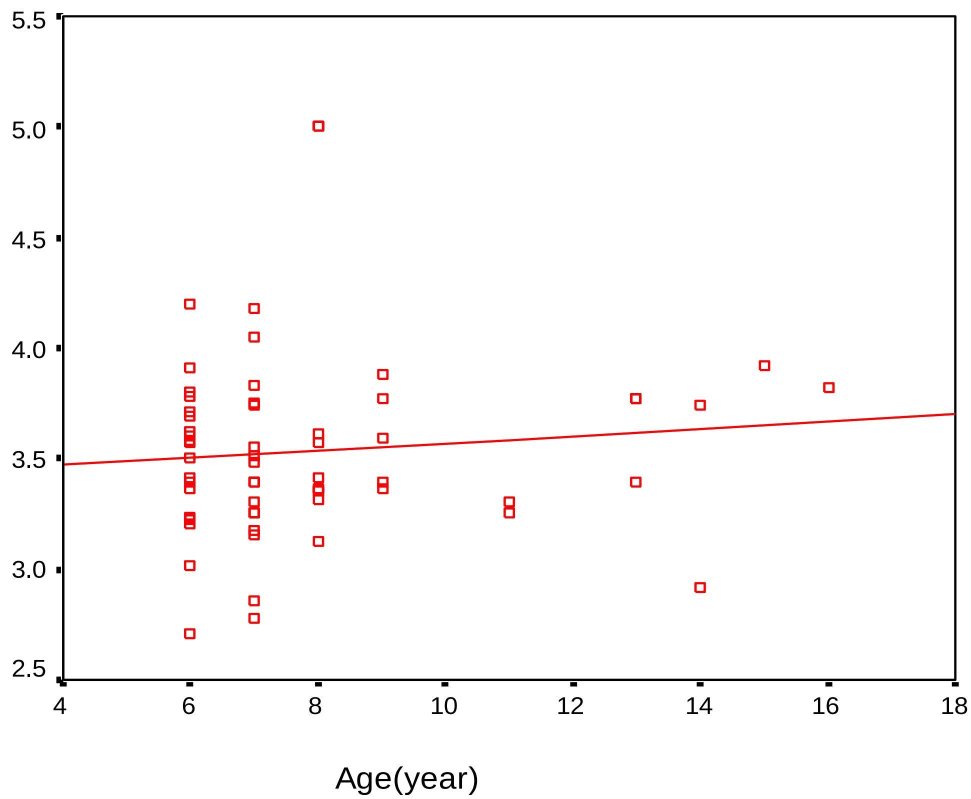

Figure (4.2): Correlation between potassium level and age of malnourished children (r= 0.099, p-value= 0.451).

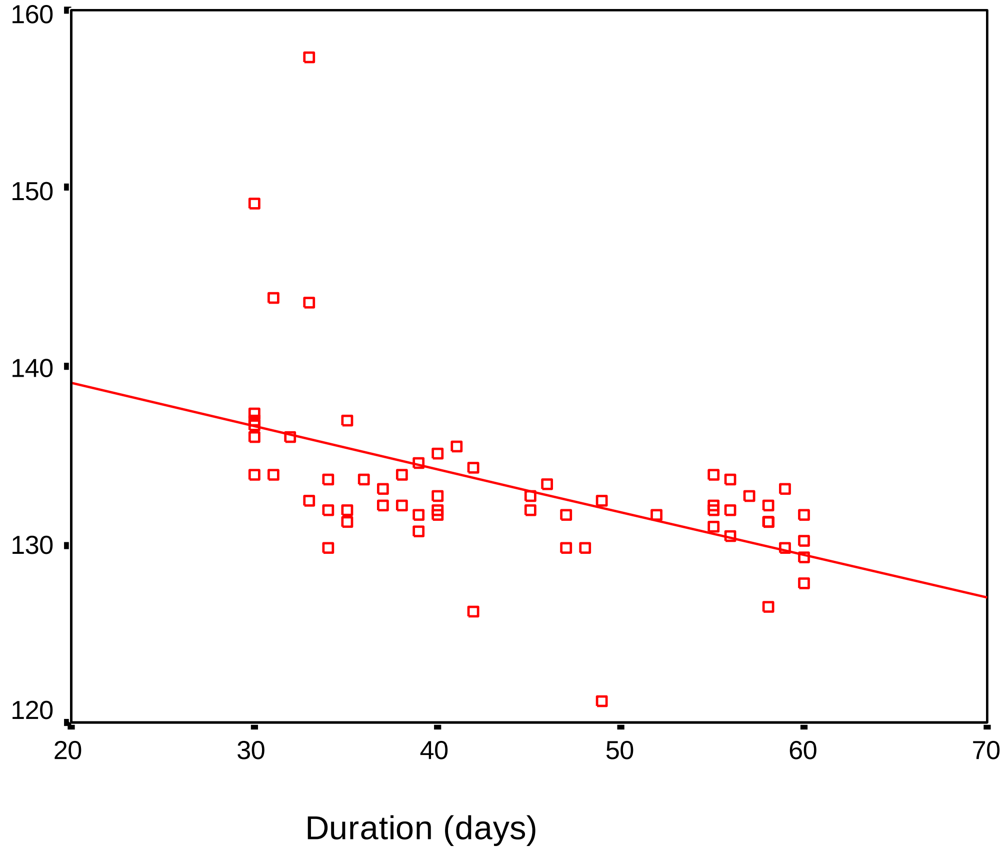

Figure (4.3): Correlation between sodium level and duration of malnourished children (r = - 0.493, p-value = 0. 000).

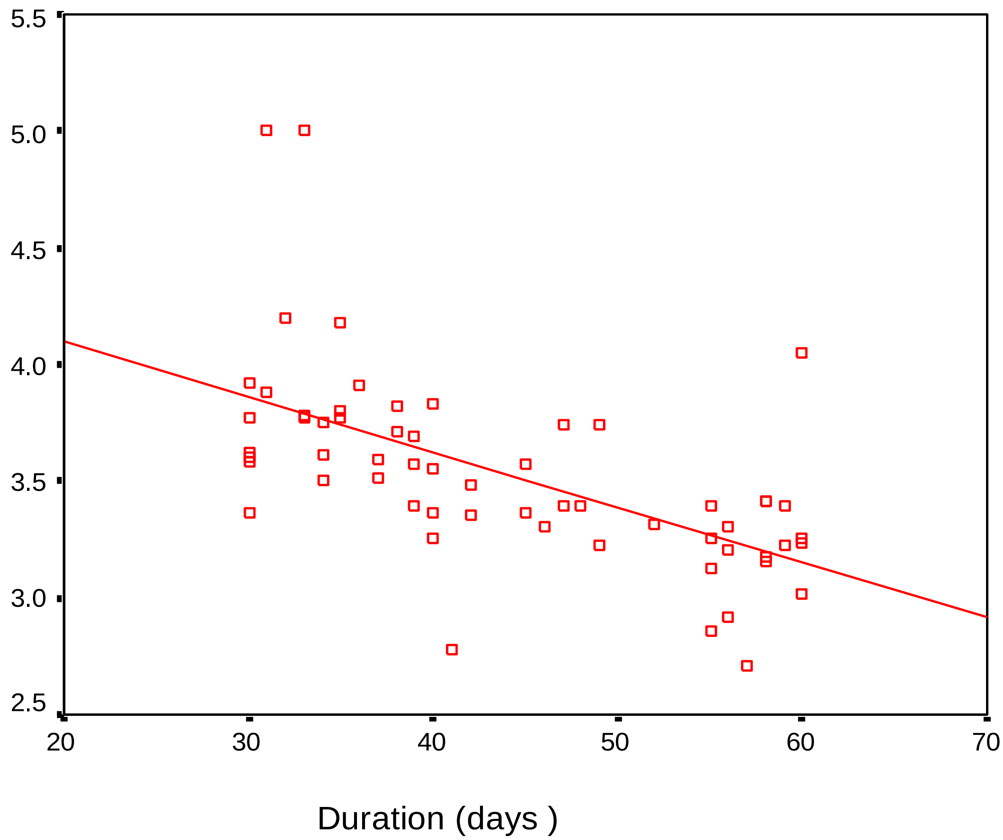

Figure (4.4): Correlation between potassium level and duration of malnourished children (r = - 0. 589, p-value =0.000).

Chapter Five

Discussion

5.1- Discussion:

Malnutrition is generally a nutritional problem that results from varying proportion of protein and calories deficiency in infant and young children and is a complicating factor for other illnesses in developing countries.(Mubarak *etal.*, 2003). Malnutrition affects many substances in the body by increasing them .this study conducted to get the effect of malnutrition on the levels of sodium and potassium. From the finding of this study, it appears that plasma levels of sodium and potassium were significantly decreased in malnourished children group compared to control group.This results agreed with a study carried by (Yasmeen *etal* . , 2007) , which showed that ; Plasma sodium and potassium concentration were decreased in malnourished children, because diarrhea results in large losses of water and electrolyte especially sodium and potassium .

Also the results was in agreement with another studies carried by many authors (Shirin *etal* . ,2014; Shaheen *etal* . , 2013 ; Anna *etal* . ,2008) them finding confirmed that malnourished children are at greater risk of developing hyponatremia and hypokalemia and place them at risk of developing life threatening situation. Also the study showed there was significantly decreased in the mean of BMI in patients compared to control group .This results agreed with a study carried by(Katherine , 2007) , which showed that ; body mass index decreased in malnourished children, because diarrhea results in large losses of water and nutrient from the body leading to weight loss .The result of this study showed that PEM most common among age between (6-9) years (88%) .This result agreed with another result carried by many authors (Chukwuma, 2015; Irena , 2011; Jobia ,2008) which showed that , malnutrition tendency to develop in lower aged group in African (Nigeria) and Asian (Bangladesh) countries .The finding obtained from especially designed questionnaire revealed that, (56 .7%) of patients were females and (43.3%) of patients were males. This result agreed with another study carred by (kaneta,2000) which showed that malnutrition most abundant in femals than males . Also the result showed that, there was no correlation between sodium levels and age of malnourished children. This result agreed with another result, which showed that, there was no correlation between sodium level and age of malnourished children (Ahmad , 2016) . According to figure (4-2) the result showed that, there was no correlation between potassium level and age of malnourished children. This result disagreed with another result, which showed that, there was a weak negative correlation between age of malnourished children and potassium levels (Ahmad *etal* . ,2016) . Also the findings of this study showed that, there were moderate negative correlation between duration of malnutrition and concentration of sodium and potassium as appeared in figure (4-3) and (4-4) respectively . These results agreed with previous results which revealed that, there were significant negative correlation between plasma sodium and potassium levels and the duration of malnutrition. (Yasmeen *etal* . , 2007) .

5.2. Conclusion:

From the results and finding of this study , it is concluded that :

1. Sodium and potassium concentration are significantly decreased in malnourished children.
2. The Body Mass index was significantly reduced in patients with PEM.
3. There are significantly moderate negative correlation between duration of malnutrition and plasma levels of sodium and potassium .

5.3. Recommendations:

From the findings of this study it is recommended that

1. Malnourished children should be monitor Sodium and potassium regularly to avoid hypokalemia and hyponatremia.
2. Patients with malnutrition should receive sodium and potassium supplement to avoid hypokalemia and hyponatremia.
3. Uptake of adequate sodium and potassium rich nutrition
4. More studies should be carried out on the effect of malnutrition on plasma sodium and potassium concentration with large sample size and to cover area with high population.

References

References

-Bishop , M. L .,Englkirk , L. D and Fody , E. P . (2000). Clinical chemistry principles procedures correlations; Lippincou Williams and Wilkins,4th ed -454.

- Doud, M. (2002) . Prevalence of Fungal Infection among Children with Protein Energy Malnutrition and its Correlation with Type and Severity of the Disease. Ph . D Thesis, in Pediatrics Faculty of Medicine.

-Gomez, F., Ramos Galvan, R . , Frenk, S . , Mufioz , J . C., Chivez , R., and Vazquez , J. (1956). Mortality in second and third degree malnutrition. Journal of Tropical Pediatrics, 2: 77-83.

- **Heymsfield, S . , Tighe, A and Wang, Z**. (1994). *Anthropometric and Biochemical Methods.* In, Shils, M.E., Olson, J.A and Shike, M. (eds) Method Nutrition in Health and Disease 8th ed ; I Williams and Wilkins Phil, U.S.A : 812-838.

- **Jospe , N and Forbes, G**.(1996) . Fluid and electrolytes clinical aspect. *Pediatric Rev* ; 17**(11**): 395-403 .

-kaneta, k . , Choudhury , M . , Hanifi , S and Abbas , A . (2000).gender inequality and sever malnutrition among children in a Remote Rural Area of Bangladesh .*J health popul nutr* , center For Health and population Research; 18**(3):**123-130 .

-Katherine,M.E. , Desha , N . , Tim, j .C. (2007). Body mass index cat off to define thinness in children and adolescent . *International survey*: 194- 204.

- Ladipo, O. (2000) . Nutrition in Pregnancy: Mineral and Vitamin Supplements. *American Journal of Clinical Nutrition* ; 72**(1)** : 280-290.

- **Mesham , A.R and Chatterjee , M** .(1999) . *Wasting away* . The crises of malnutrition in India . Washington DC :The World Bank .

-**Mirza, S. , Abdul , W. , Ahmad, N and Ramlah** , **M** .(2016) .Prevalence of Electrolyte Disorders Among Cases of Diarrhea with Severe Dehydration and Correlation of Electrolyte Levels with Age of the Patients ,*Journal of the College of Physicians and Surgeons Pakistan ,* 26 **(5**): 394-398.

-Mubarak , A . , Atta-ullah,M. and Abid ,H .(2003) . Acute hypokalemic flaccid paralysis in malnourished children . *Pak Pead J* ; 27**(4)** : 166-171 .

-Norbert ,W. T . (1987) . Tietz *Fundamentals of clinical chemistry* and molecular diagnostics .3 nd ed. Saunders , an imprint of elseviere INC . mayo foundation for medical education and research : 50-52.

- Pauline, I. A. (2008). *Biochemical changes associated with protein energy malnutrition among pregnant women in Enugu metropolis*. university of nigerie nsrkka :13-40 .

-Post, T. , and Burton, R .(2001) . *Clinical physiology of acid base and electrolyte disorders* . 5th ed. New York : MC Graw - Hill Professional :97 -103.

- Schutz ,Y. , Kyle ,U.U and Pilchard , C.(2002) . Fat-free mass index and fat mass index percentiles in Caucasians aged 18-98 years . *Int J Obese Relate Metab Disorder* ; 26 :953-960..

-Stanfield, P., Brueton , M ., Chan , M ., Parkins , M and Waterston, T. (1978).*Diseases of Children in the Subtropics and Tropics*: 4th ed. Edward Arnold, Hodder and Stoughton. London : 335 - 366.

-Toigo, G. (2000) . Expert working Group Report on Nutrition in Adults Patients with Renal insufficiency. *Journal of Clinical Nutrition*, ;19**(3)** :197-207.

- Torun, B and Chew, F. (1994). *Protein Energy Malnutrition.* In Shills, M . E.,Olsen, J. A and Shike, M. eds, Modern Nutrition in Health and Diseases. 8th ed. Vol 1 Williams and Wilkins Phil. U.S.A : 950 -974.

- Uysal , G . , Sokmen , A and Vidinlisan , S .(2000) . Clinical risk factors for fatal diarrhea in hospitalized children . *Ind J Paedtr* ; 67(**5**) : 329-333 .

- **Welcome Trust Working Party** . (1970). *50th Centile of Havard Standard*. Lancet, 2: 302.

-World Health Organization (WHO). (1995) .Physical status. the use and interpretation of anthropometry. *Report of a WHO expert committee*. World Health Organization technical report series : 854.

-World Health Organization (WHO). (1997). The world Health Report 1997: *conquering suffering, enriching Humanity*. WHO. Geneva.

- Yasmeen, M . , Rehana ,M . , Mohammad, H. G. , Salma, S.(2007) .Serum electrolytes changes in malnourished children with diarrhoea, pakistan journal of medical science ,profiessional nedical publication ,23**(5)** :1681-1715.

-Zulqarnain , A . Jaffar , Z and Iqbal , I . (2015) . Malnourished children with diarrhea; to assess the frequency of serum electrolytes (Na+, K+ & Ca+) disturbances. *Professional Med J* ;22**(5):**610-661.

Appendixes

Appendix I

Sudan University Of Science And Technology
Collage Of Graduate Studies

Assessment of plasma levels of sodium and potassium among Sudanese malnourished children in Khartoum state.

Questionnaire:

Name …………………………………………………...
BMI …………………………………………….(k.g)
age ....(years)
Duration ....(days)

Gender	Male	☐	Female	☐
Malnutrition with diarrhea		☐	without diarrhea	☐
Liver disease	Yes	☐	No	☐
Diabetes	Yes	☐	No	☐
Vomiting	Yes	☐	No	☐
Bone disease	Yes	☐	No	☐
Cancer treatment	Yes	☐	No	☐

Other chronic diseases…………..

Date:................... Sig:............................