AD________________

Award Number: DAMD17-98-1-8513

TITLE: Exercise and Bone Density: Meta-Analysis

PRINCIPAL INVESTIGATOR: George Kelley, M.D.

CONTRACTING ORGANIZATION: Northern Illinois University
DeKalb, Illinois 60115

REPORT DATE: September 1999

TYPE OF REPORT: Annual

PREPARED FOR: U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

REPORT DOCUMENTATION PAGE

OMB No. 074-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	September 1999	Annual (1 Sep 98 - 1 Sep 99)

4. TITLE AND SUBTITLE
Exercise and Bone Density: Meta-Analysis

5. FUNDING NUMBERS
DAMD17-98-1-8513

6. AUTHOR(S)
George Kelley, M.D.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Northern Illinois University
DeKalb, Illinois 60115

E-MAIL:
gkelley@niu.edu

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 Words)*

Purpose: To use the meta-analytic approach to examine the effects of exercise on bone mineral density in men and women. **Scope:** The specific aims of this project are to: (1) statistically integrate existing research studies to determine the overall effect of exercise on bone mineral density in adults, (2) determine the effects of potentially confounding variables on changes in bone mineral density, and (3) develop an annotated literature base of exercise and bone mineral density studies. **Major findings:** Exercise resulted in small, statistically significant effect size (ES) changes in men when bone mineral density sites assessed were specific to the sites loaded during exercise (ES = 0.213, 95% bootstrap confidence interval (BCI) = 0.007 to 0.452). Moderate, statistically significant ES changes were found for older (> 31 years) but not younger (< 31 years) adults, with differences between groups statistically significant ($p = 0.04$). Moderate to large ES changes were observed at the femur, lumbar, and os calcis sites in older men. **Results/Significance:** Site-specific exercise increases and helps maintain bone mineral density at the femur, lumbar, and os calcis sites in older men. In addition, an annotated literature base on the effects of exercise on bone mineral density was established.

14. SUBJECT TERMS
exercise, bone, meta-analysis, osteoporosis, bone density, physical activity, physical fitness, men, women

15. NUMBER OF PAGES
38

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

FOREWORD

Opinions, interpretations, conclusions and recommendations are those of the author and are not necessarily endorsed by the U.S. Army.

N/A Where copyrighted material is quoted, permission has been obtained to use such material.

N/A Where material from documents designated for limited distribution is quoted, permission has been obtained to use the material.

N/A Citations of commercial organizations and trade names in this report do not constitute an official Department of Army endorsement or approval of the products or services of these organizations.

N/A In conducting research using animals, the investigator(s) adhered to the "Guide for the Care and Use of Laboratory Animals," prepared by the Committee on Care and use of Laboratory Animals of the Institute of Laboratory Resources, national Research Council (NIH Publication No. 86-23, Revised 1985).

N/A For the protection of human subjects, the investigator(s) adhered to policies of applicable Federal Law 45 CFR 46.

N/A In conducting research utilizing recombinant DNA technology, the investigator(s) adhered to current guidelines promulgated by the National Institutes of Health.

N/A In the conduct of research utilizing recombinant DNA, the investigator(s) adhered to the NIH Guidelines for Research Involving Recombinant DNA Molecules.

N/A In the conduct of research involving hazardous organisms, the investigator(s) adhered to the CDC-NIH Guide for Biosafety in Microbiological and Biomedical Laboratories.

Dr. George Kelly — 8/23/99

PI - Signature — Date

TABLE OF CONTENTS

I. INTRODUCTION

Bone health is critical for optimal performance and the prevention of fractures associated with low bone density. The purpose of this project is to use the meta-analytic approach to examine the effects of exercise on bone mineral density in men and women. The specific aims of this project are to (1) statistically integrate (meta-analyze) existing research studies to determine the overall magnitude and direction of changes in bone mineral density in men and women as a result of resistance and endurance type exercise, (2) determine the effects of potentially confounding variables such as age, gender, and training program characteristics on changes in bone mineral density, and (3) develop an annotated literature base that will be made available to military personnel interested in the effects of resistance and endurance type exercise on bone mineral density. The results of this project will provide the Armed Forces with information necessary for developing appropriate physical training programs aimed at (1) improving bone health of young men and women, (2) enhancing military readiness by reducing the incidence of fracture during physically intensive training, and (3) reducing the incidence of osetoporosis later in life.

II. BODY

A. Statement of Work

Our original approved statement of work for the first year is listed in the table below.

Task	Time Line	Task Accomplished?
Conduct literature search - computer - hand - contact experts to review references	Year one	Yes
Copy, classify, relevant studies	Year one	Yes
Develop, refine, modify coding sheet	Year one	Yes
Contact experts to review coding sheets	Year one	Yes
Begin coding of studies	Year one	Yes

As described below, we have successfully completed all tasks as originally proposed in our approved statement of work.

1. **<u>Conduct literature search (computer, hand, contact experts to review reference list).</u>** We have conducted and successfully completed our literature search according to our original proposal. Computer searches were conducted by both the Principal Investigator and Research Technician using the following databases: (1) Medline, (2) Old Med, (3) Current Contents, (4) Sport Discus, and Dissertation Abstracts International. Keywords included in these searches included various combinations of the following: exercise, physical fitness, physical activity, weight training, resistance training, resistance exercise, dynamic resistance exercise, osteoporosis, bone, bone density, bone mineral density, bone mineral content, bone mass, premenopausal, postmenopausal. In addition, we performed hand searches of the following journals:

- *Age and Ageing*
- *American Journal of Physical Medicine and Rehabilitation*
- *Archives of Physical Medicine & Rehabilitation*
- *Bone*
- *British Journal of Sports Medicine*
- *British Medical Journal*
- *Calcified Tissue International*
- *Clinical Orthopaedics*
- *Clinics in Geriatric Medicine*
- *European Journal of Applied Physiology*
- *JAMA*
- *Journal of Aging and Physical Activity*
- *Journal of Applied Physiology*
- *Journal of Bone and Joint Surgery* (both *American* and *British publications)*
- *Journal of Bone and Mineral Research*
- *Journal of Gerontology*
- *Journal of Sports Medicine and Physical Fitness*
- *Journal of the American Geriatrics Society*
- *Journal of Women's Health & Gender-Based Medicine*
- *Lancet*
- *Medicine and Science in Sports & Exercise*
- *New England Journal of Medicine*
- *Osteoporosis International*
- *Research Quarterly for Exercise and Sport*
- *Scandinavian Journal of Medicine and Science in Sport*
- *Spine*

We also cross-referenced from the bibliographies of review and original articles. Upon completion of the above, three experts on exercise and bone density (Dr. Charlotte Sanborn, Dr. David Nichols, Dr. Christine Snow) reviewed our reference list for thoroughness and completeness. While we originally proposed to search from January 1962 through December 1997, we expanded our search to include studies through December 1998 in order to be more thorough.

2. <u>Copy, classify, relevant studies</u>. A total of 3,141 titles and abstracts were identified and reviewed by both the Principal Investigator and Research Technician. From the 3,141 titles and abstracts reviewed, 119 publications were still deemed eligible for inclusion, and thus, were retrieved. Both the Principal Investigator and Research Technician then independently reviewed all 119 publications to see if they met the following inclusion criteria: (1) randomized and non-randomized clinical trials dealing with the effects of aerobic and/or resistance exercise in humans, (2) non-exercise control group included, (3) published studies in the English-language literature between January 1962 and December 1998, (4) changes in bone mineral density (regional, total) reported in adults ages 18 years and older. Disagreements between the Principal Investigator and Research Technician were resolved by consensus. From the 119 publications reviewed, 14 were excluded because of an inadequate control group while 11 were excluded because it did not appear that bone mineral density was assessed. Thus, 94 publications met our criteria for inclusion.[1-94] However, 12 of the publications included the same subjects as 12 other publications. In other words, duplicate publications were produced from 12 studies. Therefore, in order to avoid duplication in our coding, we extracted the maximum amount of information possible from both publications (void of duplication) but only counted this as one study. Consequently, 82 studies were deemed eligible for coding. Still, another six studies were excluded because they did not provide appropriate bone density data despite our request for such. This resulted in an approximate 7% (6/82) loss to our inclusion criteria. Thus, we plan to code 76 studies.

While not part of our original proposal, we have made available via the Internet the 94 publications that met our inclusion criteria. These may be found at the following website address: *http://www.niu.edu/knpe/research/kelley/exercise.html.* A copy of these references as they appear on the Internet can also be found in the Appendices on pages 21-29.

3. **Develop, refine, and modify coding sheet/contact experts to review coding sheet.** A coding sheet that could hold 249 pieces of information per study was developed in consultation with three experts on exercise and bone density (Dr. Charlotte Sanborn, Dr. David Nichols, Dr. Christine Snow) (See Appendices on pages 31-36). One of the questions raised during the review of our grant was the approach we would use in the calculation of our primary outcome. While not part of our original proposal, we felt it was important to address this issue prior to developing our coding sheet. We then conducted a small study with a representative sample of exercise and bone studies in order to compare the original metric (percent change in bone mineral density) to the standardized difference approach.[95] We found no difference between the two and suggested that the original metric should be used because it would be more meaningful to both clinicians and researchers. However, during the pilot testing of our coding sheet we found that because of missing variance data, use of the original metric would have resulted in the exclusion of several additional studies that otherwise met our inclusion criteria. Therefore, in order to limit our percent loss that met our inclusion criteria, the standardized difference approach was used as our primary outcome measure.

4. **Begin coding of studies.** As originally indicated in our statement of work, we have begun the coding of studies and are scheduled to complete the coding as originally proposed. We have, to date, coded eight studies. Both the Principal Investigator and Research Technician are coding all studies, independent of each other. After approximately every eight studies, the Principal Investigator and Research Technician compare codebooks for accuracy and consistency. Any discrepancies are resolved by consensus.

5. **Other.** Despite the fact that we are only in the first year of this study, we have completed one unpublished study (currently under review in a refereed journal) dealing with the effects of exercise on bone mineral density in men. A total of 26 effect sizes (ES) representing 225 subjects from eight studies met the criteria for inclusion. Small but statistically significant ES changes were found when bone mineral density sites assessed were specific to the sites loaded during exercise (ES = 0.213, 95% bootstrap confidence interval (BCI) = 0.007 to 0.452). Moderate and statistically significant ES changes were found for older (> 31 years) but not younger (< 31 years) adults, with differences between groups statistically significant ($p = 0.04$). Moderate to large ES changes were observed at the femur, lumbar, and os calcis sites in older men. The results of this study

suggest that site-specific exercise increases and helps maintain bone mineral density at the femur, lumbar, and os calcis sites in older men.

III. KEY RESEARCH ACCOMPLISHMENTS

- Completed literature search
- All relevant studies copied and classified
- Code book and instructions developed
- Completed study dealing with the effects of exercise on bone mineral density in men

IV. REPORTABLE OUTCOMES

- Exercise and bone mineral density references posted on the Internet (*http://www.niu.edu/knpe/research/kelley.html*)
- Abstract completed on the use of the original metric versus standardized effect size (see Appendices on pages 37-38)
- Applied and approved for continued funding from the Department of Defense (United States Army) in order to compare exercise and bone density data using summary versus individual patient data
- Manuscript submitted on the effects of exercise on bone mineral density in men

V. CONCLUSIONS

A. Importance of Completed Research

Low bone density is a major public health problem. Unfortunately, the effects of exercise on bone mineral density are not well established. Our development of an annotated literature base that is easily accessible on the Internet is important because it provides clinicians and researchers with the opportunity to quickly identify studies dealing with the effects of exercise on bone mineral density. Clinicians and researchers may then retrieve and review these studies and form their own opinion as to the effects of exercise on bone mineral density. In addition, access to these studies provides researchers with the opportunity to identify areas in which additional investigation appears warranted.

The use of the original metric versus standardized effect size for calculating primary outcomes in meta-analytic research has been controversial. Our small study has demonstrated that when calculating bone mineral density outcomes, both yield similar results.[95] Thus, it would seem appropriate that the original metric (percent change in bone mineral density) be used when calculating primary outcomes as long as one does not exclude studies that meet the established inclusion criteria. However, if the latter were the case, use of the standardized effect size would be more appropriate in order to minimize the number of studies that would have to be excluded from the analysis.

The results of our study on exercise and bone density in men suggest that site-specific exercise improves bone mineral density in older men. These results also support the notion that changes in bone mineral density are specific to the sites loaded during the exercise. These findings are important given the health-care consequences of low bone mineral density in men. In addition, the fact that exercise is an inexpensive, nonpharmacologic approach that is available to most of the general public makes this form of treatment particularly appealing, especially given the other physiological and psychological benefits that may be derived from participation in such. The fact that little change was seen in bone mineral density among younger subjects may be the result of subjects already possessing optimal levels of bone mineral density and/or the fact that the loss of bone mineral density generally occurs during the later versus younger years. In addition, it may also be that more subjects in the older group had been sedentary for a longer period of time. Irregardless, we believe that site-specific exercise should almost always be recommended for younger people in order to develop as much bone mineral density as possible during the younger years so that greater bone mineral density is present when and if age-related declines in bone mineral density take place.

B. Suggestions For Future Work

One of the common problems when conducting meta-analytic research is the issue of missing data. This may include both primary outcome data (changes in bone mineral density) and secondary data (for example, changes in percent body fat). Given our inclusion criteria, the absence of primary outcome data would only be a function of a lack of reporting while the absence of secondary outcome data could be the result of either an absence of reporting or the fact that a particular variable was not assessed in the study. While several different methods of data imputation are available, we are not comfortable with the creation of "artificial" data. Ideally, requesting both missing primary and secondary outcome data from the original authors would be the ideal. However, the retrieval of such information from the original authors would constitute a significant amount of time and effort on their part. Therefore, we limited our queries in this study to only those data having to do with missing primary outcomes, in this case, bone mineral density data (sample sizes, means, and standard deviations), in order to maximize our responses to our data requests, We believe that requesting additional data beyond this would have decreased our response rate. In fact, we were encouraged by the small percentage of studies (approximately 7%) that we were not able to include because of the inability to obtain missing primary outcome data. The former notwithstanding, we would suggest that in the future original investigators be compensated for the retrieval of information beyond primary outcome data. This will enhance our ability to examine potential confounders when examining the effects of exercise on bone mineral density.

The generation of valid and reliable information through research is important. However, anyone's research is of little value if people don't utilize it. One of the major problems that we find across all research domains is the gap between research and practice. One of the ways that we may be able to narrow this gap is by providing information via the Internet. For example, during the first year of this proposal we have provided references via the Internet to anyone interested in the effects of exercise on bone mineral density. While we believe that this is valuable, the ability to have Internet access to the data from our original coding sheet would empower clinicians and researchers to quickly and efficiently conduct their own meta-analysis based on their own needs. This could be accomplished by simply allowing individuals to download the data into one of their own statistical packages and/or allowing one to conduct statistical analyses as the data appear on the Internet.

It has recently been suggested that individual patient data versus summary data may provide the most reliable means of combining information from similar clinical trials.[96] To date, no meta-analysis exists using individual patient data to examine the effects of exercise on bone mineral density. It is important to identify the feasibility of using individual patient data as well as whether results differ between the use of summary versus individual patient data.

C. So What?

Our work to date suggests that exercise helps to increase and maintain bone mineral density in older (>31 years of age) men. However, exercise across all groups of men is important.

VI. REFERENCES

1. Aloia JF, Cohn SH, Babu T, Abesamis C, Kalici N, Ellis K. Skeletal mass and body composition in marathon runners. Metabolism 1978; 27:1793-6.

2. Ayalon J, Simkin A, Leichter I, Raifmann S. Dynamic bone loading exercises for postmenopausal women: effect on the density of the distal radius. Archives of Physical Medicine and Rehabilitation 1987; 68:280-3.

3. Bassey EJ, Rothwell MC, Littlewood JJ, Pye DW. Pre- and postmenopausal women have different bone mineral density responses to the same high-impact exercise. Journal of Bone and Mineral Research 1998; 13:1805-13.

4. Bennell KL, Malcolm SA, Khan KM et al. Bone mass and bone turnover in power athletes, and controls: a 12-month longitudinal study. Bone 1997; 20(5):477-84.

5. Bloomfield SA, Mysiw WJ, Jackson RD. Bone mass and endocrine adaptations to training in spinal cord injured individuals. Bone 1996; 19(1):61-8.

6. Bloomfield SA, Williams N, Lamb D, Jackson R. Non-weightbearing exercise may increase lumbar spine bone mineral density in healthy postmenopausal women. American Journal of Physical Medicine and Rehabilitation 1993; 72:204-9.

7. Blumenthal JA, Emery CF, Madden DJ et al. Cardiovascular and behavioral effects of aerobic exercise training in healthy older men and women. Journal of Gerontology 1989; 44:147-57.

8. Blumenthal JA, Emery CF, Madden DJ et al. Effects of exercise training on bone density in older men and women. Journal of the American Geriatrics Society 1991; 39:1065-70.

9. Bouxsein ML. Physical activity and bone density. Palo Alto, California: Stanford University, 1992.

10. Braith RW, Mills RM, Welsch MA, Keller JW, Pollock ML. Resistance training restores bone mineral density in heart transplant patients. Journal of the American College of Cardiology 1996; 28:1471-7.

11. Bravo G, Gauthier P, Roy P-M et al. Impact of a 12-month exercise program on the physical and psychological health of osteopenic women. Journal of the American Geriatrics Society 1996; 44:756-62.

12. Brooke-Wavell KSF, Jones PRM, Hardman AE. Brisk walking reduces calcaneal bone loss in post-menopausal women. Clinical Science 1997; 92:75-80.

13. Caplan GA, Ward JA. The benefits of exercise in postmenopausal women. Australian Journal of Public Health 1993; 17:23-6.

14. Cavanaugh DJ, Cann CE. Brisk walking does not stop bone loss in postmenopausal women. Bone 1988; 9:201-4.

15. Chilibeck PD, Calder A, Sale DG, Webber CE. Twenty weeks of weight training increases lean tissue mass but not bone mineral mass or density in healthy, active young women. Canadian Journal of Physiology and Pharmacology 1996; 74:1180-5.

16. Cohen B, Millet PJ, Mist B, Laskey MA, Rushton N. Effect of exercise training programme on bone mineral density in novice college rowers. British Journal of Sports Medicine 1995; 29:85-8.

17. Dalsky GP, Stocke KS, Ehsani AA, Slatopolsky E, Lee WC, Birge SJ. Weight-bearing exercise training and lumbar bone mineral content in postmenopausal women. Annals of Internal Medicine 1988; 108:824-8.

18. Danz AM, Zittermann A, Schiedermaier U, Klein K, Hotzel D, Schonau E. The effect of a specific strength-development exercise on bone mineral density in perimenopausal and postmenopausal women. Journal of Womens Health 1998; 7:701-9.

19. Delaney TA. Association of insulin-like growth factor-I with body composition, diet and bone mineral indices in weight resistance-trained premenopausal women. Davis, California: University of California at Davis, 1991.

20. Dornemann TM. The effect of a weight training program on the bone density of women aged 40-50 years. Chapel Hill, North Carolina: University of North Carolina @ Chapel Hill, 1994.

21. Dornemann TM, McMurray RG, Renner JB, Anderson JJB. Effects of high-intensity resistance exercise on bone mineral density and muscle strength of 40-50-year-old women. Journal of Sports Medicine and Physical Fitness 1997; 37:246-51.

22. Ebrahim S, Thompson PW, Baskaran V, Evans K. Randomized placebo-controlled trial of brisk walking in the prevention of postmenopausal osteoporosis. Age and Ageing 1997; 26:253-60.

23. Fujimura R, Ashizawa N, Watanabe M et al. Effect of resistance exercise training on bone formation and resorption in young male subjects assessed by biomarkers of bone metabolism. Journal of Bone and Mineral Research 1997; 12:656-62.

24. Gleeson PB, Protas EJ, LeBlanc AD, Schneider VS, Evans HJ. Effects of weight lifting on bone mineral density in premenopausal women. Journal of Bone and Mineral Research 1990; 5:153-8.

25. Greendale G, Hirsch S, Hahn T. The effect of a weighted vest on perceived health status and bone density in older persons. Quality of Life Research 1993; 2:141-52.

26. Grove CA. The effects of high impact exercise versus low impact exercise on bone density in postmenopausal women. Columbia, Missouri: University of Missouri, 1990.

27. Grove KA, Londeree BR. Bone density in postmenopausal women:high impact versus low impact exercise. Medicine and Science in Sports and Exercise 1992; 24:1190-4.

28. Hartard M, Haber P, Ilieva D, Preisinger E, Seidl G, Huber J. Systematic strength training as a model of therapeutic intervention. American Journal of Physical Medicine and Rehabilitation 1996; 75:21-8.

29. Hatori M, Hasegawa A, Adachi H et al. The effects of walking at the anaerobic threshold level on vertebral bone loss in postmenopausal women. Calcified Tissue International 1993; 52:411-4.

30. Heinonen A, Kanus P, Sievanen H et al. Randomised control trial of effect of high-impact exercise on selected risk factors for osteoporotic fractures. Lancet 1996; 348:1343-7.

31. Heinonen A, Oja PSH, Pasanen M, Vuori I. Effect of two training regimens on bone mineral density in healthy perimenopausal women: a randomized controlled trial. Journal of Bone and Mineral Research 1998; 13:483-90.

32. Heinonen A, Sievanen H, Kannus P, Oja P, Vuori I. Effects of unilateral strength training and detraining on bone mineral mass and estimated mechanical characteristics of the upper limb bones in young women. Journal of Bone and Mineral Research 1996; 11:490-501.

33. Iwamoto J, Takeda T, Otani T, Yabe Y. Effect of increased physical activity on bone mineral density in postmenopausal osteoporotic women. Keio Journal of Medicine 1998; 47:157-61.

34. Jarvinen TLN, Jarvinen TAH, Sievanen H et al. Vitamin D receptor alleles and bone's response to physical activity. Calcified Tissue International 1998; 62:413-7.

35. Kerr D, Morton A, Dick I, Prince R. Exercise effects on bone mass in postmenopausal women are site-specific and load-dependent. Journal of Bone and Mineral Research 1996; 11:218-25.

36. Kohrt WM, Ehsani AA, Birge SJ. Effects of exercise involving predominantly either joint-reaction or ground-reaction forces on bone mineral density in older women. Journal of Bone and Mineral Research 1997; 12:1253-61.

37. Kohrt WM, Ehsani AA, Birge SJ. HRT preserves increases in bone mineral density and reductions in body fat after a supervised exercise program. Journal of Applied Physiology 1998; 84:1506-12.

38. Kohrt WM, Snead DB, Slatopolsky E, Birge SJ. Additive effects of weight-bearing exercise and estrogen on bone mineral density in older women. Journal of Bone and Mineral Research 1995; 10:1303-11.

39. Kronhed G, Moller AC. Effects of physical exercise on bone mass, balance skill and aerobic capacity in women and men with low bone mineral density, after one year of training-a prospective study. Scandinavian Journal of Medicine and Science in Sports 1998; 8:290-8.

40. Lau EMC, Woo J, Leung PC, Swaminathan R, Leung D. The effects of calcium supplementation and exercise on bone density in elderly Chinese women. Osteoporosis International 1992; 2:168-73.

41. Little KD. Effect of exercise mode on bone mineral mass in recently postmenopausal women. Kent, Ohio: Kent State University, 1992.

42. Lohman T, Going S, Pamenter R et al. Effects of resistance training on regional and total bone mineral density in premenopausal women: a randomized prospective study. Journal of Bone and Mineral Research 1995; 10:1015-24.

43. Lord SR, Ward JA, Williams P, Zivanovic E. The effects of community exercise program on fracture risk factors in older women . Osteoporosis International 1996; 361-7.

44. Martin D, Notelovitz M. Effects of aerobic training on bone mineral density of postmenopausal women. Journal of Bone and Mineral Research 1993; 8:931-6.

45. Mayoux-Benhamou MA, Bagheri F, Roux C, Auleley GR, Rabourdin JP, Revel M. Effect of psoas training on postmenopausal lumbar bone loss: a 3-year follow-up study. Calcified Tissue International 1997; 60:348-53.

46. Mazel S. Effects of strength training on bone mineral density and bone remodeling in middle aged and older men. College Park, Maryland: University of Maryland @ College Park, 1991.

47. McCartney N, Hicks AL, Martin J, Webber CE. Long-term resistance training in the elderly: effects on dynamic strength, exercise capacity, muscle, and bone. Journal of Gerontology 1995; 50A:B97-B104.

48. McCartney N, Hicks AL, Martin J, Webber CE. A longitudinal trial of weight training in the elderly: Continued improvements in year 2. Journal of Gerontology 1996; 6:B425-B433.

49. McMurdo MET, Mole PA, Paterson CR. Controlled trial of weight-bearing exercise in older women in relation to bone density and falls. British Medical Journal 1997; 314:569.

50. Menkes A, Mazel S, Redmond RA et al. Strength training increases regional bone mineral density and bone remodeling in middle-aged and older men. Journal of Applied Physiology 1993; 74:2478-84.

51. Michel BA, Lane NE, Bjorkengren A, Bloch DA, Fries JF. Impact of running on lumbar bone density: a 5-year longitudinal study. Journal of Rheumatology 1992; 19:1759-63.

52. Milliken LA. Bone mineral density, bone remodeling, insulin-like growth factors, hormone replacement therapy, and exercise training in postmenopausal women. Tuscon, Arizona: University of Arizona, 1998.

53. Nelson ME, Fiatarone MA, Morganti CM, Trice I, Greenberg RA, Evans WJ. Effects of high-intensity strength training on multiple risk factors for osteoporotic fractures:a randomized controlled trial. Journal of the American Medical Association 1994; 272:1909-14.

54. Nelson ME, Fisher EC, Dilmanian FA, Dallal GE, Evans WJ. A 1-y walking program and increased dietary calcium in postmenopausal women: effects on bone. American Journal of Clinical Nutrition 1991; 53:1304-11.

55. Nichols DL, Sanborn CF, Bonnick SL, Ben-Ezra V, Gench B, DiMarco NM. The effects of gymnastics training on bone mineral density. Medicine and Science in Sports and Exercise 1994; 10:1220-5.

56. Nichols JF, Nelson KP, Peterson KK, Sartoris DJ. Bone mineral density responses to high-intensity strength training in active older women. Journal of Aging and Physical Activity 1995; 3:26-38.

57. Notelovitz M, Martin D, Tesar R et al. Estrogen therapy and variable resistance weight training increase bone mineral in surgically menopausal women. Journal of Bone and Mineral Research 1991; 6:583-90.

58. Payne SG. The effects of weight training on bone mineral density of premenopausal females. Texas Woman's University, 1995.

59. Peterson SE, Peterson MD, Raymond G, Gilligan C, Checovich MM, Smith EL. Muscular strength and bone density with weight training in middle-aged women. Medicine and Science in Sports and Exercise 1991; 23:499-504.

60. Preisinger E, Alacamlioglu Y, Pils K, Saradeth T, Schneider B. Therapeutic exercise in the prevention of bone loss: A controlled trial with women after menopause. American Journal of Physical Medicine and Rehabilitation 1995; 74:120-3.

61. Preisinger E, Alacamlioglu Y, Pils K et al. Exercise therapy for osteoporosis:results of a randomised controlled trial. British Journal of Sports Medicine 1996; 30:209-12.

62. Prince R, Devine A, Criddle A et al. The effects of calcium supplementation (milk powder or tablets) and exercise on bone density in postmenopausal women. Journal of Bone and Mineral Research 1995; 10:1068-75.

63. Prince RL, Smith M, Dick IM et al. Prevention of postmenopausal osteoporosis: a comparative study of exercise, calcium supplementation, and hormone replacement therapy. The New England Journal of Medicine 1991; 325:1189-95.

64. Pritchard JE, Nowson CA, Wark JD. Bone loss accompanying diet-induced or exercise-induced weight loss:a randomised controlled study. International Journal of Obesity 1996; 20:513-20.

65. Protiva KW. Weighted vest exercise improves functional ability in women over 75 years of age. Corvallis, Oregon: Oregon State University, 1997.

66. Pruitt L. The effect of an isotonic weight-training program upon bone density and selected indices of bone turnover in early postmenopausal women. Columbus, Ohio: Ohio State University, 1989.

67. Pruitt LA, Jackson RD, Bartels RL, Lehnhard HJ. Weight-training effects on bone mineral density in early postmenopausal women. Journal of Bone and Mineral Research 1992; 7:179-85.

68. Pruitt LA, Taafe DR, Marcus R. Effects of a one-year high intensity versus low-intensity resistance training program on bone mineral density in older women. Journal of Bone and Mineral Research 1995; 10:1788-95.

69. Revel M, Mayoux-Benhamou MA, Rabourdin JP, Roux C. One-year psoas training can prevent lumbar bone loss in postmenopausal women:a randomized controlled trial. Calcified Tissue International 1993; 53:307-11.

70. Rikli RE, McManis BG. Effects of exercise on bone mineral content in postmenopausal women. Research Quarterly for Exercise and Sport 1990; 61:243-9.

71. Robinson RJ, Krzywicki T, Almond L et al. Effect of a low-impact exercise program on bone mineral density in Crohn's disease: a randomized controlled trial. Gastroenterology 1998; 115:36-41.

72. Rockwell. J. C, Sorenson AM, Baker S et al. Weight training decreases vertebral bone density in premenopausal women: a prospective study. Journal of Clinical Endocrinology and Metabolism 1990; 71:988-93.

73. Ryan AS, Nicklas BJ, Dennis KE. Aerobic exercise maintains regional bone mineral density during weight loss in postmenopausal women. Journal of Applied Physiology 1998; 84:1305-10.

74. Ryan AS, Treuth MS, Hunter GR, Elahi D. Resistive training maintains bone mineral density in postmenopausal women. Calcified Tissue International 1998; 62:295-9.

75. Shaw J. The effects of resistance training on fracture risk and psychological variables in postmenopausal women. Corvallis, Oregon: Oregon State University, 1995.

76. Shaw JM, Snow CM. Weighted vest exercise improves indices of fall risk in older women. Journal of Gerontology 1998; 53:M53-M58.

77. Simkin A, Ayalon J, Leichter I. Increased trabecular bone density due to bone-loading exercises in postmenopausal osteoporotic women. Calcified Tissue International 1987; 40:59-63.

78. Sinaki M, Wahner H, Bergstrahl E et al. Three-year randomized trial of the effect of dose-specified loading and strengthening exercises on bone mineral density of spine and femur in nonathletic, physically active women. Bone 1996; 19:233-44.

79. Sinaki M, Wahner HW, Offord KP, Hodgson SF. Efficacy of nonloading exercises in prevention of vertebral bone loss in postmenopausal women: a controlled trial. Mayo Clinic Proceedings 1989; 64:762-9.

80. Smidt GL, Lin S-Y, O'Dwyer KD, Blanpied PR. The effect of high-intensity trunk exercise on bone mineral density of postmenopausal women. Spine 1992; 17:280-5.

81. Smith E, Gilligan C, McAdam M, Ensign CP, Smith P. Deterring bone loss by exercise intervention in premenopausal and postmenopausal women. Calcified Tissue International 1989; 44:312-21.

82. Smith EL, Reddan W, Smith PE. Physical activity and calcium modalities for bone mineral increase in aged women. Medicine and Science in Sports and Exercise 1981; 113:60-4.

83. Smith EL, Smith PE, Ensign CJ, Shea MM. Bone involution decrease in exercising middle-aged women. Calcified Tissue International 1984; 36:S129-S138.

84. Snow-Harter C, Bouxsein ML, Lewis BT, Carter DR, Marcus R. Effects of resistance and endurance exercise on bone mineral status of young women: a randomized exercise intervention trial. Journal of Bone and Mineral Research 1992; 7:761-9.

85. Svendsen OL, Hassager C, Christiansen C. Six months' follow-up on exercise added to a short-term diet in overweight postmenopausal women - effects on body composition, resting metabolic rate, cardiovascular risk factors and bone. International Journal of Obesity 1994; 18:692-8.

86. Svendsen O, Hassager C, Christiansen C. Effect of an energy-restrictive diet, with or without exercise, on lean tissue mass, resting metabolic rate, cardiovascular risk factors, and bone in overweight postmenopausal women. The American Journal of Medicine 1993; 95:131-40.

87. Taafe DR, Pruitt L, Pyka G, Guido D, Marcus R. Comparative effects of high- and low-intensity resistance training on thigh muscle strength, fiber area, and tissue composition in elderly women. Clinical Physiology 1996; 16:381-92.

88. Taaffe DR, Robinson TL, Snow CM, Marcus R. High-impact exercise promotes bone gain in well-trained female athletes. Journal of Bone and Mineral Research 1997; 12(2):255-60.

89. Thorvaldson CL. The effects of a specific weight-training exercise program and hormone replacement therapy on bone mass in healthy postmenopausal women. Edmonton, Alberta: University of Alberta, 1990.

90. Tsukahara N, Toda A, Goto J, Ezawa I. Cross-sectional and longitudinal studies on the effect of water exercise in controlling bone loss in postmenopausal women. Journal of Nutritional Science and Vitaminology 1994; 40:37-47.

91. Tsuritani I, Brooke-Wavell KSF, Mastana SS, Jones PRM, Hardman AE, Yamada Y. Does vitamin D receptor polymorphism influence the response of bone to brisk walking in postmenopausal women? Hormone Research 1998; 50:315-9.

92. Vuori I, Helnonen A, Slevanen H, Kannus P, Pasanen M, Oja P. Effects of unilateral strength training and detraining on bone mineral density and content in young women: a study of mechanical loading and deloading on human bones. Calcified Tissue International 1994; 55:59-67.

93. Welsh L, Rutherford OM. Hip bone mineral density is improved by high-impact aerobic exercise in postmenopausal men and women over 50 years. European Journal of Applied Physiology 1996; 74:511-7.

94. Williams JA, Wagner J, Wasnich R, Heilbrun L. The effect of long-distance running upon appendicular bone mineral content. Medicine and Science in Sports and Exercise 1984; 16:223-7.

95. Kelley GA, Kelley KS. Common metric versus standardized difference for meta-

analysis of bone density studies. Medicine and Science in Sports and Exercise 1999;31:S249.

96. Stewart LA, Clarke MJ. Practical methodology of meta-analyses (overviews) using updated individual patient data. Statistics in Medicine 1995;14:2057-2079.

VII. APPENDICES

EXERCISE AND BONE MINERAL DENSITY REFERENCES

These references are provided because of a meta-analysis grant on exercise and bone density that was funded by the **United States Department of Defense, Army Medical Research and Material Command Award #17-98-1-8513.** These references are limited to those that meet that following inclusion criteria: (1) randomized and non-randomized clinical trials dealing with the effects of aerobic and/or resistance exercise in humans, (2) non-exercise control group or control period included, (3) studies in the English-language literature between January 1962 and December 1998, (4) changes in bone mineral density (regional, total) reported in adults ages 18 years and older. If you have any suggestions or comments regarding these references, please contact Dr. George Kelley at gkelley@niu.edu.

1. Aloia JF, Cohn SH, Babu T, Abesamis C, Kalici N, Ellis K. Skeletal mass and body composition in marathon runners. Metabolism 1978; 27:1793-6.

2. Ayalon J, Simkin A, Leichter I, Raifmann S. Dynamic bone loading exercises for postmenopausal women: effect on the density of the distal radius. Archives of Physical Medicine and Rehabilitation 1987; 68:280-3.

3. Bassey EJ, Rothwell MC, Littlewood JJ, Pye DW. Pre- and postmenopausal women have different bone mineral density responses to the same high-impact exercise. Journal of Bone and Mineral Research 1998; 13:1805-13.

4. Bennell KL, Malcolm SA, Khan KM et al. Bone mass and bone turnover in power athletes, and controls: a 12-month longitudinal study. Bone 1997; 20(5):477-84.

5. Bloomfield SA, Mysiw WJ, Jackson RD. Bone mass and endocrine adaptations to training in spinal cord injured individuals. Bone 1996; 19(1):61-8.

6. Bloomfield SA, Williams N, Lamb D, Jackson R. Non-weightbearing exercise may increase lumbar spine bone mineral density in healthy postmenopausal women. American Journal of Physical Medicine and Rehabilitation 1993; 72:204-9.

7. Blumenthal JA, Emery CF, Madden DJ et al. Cardiovascular and behavioral effects of aerobic exercise training in healthy older men and women. Journal of Gerontology 1989; 44:147-57.

8. Blumenthal JA, Emery CF, Madden DJ et al. Effects of exercise training on bone density in older men and women. Journal of the American Geriatrics Society 1991; 39:1065-70.

9. Bouxsein ML. Physical activity and bone density. Palo Alto, California: Stanford University, 1992.

10. Braith RW, Mills RM, Welsch MA, Keller JW, Pollock ML. Resistance training restores bone mineral density in heart transplant patients. Journal of the American College of Cardiology 1996; 28:1471-7.

11. Bravo G, Gauthier P, Roy P-M et al. Impact of a 12-month exercise program on the physical and psychological health of osteopenic women. Journal of the American Geriatrics Society 1996; 44:756-62.

12. Brooke-Wavell KSF, Jones PRM, Hardman AE. Brisk walking reduces calcaneal bone loss in post-menopausal women. Clinical Science 1997; 92:75-80.

13. Caplan GA, Ward JA. The benefits of exercise in postmenopausal women. Australian Journal of Public Health 1993; 17:23-6.

14. Cavanaugh DJ, Cann CE. Brisk walking does not stop bone loss in postmenopausal women. Bone 1988; 9:201-4.

15. Chilibeck PD, Calder A, Sale DG, Webber CE. Twenty weeks of weight training increases lean tissue mass but not bone mineral mass or density in healthy, active young women. Canadian Journal of Physiology and Pharmacology 1996; 74:1180-5.

16. Cohen B, Millet PJ, Mist B, Laskey MA, Rushton N. Effect of exercise training programme on bone mineral density in novice college rowers. British Journal of Sports Medicine 1995; 29:85-8.

17. Dalsky GP, Stocke KS, Ehsani AA, Slatopolsky E, Lee WC, Birge SJ. Weight-bearing exercise training and lumbar bone mineral content in postmenopausal women. Annals of Internal Medicine 1988; 108:824-8.

18. Danz AM, Zittermann A, Schiedermaier U, Klein K, Hotzel D, Schonau E. The effect of a specific strength-development exercise on bone mineral density in perimenopausal and postmenopausal women. Journal of Womens Health 1998; 7:701-9.

19. Delaney TA. Association of insulin-like growth factor-I with body composition, diet and bone mineral indices in weight resistance-trained premenopausal women.Davis, California: University of California at Davis, 1991.

20. Dornemann TM. The effect of a weight training program on the bone density of women aged 40-50 years. Chapel Hill, North Carolina: University of North Carolina @ Chapel Hill, 1994.

21. Dornemann TM, McMurray RG, Renner JB, Anderson JJB. Effects of high-intensity resistance exercise on bone mineral density and muscle strength of 40-50-year-old women. Journal of Sports Medicine and Physical Fitness 1997; 37:246-51.

22. Ebrahim S, Thompson PW, Baskaran V, Evans K. Randomized placebo-controlled trial of brisk walking in the prevention of postmenopausal osteoporosis. Age and Ageing 1997; 26:253-60.

23. Fujimura R, Ashizawa N, Watanabe M et al. Effect of resistance exercise training on bone formation and resorption in young male subjects assessed by biomarkers of bone metabolism. Journal of Bone and Mineral Research 1997; 12:656-62.

24. Gleeson PB, Protas EJ, LeBlanc AD, Schneider VS, Evans HJ. Effects of weight lifting on bone mineral density in premenopausal women. Journal of Bone and Mineral Research 1990; 5:153-8.

25. Greendale G, Hirsch S, Hahn T. The effect of a weighted vest on perceived health status and bone density in older persons. Quality of Life Research 1993; 2:141-52.

26. Grove CA. The effects of high impact exercise versus low impact exercise on bone density in postmenopausal women. Columbia, Missouri: University of Missouri, 1990.

27. Grove KA, Londeree BR. Bone density in postmenopausal women:high impact versus low impact exercise. Medicine and Science in Sports and Exercise 1992; 24:1190-4.

28. Hartard M, Haber P, Ilieva D, Preisinger E, Seidl G, Huber J. Systematic strength training as a model of therapeutic intervention. American Journal of Physical Medicine and Rehabilitation 1996; 75:21-8.

29. Hatori M, Hasegawa A, Adachi H et al. The effects of walking at the anaerobic threshold level on vertebral bone loss in postmenopausal women. Calcified Tissue International 1993; 52:411-4.

30. Heinonen A, Kanus P, Sievanen H et al. Randomised control trial of effect of high-impact exercise on selected risk factors for osteoporotic fractures. Lancet 1996; 348:1343-7.

31. Heinonen A, Oja PSH, Pasanen M, Vuori I. Effect of two training regimens on bone mineral density in healthy perimenopausal women: a randomized controlled trial. Journal of Bone and Mineral Research 1998; 13:483-90.

32. Heinonen A, Sievanen H, Kannus P, Oja P, Vuori I. Effects of unilateral strength training and detraining on bone mineral mass and estimated mechanical

characteristics of the upper limb bones in young women. Journal of Bone and Mineral Research 1996; 11:490-501.

33. Iwamoto J, Takeda T, Otani T, Yabe Y. Effect of increased physical activity on bone mineral density in postmenopausal osteoporotic women. Keio Journal of Medicine 1998; 47:157-61.

34. Jarvinen TLN, Jarvinen TAH, Sievanen H et al. Vitamin D receptor alleles and bone's response to physical activity. Calcified Tissue International 1998; 62:413-7.

35. Kerr D, Morton A, Dick I, Prince R. Exercise effects on bone mass in postmenopausal women are site-specific and load-dependent. Journal of Bone and Mineral Research 1996; 11:218-25.

36. Kohrt WM, Ehsani AA, Birge SJ. Effects of exercise involving predominantly either joint-reaction or ground-reaction forces on bone mineral density in older women. Journal of Bone and Mineral Research 1997; 12:1253-61.

37. Kohrt WM, Ehsani AA, Birge SJ. HRT preserves increases in bone mineral density and reductions in body fat after a supervised exercise program. Journal of Applied Physiology 1998; 84:1506-12.

38. Kohrt WM, Snead DB, Slatopolsky E, Birge SJ. Additive effects of weight-bearing exercise and estrogen on bone mineral density in older women. Journal of Bone and Mineral Research 1995; 10:1303-11.

39. Kronhed G, Moller AC. Effects of physical exercise on bone mass, balance skill and aerobic capacity in women and men with low bone mineral density, after one year of training-a prospective study. Scandinavian Journal of Medicine and Science in Sports 1998; 8:290-8.

40. Lau EMC, Woo J, Leung PC, Swaminathan R, Leung D. The effects of calcium supplementation and exercise on bone density in elderly Chinese women. Osteoporosis International 1992; 2:168-73.

41. Little KD. Effect of exercise mode on bone mineral mass in recently postmenopausal women. Kent, Ohio: Kent State University, 1992.

42. Lohman T, Going S, Pamenter R et al. Effects of resistance training on regional and total bone mineral density in premenopausal women: a randomized prospective study. Journal of Bone and Mineral Research 1995; 10:1015-24.

43. Lord SR, Ward JA, Williams P, Zivanovic E. The effects of community exercise program on fracture risk factors in older women . Osteoporosis International 1996; 361-7.

44. Martin D, Notelovitz M. Effects of aerobic training on bone mineral density of postmenopausal women. Journal of Bone and Mineral Research 1993; 8:931-6.

45. Mayoux-Benhamou MA, Bagheri F, Roux C, Auleley GR, Rabourdin JP, Revel M. Effect of psoas training on postmenopausal lumbar bone loss: a 3-year follow-up study. Calcified Tissue International 1997; 60:348-53.

46. Mazel S. Effects of strength training on bone mineral density and bone remodeling in middle aged and older men College Park, Maryland: University of Maryland @ College Park, 1991.

47. McCartney N, Hicks AL, Martin J, Webber CE. Long-term resistance training in the elderly: effects on dynamic strength, exercise capacity, muscle, and bone. Journal of Gerontology 1995; 50A:B97-B104.

48. McCartney N, Hicks AL, Martin J, Webber CE. A longitudinal trial of weight training in the elderly: Continued improvements in year 2. Journal of Gerontology 1996; 6:B425-B433.

49. McMurdo MET, Mole PA, Paterson CR. Controlled trial of weight-bearing exercise in older women in relation to bone density and falls. British Medical Journal 1997; 314:569.

50. Menkes A, Mazel S, Redmond RA et al. Strength training increases regional bone mineral density and bone remodeling in middle-aged and older men. Journal of Applied Physiology 1993; 74:2478-84.

51. Michel BA, Lane NE, Bjorkengren A, Bloch DA, Fries JF. Impact of running on lumbar bone density: a 5-year longitudinal study. Journal of Rheumatology 1992; 19:1759-63.

52. Milliken LA. Bone mineral density, bone remodeling, insulin-like growth factors, hormone replacement therapy, and exercise training in postmenopausal women. Tuscon, Arizona: University of Arizona, 1998.

53. Nelson ME, Fiatarone MA, Morganti CM, Trice I, Greenberg RA, Evans WJ. Effects of high-intensity strength training on multiple risk factors for osteoporotic fractures:a randomized controlled trial. Journal of the American Medical Association 1994; 272:1909-14.

54. Nelson ME, Fisher EC, Dilmanian FA, Dallal GE, Evans WJ. A 1-y walking program and increased dietary calcium in postmenopausal women: effects on bone. American Journal of Clinical Nutrition 1991; 53:1304-11.

55. Nichols DL, Sanborn CF, Bonnick SL, Ben-Ezra V, Gench B, DiMarco NM. The effects of gymnastics training on bone mineral density. Medicine and Science in Sports and Exercise 1994; 10:1220-5.

56. Nichols JF, Nelson KP, Peterson KK, Sartoris DJ. Bone mineral density responses to high-intensity strength training in active older women. Journal of Aging and Physical Activity 1995; 3:26-38.

57. Notelovitz M, Martin D, Tesar R et al. Estrogen therapy and variable resistance weight training increase bone mineral in surgically menopausal women. Journal of Bone and Mineral Research 1991; 6:583-90.

58. Payne SG. The effects of weight training on bone mineral density of premenopausal females. Texas Woman's University, 1995.

59. Peterson SE, Peterson MD, Raymond G, Gilligan C, Checovich MM, Smith EL. Muscular strength and bone density with weight training in middle-aged women. Medicine and Science in Sports and Exercise 1991; 23:499-504.

60. Preisinger E, Alacamlioglu Y, Pils K, Saradeth T, Schneider B. Therapeutic exercise in the prevention of bone loss: A controlled trial with women after menopause. American Journal of Physical Medicine and Rehabilitation 1995; 74:120-3.

61. Preisinger E, Alacamlioglu Y, Pils K et al. Exercise therapy for osteoporosis:results of a randomised controlled trial. British Journal of Sports Medicine 1996; 30:209-12.

62. Prince R, Devine A, Criddle A et al. The effects of calcium supplementation (milk powder or tablets) and exercise on bone density in postmenopausal women. Journal of Bone and Mineral Research 1995; 10:1068-75.

63. Prince RL, Smith M, Dick IM et al. Prevention of postmenopausal osteoporosis: a comparative study of exercise, calcium supplementation, and hormone replacement therapy. The New England Journal of Medicine 1991; 325:1189-95.

64. Pritchard JE, Nowson CA, Wark JD. Bone loss accompanying diet-induced or exercise-induced weight loss:a randomised controlled study. International Journal of Obesity 1996; 20:513-20.

65. Protiva KW. Weighted vest exercise improves functional ability in women over 75 years of age. Corvallis, Oregon: Oregon State University, 1997.

66. Pruitt L. The effect of an isotonic weight-training program upon bone density and selected indices of bone turnover in early postmenopausal women. Columbus, Ohio: Ohio State University, 1989.

67. Pruitt LA, Jackson RD, Bartels RL, Lehnhard HJ. Weight-training effects on bone mineral density in early postmenopausal women. Journal of Bone and Mineral Research 1992; 7:179-85.

68. Pruitt LA, Taafe DR, Marcus R. Effects of a one-year high intensity versus low-intensity resistance training program on bone mineral density in older women. Journal of Bone and Mineral Research 1995; 10:1788-95.

69. Revel M, Mayoux-Benhamou MA, Rabourdin JP, Roux C. One-year psoas training can prevent lumbar bone loss in postmenopausal women:a randomized controlled trial. Calcified Tissue International 1993; 53:307-11.

70. Rikli RE, McManis BG. Effects of exercise on bone mineral content in postmenopausal women. Research Quarterly for Exercise and Sport 1990; 61:243-9.

71. Robinson RJ, Krzywicki T, Almond L et al. Effect of a low-impact exercise program on bone mineral density in Crohn's disease: a randomized controlled trial. Gastroenterology 1998; 115:36-41.

72. Rockwell. J. C, Sorenson AM, Baker S et al. Weight training decreases vertebral bone density in premenopausal women: a prospective study. Journal of Clinical Endocrinology and Metabolism 1990; 71:988-93.

73. Ryan AS, Nicklas BJ, Dennis KE. Aerobic exercise maintains regional bone mineral density during weight loss in postmenopausal women. Journal of Applied Physiology 1998; 84:1305-10.

74. Ryan AS, Treuth MS, Hunter GR, Elahi D. Resistive training maintains bone mineral density in postmenopausal women. Calcified Tissue International 1998; 62:295-9.

75. Shaw J. The effects of resistance training on fracture risk and psychological variables in postmenopausal women. Corvallis, Oregon: Oregon State University, 1995.

76. Shaw JM, Snow CM. Weighted vest exercise improves indices of fall risk in older women. Journal of Gerontology 1998; 53:M53-M58.

77. Simkin A, Ayalon J, Leichter I. Increased trabecular bone density due to bone-loading exercises in postmenopausal osteoporotic women. Calcified Tissue International 1987; 40:59-63.

78. Sinaki M, Wahner H, Bergstrahl E et al. Three-year randomized trial of the effect of dose-specified loading and strengthening exercises on bone mineral density of spine and femur in nonathletic, physically active women. Bone 1996; 19:233-44.

79. Sinaki M, Wahner HW, Offord KP, Hodgson SF. Efficacy of nonloading exercises in prevention of vertebral bone loss in postmenopausal women: a controlled trial. Mayo Clinic Proceedings 1989; 64:762-9.

80. Smidt GL, Lin S-Y, O'Dwyer KD, Blanpied PR. The effect of high-intensity trunk exercise on bone mineral density of postmenopausal women. Spine 1992; 17:280-5.

81. Smith E, Gilligan C, McAdam M, Ensign CP, Smith P. Deterring bone loss by exercise intervention in premenopausal and postmenopausal women. Calcified Tissue International 1989; 44:312-21.

82. Smith EL, Reddan W, Smith PE. Physical activity and calcium modalities for bone mineral increase in aged women. Medicine and Science in Sports and Exercise 1981; 113:60-4.

83. Smith EL, Smith PE, Ensign CJ, Shea MM. Bone involution decrease in exercising middle-aged women. Calcified Tissue International 1984; 36:S129-S138.

84. Snow-Harter C, Bouxsein ML, Lewis BT, Carter DR, Marcus R. Effects of resistance and endurance exercise on bone mineral status of young women: a randomized exercise intervention trial. Journal of Bone and Mineral Research 1992; 7:761-9.

85. Svendsen OL, Hassager C, Christiansen C. Six months' follow-up on exercise added to a short-term diet in overweight postmenopausal women - effects on body composition, resting metabolic rate, cardiovascular risk factors and bone. International Journal of Obesity 1994; 18:692-8.

86. Svendsen O, Hassager C, Christiansen C. Effect of an energy-restrictive diet, with or without exercise, on lean tissue mass, resting metabolic rate, cardiovascular risk factors, and bone in overweight postmenopausal women. The American Journal of Medicine 1993; 95:131-40.

87. Taafe DR, Pruitt L, Pyka G, Guido D, Marcus R. Comparative effects of high- and low-intensity resistance training on thigh muscle strength, fiber area, and tissue composition in elderly women. Clinical Physiology 1996; 16:381-92.

88. Taaffe DR, Robinson TL, Snow CM, Marcus R. High-impact exercise promotes bone gain in well-trained female athletes. Journal of Bone and Mineral Research 1997; 12(2):255-60.

89. Thorvaldson CL. The effects of a specific weight-training exercise program and hormone replacement therapy on bone mass in healthy postmenopausal women. Edmonton, Alberta: University of Alberta, 1990.

90. Tsukahara N, Toda A, Goto J, Ezawa I. Cross-sectional and longitudinal studies on the effect of water exercise in controlling bone loss in postmenopausal women. Journal of Nutritional Science and Vitaminology 1994; 40:37-47.

91. Tsuritani I, Brooke-Wavell KSF, Mastana SS, Jones PRM, Hardman AE, Yamada Y. Does vitamin D receptor polymorphism influence the response of bone to brisk walking in postmenopausal women? Hormone Research 1998; 50:315-9.

92. Vuori I, Helnonen A, Slevanen H, Kannus P, Pasanen M, Oja P. Effects of unilateral strength training and detraining on bone mineral density and content in young women: a study of mechanical loading and deloading on human bones. Calcified Tissue International 1994; 55:59-67.

93. Welsh L, Rutherford OM. Hip bone mineral density is improved by high-impact aerobic exercise in postmenopausal men and women over 50 years. European Journal of Applied Physiology 1996; 74:511-7.

94. Williams JA, Wagner J, Wasnich R, Heilbrun L. The effect of long-distance running upon appendicular bone mineral content. Medicine and Science in Sports and Exercise 1984; 16:223-7.

Bone Density Coding Items and Instructions

	VARIABLE	DESCRIPTION
1	Row #	Row number
2	ID#	Study id number
3	Author	Author(s) of study
4	Group-Described	Description of group/effect size
5	SC	Will this row be used to analyze data according to study characteristics? Coded as Yes or No
6	GC-Ex	Will this row be used to analyze data according to exercise group characteristics? Coded as Yes or No
7	GC-Con	Will this row be used to analyze data according to control group characteristics? Coded as Yes or No
8	Source	Coded as journal, dissertation or other
9	Year	Year study was published
10	Language	Language of journal
11	Country	Country study was conducted in
12	Design	Study design, coded as randomized control trial (RCT) or controlled trial (CT)
13	Matching	matching procedures, coded as age (age), height (ht), weight (wt), body mass index (BMI), max vo2 (VO2max), yrs. postmenopauase (yrspm)
14	Crossover trial	Was the study a crossover trial? Coded as yes or no
15	Study Quality	rating of study quality score will be generated from quality rating scale of Jadad et al.
16	Analysis?	Analysis: coded as intention to treat (ITT) or analysis by protocol (ABP) or analysis by protocol with follow-up (ABPWF)
17	#Groups-Ex	number of exercise groups
18	#Groups-Con	number of control groups
19	#Groups-Total	total number of groups (automatically calculated)
20	#ES-Total	total number of effect sizes
21	InitialN-Ex	initial number of exercise subjects
22	InitialN-Con	initial number of control subjects
23	InitialN-Total	initial total number of subjects (automatically calculated)
24	FinalN-Ex	final number of exercising subjects
25	FinalN-Con	final number of control subjects
26	FinalN-Total	final total number of subjects (automatically calculated)
27	%Dropout-Ex	percent dropout in the exercise groups (automatically calculated)
28	%Dropout-Con	percent dropout in the control groups (automatically calculated)
29	%-Females	% of female subjects in the study
30	Race	Ethnicity of subjects
31	Total N-Ex+Co	Total number of subjects bone density was assessed in (exercise plus control) (automatically calculated)
32	BONE RESULTS	leave as is
33	N-Ex	Number of exercising subjects in which bone density was assessed
34	I-Ex	initial bone density for exercise groups
35	I-SD-Ex	initial standard deviation for bone density of the exercise groups
36	F-Ex	final bone density for the exercise groups
37	F-SD-Ex	final standard deviation for final bone density for the exercise groups
38	D-Ex	difference in bone density for the exercise groups (automatically calculated)

39	D-SD-Ex	standard deviation of the difference in bone density for exercise groups
40	P-Ex	% change in bone density for the exercise groups (automatically calculated)
41	P-SD-Ex	standard deviation of difference in % change in bone density for exercise groups
42	N-Con	Number of subjects in the control groups in which bone density was assessed
43	I-Con	initial bone density for the control groups
44	I-SD-Con	initial standard deviation for bone density in the control groups
45	F-Con	final bone density for the control groups
46	F-SD-Con	final standard deviation for bone density in the control groups
47	D-Con	difference in bone density for the control groups (automatically calculated)
48	D-SD-Con	standard deviation of the difference in bone density for the control groups
49	P-Con	% change in bone density for the control groups (automatically calculated)
50	P-SD-Con	standard deviation for % change in bone density for the control groups
51	P-Ex-Con	percent change for exercise and control groups (automatically calculated)
52	Metric	Metric used for bone density. Code as reported (ex . gm/cm2)
53	ES-Method	method used for calculating bone density effect size, coded as pre-post, change outcome, other
54	ES-Raw(g)	raw effect size (g) calculated from DSTAT program (calculate later)
55	ES-Corrected(d)	effect size(d) corrected for small sample bias (automatically calculated later)
56	ES-Var(d)	effect size variance (automatically calculated later)
57	ES-SD(d)	effect size (SD) for bone density (automatically calculated later)
58	ES-L95CI(d)	lower 95%CI for effect size (automatically calculated later)
59	ES-U95CI(d)	upper 95%CI for effect size (automatically calculated)
60	Significant?	Did the author(s) report the results to be statistically significant in favor of the treatment group? coded as yes or no.
61	PHYSICAL TRAITS	leave as is
62	Age-Ex	age of exercise groups
63	Age-SD-Ex	standard deviation for age of exercise groups
64	Age Range-Ex	age range for exercise groups
65	Height-Ex	height (cm) for exercise groups
66	Height-SD-Ex	standard deviation for height of exercise groups
67	I-Weight-Ex	initial weight (kg) for exercise groups
68	I-Weight-SD-Ex	standard deviation for initial weight (kg) of exercise groups
69	F-Weight-Ex	final weight (kg) for exercise groups
70	F-Weight-SD	standard deviation for final weight (kg) for exercise groups
71	D-Weight-Ex	difference in weight (kg) for exercise groups (automatically calculated)
72	D-Weight-SD-Ex	standard deviation for the difference in weight (kg) for exercise groups (automatically calculated)
73	P-Weight-Ex	% change in weight (kg) for the exercise groups (automatically calculated)
74	I-BMI-Ex	initial body mass index for the exercise groups
75	I-BMI-SD-Ex	standard deviation for initial body mass index for the exercise groups
76	F-BMI-Ex	final body mass index for the exercise groups
77	F-BMI-SD-Ex	standard deviation for final body mass index for the exercise groups
78	D-BMI-Ex	difference in body mass index for the exercise groups (automatically calculated)
79	D-BMI-SD-EX	standard deviation of the difference in body mass index for the exercise groups (automatically calculated)
80	P-BMI-Ex	% change in body mass index for the exercise groups (automatically calculated)

81	I-Fat-Ex	initial % fat for exercise groups
82	I-Fat-SD-Ex	standard deviation for initial % fat for exercise groups
83	F-Fat-Ex	final % fat for exercise groups
84	F-Fat-SD-Ex	standard deviation for final % fat for exercise groups
85	D-Fat-Ex	difference in % fat for exercise groups (automatically calculated)
86	D-Fat-SD-Ex	standard deviation for difference in % fat (automatically calculated)
87	P-Fat-Ex	% fat for exercise groups (automatically calculated)
88	I-LBM-Ex	initial lean body mass (kg) for exercise groups
89	I-LBM-SD-Ex	standard deviation for initial lean body mass (kg) for exercise groups
90	F-LBM-Ex	final lean body mass (kg) for exercise groups
91	F-LBM-SD-Ex	standard deviation for final lean body mass (kg) for exercise groups
92	D-LBM-Ex	difference in lean body mass (kg) for exercise groups (automatically calculated)
93	D-LBM-SD-Ex	standard deviation of the difference in lean body mass (kg) for exercise groups (automatically calculated)
94	P-LBM-Ex	% change in lean body mass (kg) for exercise groups (automatically calculated)
95	I-VO2-Ex	initial maximum oxygen consumption (ml/kg/min) for exercise groups
96	I-VO2-SD-Ex	standard deviation for initial maximum oxygen consumption (ml/kg/min) for exercise groups
97	F-VO2-Ex	final maximum oxygen consumption (ml/kg/min) for exercise groups
98	F-VO2-SD-Ex	standard deviation for final maximum oxygen consumption (ml/kg/min) for exercise groups
99	D-VO2-Ex	difference in maximum oxygen consumption (ml/kg/min) for exercise groups (automatically calculated)
100	D-VO2-SD-Ex	difference in maximum oxygen consumption (SD in ml/kg/min) for exercise groups (automatically calculated)
101	P-VO2-Ex	% change in maximum oxygen consumption (ml/kg/min) for exercise groups (automatically calculated)
102	I-RHR-Ex	initial resting heart rate (bts/min) for the exercise groups
103	I-RHR-SD-Ex	standard deviation for initial resting heart rate (bts/min) for exercise groups
104	F-RHR-Ex	final resting heart rate (bts/min) for exercise groups
105	F-RHR-SD-Ex	standard deviation for final resting heart rate (bts/min) for the exercise groups
106	D-RHR-Ex	difference in resting heart rate (bts/min) for the exercise groups (automatically calculated)
107	D-RHR-SD-Ex	standard deviation for the difference in resting heart rate (bts/min) for exercise groups (automatically calculated)
108	P-RHR-Ex	% change in resting heart rate (bts/min) for exercise groups (automatically calculated)
109	%D-Strength-Ex	percent change in strength for the exercise groups
110	Postmenopausal?-Ex	were exercising subjects postmenopausal women? coded as yes, no, some
111	Yrs Postmenopause-Ex	number of years exercising subjects were postmenopausal
112	Yrs Postmenopause-SD-Ex	standard deviation for number of years exercising women were postmenopausal
113	I-Ca-Ex	initial calcium levels for exercise subjects
114	I-Ca-SD-Ex	initial standard deviation for calcium levels for exercise subjects
115	F-Ca-Ex	final calcium levels for exercise subjects
116	F-Ca-SD-Ex	final standard deviation for calcium levels of exercising subjects
117	D-Ca-Ex	difference in calcium levels for exercising subjects (automatically calculated)
118	D-Ca-SD-Ex	standard deviation for differences in calcium levels for exercising subjects (automatically calculated)
119	%D-Ca-Ex	percent difference in calcium levels for exercising subjects (automatically calculated)
120	Ca-Supp-Ex	calcium supplementation for exercise subjects: coded as yes, no, some
121	Drugs-Ex	were any of the exercisers taking drugs to enhance or maintain bone density: coded as yes, no, some
122	Smoking-Ex	smoking status of exercising subjects: coded as yes, no, some

123	Alcohol-Ex	did exercising subjects drink alcohol?: coded as yes, no, some
124	Diet-Ex	did exercising subjects' nutrition intake vary between initial and final testing? coded as yes, no, some
125	Previous PA-Ex	were the subjects previously active?: coded as yes, no, some
126	Previous Fractures-EX	did exercising subjects have previous fractures?: coded as yes, no, some
127	Age-Con	age for control groups
128	Age-SD-Con	standard deviation for age of control groups
129	Age Range-Con	age range for control groups
130	Height-Con	height (cm) for control groups
131	Height-SD-Con	standard deviation for height (cm) in control groups
132	I-Weight-Con	initial weight (kg) for control groups
133	I-Weight-SD-Con	standard deviation for initial weight (kg) for control groups
134	F-Weight-Con	final weight (kg) for control groups
135	F-Weight-SD-Con	standard deviation for final weight (kg) for control groups
136	D-Weight-Con	difference in weight (kg) for control groups
137	D-Weight-SD-Con	standard deviation for difference in weight (kg) for control groups
138	P-Weight-Con	% change in weight (kg) for control groups
139	TE-Weight	treatment effect for differences in bodyweight
140	TE-Weight-Var	overall variance for treatment effect weight
141	TE-Weight-SD	standard deviation for treatment effect weight
142	TE-Weight-PCHG	treatment effect percent change for weight
143	I-BMI-Con	initial body mass index for control groups
144	I-BMI-SD-Con	standard deviation for initial body mass index in control groups
145	F-BMI-Con	final body mass index for control groups
146	F-BMI-SD-Con	standard deviation for final body mass index in control groups
147	D-BMI-Con	difference in body mass index for control groups
148	D-BMI-SD-Con	standard deviation for final body mass index for control groups
149	P-BMI-Con	% change in body mass index for control groups
150	TE-BMI	treatment effect for BMI (automatically calculated)
151	TE-BMI-Var	overall variance for BMI treatment effect (automatically calculated)
152	TE-BMI-SD	standard deviation for BMI treatment effect (automatically calculated)
153	TE-BMI-PCHG	treatment effect percent change for BMI (automatically calculated)
154	I-Fat-Con	initial %fat for control groups
155	I-Fat-SD-Con	initial %fat standard deviation for control groups
156	F-Fat-Con	final %fat for control groups
157	F-Fat-SD-Con	final %fat standard deviation for control groups
158	D-Fat-Con	differences in %fat for control groups
159	D-Fat-SD-Con	differences in %fat standard deviation for control groups
160	P-Fat-Con	% change difference in %fat for control groups
161	TE-Fat	treatment effect for %fat (automatically calculated)
162	TE-Fat-Var	overall variance for treatment effect %fat (automatically calculated)
163	TE-Fat-SD	standard deviation for %fat treatment effect (automatically calculated)
164	TE-Fat-PCHG	treatment effect percent change for %fat (automatically calculated)

165	I-LBM-Con	initial lean body mass (kg) for control groups
166	I-LBM-SD-Con	standard deviation for initial lean body mass (kg) for control groups
167	F-LBM-Con	final lean body mass (kg) for control groups
168	F-LBM-SD-Con	standard deviation for final lean body mass (kg) for control groups
169	D-LBM-Con	difference in lean body mass (kg) for control groups (automatically calculated)
170	D-LBM-SD-Con	standard deviation for differences in lean body mass (kg) for control groups
171	P-LBM-Con	% fat differences for lean body mass (kg) control groups (automatically calculated)
172	TE-LBM	treatment effect for lean body mass (kg) (automatically calculated)
173	TE-LBM-Var	overall variance for treatment effect lean body mass (kg) (automatically calculated)
174	TE-LBM-SD	standard deviation for lean body mass (kg) treatment effect (automatically calculated)
175	TE-LBM-PCHG	treatment effect percent change for lean body mass (kg) (automatically calculated)
176	I-VO2-Con	initial maximum oxygen consumption (ml/kg/min) for control groups
177	I-VO2-SD-Con	standard deviation for initial maximum oxygen consumption (ml/kg/min) for control groups
178	F-VO2-Con	final maximum oxygen consumption (ml/kg/min) for control groups
179	F-VO2-SD-Con	standard deviation for final maximum oxygen consumption (ml/kg/min) for control groups
180	D-VO2-Con	difference in maximum oxygen consumption (ml/kg/min) for control groups
181	D-VO2-SD-Con	standard deviation for differences in maximum oxygen consumption (ml/kg/min) for control groups
182	P-VO2-Con	% change difference in maximum oxygen consumption (ml/kg/min) for control groups
183	TE-VO2	treatment effect for maximum oxygen consumption (automatically calculated)
184	TE-VO2-Var	overall variance for maximum oxygen consumption treatment effect (automatically calculated)
185	TE-VO2-SD	standard deviation for maximum oxygen consumption treatment effect (automatically calculated)
186	TE-VO2-PCHG	treatment effect percent change for maximum oxygen consumption (automatically calculated)
187	I-RHR-Con	initial resting heart rate (bts/min) for control groups
188	I-RHR-SD-Con	standard deviation for initial resting heart rate (bts/min) for control groups
189	F-RHR-Con	final resting heart rate (bts/min) for control groups
190	F-RHR-SD-Con	standard deviation for final resting heart rate (bts/min) for control groups
191	D-RHR-Con	difference in resting heart rate (bts/min) for control groups (automatically calculated)
192	D-RHR-SD-Con	standard deviation for differences in resting heart rate (bts/min) for control groups (automatically calculated)
193	P-RHR-Con	% change in resting heart rate (bts/min) for control groups (automatically calculated)
194	TE-RHR	treatment effect for changes in resting heart rate (automatically calculated)
195	TE-RHR-Var	treatment effect variance for resting heart rate (automatically calculated)
196	TE-RHR-SD	treatment effect (SD) for resting heart rate (automatically calculated)
197	TE-RHR-PCHG	treatment effect percent change for resting heart rate (automatically calculated)
198	%D-Strength-Con	percent change in strength for the control group
199	TE-Strength-Ex-Con	treatment effect for strength (automatically calculated)
200	Postmenopausal?-Con	were control subjects postmenopausal women? coded as yes, no, some
201	Yrs Postmenopause-Con	number of years control subjects were postmenopausal
202	Yrs Postmenopause-SD-Con	standard deviation for number of years control subjects were postmenopausal
203	I-Ca-Con	initial calcium levels for control subjects
204	I-Ca-SD-Con	initial standard deviation for calcium levels for control subjects
205	F-Ca-Con	final calcium levels for control subjects
206	F-Ca-SD-Con	final standard deviation for calcium levels of control subjects

207	D-Ca-Con	difference in calcium levels for control subjects (automatically calculated)
208	D-Ca-SD-Con	standard deviation for differences in calcium levels for control subjects (automatically calculated)
209	%D-Ca-Con	percent difference in calcium levels for exercising subjects (automatically calculated)
210	TE-Calcium	treatment effect for calcium levels (automatically calculated)
211	TE-Calcium-Var	treatment effect variance for calcium levels (automatically calculated)
212	TE-Calcium-SD	treatment effect (SD) for calcium (automatically calculated)
213	TE-Calcium-PCHG	percent change treatment effect for calcium levels (automatically calculated)
214	Ca-Supp-Con	calcium supplementation for control subjects: coded as yes, no, some
215	Drugs-Con	were any of the controls taking drugs to enhance bone density? coded as yes, no, some
216	Smoking-Con	smoking status of control subjects: coded as yes, no, some
217	Alcohol-Con	did control subjects drink alcohol? coded as yes, no, some
218	Diet-Con	did the nutrition intake of subjects vary between initial and final testing? coded as yes, no, some
219	Previous PA-Con	were the subjects active prior to taking part in the study? coded as yes, no, some
220	Previous Fractures-Con	did control subjects have previous fractures?: coded as yes, no, some
221	BONE ASSESSMENT	leave as is
222	Type	type of bone assessment instrument used: coded as DEXA, DPA, QCT, SPA, Other
223	Model Name	model name of bone assessment instrument used: coded as reported in the study
224	Model #	model number of instrument used: coded as reported in the study
225	Total or Regional?	Was total and/or regional bone density assessed: coded as total or regional
226	Site-General	general sites assessed: coded as total, hip, back, forearm, heel, other
227	Site-Specific	specific sites assessed: coded as reported (for example L1-L4)
228	Assessment-Specific	Was the site assessed specific to the site loaded? Coded as yes or no
229	Reliability	reliability (coefficient of variation): code numbers reported in percent
230	Tester Blinded?	was tester blinded to treatment? coded as yes or no
231	EXERCISE PROGRAM	leave as is
232	Type of Exercise	type of exercise: coded as strength, aerobic, both, other
233	Length	length (weeks) of training
234	Frequency	frequency of training (days/week)
235	Frequency-SD	standard deviation for frequency of training (days/week)
236	Frequency-range	range of frequency of training (days/week)
237	Intensity-VO	intensity of training: coded as a % of maximum oxygen consumption
238	Intensity-VO-SD	standard deviation for intensity of training (% maximum oxygen consumption)
239	Intensity range	range for intensity of training (% maximum oxygen consumption)
240	Duration	duration of training (minutes/session)
241	Duration-SD	standard deviation for duration of training (minutes/session)
242	Duration range	range for duration of training (minutes/session)
243	Total minutes	total minutes of training, the product of length x frequency x duration (automatically calculated)
244	Sets	number of sets completed per exercise: code mean number or range
245	Reps	number of reps completed per exercise: code mean number or range
246	%1RM	percentage of 1RM
247	Rest Bewteen Sets	amount of rest, in seconds, between sets
248	# Exercises	number of exercises performed: code mean number or range

249	Mode(s)	mode of training: coded as walking (W), jogging (J), cycling (C), swimming (S), aerobic dance (AD), stair climbing (SC), Other (O)
250	Compliance	% of exercise sessions that subjects attended
251	Compliance-SD	standard deviation for % of exercise sessions that subjects attended
252	Code Time	Time it took to code study
253	Date Coded	Date study was coded
	Notes:	Unless otherwise, all data are coded as means.
	Notes:	ND means not reported, not able to code based on reporting method, or not applicable.
	Notes:	All columns that are automatically calculated may be overwritten with original data.

Volume 31 ~ Number 5 ~ May 1999
Supplement to

MEDICINE & SCIENCE IN SPORTS & EXERCISE®

Official Journal of the American College of Sports Medicine

LIPPINCOTT WILLIAMS & WILKINS

ISSN: 0195-9131

1189 COMMON METRIC VERSUS STANDARDIZED DIFFERENCE FOR META-ANALYSIS OF BONE DENSITY STUDIES

G.A. Kelley, FACSM, K.S. Kelley e-mail: gkelley@niu.edu. Northern Illinois University, De Kalb, IL

The purpose of this study was to compare the use of the common metric versus standardized difference effect size for pooling results from a sample of controlled trials examining the effects of exercise on bone density at the hip in postmenopausal women. The most commonly reported metric (percent change) was compared to the standardized difference effect size. A total of 13 values were included in the analysis. Using a fixed-effects model, common metric (CM+) effect size showed an increase of 0.36 percent (95 percent confidence interval = -0.09 to 0.81). From a clinical standpoint, this is considered a "small" effect. The standardized approach (STD+) showed an average effect of 0.20 (95 percent confidence interval = 0.02 to 0.38). This is also considered a "small" effect. No significant heterogeneity (Q) was observed for either common metric or standardized results (common metric, Q = 18.80, p = 0.09, standardized difference, Q = 13.61, p = 0.33). For this set of studies, the use of either the most commonly reported metric (percent change) or the standardized effect size produced similar results. This is evidence to support recommending the use of the commonly reported metric when studies included in a meta-analysis report outcomes in the same metric. For clinicians and researchers, use of the common metric will be more clinically meaningful and will enhance interpretation of results for a wider range of readers. Supported by U.S. Department of Defense DAMD17-8513

1190 CURRICULUM CONTENT OF EXERCISE UNDERGRADUATE PROGRAMS IN THE SOUTHEASTERN UNITED STATES

K.Wood Woeber and Amy Wheat. Exercise and Sports Science, The University of South Carolina, Aiken, SC 29801

The undergraduate curricula of 60 exercise science programs within 47 institutions of higher learning, located within the southeastern United States (AL, FL, GA, KY, LA, MS, NC, SC, TN, and VA), were reviewed for content. They were then compared to the minimum educational guidelines recommended by the Southeast Regional Chapter of the American College of Sports Medicine in January of 1998. University bulletins, internet web pages, faxed materials and phone calls were utilized to evaluate each program. A broad definition of each content area was accepted for meeting the guidelines. The most frequently met content areas by the university exercise science programs were Physiology of Exercise (98%), Kinesiology and/or Biomechanics (98%), and Anatomy and Physiology (90%). In contrast, Behavior Change and Exercise Leadership, both at 33%, were the areas least often met by these programs. Others which fell in between were Exercise Testing/Assessment (83%), Exercise Prescription (75%), Practicum Experience (73%), First Aid (68%), Computer Proficiency (66%), Nutrition (65%), Athletic Training (60%), and Statistics (58%). Many programs appear to meet most of the Southeast ACSM curricular content guidelines but no program met all of the criteria. Common content areas in exercise science will help insure greater standardization of competencies for undergraduate majors, as well as assist in the possible pursuit of licensure for individuals in this field. As movement is made in these directions, clearer definition of the content areas will need to be made and a better ability to assess quality of program content will be necessary.

E-27 POSTER CARDIORESPIRATORY & MUSCULOSKELETAL EVALUATION

1191 EXERCISE CAPACITY AND CARDIAC AUTONOMIC FUNCTION IN RECENT KIDNEY & KIDNEY-PANCREAS TRANSPLANT RECIPIENTS

P. Cowan, D.K. Hathaway, R. Kreider, FACSM, J. Soberman, P. Jordan, M.N. Wicks, K. Englehardt, A.K. Cashion, J. Milstead & A.O. Gaber. Colleges of Nursing & Medicine, U. of Tennessee - Memphis, Memphis, TN 38163

This study identified the exercise capacity of kidney (K) and kidney-pancreas (KP) transplant recipients and examined the relationship between exercise capacity (peak relative VO_2) and cardiac autonomic function (CAF). Between 6 to 16 weeks post-transplant, subjects completed a maximal cardiopulmonary exercise tolerance test (ETT) using the Branching protocol and performed evoked CAF tests including valsalva (VR) and sinus arrhythmia (SA). Subjects (n=27) were predominantly male (67%), African American (70%), received hemodialysis prior to transplantation (81%), never had diabetes (n=59%), and were 43.5±10.2 (mean±S.D.) years old (range 19-60 years). Peak relative VO_2 was 16.1 ± 4.2 ml/kg/min and ranged from 29-60% of age predicted maximum with VANT occurring at 13.1±3.4 ml/kg/min (81% of peak VO_2). No significant difference in relative VO_2 existed between transplant groups (p=0.18). Non-diabetics receiving a K (n=16), diabetics who received a KP (n=6), and diabetics who received only a K (n=5) had relative VO_2 (ml/kg/min) of 17.2±3.5, 15.1±2.2, and 13.5±4.8 (mean±S.D.), respectively. Clinically, four of the six KP transplant recipients (67%) exhibited early positive ETT for myocardial ischemia at this time. Three had undergone cardiac catheterization less than 6 months prior to transplantation with one requiring coronary artery bypass surgery (CABG) of 1 vessel, while a second was found to have a 40% occlusion of one vessel and the third subject's previous CABG was deemed patent. Peak VO_2 was positively related to both VR (r=0.44, p≤ 0.05) and SA (r=0.21, p≤0.05). The exercise capacity of K and KP transplant recipients was lower than previously reported in the literature. These results emphasize the accelerated arteriosclerotic process that occurs with diabetes and the importance of maximal ETT for transplant recipients entering exercise program to detect myocardial ischemia and to prescribe exercise below VANT.

Supported in part by ITNS/Fujisawa grant.

1192 RELIABILITY OF A DYNAMOMETER-PLATFORM FOR THE MEASUREMENT OF STRENGTH IN THE GLUTEUS MAXIMUS AND MEDIUS

N. Hauesien, S. Nadler, FACSM, G. Malanga, FACSM, E. Price, T. Stitik, M. DePrince. UMDNJ-Department of Physical Medicine and Rehabilitation and Kessler Sports Institute (Sponsor: S. Nadler, FACSM)

Altered strength, fatigability, endurance, and firing patterns have been demonstrated in the glutei of individuals with various injuries and conditions. The measurement of strength in the gluteus maximus and medius; however, is difficult to accurately assess by physical examination. Presently, a standardized technique to objectively measure muscle strength of these muscles has not been available; therefore, an apparatus to perform such measurements was developed. A Chatillon Model CSD500 Strength Dynamometer was attached to a specially designed adjustable platform. The objective of this study was to assess the reliability of the dynamometer-platform in the measurement of proximal muscle strength. Ten subjects (ages 25-35) had the strength of their gluteus maximus and medius assessed with this device. One week later, the same subjects were retested, with the evaluator blinded to the initial results. In both the test and retest, average and maximum values of strength were calculated for each muscle. Reliability of the device was assessed by computing the test-retest correlations of the muscle strength measures. The correlation coefficients for the calculated strengths of the gluteus medius and maximus muscles were greater than 0.96 for all measures. This apparatus has been found to reliably measure hip girdle strength and may be a clinically useful tool in the evaluation of muscloskeletal injury.

1193 VENTRICULAR FUNCTION DURING TWO MODES OF LOWER EXTREMITY EXERCISE IN CARDIAC REHABILITATION PATIENTS

DS Tarrabochia, M Maggio, DL Petersen, and DG Dolny. Gritman Medical Center, Moscow, ID 83843.

Eight male cardiac rehabilitation (CR) patients (age = 66±7 yr) were evaluated on separate days for ventricular function during 10 min of exercise at 53±7 W on a semi-recumbent cycle (SRC) ergometer and an Omnikinetic (OMK), a bilateral, concentric-extension, eccentric-flexion semi-recumbent stair stepping ergometer. Measures of heart rate (HR), blood pressure (BP), ratings of perceived exertion (RPE), angina, and dyspnea were recorded at rest and during the final minute of exercise. 2-D echocardiography estimates of ventricular dimensions (ESV, EDV, EF), and Doppler measures of transmitral and aortic blood flow (SV, Q, VTI, E,A, E/A, VTIe, VTIa, LVOT, and LVOT-VTI) were measured at rest and during the last 2 min of exercise. There were no significant differences between SRC and OMK for Echo or Doppler parameters except for a greater (P<0.05) LVOT-VTI (21.7±1.7 vs 21.1±3.1) and SV (89±10 vs 83±16 ml) combined with a lower (P<0.05) HR (103±9 vs 110±11 bpm) during OMK exercise. Total peripheral resistance tended to be lower during OMK. RPE, angina, and dyspnea ratings were similar for both modes of exercise. These results suggest that under similar submaximal workloads the OMK provides a potential advantage over SRC in terms of HR and SV response. The lower HR and greater SV during OMK exercise may be a result of differences in lower extremity motion and blood flow between SRC and OMK.

1194 TRIAGING HOSPITALIZED PATIENTS WITH CHEST PAIN VIA EXERCISE TESTING: ROLE OF PARAMEDICAL PERSONNEL

D. McCollom, M.Ross, S. Compton, M. White, B.A. Franklin. William Beaumont Hospital, Royal Oak, MI (Sponsor: B.A.Franklin, FACSM)

Exercise testing is being increasingly used to guide the management of patients (pts) presenting to the Emergency Center (EC) with chest pain (CP) to rule out acute myocardial infarction (MI) and facilitate an accelerated hospital discharge. The purpose of the study was to retrospectively review the outcomes of such testing, with specific reference to pt characteristics, results, and the safety of exercise testing by non-physician personnel. Between 1996-1998, 1093 pts presented to our EC with CP. Of these, 752 (388 ♂, $\bar{x}$±SD age = 46.9±13.8 yrs; 364 ♀, $\bar{x}$±SD age = 52.0±13.1) underwent a progressive exercise test, with or without concomitant myocardial perfusion imaging (MPI), after ruling out for acute MI via serial ECGs and cardiac enzymes. Only 40 of the 752 pts (5%) had a cardiac history. Using a modified/conventional Bruce protocol, the average pt exercised for 9.3±3.0 min, achieving 90.4±11.9% of the age-predicted HRmax. Seventy four pts (9.8%) experienced angina, but only 15 (20%) had the test terminated due to symptoms. ECG analyses revealed that 679 (90.3%) were normal (i.e., ST↓<1mm), 43 (5.7%) were equivocal, and 30 (4%) were abnormal. Of those pts who underwent MPI, only 46 (6.1%) demonstrated a reversible perfusion defect. Duke scores were calculated on 692 pts: 388 (56.1%), 295 (42.6%), and 9 (1.3%) were classified as low, intermediate, and high risk, respectively. Of the 752 pts only 1 non-fatal complication occurred (0.13%). Seventy-four pts (9.8%) underwent further observation. **Conclusion:** Selected pts admitted for CP can be safely exercise tested by trained health care providers. The results are helpful in triaging pts for additional interventions or early discharge.