

Editor's Review

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Does Aquatic Exercise Maintain and Build Bone Density?

The controversy surrounding aquatic exercise and its ability to build and maintain bone mass continues. Fortunately the controversy has spawned some exciting research in this area in the past two years. Below you will find a summary of past research surrounding this subject, two abstracts summarizing new research that has been conducted, and a summary of additional research which has surfaced.

Past Research

The influence of weight-bearing water exercises on bone density of post-menopausal women.

Goldstein, E., Simkin, A., Epstein, L., Peritz, E. and Harush, D., Wingate Institute, 1994

This was one of the first studies to suggest using water resistance as a bone loading activity. Postmenopausal volunteers were divided into a land and an aquatic exercise group. Both groups started with 32 participants and at the end of a five month, three times per week exercise program, 25 were left in each group. Bone density was measured at the distal end of the radius, in the wrist, using Compton Scattering Technique. The goals of the study were to compare the mean change in bone density between the two groups and compare the mean change in bone density within each group. Statistical analysis revealed significant increases in bone density between pre and post measurements. The water group also showed significantly greater increases compared to the land group.

Since the measurement in this study was taken at the wrist, this study may have given one of the first clues that the water's resistance may play a factor in building bone density. Use of the arms against the water's resistance may have contributed to the higher scores in the water program as compared to the land program.

Cross-sectional and longitudinal studies on the effect of water exercise in controlling bone loss in Japanese postmenopausal women.

Tskahara, N., Toda, A., Goto, J., and Ezawa, I. Journal of Nutritional Science and Vitaminology, February, 1994. Japan Women's University.

In this study, it was found that the bone mineral density of the lumbar spine in women who were considered veterans (exercising for 35.2 months on average) was significantly higher than that in the newcomers who had only begun to exercise 3 or 4 weeks before, and the non-exercisers, who served as a control. The rate of change in bone mass density of the lumbar spine was -0.92%/ year in the non-exercisers (N=30), +1.55%/year in the veterans (N=20). The researchers report that "the results of questionnaires showed that subjects' general awareness of health and fitness in daily life was enhanced after starting the water exercise program. These results suggest that consistently participating in water exercise is an important factor in preventing bone loss, and moreover, appears not only to indirectly improve awareness of daily physical activity but also to promote health and improve daily life."

A weight-bearing, water-based exercise program for osteopenic women: its impact on bone, functional fitness, and well-being.

Bravo, G., Gauthier, P., Roy, P.M., Payette, H., Gaulin, P. Arch Phys Med Rehabil, December 1997

Seventy-seven postmenopausal women, 50 to 70 years of age, with spinal or femoral bone density below the fracture threshold participated in this study. The exercise protocol was completed in a pool with waist-high water for 60 minutes, 3 days a week, over a 12-month period. Forty minutes of each session were devoted to successive jumps and muscular exercises designed to promote bone accretion, strength, and endurance. Spinal and femoral bone mineral density was measured by dual-energy X-ray absorptiometry. Although functional fitness and psychological well being improved, there was a significant decrease in spinal bone mass density and there was no change in femoral neck bone mass density. The researchers conclude that "future studies are needed to identify water exercises that are safe yet exert enough stress on the bones to initiate a bone response."

New Research on Aquatic Exercise and Bone Density

A 113 - Abstract

Authors: Deborah (Mushi) Harush and Dr. Arie Rotstein (Supervisor)

Title: The Effect of a Water Exercise Program on Bone Density among Postmenopausal Women.

Thesis submitted in partial fulfillment of the requirements for Master Degree, University of Haifa, School of Education, Department of Education, December 2004. Israel.

Osteoporosis is a bone disease common among women and it constitutes one of the dominant factors reducing quality of life and even shortening life span. Almost 25 million people in the United States suffer from this disease, 80% of them post-menopausal women (Biondi, 1999; Birdwood, 1995; Riggs & Melton, 1995). In a national study of women's health conducted in Israel in 1998, osteoporosis was diagnosed among 7% of the women aged 45-54, 14% of the women aged 55-65, and 25% of the women aged 65-74 (Merom, 1999). The reason for the higher frequency of the disease with old age is attributable to the fact that as women age, the monthly period ceases and a gradual process of bone density loss commences, which may lead in the final analysis to fractures of spinal vertebrae, hip and wrist bones (Ish-Shalom, 1999; ACSM, 1997). Studies have shown that physical activity plays an important role in preventing and treating osteoporosis. Bone is built and develops in direct response to the application on it of mechanical loads (Dalsky, 1990) and when the load on the skeleton is reduced, more bone is lost than is created (Dalsky, 1990; Laynon, 1987; Renfro & Brown, 1998). Therefore, physical activity and especially activity that increases muscle tension or loads on the bones, helps to prevent the process of bone density loss (Riggs & Melton, 1998; Simkin & Ayalon, 1990). The conclusions of studies focusing on the effect of water exercise on post-menopausal women have not been unequivocal about its effect on bone density (Tsukahara, 1994; Goldstein & Simkin, 1994; Bravo, 1997). The present study focuses on the question of whether water exercise can delay bone density loss among post-menopausal women. 35 women, mean age 55.45 ± 3.97 , volunteered to participate in the study. Over a period of seven months the women in the experimental group (N=25) participated in a water training program that included three one-hour sessions per week. At the same time, a control group (N=10) did not engage in any physical activity at all. Two hypotheses were formulated: a) Women in the control group, who did not participate in a water training program, would manifest a decline in bone density; and b) Women who engaged in water exercise would register no bone density loss, and might perhaps

increase density by the end of the study, or, if there were a loss, it would be less severe than in the control group. Bone density was measured by means of DEXA and QUS equipment in four different parts of the body: vertebrae L1-L4, the neck of the hip bone on both legs, the proximal radius and the midshaft tibia. Bone density for all of the women was measured in the same part of the body before and after the training program (the proximal radius and the midshaft tibia were measured only for the experimental group). The main finding of the study was that although no significant pre- and post-test differences in bone density were found in the vertebrae (L1-L4 and L2-L4) for both the experimental and the control groups, a significant interaction was found between the variable Time and the variable Group for all four measures of BMD, BMC, T-Score and Z-Score. This interaction indicates that water exercise had a positive effect on bone density and allowed women in the experimental group to preserve and even increase their bone density, in comparison to the control group which registered a loss. On the other hand, for hip bone density a significant interaction was found between the variable Time and the variable Group only for BMC and in the right leg only ($p < 0.01$). No significant pre- and post-test differences in bone density (as measured by means of QUS) were found in the radius or the tibia for the experimental group. The main conclusion of this study is that water exercise several times a week constitutes appropriate medium for preserving bone density among post-menopausal women who generally suffer from a natural decline of about 1%-2% per year in bone density. It should also be noted, however, that the relatively small number of participants in the study and the slow rate of changes in bone make it difficult to take a definitive, unequivocal stand in the matter.

A 114 – Abstract

Authors: Tanya R. Littrell, Ph.D. and Christine M. Snow, Ph.D., FACSM

Title: Bone Density and Physical Function in Postmenopausal Women after a 12-Month Water Exercise Intervention

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Exercise may be the most effective strategy to reduce osteoporotic fractures in older adults because of its potential to reduce both bone loss and fall risk. It is unclear whether water exercise is an effective strategy to reduce fracture risk in postmenopausal women.

Purpose: To examine the effects of a 12-month shallow water exercise program on bone mineral density (BMD) and physical function in postmenopausal women.

Methods: We recruited 59 women (≥ 5 years past menopause; 27 exercisers and 32 controls) and evaluated subject characteristics (weight and age), BMD (spine, total hip, femoral neck) by dual energy x-ray absorptiometry, and physical function (leg power, arm endurance, cardiorespiratory fitness, flexibility) at baseline and 12 months. The exercise group participated in a 45-minute shallow water exercise class 3 times per week for 12 months, while the control group was asked to maintain initial activity levels.

Results: Using ANCOVA (covariates: initial BMD and weight) BMD difference scores at the spine, total hip, and femoral neck were similar between exercisers and controls after the 12-month intervention ($p = 0.14-0.31$). However, one-sample t-tests revealed that over the 12 months, femoral neck BMD decreased 1.7% in controls ($p < 0.01$) but did not change in exercisers ($p = 0.98$). Using ANCOVA to evaluate difference scores in physical function

(covariates: initial weight and age), exercisers exhibited greater cardiorespiratory fitness after 12 months of water exercise than controls ($p=0.03$), but leg power, arm endurance, and flexibility were not different between groups. One-sample t-tests revealed that exercisers increased leg power (+14.1%, $p=0.01$), flexibility (+11.4%, $p<0.01$), and mobility (+13.4% to 17.4%, $p<0.01$), while values for controls did not change (i.e. were not different from zero). One-sample t-tests also demonstrated that balance decreased 16.1% in controls ($p=0.03$), but did not change in exercisers (-4.0%, $p=0.47$).

Conclusion: Our results provide *preliminary* evidence that shallow water exercise maintains femoral neck BMD in postmenopausal women. Furthermore, we conclude that shallow water exercise is an effective means of maintaining and improving physical function as women age.

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Additional Research

Two additional research studies concerning aquatic exercise and bone density have been published in the American Journal of Medicine and Rehabilitation in December of 2003 and January of 2005. These pieces shed additional light on the controversy.

Evaluation of hormonal response and ultrasonic changes in the heel bone by aquatic exercise in sedentary postmenopausal women.

A. Ay and M. Yurtkuran. Department of Physical Therapy and Rehabilitation, Uludag University Atatürk Balneotherapy and Rehabilitation Center, Kukurtlu, Bursa, Turkey.

The objective of this study was to discover whether moderate increased physical activity such as aquatic exercise has anabolic effects on bone. The evaluation used quantitative ultrasound and hormonal variables.

Forty one postmenopausal women participated in a 6 month aquatic exercise program or as controls for the study. Results show a 36% increase in serum levels of insulin-like growth factor-1, a 75% increase in growth hormone, a 54% increase in calcitonin, and a 31% decrease in parathormone compared with the initial values in the exercise group. The control group showed a 61% decrease in serum levels of growth hormone and no statistically significant changes in insulin-like growth factor-1, calcitonin, or parathormone. Ultrasound attenuation increased by 19% and speed of ultrasound increased by 63% in the exercise group, whereas there were decreases in the control group. The conclusion stated that "aquatic exercise was determined to be effective to make an anabolic effect on the bone of the postmenopausal, sedentary subjects."

Additional summary information to interpret this study:

- Growth hormone plays an important role in skeletal growth. It increases bone turnover with a net increase in bone mass and periosteal appositional growth.
- Insulin-like growth factor-1 is produced by the liver and has a unique property of stimulating de novo bone formation in a manner analogous to fracture repair and endochondral ossification.
- Parathormone has effects on both osteoclasts and osteoblasts and is believed to have a positive effect on bone resorption and turnover.

- Calcitonin effects osteoclasts causing inhibition of osteoclastic resorption. Its primary effect is to decrease serum levels of calcium.
- Calcaneal broadband ultrasound attenuation (BUA) is considered a valuable tool for the quantification of cancellous bone and for hip fracture prediction. Because cancellous bone turns over much more rapidly than cortical bone, functional adaptations are likely to occur first in this more metabolically active tissue.

Influences of aquatic and weight-bearing exercises on quantitative ultrasound variables in postmenopausal women.

A. Ay and M. Yurtkuran. Department of Physical Therapy and Rehabilitation, Uludag University Atatürk Balneotherapy and Rehabilitation Center, Kukurtlu Kaplıcaları, PK:16080, Bursa, Turkey.

The objective of this study was to ascertain the effects of weight bearing and aquatic exercises on the calcaneal ultrasonic scores of postmenopausal sedentary women.

Sixty two postmenopausal sedentary women (mean age 54.1 +/- 7 years) with broadband ultrasound attenuation (BUA) T-score variables less than -1 were randomized into aquatic exercise (n=21), weight bearing exercise (n=21), and control (n=20) groups. The exercise groups participated in a 6 month program.

Results indicate an increase in calcaneal broadband ultrasound attenuation (BUA) in the weight bearing exercise group of 4.2% and the aquatic exercise group of 3.1%. The control group had a decrease in calcaneal BUA of 1.3%. Speed of ultrasound did not change in any of the groups. There was no statistically significant differences between exercise groups for BUA and speed of ultrasound.

The researchers concluded that “although weight-bearing physical exercise is known to be superior to no-weight-bearing activity to increase the bone mass, our present evidence shows that aquatic and weight-bearing exercises both can increase calcaneal BUA.”

Type of Aquatic Exercise Stimulus

One of the primary factors for consideration of the practicality of bone density research to the aquatic fitness professional is knowledge about the type of exercise intervention used in the research studies that stimulated bone growth.

In the study presented by Harush, the exercise group participated for 6 months three times per week for 60 minutes. Equipment used included hand bars, resistance cuffs and noodles. AEA and ACSM recommendations were used to set the guidelines for the program. Water temperature was 27 to 29 degrees C. Progressive overload was practiced, form and technique was emphasized, and full range of motion was encouraged. The primary format consisted of a warm-up (7-10 minutes), aerobic set (20 minutes), muscle strengthening and bone loading (20 minutes), and a cool down/post stretch (10 minutes).

Littrell's study was for 12 months, 3 times per week, for 45 minutes. The chest deep shallow water exercise class consisted of a 7-minute warm-up, 15-20 minutes of general muscle/ cardiorespiratory endurance exercises, 10-15 minutes of specific muscle fitness and stability training, and an 8 minute warm down including flexibility exercises.

Ay and Yurtkuran's first study published in December 2003 specifically used deconditioned women. In the first week of the study the sessions lasted 30 minutes and included 5 minutes of warm-up, 10 minutes of aerobic exercise (walking fast, jumping, and swaying in the water), 5 minutes of cool down, and 5 minutes of stretching outside of the pool. In the following weeks the aerobic segment was progressively increased to 25 minutes and total exercise duration after the 4th week was 40 minutes for each session. Frequency was 3

times/week and subjects were instructed to exercise at a submaximal intensity of 10-13 according to the Borg scale. Water depth was 1.25 meters and water temperature was between 29 and 30 degrees C.

In Ay and Yurtkuaran's second study published in January of 2005, the same protocol was used for the aquatic exercise group as it the first study. Deconditioned women were again chosen for the three intervention groups. The weight-bearing group was reported to use the same protocol as the aquatic protocol (warming up, walking, jumping, swaying, and cooling down), only the exercise was performed on a flat platform in the rehabilitation department.

The four exercise protocols presented in these studies appear to mimic what is believed to be an "average" or "typical" aquatic exercise program following basic guidelines as promoted by the Aquatic Exercise Association (AEA) and the American College of Sports Medicine (ACSM). A direct comparison of actual movements and additional variables such as water depth, state of bone mass density at the onset of the study, initial physical conditioning, etc. would provide additional insight into forming a "general" exercise protocol that would optimize bone health in shallow water.

Implications for Further Research

Research continues to indicate that aquatic exercise is a viable means for building and retaining bone mass. It appears that despite the reduction in body mass that occurs in shallow water exercise programs, the viscosity of the water offers enough resistance to produce positive effects on bone turnover and produce an anabolic effect.

Future considerations include:

- Reviewing current research on weight bearing land exercise used to increase bone health, and extracting implications that could increase the effectiveness of shallow water exercise programs for building bone density.
- Continued clarification of current aquatic exercise practices and more specific determination of which types of activity in shallow water offer the most optimal impact on bone health.
- Continued investigation of the use and benefits of aquatic equipment that contribute to bone health.
- Investigation of the effect of deep water (non-weight bearing) exercise on building and maintaining bone mass. Is the water's viscosity enough alone to build bone, and does the inclusion of deep water equipment augment the process.