Assessment Of Lactose Intolerance Among University Of Khartoum Students

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بسم الله الرحمن الرحيم

(سُنِّيهمَّ آيَاتًا في الأفق وَفي أنفسهمُ حَتَّى يَتَبَيَّنَ لَهُمُ أنَّهُ الحقُّ أَوَلَمْ يَكُفُّ بِرَبِّكَ أنَّهُ عَلَى كُلِّ شَيْءٍ شَهِيدٌ)

قُرآنَّ 2:53

(53) أَوَلَمْ أَنْ يَتَبَيَّنَ لَهُمُ أنَّهُ الحقُّ أَوَلَمْ يَكُفَّ بِرَبِّكَ أنَّهُ عَلَى كُلِّ شَيْءٍ شَهِيدٌ)
DEDICATION

This work is dedicated to:
The soul of my parents,
Brothers, Sisters

&
Husband

With everlasting love and respect.
ACKNOWLEDGEMENT

First of all, my thanks and praise to Allah who gave me patience and will to accomplish this work.

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Abstract

As there was shortage of data on the prevalence of lactose intolerance and nutritional status, this study aimed to determine this relation and its effects on food habits of the study sample. Data was collected from students of five faculties in Khartoum University. A total of 140 students (70 of them were selected according to the symptoms they suffer from after drinking milk (experimental group) and the same number was selected because they drink milk without any complaints (controls).

Data collection was completed at the five Faculties using questionnaires (Socio-demographics, symptoms and food habits), anthropometric measurements and Laboratory investigations. The age of the studied sample ranged between 18 and 24 years. The majority of the studied sample was females (78%). No significant differences were found between the two sexes. Lactose intolerance was found to be significantly higher among the older age group (P < 0.021).

The study reviled that the nutritional status of the sample studied was found to be below average, as indicated by their anthropometrics. The majority of average heights and weights of females and males were between the 25th and 50th percentiles except for males whose heights were even worse. Most of them were between 15th and 25th percentiles compared to US reference population (NCHS, 1994).

Nausea was the highest complaint felt after consuming milk, only 72.9% of the student who were milk intolerant was found to be mal-digerester. (Blood glucose below 20 mg /100 ml), and 27.1% were digesters.

Among the studied sample, it was found that yogurt and cheese intake of lactose intolerant students was significantly higher than among lactose tolerant students (P≥0.05).
Subjects’ food intake during the last 24 hours was categorized into food groups and it was found that vegetables were not taken by a high percentage of students (25%) among both lactose tolerant and intolerants and there were no significant differences between them. Fruits intake was found to be significantly higher among lactose intolerants (P>0.05); nevertheless, the number of students who took fruits was very low from the two groups (22.1% and 12.9% respectively). Nutrition education programs targeting university students encouraging more consumption of vegetables and fruits are very important. Lactose intolerants students should learn that the consumption of small amount of milk with solid foods could mitigate symptoms in many intolerant individuals. They can also easily tolerate yogurt and cheese.
ملخص البحث باللغة العربية

وأما أن هناك قصور في المعلومات المتاحة عن انتشار عدم تحمل اللاكتوز وعلاقته بالحالة التغذوية، هدفت هذه الدراسة التي تحديد هذه العلاقة وارتباطها بالعادات الغذائية لمجتمع الدراسة.

تم جمع المعلومات من طلاب خمس كليات بجامعة الخرطوم وكان عددهم 140 طالب وطالبة، 70 منهم تم اختيارهم نتيجة لأعراض تظهر عليهم بعد تناول الحليب (مجموعة تجريبية) ونفس العدد تم اختيارهم لأنهم يتناولون الحليب دون أي نوع من الشكوى (مجموعة ضابطة). تراحت أعمار الطلاب ما بين 18-24 عاما.

تم جمع المعلومات من خمس كليات عن طريق استخدام الاستبيان (المعلومات الديموغرافية، الاجتماعية، الاقتصادية والعادات الغذائية) ثم القياسات الجسدية والفحص المعملي 78% من عينة الدراسة من الإناث ولا يوجد فرق ذو دلالة إحصائية بين الجنسين، وقد كانت نسبة عدم تحمل اللاكتوز عالية في الفئة العمرية الأكبر (60.3%).


الشعور بالغثيان كان هو الأكثر في شعوري الطلاب بعد تناول الحليب (72%). كما أظهرت نتيجة الفحص المعملي لم لا يتحملون اللاكتوز أن 72.9% لم يهضموا اللاكتوز (مستوي السكر في الدم أقل من 20 مغم/100مل) بينما 27.1% استطاعوا هضم اللاكتوز. أظهرت الدراسة أيضا ارتباط ذو دلالة إحصائية إيجابي بين تناول الزبادي والجبنة، ومجموعة عدم تحمل اللاكتوزهم الأكثر تناول مقارنة مع مجموعة تحمل اللاكتوز.

ظهرت نتائج تناول الطلاب للاطعمة خلال ال24 ساعة السابقة، أن نسبة الذين لا يتناولون الخضروات عالية (25%). بينما وجد أن هنالك ارتباط ذو دلالة إحصائية إيجابي بين الذين لا يتحملون اللاكتوز وتناول الفواكه (22.1% مقابل 12.9%), بيد أن عدد الطلاب الذين يتناولون الفواكه من المجموعتين قليل جدا.

التنقيف الغذائي لطلاب الجامعات يجب أن يوجه لحظر على تناول الفواكه والخضروات كما أن تناول الألبان مع الأغذية الصلبة يخفف من الأعراض التي توجد عند العديد منهم. كذا يمكن تناول الأغذية سهلة الهضم مثل الذبادي والجبنة.
Milk is distinguished by its high quality of proteins and high content of calcium and phosphorus. It is a good source of riboflavin and retinol and supplies generous quantities of lactose and readily digested milk fat (Tover et al., 1981). There is no adequate substitute for milk and no food has a wider acceptability or offers a greater variety of uses like milk (March, 1975).

People in Africa use milk from cows, sheep, goats and camels, and of these sources cows milk is the most widely produced and processed (FAO, 1990). When milk and milk products are not consumed during adult years, the body may have to deplete the bone (the calcium bank) to obtain the needed amount of this essential nutrient (Rebecca et al., 1999).

Lactose intolerance is the most common carbohydrate intolerance and affects persons of all age groups. Intolerance to lactose is caused by a deficiency of lactase enzyme that digests the sugar in milk. Lactose that is not hydrolyzed into galactose and glucose remains in the gut and acts osmotically to draw water into the intestine. Bacteria ferment the undigested lactose, generating lactic acid and other organic acids, carbon dioxide and hydrogen gases. The result is bloating, flatulence, cramps and diarrhea (Zeman and Ney 1996 and Christian and Greger 1994).

All mammals are born with sufficient amounts of lactase to accommodate the high lactose levels in mothers’ milk. In animal species the amount of enzyme activity drops off significantly shortly after birth. In most human beings, this drop occurs after the age of 5 years. Only a few among the human species of the world do not experience this significant childhood drop in the enzyme lactase (Williams, 1997).
Lactose intolerance is common among Africans, Asians, Mediterraneans, and Native Americans. Approximately 70% of the world’s population has it (Christian and Greger1994). A large part among these populations avoid milk, cheese, ice cream and other milk products because they have found that these types of foods don’t agree with them (MFN, 2005).

Milk and other dairy products are very rich sources of many nutrients, the most important of those nutrients is calcium, which is needed for the growth and repair of bones throughout life; this may be a point of attention that the lactose intolerance affects the nutritional status. A shortage of calcium may lead to osteoporosis in later year (MFN, 2005). That is why it is important to know the incidence or prevalence of lactose intolerance in the general population and among university students as well.

Two studies have been carried out in Sudan regarding lactose intolerance. A study by Arbab in 1973, on 25 male university students (ages ranged from 20-26 years), found that 12 have low blood sugar after consumption of lactose. These twelve students are most probably suffering from primary lactase deficiency.

Another study in 1979 by Bayoumi et al. found that the population of the Nile valley has high proportions of lactose malabsorbers but the highest frequency is found among the aboriginal Negroid groups of the central hill areas, particularly in the Nuba (79.3%). The sample from Southern Sudan was small but nevertheless suggests a high prevalence of lactose malabsorption in the Nilotic tribes (66.7%). For the population with a long history of nomadic dairying, the prevalence of lactose malabsorption is unexpectedly high. The lowest prevalence was found among the Bedja, (11.1%).

Generally, nutritional status may affect lactose absorption, so that lactose malabsorbers may be less in well nourished than lactose absorbers. However, such a poor nutritional status may have caused, or have been caused by, the lactose malabsorption.
There are very few, if any, studies in Sudan investigating the relationship between lactose intolerance and nutritional status. Therefore, this study was focused on these relations and how lactose intolerance affects food habits of university students.

1. Objectives of the study:

   **General objective:**
   
   To improve the nutritional status of university students.

   **Specific objectives:**
   
   1- To describe the general characteristics of lactose intolerant students.

   2- To examine the effect of lactose intolerance on food habits and the nutritional status of the sample studied.
Lactose or milk sugar is the sugar found in milk, which is unique to mammals. Lactose comprises about 7.1% of the total content of human milk and 4% of cow’s milk. Milk is an outstanding source of calcium, and is also the only source of lactose. Lactose has several functions in the gastrointestinal tract: it promotes the growth of desirable bacteria, some of which are useful in the synthesis of B-complex vitamins. Lactose also enhances the absorption of calcium (Oconnor, 1995).

Lactose intolerance is the most common carbohydrate intolerance and it affects persons of all age groups. It is also called lactase deficiency, lactose nonresistance, lactose malabsorption, and lactose maldigestion. It occurs when a person is unable to digest much lactose because the body produces only a low level of lactase (Christian and Greger, 1994). Also it is defined as the condition that results in abdominal cramps, nausea, bloating, or diarrhea when milk is consumed (Williams, 1997 and, Zeman and Ney, 1996).

Lactose intolerance is a condition that usually develops gradually, people who have it as adults probably did not have it as infants or young children. Most people are born with the ability to produce lactase, but starting as early as 2 years of age their bodies begin to produce less and less.

Nevertheless, even most lactose intolerant people produce at least a small amount of lactase. Therefore, the amount of lactose a person can tolerate is a very individual matter. Most people will not develop symptoms from consuming a single (250ml) serving of milk especially if it is consumed with other foods, but at some level above that, problems occur (Christian and Greger, 1994).

Lactose maldigestion has been intensively studied since its discovery in the 1960s (Vesa et al, 2000). During the period following World War II, a
number of the more prosperous countries of the north temperate region, particularly the United States, decided that the food shortages of many tropical countries could be aided by broad based programmes which included food supplementation, specially milk, which was dehydrated and provided to many of the countries which suffered from shortage of food.

By the 1960s, it was observed that in many populations these food supplements often resulted in widespread diarrhea. Further research showed that many adults developed diarrhea when they ingested significant quantities of milk. Subsequent research showed that a major proportion of the world’s population couldn’t digest the lactose contained in fresh milk because of lack of the lactase enzyme (Harrison et al., 1988). On the other hand, a small minority of human populations largely from Northern European extraction continue to express large amounts of the enzyme throughout life. Genetic modification is thought to have allowed these populations to express lactase throughout life and thus to absorb the lactose in milk. Such a mutation would have allowed individuals to survive while others perished. Early humans who survived would have transmitted the altered gene to their offsprings. As a result, their descendents are able to consume large amounts of lactose-containing milk without difficulty, (Krause’s et al. 1996).

2-1 Digestion and Metabolism of lactose:

Lactase (a digestive enzyme) hydrolyses the disaccharide lactose into its component monosaccharines, glucose and galactose for absorption (Williams, 1994 and Howard and Herbold, 1978).

Lactase is found most abundantly in the jejunum, (at the beginning of the small intestine), and hydrolyzes specifically lactose. It is found at the tip of the intestinal villi and is therefore more vulnerable to intestinal diseases that cause cell damage than other disaccharidases, which are located deeper (Vesa et al, 2000).
Disaccharides are formed when two monosaccharides combine in a so-called condensation reaction. In this reaction a water molecule is released and a glycosidic bond forms between the two monosaccharides.

The purpose of carbohydrate digestion is to hydrolyze the di- and polysaccharides of the diet to their constituent simple sugars. This is accomplished by enzymes of the digestive juices yielding these end products.

The principal site of digestion of carbohydrate is in the small intestine. Sucrose, lactose, and maltose are hydrolyzed within the brush border of epithelial cells (Harrison, 1975).

Monosaccharides can be absorbed intact through the small intestine (Christian and Greger, 1994). The resultant glucose and galactose pass through the mucosal cells and via the capillary of the villi, into the bloodstream where they are carried by the portal vein to the liver. Glucose is transported from the liver to the tissues, and some glucose is also stored in the liver and muscles as glycogen (Krause’s et al, 1996).

Undigested lactose remains in the intestinal lumen, and as it reaches the colon, colonic bacteria ferment it. The products of this process include short-chain fatty acids such as lactate, butyrate, acetate and propionate (Adolfsson et al, 2004 and Ganong, 1995). These fatty acids associate with 12 electrolytes and lead to an osmotic load that can induce diarrhea. Furthermore, fermentation of lactose by colonic bacteria produces methane, hydrogen, and carbon dioxide.

These gases may stay in the lumen and eventually will both be excreted as flatus, diffusing into the circulation, and be exhaled via the lungs (Adolfsson et al, 2004).

In the intestine, lactose helps the right kind of bacteria (i.e.) lactobacillus to grow. Lactobacillus and lactose help to keep the intestinal contents acidic, which inhibit the growth of harmful bacteria. Lactose plays an
important role in maintaining low electrolyte concentration (Zeman and Ney, 1996).

2-2 Types of lactase deficiency:

2-2-1 Congenital lactase deficiency:

This is a rare autosomal recessive heritable genetic defect, which is evident immediately after birth. Affected newborns respond to their first milk feed with diarrhea (Johnson et al., 1981 and Murray et al., 1996). There have been only a few dozen documented cases in the world, most of them in Finland (Vesa et al., 2000).

2-2-2 Primary or adult-type lactose malabsorption:

In primary hypolactasia, lactase activity is high at birth, decreases in childhood and adolescence, and remains low in adulthood (Sieber et al., 1997).

The adaptive hypothesis suggests that the enzyme activity depends on lactose feeding and they propose that the hypolactasia appears merely because of the lack of milk supply (the major lactose source) (Bolin et al., 1971).

This is a relatively common syndrome particularly among non-white population. Since intolerance to lactose was not a feature of the early life of adults, a gradual decline in the activity of lactase in susceptible individuals was mainly due to reduction in expression of the enzyme. However, this is not due to lack of lactase mRNA. Failure in translation appears to be a likely cause of the deficiency (Murray et al., 1996 and Gorshoff, 1990).

2-2-3 Secondary lactose malabsorption:

Secondary hypolactasia or maldigestion can result from small intestinal resection, and from gastrectomy and from diseases that damage the intestinal epithelium, e.g. untreated celiac disease or intestinal inflammation.

When the epithelium heals, the activity of lactase returns. However, in a study by Vesa et al., (1998) about the role of irritable bowel syndrome in
subjective lactose intolerance showed a strong relation among subjective lactose intolerance (LI) and irritable bowel syndrome (IBS).

Saberi-Firoozi et al. (2007) studied subjective lactose intolerance in apparently healthy adults in southern Iran. They found that the individuals with IBS had significantly more subjective LI than those without IBS.

2-3 Prevalence of primary adult lactose malabsorption:

2-3-1 Internationally:

Lactase activity is usually high at birth, decreases in childhood and adolescence, and remains low in adulthood. This primary hypolactasia is also called lactase non-persistence and is a normal physiologic situation for mammals and humans (Sieber et al., 1997). With the exception of the population of Northern and Central Europe and their offspring in America and Australia, 70–100% of adults worldwide are lactose malabsorbers. The prevalence of primary lactose maldigestion is 3–5% in Scandinavia, 17% in Finland, 5–15% in Great Britain, 15% in Germany, 15–20% in Austria, 17% in Northern France, 65% in Southern France, 20–70% in Italy, 55% in the Balkans, 80% in Central Asia, 90–100% in Eastern Asia, 30% in Northern India, 70% in Southern India, 15% in North American whites, 80% in North American blacks, 53% in North American Hispanics, and 65–75% in South America (Johnson, 1993). Australia and New Zealand have prevalence’s of 6% and 9% respectively (Scrimshaw and Murray, 1994).

According to Simoons (1978), the occurrence of lactose intolerance is generally high in the black population of Africa but shows interesting variations as follows:

- Prevalence of lactose malabsorption (LM) is 90.1% in Kung Bushmen of Namibia, Bushmen of Botswana and Twa pygmies of Rwanda.
- Nigerians, Ghana, Bantu of various tribes, Zaire, Bantu of Cameroon prevalence of LM. 85.9%.
- Kenyans (mainly Kikuyu, Kamba and other agricultural tribes; Bantu of
Zambia, Bantu of South Africa, Ganda and other Uganda Bantu prevalence of LM 88.1%.

- Prevalence of LM 8.9% in Nomadic Fulani, Tussi.
- Ethiopians / Eritrians (mainly Amhare and Tigre) prevalence of LM 90%.
- Hausa of Nigeria. Prevalence of LM 76%.
- Nilotes or Nilo-Hamites in Uganda. Prevalence of LM 44%.
- Nilotic Masai. High prevalence of LM 62%
- Rehoboth Basters. Genetically mixed people (50% Caucasoid, 50% Hottentot) prevalence of LM 65%.

Segal et al (1983), in a study about lactase deficiency in different tribes of the South African black population, found that Lactase deficiency was common (78%), despite the fact that two of the largest tribes (Zulu and Xhosa) are cattle herders and milk drinkers. This might be due to the consumption of traditional fermented buttermilk, ("amasi" which has low lactose content) instead of fresh milk. The most important reason for lactase deficiency, however, is that the South African blacks originated from the West and Central African zone took up dairying and milk use fairly recently. Thus they have not had enough time for genetic selection for lactase deficiency through life.

Sane et al, (2003) studied the incidence of lactose intolerance among Kuwaiti and Asian healthy volunteers. The study involved 70 Kuwaiti and 79 Asian healthy volunteers as measured by breath hydrogen level following challenge with lactose drink. Thirty-three (47%) of the 70 Kuwaitis and 46 (58%) of the 79 Asians were positive for the breath hydrogen test. The clinical symptoms of flatulence, abdominal pain, and diarrhea were associated with high levels of breath hydrogen. These findings indicated that the Kuwaiti volunteers had higher breath hydrogen levels than Asians, but the incidence of lactose intolerance was similar in both groups.
Hussein and Ezilarab, (1994) studied the frequency distribution of lactose malabsorption among adult populations from the Eastern and Western Egyptian deserts. The study consisted of 172 subjects belonging to ethnic groups from Sinai in the Eastern Desert and the New Valley in the Western Desert. The overall prevalence rate in those populations was 34.3%. The proportion of lactose malabsorbers was 11.1% in Sinai and 51.0% in the New Valley. Highly significant differences (P < 0.0001) were found between the two ethnic groups with regard to the frequency and distribution of lactose malabsorption. The existence of an east-west gradient of increasing frequencies of lactose malabsorption gene was suggested.

**2-3-2 Sudan:**

The first primary lactase deficiency reported in the Sudan was by Arbab in 1973. His study was carried out on male university students, age ranged (20-26) with flatulence. The duration of symptoms ranged from months to seven years. A detailed history was taken and a full medical examination was done on each student. A Lactose Tolerance Test was carried out on each student and any symptoms occurring during the test were recorded. Twelve were found to have low blood sugar after lactose. These twelve students were most probably suffering from primary lactase deficiency.

Six years later a bigger study was carried out by Bayoumi et al. (1979). They studied the distribution of adult lactase phenotype, lactose absorption, and lactose malabsorption in the population of the Democratic Republic of the Sudan. Five hundred and sixty three healthy adult Sudanese subjects, 549 males and 14 females were examined with lactose tolerance test with multiple breath collection and gas chromatographic hydrogen determination. The frequency of the (hypolactasia allele) ranged between 0.6 and 0.87 in the major regional groups.
The distribution of lactase phenotypes in distinct ethnic subgroups, were selected according to importance and sample size. The population of the Nile valley had high proportions of lactose malabsorbers but the highest frequency was found among the aboriginal Negroid groups of the central hill areas, particularly in the Nuba. The sample from Southern Sudan was small, but nevertheless, suggests a high prevalence of lactose malabsorption in the Nilotic tribes. For the population with a long history of nomadic dairying, the prevalence of lactose malabsorption was unexpectedly high. In all subgroups, with the possible exception of the Bedja, the hypolactasia gene is more frequent than the lactase persistence gene. As expected, the residential agriculturalists of the Nile valley and the hill regions of Central Sudan had the highest proportions of lactose malabsorption in the central region (Khartoum, Gezira). This was possibly due to the economically attractive areas surrounding the capital. Examples of such migration are the Gomoeia tribe, originally nomads in the Northern Khordofan, who intermarried with the Nile valley tribe Jalli in the region of Shendi (Northern of Khartoum). Similarly, part of the Halawi tribe, traditionally eastern nomads related to the Bedja, now have settled in the Gezira, the triangle between the Blue and White Niles. On account of the low prevalence of lactose malabsorption in the northern nomadic groups, a considerable dilution of the frequency of the hypolactasia gene in the Nile valley population is expected as the result of this Migration. Details of this study are shown in Table 2-3-2.
<table>
<thead>
<tr>
<th>Geographic group-Tribal subdivision</th>
<th>No</th>
<th>LA</th>
<th>LM</th>
<th>%LM</th>
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<td>103</td>
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<tr>
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<td>16</td>
<td>26</td>
<td>61.9</td>
<td></td>
</tr>
<tr>
<td>2- Central Sudan</td>
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<td>88</td>
<td>81</td>
<td>47.9</td>
<td>0.6923+0.0278</td>
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<tr>
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<td>60</td>
<td>53</td>
<td>46.9</td>
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<tr>
<td>3-Northern Nomads</td>
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<td>52</td>
<td>32</td>
<td>38.1</td>
<td>0.6172+0.0429</td>
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<tr>
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</tr>
<tr>
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<td>31</td>
<td>8</td>
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<tr>
<td>Bedja</td>
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<td>8</td>
<td>1</td>
<td>11.1</td>
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<tr>
<td>4- Baggara</td>
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<td>44</td>
<td>48</td>
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<tr>
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<tr>
<td>Habbani</td>
<td>19</td>
<td>9</td>
<td>10</td>
<td>52.6</td>
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<tr>
<td>5- Aboriginal Negroid</td>
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<td>20</td>
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<td>6- Souther Sudan</td>
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<td>6</td>
<td>12</td>
<td>66.7</td>
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<tr>
<td>Total</td>
<td>563</td>
<td>253</td>
<td>310</td>
<td>55.1</td>
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</table>

Selective adult-type hypolactasia is inherited through a single autosomal recessive gene (Sahi and Launiala, 1977). A culture-historical hypothesis has been proposed for lactase persistence (Simoons, 1978). After the beginning of dairy farming, when there were periods of dietary stress, there would have been an advantage for those individuals who had high levels of intestinal lactase. As a result of increased survival, high intestinal lactase activity would have become typical of such a group. Lactase persistence is, indeed, more common in the areas with long traditions of dairy farming. However, production of the enzyme does not seem to be induced by lactose consumption. At some point in prehistory, a genetic mutation occurred and lactase activity persisted in a majority of the adult population of Northern and Central Europe. Persistence of intestinal lactase, the uncommon trait worldwide, is inherited as a highly penetrant autosomal-dominant characteristic. Both types of progeny are almost equally common when one parent is a lactose maldigester and the other a lactose digester (Scrimshaw and Murray, 1994). Another genetic hypothesis suggests that the decline in lactase activity in adult is generally defined and not related to lactose feeding.

Recessive inheritance of lactase decline, adult type hypolactasia, was supported by family studies (Sahi, 1974).

The lactose phlorizin hydrolase (LPH) gene has been observed in different populations with only 3 common haplotypes, one particular haplotype, called A, seemed to be associated with lactase persistence and was found in much higher frequencies in Northern Europeans than any other population (Hollox et al. 2001).

Randerson (2002) studied the genetic basis for lactose intolerance; he studied nine extended Finnish families, as well as some Germans, Italians and South Koreans. He found two variations in the human genome associated with lactose intolerance. One of these "single nucleotide polymorphisms", or
SNPs, was present in all 236 people who were lactose intolerant, while the other was found in 229. Both SNPs are near the lactase gene, and probably affect proteins that regulate the expression of the gene.

The fact that the same variations occur in distantly related populations supports the theory that all humans were once lactose intolerant, and that "lactase persistence" evolved only after people domesticated animals and began drinking their milk.

Kolho and Savlahti, (2000) In Finland studied 223 children (2-18 years). They were undergoing upper gastrointestinal endoscopy in 1997 and 1998. The ancestry was Finnish in 188 children, African in 27 children. They found that ethnicity has a strong effect on disaccharidase values in children with normal villi structure. African children have lower activities of lactase, sucrase, and maltase in duodenal specimens than do children of Finnish origin.

2-5 Demographics and Socio-economic Factors Affecting lactose intolerance:

2-5-1 Sex:

A study by Vesa et al (1998) showed that there was a strong relation between lactose intolerance and female sex. On the other hand in a randomly selected population, gender did not have any effect on the prevalence of hypolactasia (Rao et al, 1994). Although many studies showed that hydrogen exhalation after lactose ingestion is greater in men than in women, lactose maldigestion causes significantly more symptoms in women than in men (Krause’s et al, 1996 and Rao et al, 1994).

2-5-2 Age:

There is some evidence that intestinal lactase activity does not continue to decline with age, because there were no differences in the prevalence of hypolactasia between older and younger adults (Jussila et al, 1970). However,
it is well documented that the prevalence of hypolactasia is more common in adults than in children (Caskey et al., 1977 and Welsh et al., 1970).

Carroccio et al. (1998) found that 36.2% of the study subjects were lactose maldigesters. As was predicted, the frequency of cases of maldigesters increased as subject age increased: in the pediatric age group (range 5 to 16 years) prevalence was 23% (17/72 subjects), in the adults group (age range 17 to 64 years) prevalence was 38% (54/141 subjects) in the group of elderly subjects (age range 65 to 85 years) prevalence was 42% (46/110 subjects). Only 13 of the maldigesters complained of symptoms in the hours following lactose load; of these subjects, two were in the pediatric age group, six in the adult group and five in the elderly group.

Rana et al. (2004) reported that the frequency of lactose maldigestion did not differ significantly among the age groups. Thus, this study suggests that lactose maldigestion is not associated with age stratification among North Indians.

Saberi-Firoozi et al., (2007) in a survey among 1,978 individuals older than 35 years conducted in Shiraz, Southern Iran, using a questionnaire that consisted of items regarding demographic data, observed that, a total of 562 subjects reported LI (28.41%). The prevalence was also higher in the 35-44 and 45-54 years age groups but not statistically significant.

A study by Saltzberg et al. (1988) showed that the elderly subjects had significantly greater breath H₂ concentrations than the younger subjects at 150 minutes (P < 0.05). Sex, race, and functional complaints did not influence H₂ production.

Welsh et al. (1970) conducted a study on 399 persons (339 whites, 53 blacks, and 7 American Indians) ages 1 month to 93 years, with normal intestinal histology. Among whites, all 117 children 5 years old or under had high lactase levels, whereas low levels were found only in subjects over 5 years of age. No low lactase levels were identified among the 11 black
children 3 years old or under, but in comparison to White children, their mean lactase activity was significantly less. The majority of older Blacks had low lactases. Of the 7 American Indians, none under 26 months old had low lactase levels, whereas the 4 over 10 years old had low activities.

Suarez and Savaiano, (1994) conducted a study in adult and elderly Asian Americans in relation to lactose digestion and tolerance. Twenty adults (20-40-y old) and 20 elderly (> or = 65-y old) Asian- Americans, they found that these two groups did not differ in their metabolism and tolerance of lactose.

Rao et al. (1994) studied the prevalence of lactose maldigestion and its interaction with age, race, and sex. Ninety-eight adults ranging from 20 to 89 years in age (52 blacks, 46 whites, 48 males, 50 females) were tested for lactose maldigestion by breath hydrogen analysis after consuming milk containing 16.5 g lactose (360 ml milk). They found that the prevalence of lactose maldigestion significantly increases with age in blacks compared to whites and that the magnitude of the problem may be greater in black maldigesters than in white maldigesters.

2-5-3 Income:

The suggestion that in Africa lactose intolerance is related to malnutrition or to diminished milk intake has been disproved by Cook and Kajubi (1966) who found isolated lactase deficiency in the Baganda and other Bantu tribes of Uganda whereas patients from tribes such as the Rwanda, were found to have high levels of lactase activity, despite the fact that they ate the same food as the Bantu. Some of the Bantu examined were members of high-income Ugandan families with adequate milk intake, and in whom there was no question of undernourishment.
2-6 Symptoms and signs:

Symptoms of lactose intolerance include abdominal pain and bloating, nausea and loose stool (Vesa et al, 2000). It can begin anywhere from 30 minutes to 2 hours after eating (Christian and Greger, 1994).

Patients have great variability in clinical symptoms depending on the severity of lactose ingested. With mild to moderate amounts of lactose malabsorption, patients may experience bloating, abdominal cramps and flatulence. With higher lactose ingestion, an osmotic diarrhea will result. Most patients can tolerate one to two glasses of milk daily with minimal or no symptoms. While others, may be symptomatic with almost any lactose (Burton and Faster, 1988). A recent study showed that symptoms seemed to originate from the colon. Since lactose ingested orally and introduced directly to the colon caused similar symptoms (Vesa et al, 2000). Hummer et al, (1996) found that there was significant correlation between the time of the occurrence of peak symptoms and the time of peak breath hydrogen concentration.

Also the development of symptoms appears to depend on the dose of lactose ingested, whether ingestion is part of a recipe or is accompanied by ingestion of a meal or other food, rate of gastric emptying and small intestine transit time (Suarez et al. 1998). Most people of lactose intolerance are able to eat small amounts of dairy, but because each case is different, there is no one simple way of dealing with it. Each person needs to learn the strategies that work best for him or her depending on the symptoms and how much, if any, lactase the body produces (Mayo clinic, 2004).

Several authors have claimed that symptoms of lactose intolerance could disappear after several weeks of milk supplementation. A study by (Vesa et al, 2000), found that, faecal beta-galactosidase increased and breath hydrogen excretion and symptoms scores decreased after a two-week dietary supplementation with lactose. These results suggest a colonic adaptation to
regular lactose ingestion. A study by Jones et al. (1976) found that there was a
significant positive relationship between the amount of lactose consumed and
symptom response. On the other hand Hertzler and Savaiano. (1996), reported
a higher mean increase in breath hydrogen excretion after higher dose.
However, the fairly high baseline values of breath hydrogen, approximately
20 ppm, complicate the interpretation of the results, the subjects reported no
more symptom response after six grams of lactose than after one or two
grams.

2-7 Milk consumption and lactose intolerance:

Suarez et al. (1998) in a double blind study comparing symptoms after
the consumption of milk or lactose-hydrolyzed milk by people with self-
reported severe lactose intolerance. Symptoms experienced following
consumption of one glass of milk with a meal did not differ when lactose-
containing or lactose-hydrolyzed milk was consumed and in both cases, mean
symptom scores were classified as "trivial".

The amount of lactose a person can tolerate is a very individual matter;
each person with lactose intolerance is independent. Most people do not
develop symptoms from consuming a single 250 ml serving of milk,
especially if it is consumed with other foods, but at some level above that
problems occur (Williams, 1997). Lebenthal et al. (1975) studied the
correlation of lactase activity, lactose intolerance and milk consumption in
different age groups. The first group was individuals consuming relatively
small amounts of milk. When 12 of them were tested with an oral lactose
tolerance test the results was a flat curve with a maximum rise in blood
glucose of 9 plus or minus 3.2 mg/100 ml. The second group consumed more
milk averaging quart/day with no discomfort and when 19 were tested with
lactose tolerance tests the values were normal.

Johnson et al. (1993), studied twenty-five lactose-maldigesters and
lactose-intolerant African Americans, ranging in age from 13 to 39 years.
These were given gradually increasing amounts of lactose in milk over a period of time until the maximum lactose dose tolerated was determined. Seventeen (77%) of the 22 subjects who completed the study tolerated ≥ 12 g lactose and 5 (23%) tolerated < 12 g. Breath-hydrogen tests done on each subject with the maximum dose of lactose tolerated showed that only four (18%) had a breath-hydrogen concentration < 5 ppm above fasting concentration. This study suggests that the majority of African-American young adults who claim intolerance to moderate amounts of milk can ultimately adapt and tolerate ≥ 12 g lactose in milk (the equivalent of 8 oz of full-lactose milk) with minimal or no discomfort if milk is ingested in gradually increasing amounts. The mechanism of adaptation is assumed to be an increased tolerance to colonic lactose-fermentation products.

2-8 Milk products and lactose intolerance:

Many products derived from milk are stable in many diets of countries and cultures (David, 1981). It has been considered an excellent source of high-quality protein, calcium, potassium, phosphorus, magnesium, zinc, and the B vitamins: riboflavin, niacin, vitamin B₆ and vitamin B₁₂ (Adolfsson et al, 2004). Some of the important milk products are cheese and yogurt. Cheeses are very nutritious foods, containing 25-35% of protein of high biological value, rich in calcium, retinal and riboflavin (David, 1981).

Because dairy products are a significant source of essential nutrients, elimination of all dairy foods in the diet would be nutritionally unwise and is usually not necessary in the case of lactose maldigestion. About 250 ml milk/d can generally be taken without adverse effects. If milk is taken in combination with solid foods, lactose malabsorption may be reduced by about 50%, probably due to a slower rate of colonic fermentation, which may lower gastrointestinal symptoms in lactose malabsorbers. Adults with primary lactose intolerance can usually tolerate the amounts of milk in many prepared food such as breads, lunchmeats, and even cream soups and cream sources
providing that the lactose source is spaced throughout the day (Gorshoff, 1990). Various bacteria are used to sour or curdle milk. All of these bacteria break down lactose to glucose and galactose that are eventually converted to lactic acid, which may be as high as 3 percent. A good example is yogurt, milk that has been greatly concentrated by baling various bacteria that are inculcated for the souring (lactic acid). Soured and fermented milks contain all fat, protein and calcium and vitamins that occur in the original milk (Tover and Russell, 1981).

It is well established that, in lactase-deficient subjects, yogurt is better tolerated than milk. Tolerance to yogurt, acidophilus milk, and other microbe-containing daily foods has been suggested and is thought to be due to either a low lactose content or in vivo autodigestion by microbial beta-galactosidase. Up to 20 g of lactose in yogurt is tolerated well by lactase-deficient persons (Savaiano and Leivitt, 1987 and Sieber et al, 1997). In study by Escribano et al, (1993) about the relationship between primary lactose malabsorption and consumption of dairy products, they found that, malabsorbers consumed more fermented dairy products, ripened cheese and yogurt than did absorbers (p<0.05).

Kolars et al, (1984) used a series of breath hydrogen tests as well as a subjective assessment to ascertain whether subjects that were identified as lactose-intolerant digested and absorbed lactose in milk. The area under the curve for breath hydrogen was smaller after yogurt consumption than after consumption of milk or lactose in water, which indicated better digestion and absorption of lactose from yogurt than of that from either milk or lactose in water.

2-9 Calcium:

This is the most abundant mineral in the body. It makes about 1.5% to 2.7% of the body weight and 39% of the total body minerals. Approximately
99% of the calcium exists in the bone and teeth. The remaining 1% of calcium is in the blood and extra-cellular fluids and within the cells of all tissues, where it regulates many important metabolic functions (Krause’s, 2004). These functions include: 1- Transmission of nerve impulse. 2- Muscle contraction. 3- Normal heart rhythm, 4- Hardness of bones and teeth.

Recommended intake for adults is 1000 to 1200 mg/day. The majority of people do not consume these levels of calcium (Rebecca et al, 1999).

Milk and other dairy foods are the major sources of calcium. They are stable diets of many countries and cultures. In addition, these foods provide substantial amounts of other essential nutrients. Consequently, intake of dairy foods improves the overall nutritional quality of the diet. Other foods such as some green leafy vegetables, legumes and cereals provide calcium, but generally in lower amounts per serving than do dairy foods (Gregory et al, 2001).

Mainguet et al, (1991) evaluated the calcium intake of 134 patients with abdominal symptoms after consumption of dairy products. They found that the daily calcium intake of patients lacking lactase activity in the jejunum biopsy was significantly lower than that of controls.

**2- 10 Management of lactose intolerance:**

Treatment of the condition is based on the elimination of the offending lactose from the diet and is followed by prompt disappearance of the symptoms, since the severity of symptomatology is generally related to the quantity of lactose ingested by the patient, dietary treatment is usually highly successful since even the inadvertent of small amounts of lactose still remaining in the diet does not give rise to major reaction (Burton and Faster, 1988).

The dietary adjustment is simple since with few exceptions the only foods containing lactose are milk and milk derivatives and compounded food
products to which milk or its derivatives have been added (Burton and Faster, 1988).

An individual who is sensitive to even a small amount of lactose must become a worried label reader in order to avoid products with ingredients such as milk solids, casein and whey - some medications contain lactose as binders or fillers (Wardlaw and Insel, 1994).

Moderate lactose intolerance, however, is more common than nearly complete intolerance. Most people who are moderately intolerant quickly learn by trial and error how much lactose they can tolerate and easily adjust the amount of dairy products in the diet (Wardlaw, 1994).

They can consume some lactose (6 to 12g) without major symptoms. Also, they can tolerate 12 or more of lactose in milk, equivalent to 250 ml of full – lactose milk when introduced gradually in incremental over several weeks (March, 1975).

There are other ways of coping with lactose intolerance. Lactase enzyme solutions are available. When dropped into milk, they digest much of the lactose, scarcely affecting the taste of the milk. Also lactase tablets or capsules can be taken with lactose-containing meal, and more and more special products with little or no lactose are being developed (Christian and Greger, 1994)

Available digestive aids include pre-hydrolyzed milk and lactase preparations that can be added to milk (which is then incubated) or ingested with milk. While these products are effective in reducing symptoms, it should be emphasized that there appears to be no need for these preparations when the dosage of milk is limited to one cup per day (Suarez et al, 1995).

**2-11 Lactose intolerance patients diet:**

The goals of the diet for the lactose intolerance patient are:

1- to reduce lactose intake to a level that will not cause intestinal symptoms.
2- to provide adequate nutrients intake (Zeman and Ney, 1996)
Diet planning: Institutional diet manuals may contain a "Lactose Free Diet" for those who need complete lactose restriction, or they may present diets varying in lactose levels (Zeman and Ney, 1996). The diets for these patients are divided into 3 types including the following:

1- **In general:**

1- Avoid or restrict as necessary milk in liquid or powdered form.
2- Labels should be read carefully for the counts of milk, milk products, milk solids, skim milk, skim milk powder, skim milk solids, milk sugar and lactose. Restrict food containing these items as necessary to the patient.
3- Small amounts of cheese and butter may be tolerated.
4- Avoid the use of large quantities of milk or cream in cooking.

2- **for patients who can tolerate 10-25 g lactose:**

These patients may have:
1- 2 cup milk or ice cream/day. 1-cup milk or ice cream will provide 5-6 g lactose.
2- Patients tolerate lactose better if milk is taken with other foods and in small amounts throughout the day.
3- Some patients have a great tolerance for warmed milk, buttermilk or yogurt.
4- Consider the use of lactic-acid to increase milk intake (Zeman and Ney, 1996).

3- **for patients who can tolerate 3g or less lactose per days:**

1- Omit all milk and milk products, yogurt, and ice cream.
2- Limit cheese to 1 oz/day or less.
3- Read labels carefully. Avoid products containing "lactose “albumin dry milk solids, milk sugar, lactic acid, lactate.
4- Avoid meat products that contain lactose.
5- Avoid any products containing chocolate.
6- Avoid instant coffee, powdered soft drinks with lactose.
2-12 Diagnosis of lactose intolerance:

When mucosal lactase is deficient, lactose is not hydrolyzed and absorbed properly from the intestinal lumen (Tover and Russell, 1981). A clinical diagnosis of impaired lactose activity can be established by many means:

2-12-1 Breath hydrogen test:

The (BHT) measures the amount of hydrogen in the breath. The patient drinks a lactose loaded beverage (2 gram of lactose per kilogram body weight) in a 20% aqueous solution (Heger and Buller, 1995), and the breath is analyzed at regular intervals (each 30 minutes for about 2-3 hours). An increment of 20 ppm of hydrogen over the baseline (measured before taking the lactose) is accepted as a positive response. Increments values between 10-20 ppm are considered intermediate unless accompanied by symptoms. An increment value of 10 ppm or less is considered normal (Buller, 1990; Barr et al, 1981 and Adolfsson et al, 2004).

2-12-2 Lactose tolerance test:

The tests are carried out in the same way as glucose tolerance test (Varley, 1976). Following an overnight fast, orally 50g of lactose dissolved in 400 ml of water is administered (Henry, 1996). Fasting blood and blood samples were drawn at 60 and 120 minutes. Subjects who had maximum blood glucose rise below 20 mg/100 ml were considered to have a flat lactose tolerance curve and were designated non-digesters (Bayless and Rosenweig, 1966).
2-12-3 A biopsy assay:

A small intestinal biopsy taken to assay the lactase activity directly, the finding of small intestinal mucosal injury can also be assessed as a possible cause of secondary lactase deficiency (Heger and Buller, 1995).

2-12-4 Stool acidity test:

The lactose load in a lactose tolerance test or hydrogen breath test may be dangerous for infants and children, so doctors may use stool acidity test for young children who are suspected of having lactose intolerance. This test measures the amounts of acid in the stool, undigested and absorbed lactose ferments in the colon, creating lactic acid and other acids that can be detected in a stool sample (Tover and Russell, 1981).

Chapter Three

Materials and Methods

This study was designed to assess lactose intolerance among university students. The main objective of the study was to examine the effect of lactose intolerance on food habits and the nutritional status of population studied. This section of the study is organized in the following sequence:
1-Description of the study site and subjects.
2-Pilot study.
3-Research design.
4-Data collection.
5-Data analysis.

3.1. Site and Subjects:

This study was carried out at the University of Khartoum. It is the oldest and biggest university in Sudan. The number of university students was 11,405. In this study, data was collected from five faculties in Khartoum University (Faculty of Medical Laboratory Sciences, School of Management Studies, Faculty of Science, Faculty of Public Health and Environmental Hygiene and Faculty of Law).

A total of 140 students (70 of them were selected according to the symptoms they suffer from after drinking milk and an equal number was selected because they drank milk without any complaints (controls).

3-2 The Pilot study:

The pilot study was field work which was tested in one faculty of the University of Khartoum (Faculty of Medical Laboratory Sciences). Thirty students completed the pilot study to test the clarity and the time needed to complete the questionnaire. Some revisions were made, especially on the food frequency table. The pilot study showed that the time needed to fill out the questionnaire was 15 minutes.

3-3 Research design:

3-3-1 Sample selection:

Faculties were selected randomly (Medical Laboratory Sciences, School of Management Studies, Faculty of Science, Faculty of Law, Public Health and Environmental Hygiene).

Selection of students:
1- Experimental: The students were randomly selected to fill the questionnaire form. The student who reports symptoms of lactose intolerance was then assigned for lab tests.

2- Controls: The students were randomly selected to fill the questionnaire form. These were the students who could drink any amount of milk without showing any signs or symptoms.

**3-3-2 Study design:**

Written permissions were sent to each faculty to arrange suitable times, to be scheduled within the daily college time. The survey team consisted of one researcher, a doctor, a lab. technician and an assistant who was trained and well informed about the nature of the research and what needed to be done.

All anthropometric measurements (height and weight) were taken by the researcher and recorded by an assistant. Anthropometric equipments were obtained from the Nutrition. Dept. of the Federal Ministry of Health.

After the selection of the subjects the researcher explained the objectives of the study and the testing procedure and what was needed from them to arrange for the lactose tolerance test.

Data collection started on June 2006 and was completed at the five Faculties in about 8 months.

Data collection (140 questionnaires) was carried out at the five Faculties using three types of data collection:

1- Questionnaire data.
2- Anthropometric measurements.
3- Laboratory investigation.

**3-4 Data collection:**

**3-4-1 Questionnaire data:**

A standardized administered questionnaire form was filled. It consisted of both open and closed questions; students were asked to fill the
questionnaire with the help of the researcher and an assistant. Each student was interviewed alone. The questionnaire included the following parameters:

3-4-1-1 Demographics and Socioeconomic data:

Demographics and Socioeconomic data included age, sex, place of origin, monthly income, and the residency, (Appendix 1).

3-4-1-2 Clinical data:

Students were asked to report the symptoms they usually felt after intake of milk or other dairy products, (Appendix 1).

3-4-1-3 Dietary data:

This included information about frequency and quantity of milk, milk products consumption and intake of other food containing milk. Also the food intake of each student was collected using 24 hours dietary recall method (ie. food taken in previous day), (Appendix 1)

3-4-2 Anthropometric measurements:

To assess the nutritional status of the students, the following measurements were taken by the researcher.

3-4-2-1 Height (cm):

Height was taken while the student was standing as straight as possible without shoes, looking straight. The sliding headpiece of the standard scale was then lowered to touch the top of the head. Height was taken to the nearest (0.1cm).

3-4-2-2 Weight (kg):

Students were weighed without shoes with a standard clinic scale. Each student stood on the scale with weight equally distributed over each foot, and then the scale was read to the nearest 0.1kg. During the measurement period the researcher frequently checked the scale to make sure that it was accurate and sensitive.
3-4-2-3 Body mass index:

The weight and height measurements were used to calculate students body mass index (WHO, 2004). BMI = \( \frac{\text{Weight (kg)}}{\text{Height}^2 \text{ (m)}} \)

3-4-3 Laboratory investigation (Lactose tolerance test):

Lactose tolerance test was based on an oral dose of lactose, equivalent to the amount of 1 quart of milk (50g) (Henry, 1996), given in water to an individual after an overnight fast. Blood samples were withdrawn at 0, 60 and 120 mints (Welsh, 1970). In the presence of lactose intolerance, blood glucose increases less than 25 mg/100ml of serum above the fasting level. Gastrointestinal symptoms may appear (Henry, 1996). The occurrence of symptoms was commonly observed for 24 h after the test (Paige, et al, 1971). (Appendix 2)

3-5 Data analysis:

All data collected was analyzed using the statistical program. SPSS. Histograms of all variables were examined to assure that the selected statistical methods were appropriate. Means, standard deviations, percentiles, chi-squares and students t-tests were the main statistics performed. The significance level used was p<0.05 unless otherwise mentioned.

Chapter four

Results

This study was designed to assess lactose intolerance and nutritional status among University of Khartoum students. This section of the study was focused on the results and it was categorized into 4 parts:
1-Demographics and socioeconomic status of students.
2-Anthropometric measurements.
3-Clinical data.
4-Dietary intake and food habits.

**4.1. Demographics and socioeconomic status:**

The study included 140 subjects (70 cases and 70 controls). They were classified into two groups according to signs and symptoms, which occurred after drinking milk.

**4-1-1 Sex:**

Table 4-1-1 Distribution of students according to sex and lactose intolerance.

(N = 140)

<table>
<thead>
<tr>
<th>Gender</th>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LI</td>
</tr>
<tr>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Male</td>
<td>12</td>
</tr>
<tr>
<td>Female</td>
<td>58</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
</tr>
</tbody>
</table>

LI (lactose intolerant) LT (Lactose tolerant)

This table shows that the majority of the studied students were females (109). A higher percentage of lactose intolerance was observed among females (53.2%), compared to males (38.7%), but these differences are not statistically significant.

**4-1-2 Age:**

Table 4.1.2 Distribution of students according to age groups and lactose intolerance.

(N = 140)
Table 4.1.2 shows the distribution of lactose intolerance of the study subjects according to their age groups. Lactose intolerance was found to be significantly higher among older students (60.3%) compared to the younger group (41.6%).

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Number</th>
<th>%</th>
<th>Number</th>
<th>%</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>18–21</td>
<td>32</td>
<td>41.6</td>
<td>45</td>
<td>58.4</td>
<td>77</td>
<td>55</td>
</tr>
<tr>
<td>22–25</td>
<td>38</td>
<td>60.3</td>
<td>25</td>
<td>39.7</td>
<td>63</td>
<td>45</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>50</td>
<td>70</td>
<td>50</td>
<td>140</td>
<td>100</td>
</tr>
</tbody>
</table>

*P > 0.021

LILI (lactose intolerant) LT (Lactose tolerant)

4-1-3 Type of Residence:

Table 4.1.3. Distribution of students according to type of residence and lactose intolerance.

| Residence | Students | (N = 140) |
As shown in Table 4.1.3. 83% of the studied students lived with their families. In fact no differences were found between the students who lived with their families and those who resided at the university boarding houses regarding their lactose intolerance.

### 4-1-4 Place of origin:

Distribution of the studied population according to their place of origin is shown in Table 4-1-4. The majority of the students were from Northern parts of Sudan (56%), followed by subjects from central Sudan (25%), and 15% from the West. On the other hand, only 2% were from the south and also 2% of students were from the Eastern parts of Sudan. There were no significant association between lactose intolerance and place of origin.

<table>
<thead>
<tr>
<th>Place of origin</th>
<th>LI</th>
<th>LT</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>%</td>
<td>Number</td>
</tr>
<tr>
<td>With family</td>
<td>58</td>
<td>50</td>
<td>58</td>
</tr>
<tr>
<td>University boarding houses</td>
<td>12</td>
<td>50</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>50</td>
<td>70</td>
</tr>
</tbody>
</table>

Table 4.1.4. Distribution of students according to their place of origin and lactose intolerance.

(N = 140)
Table 4.1.5. Distribution of students according to their family income and lactose intolerance (N = 140)

<table>
<thead>
<tr>
<th>Income</th>
<th>LI</th>
<th>LT</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 600 SP</td>
<td>43</td>
<td>34</td>
<td>77</td>
</tr>
<tr>
<td>Above 600 SP</td>
<td>27</td>
<td>36</td>
<td>63</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>70</td>
<td>140</td>
</tr>
</tbody>
</table>

As shown in Table 4.1.5, 55% of the students’ families’ monthly incomes were less than 600 Sudanese Pounds. No significant association was found according to the student’s families’ income and lactose intolerance.

4.2. Nutritional status of subjects (anthropometric measurements):

4-2-1 Height: -

In this study anthropometric measurements were used as indicators of the nutritional status of students under study. Data for mean height, weight,
and body mass index (BMI) are shown in Tables (4-2-1), (4-2-2) and (4-2-3), respectively. Mean height of male lactose intolerants was $171.33 \pm 8.88$, and for lactose tolerant was $173.47 \pm 9.33$. Females mean height for lactose intolerants was $158.40 \pm 13.11$ for lactose tolerant was $161.41 \pm 7.04$. Although lactose tolerant males and females were found to be taller than the intolerant groups but these differences were not statistically significant.

Table 4.2.1. Heights in relation to lactose intolerance among University of Khartoum students.

\[
(N = 140)
\]

<table>
<thead>
<tr>
<th>Students</th>
<th>Sex</th>
<th>Mean(cm)</th>
<th>Std. Deviation</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>LI</td>
<td>Male</td>
<td>171.3333</td>
<td>8.8763</td>
<td>12</td>
<td>17.1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>158.3966</td>
<td>13.1148</td>
<td>58</td>
<td>82.9</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>160.6143</td>
<td>13.3702</td>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>LT</td>
<td>Male</td>
<td>173.4737</td>
<td>9.3355</td>
<td>19</td>
<td>27.1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>161.4118</td>
<td>7.0432</td>
<td>51</td>
<td>72.9</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>164.6857</td>
<td>9.3739</td>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>Males</td>
<td>172.6452</td>
<td>9.0721</td>
<td>31</td>
<td>22.1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>159.8073</td>
<td>10.7716</td>
<td>109</td>
<td>77.9</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>162.6500</td>
<td>11.6847</td>
<td>140</td>
<td>100</td>
</tr>
</tbody>
</table>

LI (lactose intolerant) LT (Lactose tolerant)

4-2-2 Weight: -

Table 4.2.2. Weight in relation to lactose intolerance among University of Khartoum students.

\[
(N = 140)
\]

<table>
<thead>
<tr>
<th>Students</th>
<th>Sex</th>
<th>Mean(kg)</th>
<th>Std. Deviation</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>LI</td>
<td>Male</td>
<td>65.1667</td>
<td>13.2654</td>
<td>12</td>
<td>17.1</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>53.6379</td>
<td>7.9686</td>
<td>58</td>
<td>82.9</td>
</tr>
</tbody>
</table>
Table 4.2.2. shows the distribution of the subjects by weight. Mean weight of male lactose intolerant students was $65.17 \pm 13.27$ and $61.74 \pm 9.09$ among lactose tolerants. Mean weight of the females who were lactose intolerant was $53.64 \pm 7.97$ and the other group was $55.76 \pm 10.26$. There were no significant differences between the lactose intolerant and tolerant students regarding their weights.

4-2-3 BMI: -

Table 4.2.3. Body mass index (BMI) in relation to lactose intolerance among University of Khartoum students.

\[(N = 140)\]

<table>
<thead>
<tr>
<th>Students</th>
<th>Gender</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>21.6111</td>
<td>2.8926</td>
<td>12</td>
<td>17.1</td>
</tr>
<tr>
<td>LI</td>
<td>Female</td>
<td>21.0070</td>
<td>2.9564</td>
<td>58</td>
<td>82.9</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Male</td>
<td>Female</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>-------</td>
<td>-----------</td>
<td>----------</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BMI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LI</td>
<td>21.1106</td>
<td>2.9338</td>
<td>70</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>LT</td>
<td>20.5271</td>
<td>2.6274</td>
<td>19</td>
<td>27.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21.3384</td>
<td>3.2608</td>
<td>51</td>
<td>72.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21.1182</td>
<td>3.1044</td>
<td>70</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20.9467</td>
<td>2.7382</td>
<td>31</td>
<td>22.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21.1621</td>
<td>3.0924</td>
<td>109</td>
<td>77.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21.1144</td>
<td>3.0094</td>
<td>140</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

LI (lactose intolerant) LT (Lactose tolerant)

BMI was shown in Table 4.2.3. Mean BMI of lactose intolerant males was 21.61 ± 2.89 and 20.53 ± 2.63 in the tolerant group. BMI of lactose intolerant females was 21.01 ± 2.96, and for lactose tolerant females was 21.34 ± 3.26. No significant differences were found.

The majority of the subjects (69.3%) had normal body weight, BMI between 18.5-24.9 kg/m², and the percentage of subjects who were under weight (less than 18.5 kg m²) was 20% and only 10.7% of the subjects had BMI above 25-29.9 kg/m² (over weight).

4.3. Clinical data of lactose intolerant students:

4.3.1 Symptoms after milk intake:

Table 4.3.1 shows number and percentage of students who suffered when they drank milk or ate food containing milk. Among this nausea were the highest complaining (54.3%). Also 18.6% of the students experienced more than one of the symptoms. 11.4% of students recorded diarrhea, 10% flatulence and 5.7% showed abdominal pain.

Table 4.3.1 symptoms after drinking milk, among lactose intolerant University of Khartoum students.

(N = 70)
### Table 4.3.2 The last time lactose intolerant students had consumed milk. (N = 70)

<table>
<thead>
<tr>
<th>Last time student had milk</th>
<th>LI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Months before</td>
<td>32</td>
</tr>
<tr>
<td>Year before</td>
<td>7</td>
</tr>
</tbody>
</table>

LI (lactose intolerant)

4.3.2. The consumption of milk among lactose intolerant university students

Table 4.3.2 shows that most students (54.3%) didn’t drink milk for a long time (≥year). 45.7% of them did not drink milk for a month or more. On the other hand, all lactose tolerant students used to drink milk every day. The amounts vary between a big cup (250 ml) and small cup (150 ml). More than two third of lactose tolerant students (68.6%) daily drank 250 ml of milk.

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal pain</td>
<td>4</td>
<td>5.7</td>
</tr>
<tr>
<td>Flatulence</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Nausea</td>
<td>38</td>
<td>54.3</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>8</td>
<td>11.4</td>
</tr>
<tr>
<td>Multiple symptoms (abdominal pain, flatulence, nausea, diarrhea)</td>
<td>13</td>
<td>18.6</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>100</td>
</tr>
</tbody>
</table>
4.3.3 Lactose tolerance test:

Table 4.3.3 shows the number and percentage of the studied subjects in relation to the lab. test results. Results have shown that 72.9% were none digesters (blood glucose below 20 mg /100 ml after ingestion of 50 g of lactose), and 27.1% were digesters. A statistical analysis comparing between lactose digesters (19) and non digester (51) were carried out within lactose intolerant group but no significant differences were detected.

Table 4.3.3 Digestion of lactose among lactose intolerant University of Khartoum students

(N = 70)

<table>
<thead>
<tr>
<th>Result of the test</th>
<th>LI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Positive</td>
<td>51</td>
</tr>
<tr>
<td>Negative</td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
</tr>
</tbody>
</table>

LI (lactose intolerant)

4.4 Relationships between the intake of milk products (white cheese and yogurt) and lactose intolerance.

4-4-1 Cheese intake:

As shown in Table 4-4-1 cheese was the most frequently taken milk product. Generally 91% and 86% of intolerant and tolerant students respectively were found to take cheese on daily basis. The amount of cheese
taken daily by intolerant students was found to be significantly higher than that of tolerant students \((P>0.000)\) 59% of intolerant students had taken more than 40g of cheese daily compared to 25% of tolerant students.

Table 4.4.1 Distribution of students at University of Khartoum and the amounts of cheese eaten daily.

\[(N = 124)\]

<table>
<thead>
<tr>
<th>Cheese</th>
<th>Students</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>LI</td>
<td>LT</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number</td>
<td>%</td>
<td>Number</td>
<td>%</td>
<td>Number</td>
</tr>
<tr>
<td>More than 40g/day</td>
<td>38</td>
<td>59.4</td>
<td>15</td>
<td>25</td>
<td>53</td>
</tr>
<tr>
<td>Less than 40g/day</td>
<td>26</td>
<td>40.6</td>
<td>45</td>
<td>75</td>
<td>71</td>
</tr>
<tr>
<td>Total</td>
<td>64</td>
<td>100</td>
<td>60</td>
<td>100</td>
<td>124</td>
</tr>
</tbody>
</table>

*\(P > 0.000\)  
LI (lactose intolerant) LT (Lactose tolerant)

4-4-2 Yogurt intake: -

Table 4.4.2 Distribution of students of University of Khartoum and yogurt intake

\[(N = 111)\]

<table>
<thead>
<tr>
<th>Yogurt</th>
<th>Students</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>LI</td>
<td>LT</td>
<td>Total</td>
</tr>
</tbody>
</table>

39
Table 4.5.1 shows distribution of students at University of Khartoum and intake of the most frequently consumed foods containing milk. There were no significant differences between the two groups regarding their daily intake of tea with milk. (81.4% of the intolerant students daily drink tea with milk and 91.4% of the lactose tolerant drink it), but biscuits intake showed more significant association with lactose intolerants compared to tolerant students (71.4%, vs. 55.7%) (P>0.05).

Table 4.5.1 Distribution of students at University of Khartoum and the daily intake of some foods containing milk.  
(N = 140)

<table>
<thead>
<tr>
<th>Type of food</th>
<th>LI</th>
<th></th>
<th>LT</th>
<th></th>
<th>Total</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Drink tea with milk</td>
<td>57</td>
<td>81.4</td>
<td>64</td>
<td>91.4</td>
<td>121</td>
<td>86.4</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>18.6</td>
<td>6</td>
<td>8.6</td>
<td>19</td>
<td>13.6</td>
</tr>
</tbody>
</table>

Yogurt was found to be less commonly taken by students compared to cheese. Intolerant students take yogurt most frequently than tolerant students (61.1% intolerant students at least eat one yogurt standard cup (175g) weekly compared to only 38.9% of the tolerant students).

4.5 The relationship between the daily intake of some foods containing milk and lactose intolerance.

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>%</th>
<th>Number</th>
<th>%</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>175g ≥ per week</td>
<td>44</td>
<td>75.9</td>
<td>28</td>
<td>52.8</td>
<td>72</td>
<td>64.9</td>
</tr>
<tr>
<td>175g &lt; per month</td>
<td>14</td>
<td>24.1</td>
<td>25</td>
<td>47.2</td>
<td>39</td>
<td>35.1</td>
</tr>
<tr>
<td>Total</td>
<td>58</td>
<td>52.3</td>
<td>53</td>
<td>47.7</td>
<td>111</td>
<td>100</td>
</tr>
</tbody>
</table>

*P > 0.023 LI (lactose intolerant) LT (Lactose tolerant)
Table 4.5.2 shows distribution of students at University of Khartoum and intake of some of the frequently consumed foods containing milk. 67% of all subjects at least once a month take cakes and 57% take ice cream. There were no significant associations between intake of cake, pizza, custard and ice cream and lactose intolerant group.

<table>
<thead>
<tr>
<th>Type of food</th>
<th>LI (Yes)</th>
<th></th>
<th>LT (Yes)</th>
<th></th>
<th>Total</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>%</td>
<td>Number</td>
<td>%</td>
<td>Number</td>
<td>%</td>
</tr>
<tr>
<td>Cake</td>
<td>45</td>
<td>64.3</td>
<td>50</td>
<td>71.4</td>
<td>95</td>
<td>67.9</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>35.7</td>
<td>20</td>
<td>28.6</td>
<td>45</td>
<td>32.1</td>
</tr>
</tbody>
</table>
LI (lactose intolerant) LT (Lactose tolerant)

4.6-1 Intake of good source of calcium foods and lactose intolerance among Khartoum University students.

Table 4.6.1 shows that there were significant differences between students under study. The percentages of the students who ate vegetables only or vegetables and tuna fish were found to be significantly higher in lactose tolerant compared with lactose intolerants (95.7%, 77.1% respectively) P>0.006.

Table 4-6-1 Daily intakes of vegetable and fish in relation to lactose intolerance among University of Khartoum students.

(N = 140)

<table>
<thead>
<tr>
<th>Food</th>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LI</td>
</tr>
<tr>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Vegetables</td>
<td>18</td>
</tr>
<tr>
<td>Vegetables + tuna fish</td>
<td>36</td>
</tr>
</tbody>
</table>
Neither vegetables nor fish | 16 | 22.9 | 3 | 4.3 | 19 | 13.6
---|---|---|---|---|---|---
Total | 70 | 100 | 70 | 100 | 140 | 100

*P > 0.006

**LI** (lactose intolerant) **LT** (Lactose tolerant)

### 4-7 Beverages intake:

Daily drinking of soda in relation to lactose intolerance among Khartoum University students was determined. Table 4.7.1 show that there were no significant differences between the two groups regarding their drinking of soda (22.9% among lactose intolerant and 24.3% among the lactose tolerant group).

Table 4-7-1 Daily drinking of soda in relation to lactose intolerance among students.

(N = 140)

<table>
<thead>
<tr>
<th>Drink soda</th>
<th>Students</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LI</td>
<td>LT</td>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>%</td>
<td>Number</td>
<td>%</td>
<td>Number</td>
<td>%</td>
</tr>
<tr>
<td>Yes</td>
<td>16</td>
<td>22.9</td>
<td>17</td>
<td>24.3</td>
<td>33</td>
</tr>
<tr>
<td>No</td>
<td>54</td>
<td>77.1</td>
<td>53</td>
<td>75.7</td>
<td>107</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>100</td>
<td>70</td>
<td>100</td>
<td>140</td>
</tr>
</tbody>
</table>

LI (lactose intolerant) LT (Lactose tolerant)

### 4.8 Food groups intake during the last 24 hours:

Table 4.8.1 shows that vegetables consumption mainly (potato, okra and green leafy vegetables) was 75.7% among lactose intolerant and 74.3% among tolerants. There were no significant differences between the two groups.
Fruits intake (the 3 most commonly taken were mango, orange and banana) was found to be significantly higher among lactose intolerants $P>0.05$. Nevertheless the number of students who took fruits was very low in the two groups, (22.1% and 12.9% respectively).

The majority of subjects under study had consumed at least one item from the meat group (meat, eggs & legumes) during the last 24 hours (93.6%). Meat was taken by 45% of the subjects; the consumption of eggs and legumes were 19.1% and 35.9% respectively.

Milk and milk products (cheese, yogurt) were significantly higher among lactose tolerant compared to lactose intolerants (84.3% to 65.7%) ($P>0.05$).

A higher consumption of sweets and fats (lactose intolerants 88.6% and tolerant 97.1%) was observed in the two groups.

Table 4.8.1. Distribution of students at University of Khartoum and intake of food groups during 24-recall

<table>
<thead>
<tr>
<th>Students</th>
<th>L I</th>
<th>LT</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>%</td>
<td>Number</td>
</tr>
</tbody>
</table>

44
<table>
<thead>
<tr>
<th>Category</th>
<th>Yes</th>
<th>75.7</th>
<th>52</th>
<th>74.3</th>
<th>105</th>
<th>75</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable (fresh + cocked) Yes</td>
<td>53</td>
<td></td>
<td>74.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>17</td>
<td>24.3</td>
<td>18</td>
<td>25.7</td>
<td>35</td>
<td>25</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>100</td>
<td>70</td>
<td>100</td>
<td>140</td>
<td>100</td>
</tr>
<tr>
<td>(Fruits*) Yes</td>
<td>16</td>
<td>22.1</td>
<td>9</td>
<td>12.9</td>
<td>25</td>
<td>17.9</td>
</tr>
<tr>
<td>No</td>
<td>54</td>
<td>77.9</td>
<td>61</td>
<td>87.1</td>
<td>115</td>
<td>82.1</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>100</td>
<td>70</td>
<td>100</td>
<td>140</td>
<td>100</td>
</tr>
<tr>
<td>(Meats, eggs &amp; legumes) Yes</td>
<td>68</td>
<td>97.1</td>
<td>63</td>
<td>90</td>
<td>131</td>
<td>93.6</td>
</tr>
<tr>
<td>No</td>
<td>2</td>
<td>2.9</td>
<td>7</td>
<td>10</td>
<td>9</td>
<td>6.4</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>100</td>
<td>70</td>
<td>100</td>
<td>140</td>
<td>100</td>
</tr>
<tr>
<td>(Milk &amp; milk products*) Yes</td>
<td>46</td>
<td>65.7</td>
<td>59</td>
<td>84.3</td>
<td>105</td>
<td>75</td>
</tr>
<tr>
<td>No</td>
<td>24</td>
<td>34.3</td>
<td>11</td>
<td>15.7</td>
<td>35</td>
<td>25</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>100</td>
<td>70</td>
<td>100</td>
<td>140</td>
<td>100</td>
</tr>
<tr>
<td>(Sweets &amp; Fats*) Yes</td>
<td>62</td>
<td>88.6</td>
<td>68</td>
<td>97.1</td>
<td>130</td>
<td>92.9</td>
</tr>
<tr>
<td>No</td>
<td>8</td>
<td>11.4</td>
<td>2</td>
<td>2.9</td>
<td>10</td>
<td>7.1</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>100</td>
<td>70</td>
<td>100</td>
<td>140</td>
<td>100</td>
</tr>
</tbody>
</table>

* P > 0.05  LI (lactose intolerant) LT (Lactose tolerant)

Chapter Five
Discussion
This study was designed to assess lactose intolerance and nutritional status among University of Khartoum students. The subjects in this study were university students who were selected randomly, from five faculties (140 students). This chapter of the study will be focused on discussing the results.

5.1. Demographics and socioeconomical status of the studied population

5-1-1 Age & sex:

The majority of the studied students were females (78%); the males were only 22%. There was no significant difference between females and males regarding their lactose intolerance. This finding agrees with Rao et al. (1994). In a randomly selected population, he found that gender did not have any effect on the prevalence of hypolactasia. However, another study by Krause’s et al. (1996) showed that hydrogen exhalation after lactose ingestion was greater in men than in women; lactose maldigestion caused significantly more symptoms in women than in men. A study by Vesa et al. (1998) showed that there was a strong relation among subjective lactose intolerance and female sex. Based on the results of the above studies, women seem to experience stronger gastrointestinal complaints than men, but it is not possible to draw any conclusion on the possible differences between the genders.

Observations on the distribution of lactose intolerance of the studied subjects according to their age groups, detected that lactose intolerance was significantly higher among older students 60.3% (22-25 year group) compared to the younger group (18-21 year) (41.6%). Many studies have found that the prevalence of lactose maldigestion significantly increases with age (Carroccio et al. 1998; Saltzberg et al. 1988 and Rao et al., 1994). But Rana et al. (2004) reported that among North Indians the frequency of lactose maldigestion did not differ significantly among age groups. This might be due to genetical differences among different populations.

5-1-2 Residences & Place of origin:
Eighty three percent of the studied students live with their families. No significant differences were found between the students living with their families and those who reside at the university boarding houses regarding their lactose intolerance. This study has also not found significant association between lactose intolerance and place of origin. This finding disagrees with Bayoumi et al. (1979) who studied the distribution of adult lactase phenotype, lactose absorption, and lactose malabsorption in the population of the Democratic Republic of the Sudan. They found significant differences between different populations in Sudan. Our study has a very limited number of students; also the majority of the sample studied reside at Khartoum state while Bayoumi et al. (1979) study covered most parts of the Sudan.

5-1-3 Family income

The suggestion that in Africa lactose intolerance is related to poverty, malnutrition or to diminished milk intake, has been disproved by Cook and Kajubi (1966) who found isolated lactase deficiency in the Baganda and other Bantu tribes of Uganda, whereas patients from tribes such as the Rwanda, were found to have high levels of lactase activity. In our study there were no significant association between the student's families’ income and lactose intolerance that may be due to our sample which is taken from one place.

5-2 Nutritional status of the subjects:

In this study anthropometric measurements were used as indicators of the nutritional status of students under study. The study found that there were no significant differences between lactose intolerant and tolerant students regarding their anthropometrics. Mean heights of male lactose intolerants was $171.33 \pm 8.87$ (cm), among lactose tolerant was $173.47 \pm 9.33$ (cm). Females mean heights among lactose intolerants was $158.39 \pm 13.11$ (cm), for lactose tolerants was $161.41 \pm 7.04$ (cm). When comparing these figures to the U.S reference population (NCHS, 1987), it was found that males and females mean heights were between 25th and 50th percentiles. In general the lactose
tolerant males and females were slightly taller than intolerant, but not statistically significant, this might be due to better nourishment especially during their first years of live. Mean weight of male lactose intolerants was 65.16 ± 13.26(kg) and 61, 73 ±9.09(kg) among lactose tolerants. Mean weight of females who were lactose intolerants was 53.63 ± 7.96(kg) and the other group was 55.76 ±10.25(kg). When comparing the weights of subjects to the US reference population (NCHS, 1994) it was found that, the mean weight of males did not exceed the 25th percentile; it is between 15th and 25th percentiles. But weight of females was found to be between 25th and 50th percentiles. No significant differences were found regarding weight or BMI between the two groups. Mean BMI of males was 21.61 ± 2.89 while among lactose tolerant and 20.52 ± 2.62 in the other group. BMI of female lactose intolerants was 21.00 ± 2.95 among lactose tolerant females was 21.33 ± 3.26. Twenty percent of the subjects’ studied were underweight (BMI<18.5). The majority of the subjects had normal weights BMI (between 18.5-24.9) (WHO, 2004). This result agrees with Villiers. (1988). He found that there was no significant difference in the nutritional status of the lactose intolerant and tolerant subjects, as measured by their relative weights and body mass indices.

5-3 Clinical data of lactose intolerant students:

5-3-1 Symptoms after milk intake:
It was documented that lactose intolerant subjects may experience bloating, abdominal cramps and flatulence, with higher lactose ingestion. Also osmotic diarrhea may result. Most of them can tolerate one to two glasses of milk daily with minimal or no symptoms, while others may be symptomatic with almost any lactose (Burton and Faster, 1988).

Nausea was found to be the highest complaint the subjects usually felt after consuming milk (54.3%). 18.6% of the students recorded experiencing of more than one symptoms. 11.4% of students showed symptoms of diarrhea, 10% flatulence and 5.7% abdominal pain. 44.3% among the subjects studied did not drink milk for years. However, it is well documented by many studies that the majority of lactose intolerants can easily be adapted to tolerate 12 g lactose (250ml of milk) with minimal or no discomfort if milk is ingested in gradually increasing amounts (Newcomer et al., 1978; Monro and Brand, 1991; Johnson, 1993 and Vesa et al., 1996).

5-3- 2 Lactose tolerance test:
This study has found that only 72.9% were nondigesters (blood glucose below 20 mg/100 ml), and 27.1% were digesters after ingestion of 50g lactose dissolved in water. The digesters showed unnecessary reaction to milk consumption, which might decrease their dietary calcium intake. This finding disagrees with Carrocio et al., (1998) who found that the frequency of lactose intolerance was much lower than that of lactose maldigestion. Gastrointestinal symptoms after lactose intake in self-reported milk-intolerants are found in only a very low number of these subjects.

5-4 The relationship between intake of milk, and milk products and lactose intolerance:
Among the studied population, it was found that yogurt and cheese intake of lactose intolerant students was significantly higher than among lactose tolerant students (p<0.05). This agrees with Escribano et al. (1993) who studied the relationship between primary lactose malabsorption and consumption of dairy products. They found that, malabsorbers consumed more fermented dairy products (ripened cheese and yogurt) than did absorbers. This result might be due to the reason that intolerant subjects usually do not suffer when they take these types of milk products which supply their bodies with many nutrients.

It is generally accepted that fermented milk products such as yogurt can efficiently improve lactose digestion in lactose malabsorbers and therefore, yogurt is better tolerated than milk. It is only, to some extent, tolerated by most lactose-intolerant subjects.

5-5 The relationship between the intake of some food containing milk and lactose intolerance.

The study found no significant association between the two groups and the drinking of tea with milk (81.4% of the intolerant students daily drink tea with milk and 91.4% of the lactose tolerant). This is a good cultural practice, which is very common among the majority of the Sudanese families. Biscuits daily intake was the only type of food that showed positive significant association with lactose intolerant students (71.4%). No significant association between the intake of cake, pizza, custard or ice cream and lactose intolerant students. These foods were probably consumed once or twice a month by the majority of the subjects, add to this, in Sudan these foods were more expensive compared to the other milk products or milk contains foods.

5-6 Intake of rich Calcium foods and lactose intolerance among Khartoum University students.
Because lactose intolerant students avoid milk, which is a very rich source for calcium, the study tried also to investigate the consumption of some other rich calcium containing foods such as tuna fish and dark leafy vegetables. It was found that the percentage of lactose intolerant students who used to consume tuna fish and dark leafy vegetables was significantly lower compared to tolerant students. This finding may elevate the risk of intolerants regarding all diseases which might be associated with calcium deficiency (eg. osteoporosis).

5-7 Food intakes during the last 24 hours

Intake of 3 meals (breakfast, lunch, and dinner) and snacks between these meals during the last 24 hours were reported by the students. These food intakes were then categorized qualitatively into food groups (meat, legumes, eggs, vegetables, fruits, milk and milk products, bread, sweets and beverages).

Up to 25% of the university students did not take vegetables daily. There were no significant differences between the lactose intolerant and tolerant groups. Fruits intake was found to be significantly higher among lactose intolerants. Nevertheless the numbers of students who took fruits were low from the two groups (22.1% and 12.9% respectively). These finding reflects the ignorance of these students regarding their nutritional needs and the importance of the vegetables and fruits to their health status.

The majority of subjects under study consumed at least one item of the meat group at the previous day 93%, (45% meat, legume 35.9%, and eggs 19.1%). Milk and milk products were higher among lactose tolerants compared to lactose intolerants (84.3% to 65.7% respectively). Higher consumption of these two food groups (meats and milk groups) might be due to rather: (1) They are more available and accessible at the University (as they sold at the University).(2) Or might be due to the students preference. Nevertheless the high consumption of these groups is a very good food habit and impotents to the nutritional and health status of these students.
Higher consumption of sweets and fats was found in the comparison between the lactose intolerant and tolerant groups (88.6% to 97.1% respectively).

In general, 24 hours recall dietary intake had clearly showed the decreased intake of vegetables and fruits, which nourishes our bodies with many vitamins and minerals.
Conclusions and Recommendations

Conclusions

This study was designed to assess lactose intolerance among University students and to examine the effect of lactose intolerance on food habits and the nutritional status of sample studied.

The majority of the study samples were females (78%) and lactose intolerance was found to be higher among the older age groups (22-25 years). 83% of the student's studied live with their families and were from Northern Sudan (43.6%). Males and females nutritional status as indicated by their height and weight was below the NCHS standards. Males and females mean heights and weight were between 25th and 50th percentiles except the mean weights of males were only between 15th and 25th percentiles.

Nausea was the highest complaint subjects usually felt after consuming milk. Only 72% of the students, who self-reported milk intolerance were prove tested to be maldigesters (using lactose tolerance test).

Yogurt and cheese intake of lactose intolerant students was significantly higher than among lactose tolerant students. On the other hand, vegetables and tuna fish consumption was higher among lactose tolerant compared to lactose intolerants (65.7%, and 51.4% respectively).

Vegetables and fruits consumption was found to be neglected by a number of students among both lactose tolerant and intolerants.
Recommendation

The following recommendations were extracted from this study, and it was hoped that these will promote and improve the health and nutritional status of university students.

1- Since milk and milk products are very nutritious, as well as available and affordable, nutrition education programs through the available mass-media have to stress on the importance of these products in improving the nutritional status of the majority of the Sudanese population.

2- Fortunately lactose intolerance symptoms can easily be minimized through:
   A- Drinking small amount of milk (< 250 ml).
   B- The consumption of milk with solid foods.
   C- Eating more milk products (yogurt and cheese).

Therefore, nutrition education programs targeting university students and other intolerant population should concentrate on how to mitigate symptoms of lactose intolerance.

3- Awareness programs for university students should focus on the importance of the daily consumption of vegetables and fruits by students. The university administration can also play a role regarding this important issue by encouraging the food sellers around the university to sell meals rich in vegetables served with fresh fruit juices.

4- More studies assessing the prevalence of lactose intolerance among other groups are needed.

5- In-depth studies are needed to investigate the symptomatic lactose digesters and the reasons behind their unnecessary milk avoidance.

6- Studies investigating the lower nutritional status of the university students compared to other standards are also recommended.
References


Appendix (1)

University of Khartoum
Faculty of Education
Department of Home Science

Questionnaire

Lactose Intolerance And Food Habits Among Khartoum University Students

Section (1) **Demographic and Socioeconomic data:**

Serial No. [ ]

1- Sex: male [ ] female [ ]

2- Age: 18-21 [ ] 22-25 [ ]

3- Type of Residence: With their family [ ]

University Boarding houses [ ]

4- Place of origin: North [ ] Central [ ] South [ ] West [ ]

East [ ]

5- Family income: Less than 600 SP [ ] Above 600 SP [ ]

Section (2) **Anthropometric measurements:**

1- Weight [ ] kg.

2- Height [ ] cm.

Section (3) **Clinical data:**

1- Symptoms after milk intake: Abdominal pain [ ] Flatulence [ ]

[ ] [ ]
Nausea             Diarrhea             Multiple symptoms (abdominal pain, 
Flatulence, nausea, diarrhea)  

2- Lab test result: Positive □   Negative □ 

3- The intake of milk: Yes □   No □   Big cup (250ml) □ 
Small cup (150 ml) □ 

4-The last time lactose intolerant student had consumed milk: Months before □  Year before □ Years before □ 

Section (4) **Dietary data:**

1- The intake of milk products: Yes □   No □ 

2- The intake of white cheese: Yes □   No □   More than 40g/day □ 
Less than 40g/day □ 

3- The intake of yogurt: Yes □   No □   175g > per week □ 
175g < per month □ 

4-The daily intake of some foods containing milk:  
- Tea with milk: Daily □ Every week □ Every month □ 
- Biscuit: Daily □ Every week □ Every month □ 
- Cake: Daily □ Every week □ Every month □ 
- Pizza: Daily □ Every week □ Every month □ 
- Custard: Daily □ Every week □ Every month □ 
- Ice cream: Daily □ Every week □ Every month □ 

5-The intake of vegetable and fish:  
- Vegetables: Daily □ Every week □ Every month □
- Vegetables + tuna fish: Daily  ☐  Every week  ☐  Every month – ☐

Niether vegetables nor fish: Daily  ☐  Every week  ☐  Every month☐

6- Daily drinking Soda: Yes ☐  No  ☐

7- Food intake on the last 24 hours:
   - At morning……………………………………………………………
   - Breakfast………………………………………………………………
   - After Breakfast…………………………………………………………
   - Lunch……………………………………………………………………
   - After Lunch……………………………………………………………..
   - Dinner……………………………………………………………………
   - After Dinner……………………………………………………………..
Appendix (2)

**Method of estimation glucose**

**Regent:**

Regent 1: -

1. Phosphate buffer (ph7.5).

4-Aminoantipyrine

Phenol

Glucose oxidase

Peroxidas

Mutarotase

Regent 2: -

Glucose standard.

**Assay:**

Wavelength : 456nm. 500nm.

Optical bath : 1 cm

Temperature : 20-25°C or 37°C

Measurement : against the reagent blank.

Blood sample : 2-5(cc).

Colorimeter

**Principle:**

The oxidation of glucose is catalysed by glucose oxidase (GOD) The resultant hydrogen peroxide (H₂O₂) is oxidatively coupled with 4-aminophenazone and phenol in the presence of peroxidase (POD) to yield a red quinoneminie dye, the concentration of which at 546 nm is proportional of glucose.

\[
\text{Alpha-D-Glucose \quad \rightarrow \quad Mutarotase \quad \rightarrow \quad beta-D-glucose}
\]

\[
\text{Beta-D-glucose } + \text{H}_2\text{O}_2 + \text{O}_2 \quad \rightarrow \text{GOD}\quad \rightarrow \text{D-Gluconic acid } + \text{H}_2\text{O}_2
\]

\[
\text{H}_2\text{O}_2 + \text{4aminophenazone} + \text{phenol} \quad \rightarrow \text{POD}\quad \rightarrow \text{quinoneimie} + 4\text{H}_2\text{O}
\]
**Specimen:**
Serum, plasma.
Glucose is stable for 24 hours if serum or plasma is at 2-8°C.

**Procedure:**

<table>
<thead>
<tr>
<th>Pipette into Cuvettes</th>
<th>Blank</th>
<th>Standard</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Sample</td>
<td>ml</td>
<td>-</td>
<td>0.01</td>
</tr>
<tr>
<td>Standard (Reagent2)</td>
<td>ml</td>
<td>0.01</td>
<td>-</td>
</tr>
<tr>
<td>Distilled water</td>
<td>ml</td>
<td>0.01</td>
<td>-</td>
</tr>
<tr>
<td>Reagent 1</td>
<td>ml</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Mix and incubate for 10 minutes at 20-25°C. Or 5 minutes at 37°C
Measure the absorbance of the sample (AS) and standard (A std) against the reagent blank.

**Calculation:**

\[
\text{Glucose (mg/dl)} = \frac{\text{AS}}{\text{A std}} \times \text{concentration of standard}
\]

To convert mg/dl to mmol/L divide by 18 (Trinder, 1969).