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**THE RELEVANCE OF LACTOSE INTOLERANCE ON THE DEVELOPMENT  
OF OSTEOPOROSIS IN MIDDLE-AGED ADULTS VIA BONE MASS DENSITY  
(BMD) SCANNING**

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Lactose intolerance is a common disorder characterized by the inability to break down the sugar lactose due to a lack of the enzyme lactase in the small intestine. Lactose is found in all dairy products, and, being that dairy products are the main source of calcium in the average person's diet, it would seem logical that a lack of calcium in one's diet could pose an increased risk of developing osteoporosis. Osteoporosis is a disease of the bone tissue that causes deterioration of the bone, making it more porous than it already is and thus causing someone with this condition to be more susceptible to fractures. I hypothesized that lactose intolerance does not make an individual more likely to develop osteoporosis.

I was particularly interested in this area of research because I personally know several people with lactose intolerance and I wanted to find out if they were at a higher risk of developing osteoporosis than non-lactose intolerant people so that if they were I could warn them about the potential risks. Also, there has not been much research performed on this particular issue relative to many other health problems, so it is my hope that others will use the information I've gathered in my mock experiment to continue research in this area.

The methodology of this experiment was straightforward: a sample population of 300 adults between the ages of 40-50 was divided into three groups based on level of lactose intolerance via a hydrogen breath test (HBT). After the sample population was divided, each individual was given a bone mineral density (BMD) scan of the vertebral and femoral (thigh) areas, which are both particularly susceptible to fracture. This is the typical method employed by researchers in this field, although many tend to focus on females due to the fact that osteoporosis is extremely common in postmenopausal women. Therefore, I wanted to expand my research to include men as well.

After performing statistical analyses, namely the 1-way ANOVA and the  $\chi^2$  (chi-square) analysis on the data I generated, I was able to conclude that lactose intolerance does not have any significant effect on the development of osteoporosis. This implies that although a person may be lactose intolerant, he/she is still able to consume the required amounts of calcium necessary for maintaining good bone health.

Through the process of building my own experiment and testing my results, I learned invaluable information about the scientific process. I believe that my methods were appropriate for answering my questions because they were adapted from actual research in the effects of lactose intolerance on development of osteoporosis. Being that the method was so direct, I had no problems analyzing my data.

There have not been many studies performed to answer this question; however, out of the studies I was able to find and research, my results complimented those of former researchers. Through reading actual studies performed on this topic, I was able to find answers to my hypothesis, which ultimately turned out to be incorrect according to current research. However, being that there is not a lot of research on this subject in the first place, I think that a substantial amount of new studies to find a correlation between lactose intolerance and osteoporosis must be performed in order to gather more conclusive data. My suggestions for future researchers to get these decisive results would be to use a larger, more ethnically varied sample population if possible, as well as more thorough testing to determine osteoporosis (i.e., BMD scanning of a larger number of anatomical regions).

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**Table 2.** Results from the 1-way ANOVA, including means, variances, and standard deviations of the NLT, MLT, and SLT subgroups. F-value and P-value are also included.

**Figure 1.** The means of each subgroup's individual BMD scan values from 1-way ANOVA. The X-axis represents the mean of each subgroup, and the Y-axis represents each individual subgroup (NLT, MLT, and SLT, respectively).

The purpose of this experiment was to determine whether or not lactose intolerance has an effect on the development of osteoporosis. I hypothesized that lactose intolerance would not increase a person's risk of osteoporosis. In order to test this hypothesis, a sample group of 300 people was generated. All of these people were of generally good health and between the ages of 40-50. They were separated into three subgroups based on severity of lactose intolerance by means of a hydrogen breath test: non-lactose intolerant, moderately lactose intolerant, and severely lactose intolerant. Each individual was then administered a BMD (bone mineral density) scan of the vertebral and femoral regions. The results of this experiment showed that the difference in BMD between all individuals tested was too small to be considered significant. Thus, it was determined that lactose intolerance has no noticeable effect on whether or not a person will develop osteoporosis.

## **Introduction**

Lactose intolerance is a condition characterized by the inability to digest lactose, a disaccharide found in milk and other dairy products, due to a deficiency of the enzyme lactase (Vesa et al, 2000). Lactase is produced in the small intestine. When the body does not produce enough of this enzyme, the undigested lactose causes a buildup of gas, which leads to stomach cramps and diarrhea 30 minutes to 2 hours after ingestion of dairy products. In order for a person to be diagnosed with lactose intolerance, they must display both stomach cramps and diarrhea after eating dairy products and/or drinking milk. Over 30 million Americans are lactose intolerant, but it is least likely in people of northern European descent. Conversely, 75 percent of adult African Americans and Native Americans, as well as 90 percent of Asian Americans, are lactose intolerant (nih.gov).

Osteoporosis is a condition in which bone tissue deteriorates and becomes less dense, making a person with osteoporosis more susceptible to bone fractures. An estimated 44 million Americans are at serious risk of developing osteoporosis, and 68 percent of these people are women. There are several risk factors for osteoporosis, including being underweight, having a small skeletal frame, having a family history of the disease, being postmenopausal, having a shortage of calcium in one's diet, smoking cigarettes, and drinking excessive amounts of alcohol. It is possible for osteoporosis to progress for many years without symptoms until an unexpected fracture occurs, which is why it is necessary that it be detected at an early stage (nih.gov).

It would appear that people who suffer from lactose intolerance should be at a greater risk for developing osteoporosis due to a supposedly reduced calcium intake; however, studies have been conducted to test for a relationship between lactose intolerance and osteoporosis, and the results of these studies are mixed. A study conducted in 2002 involving 218 adults with a mean age of 58 years found that lactose

intolerance has no noticeable effect on a person's risk of bone loss (Kudlacek et al, 2002). Another experiment conducted in 1995 involved fifty-eight postmenopausal Italian women; some were lactose intolerant, others were not. The results of this experiment also showed that calcium intake and bone mass density are not directly affected by lactose intolerance (Corazza et al, 1995). However, the truth is that no one really knows whether there is any correlation between the two, and the purpose of this experiment was to determine if such a correlation exists.

I hypothesized that being lactose intolerant would not significantly increase a person's risk of osteoporosis, mainly because there are other sources of calcium available besides dairy products, such as daily supplement pills. I also hypothesized that people with lactose intolerance would show more symptoms like stomach cramps and diarrhea after ingestion of lactose than non-lactose intolerant people, and the severely lactose intolerant would show the most symptoms. Two common tests were utilized in this experiment: the hydrogen breath test (HBT) and the bone mass density (BMD) scan. The hydrogen breath test is a commonly used procedure to diagnose various types of food intolerances, such as lactose and fructose. This test was administered first to determine which individuals in the sample population were lactose intolerant and to what degree. After the HBT, a BMD scan was administered to each individual for the lumbar and pelvic regions using a Dual Energy X-ray Absorptiometry (DEXA) scanner. The BMD scan compares the density measurements taken from the patient with an average index based on gender, age, and size. The results of this experiment were analyzed using two statistical measures, the chi-square ( $\chi^2$ ) test and the 1-way ANOVA test.

## **Materials & Methods**

For this experiment, a sample population of 300 people in generally good health and between the ages of 40-50 years was generated. I divided this population into three subgroups based on the level of lactose intolerance via a hydrogen breath test (HBT). This test was administered using a Micro H<sub>2</sub> handheld hydrogen monitor. Each patient was given the test after a 12-hour fasting period. Readings were taken immediately before lactose ingestion, then at 15-minute intervals within a 2-hour period after ingesting 25g of lactose. The HBT is measured in ppm. Generally speaking, non-lactose intolerant people should have a hydrogen concentration increase ( $\Delta H_2$ ) of no more than 20ppm, moderately lactose intolerant people should have an increase between 20-59ppm, and severely lactose intolerant people should have an increase exceeding 60ppm. Based on these standards, the results of the HBT were recorded and three subgroups were generated: 156 non lactose intolerant (NLT) people, 39 moderately lactose intolerant (MLT) people and 105 severely lactose intolerant (SLT) people.

After the subgroups were determined, each individual was given a BMD scan of the lumbar and pelvic regions using a DEXA scanner. The individual was placed on the scanner and the results were acquired through a computer interface. The results of the BMD scan of each individual were based on an average index. 2.5 standard deviations (SD) above to 1 SD below the average (+2.5 to -1) is considered normal. 1 to 2.5 SD below the average index (-1 to -2.5) is considered low bone mass, and 2.5 or more SD below the average (-2.5 or less) means that the person has osteoporosis. The results of the HBT were analyzed using a chi-square ( $\chi^2$ ) test, and the BMD scan results were analyzed with a 1-way ANOVA. I gained permission from the IRB at Pace University to conduct my research.

## Results

I found that people who do not have lactose intolerance (NLT subgroup) showed less symptoms of lactose intolerance after the ingestion of lactose than the moderately lactose intolerant people (MLT), with a  $\chi^2= 13.036$ . Furthermore, the individuals with severe lactose intolerance (SLT) showed even more symptoms after ingestion of lactose than both the moderately lactose intolerant and the non-lactose intolerant subgroups. Thus, the greatest difference in symptom display was between the NLT subgroup and the SLT subgroup ( $\chi^2= 88.947$ ); (Table 1).

I also found that there was no significant difference in BMD between individuals with lactose intolerance and individuals without lactose intolerance (1-way ANOVA test:  $F= 0.03$ ,  $P= 0.970448$ ). The averages of the means, variances, and standard deviations of each group were very close together, further signifying that there is no detectable link between lactose intolerance and osteoporosis (Figure 1 and Table 2).

## **Discussion**

I hypothesized that the individuals who were not lactose intolerant would show fewer symptoms like stomach cramps and diarrhea after ingesting lactose than the lactose intolerant people. After recording the symptoms of each individual after they ingested lactose for the HBT, I found that my hypothesis was correct. The NLT subgroup did in fact show the least symptoms as a whole. Also, I found that the MLT subgroup showed more symptoms than the NLT subgroup and fewer symptoms than the SLT subgroup; thus, the SLT subgroup showed the most symptoms out of all three subgroups, as was hypothesized.

It is interesting to note that the NLT subgroup did in fact have a percentage of people with severe symptoms of stomach cramps and diarrhea after ingesting the lactose. This could be due to some other gastrointestinal condition, such as irritable bowel syndrome (IBS), whose symptoms are very similar to those of lactose intolerance. Since the cause of IBS is unknown, it is possible that the ingestion of lactose could activate the symptoms observed in this experiment. Previous studies have actually shown that lactose intolerance is often misdiagnosed as IBS because the symptoms are so alike (Shaw and Davies, 1999). It should also be noted that although most of the individuals in the SLT subgroup displayed severe symptoms, there was a small percentage that did not. This could be due to a variety of reasons. Perhaps this small percentage of people takes a longer period of time to exhibit their symptoms. It is also possible that these individuals were on some medication for lactose intolerance at the time of ingestion, and this medication prevented their usual symptoms.

I also hypothesized that being lactose intolerant would not increase an individual's risk of developing osteoporosis. The results of the 1-way ANOVA test clearly show that there is no significant difference in BMD between the three subgroups,

which I hypothesized. I believe that the main reason why there is no significant difference is because people with lactose intolerance can get calcium and vitamin D, the most important nutrients for maintaining strong bones, from food sources other than dairy products. Broccoli, almonds, Brazil nuts, salmon, and shellfish are all excellent sources of calcium. Also, many food products such as bread, orange juice, and even bottled water are enriched with added calcium. There are also a lot of daily calcium supplements available over-the-counter, usually in tablet form. Vitamin D is found in various types of fish, such as salmon, mackerel, and tuna fish, as well as eggs, beef, and cereals fortified with vitamin D. Like calcium, vitamin D can also be taken in tablet form as a daily supplement.

Another possible reason why there is no significant difference could be genetics. If a person has no family history of osteoporosis and/or a naturally large skeletal frame, this would automatically put them at a smaller risk of developing the disease, regardless of their lactose tolerance level. Also, as mentioned before, northern European people are at a naturally lower risk. This experiment has offered evidence that there is no link between lactose intolerance and osteoporosis, although studies must be conducted in the future to eliminate all doubt. Considering the millions of people who suffer from osteoporosis, along with the millions that suffer from lactose intolerance, this study used a relatively small sample population. Further research must be done with larger population sizes to get more conclusive data.

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<i>H2 Breath Test Results</i>	<i>People With No Symptoms</i>	<i>People With Moderate Symptoms</i>	<i>People With Severe Symptoms</i>
NLT* (H2<20ppm): 156 people (52%)	98 (32.67%)	32 (10.67%)	26 (8.67%)
MLT* (20ppm>H2>59ppm): 39 people (13%)	12 (4%)	15 (5%)	12 (4%)
<b>SLT* (H2&gt;60ppm)</b> <b>105 people (35%)</b>	6 (2%)	39 (13%)	60 (20%)

\*NLT indicates non-lactose intolerant; MLT indicates moderately lactose intolerant; SLT indicates severely lactose intolerant.

**Table 2**

<b>DATA SUMMARY</b>	<b>NLT</b>	<b>MLT</b>	<b>SLT</b>	<b>Totals (means)</b>	<b>F = 0.03</b>	<b>P = 0.970448</b>
<b>Mean</b>	0.3094	0.2915	0.2812	0.2972		
<b>Variance</b>	0.8385	0.8406	0.7023	0.786		
<b>SD</b>	0.9157	0.9169	0.838	0.8866		

Figure 1

