JOURNAL OF APPLIED NUTRITION, VOLUME 53, NUMBER 1, 2003 ORIGINAL RESEARCH

THE INFLUENCE OF LACTIC ACID BACTERIA (OM-X) ON BONE STRUCTURE

Masayuki Kawakami[1], Iichiroh Ohhira[2], Naohiko Araki[1], Koji Inokihara[1], Hideto Iwasaki[3], and Takashi Matsubara[1]

We studied the effect of taking a lactic acid bacteria product (OM-X) on the bone structure. The subjects are 157 males and females, ages from 20 to 70 years. The bone density and bone mineral content measurements were taken on the radial and ulna on upper arm of the opposite side of each subject's handedness. The main results are as follows:

1. For both men and women, the bone mineral content showed higher in the groups taking OM-X than the groups without OM-X ($p<0.05$). In comparison with others their age, the groups over 40 had lower bone mineral content than the groups younger than 40 ($p<0.05$).

2. For both men and women, the bone density in the groups taking OM-X was higher than in the groups without OM-X ($p<0.05$). In comparison with their age, groups older than 40 had lower bone density than the groups younger than 40 ($p<0.05$).

In conclusion, it appears that lactic acid bacteria OM-X promotes the bone health. We assume that it affects enterobacteria in the intestine, improving absorption.

I. INTRODUCTION

For many years of history, eating traditional fermented foods with lactic acid bacteria produced intestine-balancing benefits to humans *(3,14,29)*. These traditionally successful foods still exist in modern civilization, along with various kinds of additional foods that may or may not be healthier *(11,12)*. Recent changes in dietary habits could affect human biological function in many ways, including the increased risk of malignant tumor and other disorders in tissue metabolism *(30,33)*. An example is a decline of immunity and resistance to infection *(22,33)*. Also, for young people in their growth stage, changes in diet may give rise to changes to physical function *(2,18)*. While the growth rate on young people is increased by the improvement of diet and other changes in environment, full development of a healthy body may be compromised *(23)*. Specifically, regarding bone structure, physical growth and bone structure may not be matched, causing various bone problems. This can be seen not only in young people but also in children. There is certainly an increased risk of bone fracture in the everyday life of people of advanced age. The issue discussed in this article is the connection of bone problems to lactic acid bacteria in the gut and its

1. College of Liberal Arts and Science
Kurashiki University of Science and the Arts
2. Research Institution of Okayama Life Science
3. Sanyo Gakuen University

effect on people of all ages *(16,17,21,22)*. We aim to bring attention to the fact that lactic acid bacteria in the gut affect this aspect of our biological functioning.

We are all aware that the food we eat is first digested in the stomach and small intestine before being absorbed. However, in addition to the activity of the body's digestive processes, enterobacterial activity is involved. This introduces the possibility that imbalances in the bacterial environment of the intestine can cause a decline in nutrient absorption.

The food processing technology that modern culture has brought to our lives also brings to our body several food additives and chemicals preservatives that affect the basic machinery of life (28,29). Food additives influence enterobacteria as well, and have a tendency to suppress or inhibit enterobacterial activity in digestion and absorption. (26,28,33). We have previously reported that intake of lactic acid bacteria increases the volume of hemoglobin in red corpuscles *(11)*. Many researchers (7,8) have reported other influences of lactic acid bacteria on human function.

In this study, we focused on the effect of lactic acid bacteria supplementation on bone health and the possible connection to osteoporosis, that substantial failure of bone structure that is often related to poor life-style choices. Osteoporosis affects not only athletes and post-menopausal women but also in rare instances even young people (32,33). With this in mind we designed an experiment to find the influences on bone structure of supplementing with lactic acid bacteria. We found that the degree of the influence differs by age and sex.

The strain of lactic acid bacteria we used in this experiment is referred to as OM-X, a vegetable fermented substance containing relatively low amount of lipid. We used an encapsulated form since lactic acid bacteria are susceptible to destruction by stomach acid. The complete ingredient list of OM-X is shown at the end of the references along with the U.S. commercial source.

II. METHODS

A. Subjects

The subjects were 157 males and females. There were 77 males who took no lactic acid bacteria (age years 26.2 ± 6.8, referred as the group A) and 27 males who took lactic acid bacteria OM-X (age years 42.6 ± 12.0, referred as the group B), making a total of 104 male subjects. There were 36 females who took no lactic acid bacteria (age years 30.9 ± 14.7, referred as the group C) and 17 females who took lactic acid bacteria OM-X (age years 48.4 ± 13.9, referred as the group D), for a total of 53 females.

In order to analyze a wide range of ages we separated the male and female subjects into a younger and an older group, ages 20 and 30 years in the younger and over 40 years of age in the older (designated as A-1, A-2, B-1, B-2, etc).

B. Methods

Group B (males) and Group D (females) took 1200mg to 4000mg (3 to 10 capsules) of OM-X per day. The number of capsules was adjusted to the weight of each subject. The supplement was used for between 2 and 24 months. We asked that the subjects take the supplement two hours after meals, since the capsule contained live lactic acid bacteria that could be damaged by high stomach acid. Group A and Group C served at controls for Group B and Group D, respectively.

The bone density measurements were made with an OSTEOMETER DTX-200 on radial and ulnar bone of the upper arm, on the opposite side of each subject's handedness.

III. RESULTS

Tables I to 4 show the results for each group at the end of the experiment.

Bone mineral content (BMC) and bone density was higher in all subjects who took OM-X.

Table 1

Group	Number	Age ± SD) (years)	Ht ± SD (cm)	Wt ± SD (kg)	BMC ± SD (g)	Bone Density ± SD (g/cm)
A-1	66	21.20 ± 2.62	170.97 ± 6.81	62.01 ± 10.84	3.51 ± 0.54	0.50 ± 0.05
A-2	11	55.91 ± 6.68	164.96 ± 4.08	66.29 ± 8.29	3.88 ± 0.61	0.50 ± 0.06
Total	77	26.16 ± 6.82	170.11 ± 6.82	62.62 ± 10.62	3.56 ± 0.57	0.50 ± 0.05

Table 2

Group	Number	Age ± SD) (years)	Ht ± SD (cm)	Wt ± SD (kg)	BMC ± SD (g)	Bone Density ± SD (g/cm)
B-1	13	28.77 ± 4.14	172.68 ± 5.52	72.42 ± 12.99	4.39 ± 0.67	0.60 ± 0.06
B-2	14	51.43 ± 8.83	166.66 ± 5.44	64.27 ± 7.99	4.30 ± 0.50	0.58 ± 0.04
Total	27	42.63 ± 12.04	168.91 ± 6.01	67.16 ± 10.82	4.35 ± 0.57	0.59 ± 0.05

Table 3

Group	Number	Age ± SD) (years)	Ht ± SD (cm)	Wt ± SD (kg)	BMC ± SD (g)	Bone Density ± SD (g/cm)
C-1	29	24.28 ± 4.96	158.30 ± 5.29	49.26 ± 6.16	2.75 ± 0.30	0.45 ± 0.04
C-2	7	58.14 ± 9.40	152.80 ± 3.99	48.70 ± 5.61	2.20 ± 0.44	0.33 ± 0.09
Total	36	30.86 ± 14.70	157.23 ± 5.44	49.15 ± 5.97	2.64 ± 0.39	0.42 ± 0.07

Table 4

Group	Number	Age ± SD) (years)	Ht ± SD (cm)	Wt ± SD (kg)	BMC ± SD (g)	Bone Density ± SD (g/cm)
D-1	5	30.40 ± 4.93	153.24 ± 2.95	53.08 ± 10.10	3.21± 0.25	0.51 ± 0.02
D-2	12	55.92 ± 7.48	153.38 ± 7.48	58.45 ± 9.27	2.98 ± 0.46	0.45 ± 0.06
Total	17	48.41 ± 13.92	153.34 ± 6.48	56.87 ± 9.83	3.05 ± 4.42	0.47 ± 0.06

Among men of all ages the difference was 22% for BMC and 18% for bone density when comparing those who took OM-X to those who did not. Among women of all ages the difference was 32% for BMC and 12% for bone density when comparing those who took OM-X to those who did not.

Although there is no baseline data for direct comparison, if we assume the subjects were near the Japanese average for BMC and bone density at the beginning of the experiment, those taking OM-X showed improvement and those not taking OM-X showed decline in bone health.

IV. DISCUSSION

Bones are basically support tissue (3,27,32). The bone tissue is synthesized with minerals (calcium and phosphorus most abundantly), on a foundation of protein and using various vitamins and other minerals as nutritional assistants (28,29,30). That is why nutrients from our daily diet are fundamental to healthy bone formation. Appropriate exercise also is needed to stimulate bone synthesis (2, 5,11,12). Bone remodeling, the dissolution of old bone and synthesis of new bone, is also required.

increased fat (22,32). It is important that the diet be well balanced, providing the vitamins and minerals that control body function along with the carbohydrates and fat for energy and protein for structure. These vitamins and minerals also have an important role in metabolic functions such as intestinal action (22,25,27,32). Simultaneously vitamins and minerals contribute greatly to the growth of the beneficial bacteria living in the intestines (28,29). An imbalance in today's food could erase a basic action of enterobacteria (26,28) and decrease the absorption of nutrients from the intestine. Thus, disorder of enterobacterial action gives rise to unfavorable influences on the mechanisms of nutrient absorption and subsequent metabolism in the liver (27,28,32). We believe that beneficial bacteria serve a key function in the intestine as an aid to nutrient absorption and the best way to ensure their presence is a supplement of lactic acid bacteria.

From these experimental results, we established that there are significant differences in the bone density measurements and bone mineral content between the groups taking OM-X and those not taking it, regardless of age and sex. Supplying OM-X apparently influenced the intestinal enterobacteria and improved the nutrient absorption from the intestine and possibly the deposition rate of minerals into bone tissue. Most markedly, taking OM-X produced considerable improvement in the bone density measurements of over-40 females compared to younger females. This is the group most in need of support since older females are more likely become osteoporotic than older males (28,33).

Judging from all the above, the long-term intake of OM-X acts effectively to improve the formation of bone tissue. This does not mean that bone density measurements alone reflect bone health. As we age, bone tissue will without question develop various kinds of disorders. One way to stop the decline of bone substance lies in intestinal maintenance, since this is the site of absorption of nutrients. For intestinal maintenance, we should promote enterobacterial activity. For reliable enterobacterial activity, we believe the best way is to supply lactic acid bacteria, which become food for other enterobacteria.

Although a variety of live bacteria comprise "lactic acid bacteria," with differing effects on enterobacteria (26,8), the OM-X strains that we used here provide numerous additional substances in precise ratios (amino acid, vitamins and minerals) necessary for biological functioning. We think it is necessary to clarify the present results by repeating the study using other kinds of lactic acid products.

REFERENCES

1. Ahlborg B. *et al.* Muscle glycogen and muscle electrolytes during prolonged physical exercise. *Acta Physiol Scand* 70, 129–142, 1967
2. Ishikawa T. *Sports and the Body* pp103–140, Iwanami Shoten, Publishers, 1991
3. Aihara H. (ed). *The Introduction to Biochemistry with Simple Expression.* Tokyo, Kyogakusha, Publishing Co., 1996
4. Astrand PO, *et al. Textbook of Work Physiology.* pp295–518 Mcgraw-Hill, , 1970
5. Ohtsuka N. *et al. Sports and BMC*, Jpn J Phys Fitness Sports Med, 1998;47:39.
6. Ohyama T. *et al. Losing weight and life-style that give influences on the bone: Structure of 20 to 39-year-old women. Jpn J Phys Fitness Sports Med,* 1997;843:46–6.
7. Ohhira I, *et al.* Protein hydrolysis and aroma production of lactic acid bacteria from traditional fermented foods in the southeast Asia. *Jpn J of Dairy and Food Science.* 1990;39: 349–360.
8. Ohhira I, *et al.* Distribution and biochemical properties of lactic acid bacteria from traditional fermented foods in southeast Asia. *Jpn. J. of Dairy and Food Science*, 1992;41: 87–98.
9. Kawakami, M. *et al. Introduction to Health and Physical Education* pp180–217, Kobayashi Publishers, 1992.
10. Kawakami, M. *et al. Health Science* pp25–124, Fumaido Publishing, Co., Ltd., 1994.
11. Kawakami, M. *et al. Training Science.* pp13–21 and 90–101, Fumaido Publishing, Co., Ltd., 1996.
12. Kawakami, M. *et al. Human Science.* pp139–170, Fumaido Publishing, Co., Ltd., 1998

The skeletons of modern people have many problems as evidenced by the prevalence of bone fracture in daily life, osteoporosis, and stress fracture in athletes (32). These appear to relate to an accumulation of complex insults to the body such as changes in food quality, a decline in nutrient absorption, lack of exercise and other inappropriate alterations in life-style (9,10,11,12,16,31).

In our search for solutions to this problem, not only the lack of nutrients but also the decline in nutrition absorption rate should be considered. Since nutrient absorption affects not only in bone formation but also health in other ways (27,28), it is something we should consider for daily life. Basically, nutrients should be obtained from foods, and taken in under the control of various enzymes and hormones (24). However, modern civilization has brought innovative techniques such as food processing into the human situation. Food processing was introduced to society largely for long term preservation of food by adding chemical products to food. However, modern society has created a market for food additives used for cosmetic reasons and for convenience, resulting in what we know as "junk food." These changes in the food environment are increasingly impinging on the health of the human body.

Processed food with its multitudinous food additives also greatly influences the bacteria living in the body, especially on enterobacteria in the gut. Humans pick up from food diverse kinds of bacteria (27,28). Inappropriate species of enterobacteria slow down food digestion and nutrient absorption (6). At the same time, humans manage to carry on normal life, living and even prospering with these unsuitable bacteria (27). In the world of enterobacteria, there are bacteria essential to the body (referred as beneficial bacteria) and other bacteria that may or may not be harmful. The beneficial enterobacteria enhance immunity and adaptation to the environment (22, 25). Unfortunately, today's altered diet and environment has begun to influence the delicate balance of beneficial and harmful bacteria (27,28,32). This is reflected in degeneration in the physical condition of modern people (27). We believe that the change in the bacteria in our environment has become one of the basic factors triggering diverse physical disorders, including allergic diseases and possibly cancer.

We think this explanation also holds for bone structure. Enough stress fractures happen to non-athletes so that the issue is no longer solely a sports disorder (32,33). We find these problems of bone structure among ordinary people in seemingly normal health. Especially with regard to osteoporosis, we need to clarify the adequacy of bone density measurements as a predictor of bone disorders in everyday life.

In this investigation on bone structure, we found out that the average values of bone mineral content and bone density for the control group are under 100% regardless of age and sex. This indicates that the hardness of bone is not keeping up with other aspects of growth, possibly due to rapid gain in height in the young people. Certainly failure in bone formation occurs in middle and advanced age, not only in the youth (33), but the fact that it is seen in young people warns us that many modern people may have a tendency to osteoporosis (32).

For this, we believe that in Japan there are two causes: first, the fact that the Japanese diet has changed from an emphasis on traditional vegetable food to animal food and second, the shift of diet from natural food to primarily processed food. Because of this, we believe there are disorders of enterobacteria in the intestinal tract leading to a decline in the absorption rate of nutrients, and that one of the consequences of a lack of beneficial bacteria seems to be poor formation of bone tissue.

The Ministry of Health and Welfare of Japan reported that normal adults have a calorie excess of about 200 to 300kcal a day from today's diet *(11,14)*. As a result of favoring animal food, the diet has changed toward higher calorie and

13. Kawakami, M. *et al.* The influences on the VO^2max of athlete with taking lactic acid bacteria (OM-X). *The Bulletin of Kurashiki University of Science and the Arts* 1998;3:134–144.
14. Campbell, P.N. *The Biosynthesis of Proteins. Progr Biophys Mol Biol* 1965;3:15.
15. Katagiri, K. The relationship among the bone density, physical strength, and diet of female athlete: Effect of bone density on body parts by exercise *Jpn J Phys Fitness Sports Med*, 1996;45:740.
16. Kitagawa, J *et al.* The relationship between life-style and bone structure (supersonic wave method). *Jpn J Phys Fitness Sports Med*, 1995;44:629.
17. Kuroda, Y, *et al. Sports Medical Science Update* pp149–153 and 704–714, Bunkodo Co.,Ltd., 1990
18. Tabata, I. *et al.* Effect of walking and badminton training on BMC of middle age women. *Jpn J Phys Fitness Sports Med*, 1994;43: 628.
19. Novelli GD. Amino acid activation for protein syntheses. Ann Rev Biochem, v36, p449 1967.
20. Nishimura C. The relationship of life-style and the bone structure of female university students. *Jpn J Phys Fitness Sports Med*, 1997;46: 837.
21. Nagata M. Effect of aging and life-style on the bone structure of adult women. *Jpn J Phys Fitness Sports Med*, 1996;45: 741.
22. Fujishiro, T. *The Living Science*. pp17–24, Tokyo-Kyogakusha, Publishing Co., 1994.
23. Fujita, T, *et al. Bone Measurements*. pp23–37, Nishimura Co., Ltd., 1990.
24. Jacob F, Monod J. Genetic Regulatory Mechanism in the Synthesis of Proteins. L Mol Biol 1961;3:318.
25. Masuhara, M. *Sports Physiology Reader*, pp21–38, Fumaido Publishing Co., Ltd., 1997
26. MacDougall JD, *et al.* Biochemical Adaptation of Human Skeletal Muscle to Heavy Resistance Training and Immobilization. *J Appl Physiol* 1977;43:700.
27. Maruyama, K. *et al. What is Life?* pp13–25 and 137–152, Tokyo-Kyogakusha Publishing Co,1996
28. *Basic Biochemistry* (trans. Miura,Y). pp54–310, Tokyokagaku Dojin, 1970
29. Miyata Y, *et al.* On the difference in sports events and the threshold value of sports strength influencing on the bone structure. *Jpn J Phys Fitness Sports Med*, 1996;45: 649.
30. Miyake, K. *et al.* The bone density measurements of the radial on 20 to 39-yearold women. *Jpn J Phys Fitness Sports Med*, 1994;43: 630.
32. Muto Y, *et al. Sports and Stress Fracture*. pp1–27 and 34–42, Nankodo Co., Ltd.,1990
33. Yuasa S. *Introduction to Bioscience*. pp94–120, SHOKABO, 1986
34. Wakamatsu, H. *et al. Bone Formation Measurements* Vol.3, pp35–36, Nishimura Co., Ltd., 1984