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14. ABSTRACT (182 words) The overall purpose of this two-year project with a one-year no-cost extension was to use the aggregate data, meta-analytic approach to determine the effects of exercise on bone mineral density (BMD) at the femoral neck (FN) and lumbar spine (LS) in adult men and women 18 years of age and older. In both premenopausal and postmenopausal women, statistically significant and clinically relevant improvements were found for both FN and LS BMD ($p < 0.05$ for all). However, no such differences were observed in men. With respect to dose-response, several associations were found between exercise-induced changes in FN and LS among premenopausal and postmenopausal women but none for load rating. Insufficient data were available to examine load ratings in men. The results of this important work suggest that exercise improves BMD at the FN and LS in both premenopausal and postmenopausal women. However, insufficient evidence currently exists to support such an effect in men. A dire need exists for additional randomized controlled trials in men as well as dose-response studies using more valid and reliable load rating instruments in both men and women.					
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I. INTRODUCTION

Bone health is critical for optimal performance and the prevention of fractures associated with low bone mineral density (BMD). The specific aims of this two year project that was granted a one-year no-cost extension focused on using the aggregate data meta-analytic approach to (1) determine the overall effects of ground reaction force exercise on BMD at the femoral neck (FN) and lumbar spine (LS) in adult humans ≥ 18 years of age, and (2) using recently developed load stimulus data for 48 different physical activities (walking, running, lower-body weight training, etc.),¹ examine the dose-response effects of exercise on BMD at the FN and LS in adult humans ≥ 18 years of age. The two-year funding period was granted a one-year no-cost extension in order to complete presentations and manuscripts.

II. BODY

A. Statement of Work – As can be seen in the table below, all approved work has been accomplished.

Task	Category	Description	Status
1	Data Sources	Search for pertinent literature dealing with the effects of exercise on bone mineral density in adults	Completed (Appendix A)
2	Study Selection	Select studies that meet inclusion criteria dealing with the effects of exercise on bone mineral density in adults	Completed (Appendix B)
3	Data Abstraction	Develop valid and reliable codebooks and code data dealing with the effects of exercise on bone mineral density in adults	Completed (Appendix C)
4	Statistical Analysis	Analyze and interpret data dealing with the effects of exercise on bone mineral density in adults	Completed (Appendix D & E)
5	Products	Present and publish results dealing with the effects of exercise on bone mineral density in adults	Completed (Appendix D & E)

B. Study-Specific Summary of Completed Research

We have learned much from the two years of funding and no-cost extension year that we were allowed for this project. As a result of this important support, we published 3 abstracts from presentations (see Appendix D) as well as three manuscripts in peer-reviewed biomedical journals (see Appendix E).²⁻⁴ For ease of understanding and interpretation, we have divided this section into a concise description regarding (1) the effects of exercise on FN and LS BMD in postmenopausal women,² (2) the effects of exercise on FN and LS BMD in premenopausal women,³ and (3) the effects of exercise on FN and LS BMD in men.⁴

1. Exercise and BMD at the FN and LS in postmenopausal women. Osteoporosis is a major public health problem affecting an estimated 200 million women worldwide.⁵ Congruent with osteoporosis is an increased risk for osteoporosis-related fractures, especially in women during the postmenopausal years, generally considered to begin around 50 years of age.⁶ Comparatively, the lifetime risk of an osteoporosis-related fracture in women is equivalent to the risk of developing cardiovascular disease.⁷ The two most common sites for osteoporosis-related fractures are the hip and the spine, with an estimated worldwide

prevalence of 1.1 million and 862,000, respectively, in women 50 years of age and older in the year 2000.⁶ In the United States, the total annual costs associated with osteoporosis-related fractures were more than \$19 billion in 2005 with a predicted increase to \$25.3 billion in 2025.⁸ The majority of the costs in 2005 were attributed to fractures of the hip (72%) followed by the spine (6%).⁸

Ground (for example, jogging) and joint reaction (for example, strength training) force exercise has been recommended across the lifespan.⁹⁻¹² However, the results of previous randomized controlled exercise intervention trials have reached conflicting and underwhelming conclusions regarding the effects of ground reaction and/or joint reaction force exercise on BMD at the femoral neck (FN) and lumbar spine (LS) in postmenopausal women.¹³⁻³⁷ The purpose of this study was to use the aggregate data meta-analytic approach to determine the effects of ground and/or joint reaction force exercise on BMD at the FN and LS in postmenopausal women.

A search of six electronic databases, cross-referencing from retrieved studies, hand searching selected journals, and expert review, resulted in the inclusion of 25 of 1,182 studies representing 63 groups (35 exercise, 28 control) and up to 1775 participants that met the following criteria: (1) randomized controlled trials, (2) exercise intervention ≥ 24 weeks, (3) comparative control group, (4) postmenopausal women, (5) participants not currently participating in any type of regular joint and/or ground reaction force exercise, (6) published and unpublished (master's theses and dissertations) studies in any language since January 1, 1989 and (7) BMD (relative value of bone mineral per measured bone area or volume) assessed at the FN and/or LS using dual-energy x-ray absorptiometry (DEXA) or dual-photon absorptiometry (DPA).¹³⁻³⁷

Using a random-effects model and standardized effect sizes (g) classified as either trivial (<0.20), small (≥ 0.20 to <0.50), medium (≥ 0.50 to <0.80), or large (≥ 0.80),³⁸ an overall statistically significant benefit ($p = 0.002$) of ground and/or joint reaction force exercise on FN BMD was observed (Figure 1). In addition, non-overlapping confidence intervals (CIs) were observed. The number-needed-to-treat (NNT) was 6 with an estimated 127,968 postmenopausal US women experiencing benefit in FN BMD if they began and maintained a regular exercise program. A statistically significant association between increases in FN BMD and decreased compliance (combined aerobic and strength training groups only), decreases in BMI, decreases in body weight and decreases in percent body fat were observed ($p < 0.05$ for all). A trend ($p < 0.05$ but ≤ 0.10), for a statistically significant association was observed for increases in FN BMD and increases in intensity (strength only), increased compliance (strength training group only) and increases in static balance. No association was found between changes in FN BMD and load rating.

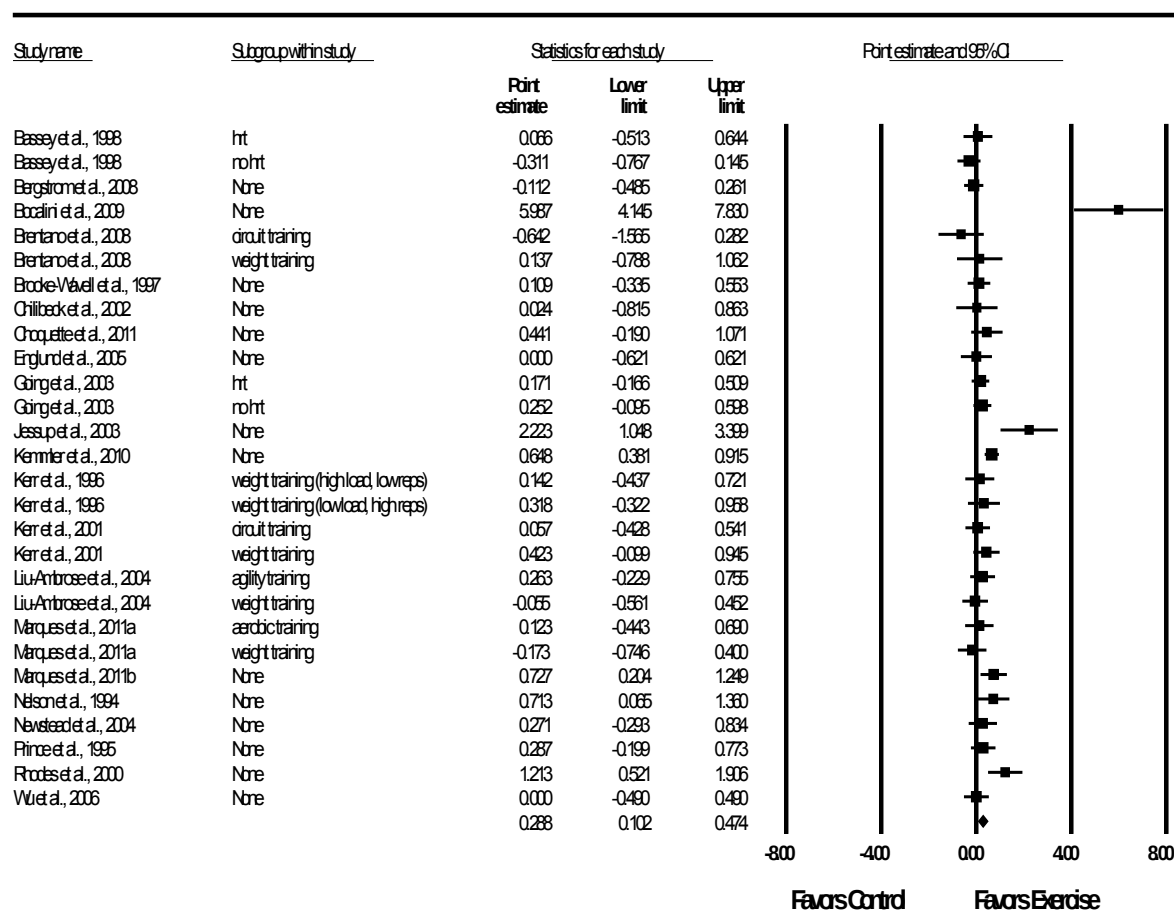


Figure 1. Forest plot for changes in FN BMD among postmenopausal women. The black squares represent the standardized mean difference (g) while the left and right extremes of the squares represent the corresponding 95% confidence intervals. The middle of the black diamond represents the overall standardized mean difference (g) while the left and right extremes of the diamond represent the corresponding 95% confidence intervals. For subgroup, HRT means hormone replacement therapy.

A statistically significant benefit and slightly overlapping 95% CIs were observed for LS BMD (Figure 2). The NNT was 6 with an estimated 80,219 postmenopausal US women maintaining and/or increasing their LS BMD if they began and maintained a regular exercise program. Meta-regression analysis revealed a statistically significant association between increases in LS BMD and older age, greater number of years postmenopausal, fewer minutes of training per session (aerobic groups only), fewer minutes of training per week, greater intensity of training (strength only), increased compliance (strength only), decreased compliance (combined aerobic and strength training only), increases in static balance, decreases in BMI, body weight and percent body fat. A trend for a statistically significant association was found between increases in LS BMD and smaller increases in aerobic fitness as well as increases in lean body mass. No association was found between changes in LS BMD and load rating.

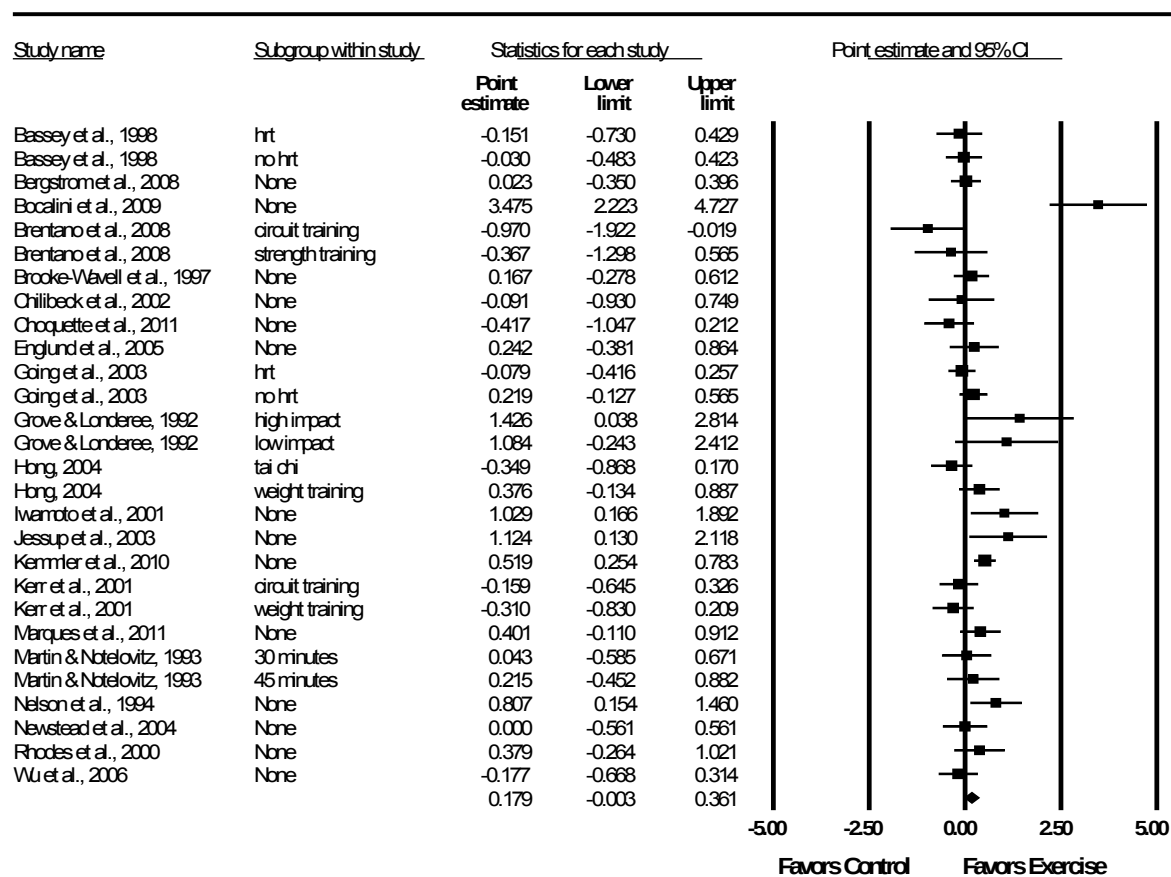


Figure 2. Forest plot for changes in LS BMD among postmenopausal women. The black squares represent the standardized mean difference (g) while the left and right extremes of the squares represent the corresponding 95% confidence intervals. The middle of the black diamond represents the overall standardized mean difference (g) while the left and right extremes of the diamond represent the corresponding 95% confidence intervals. For subgroup, HRT means hormone replacement therapy.

The overall results suggest that ground and joint reaction force exercise may result in clinically important benefits in FN and LS BMD in postmenopausal women, with results more convincing for FN BMD. Based on previous prediction models,³⁹ the exercise-induced changes in BMD observed at the FN and LS in the current meta-analysis would reduce the 20-year relative risk of osteoporotic fracture at any site by approximately 11% and 10%, respectively.

Several interesting associations were found when simple meta-regression was performed for changes in FN and LS BMD. For both FN and LS BMD, greater increases were associated with both greater intensity and compliance in the strength training (joint-reaction force) groups. These findings suggest that greater loads per repetition as well as greater adherence may provide greater benefit to FN and LS BMD. Greater improvements in both FN and LS BMD were also associated with increases in static balance. These associations may be especially important for reducing the risk of falling as well as subsequent fracture risk. Greater increases in both FN and LS BMD were also associated with decreases in BMI, body weight and percent body fat. In addition, increases in LS BMD were associated with increases in LBM. All of these associations may be reflective of greater exercise effort. The

inverse association between increases in both FN and LS BMD with poorer compliance to aerobic and strength training protocols may be nothing more than the play of chance. Alternatively, studies with poorer compliance may have yielded greater benefits in FN and LS BMD because of the greater overall volume of training prescribed. For LS BMD, the positive association between increases in LS BMD and older age as well as a greater number of years postmenopausal may be the result of lower initial levels of BMD. However, we found no association between baseline LS BMD and changes in LS BMD. The negative associations between increases in LS BMD with shorter duration and total minutes of training per week for aerobic exercise studies may help to reinforce the belief that shorter duration activities such as jumping may be more beneficial to LS BMD than activities such as walking.¹¹ One potential reason for this negative association may be the result of calcium loss from excessive sweating in longer duration and/or higher intensity activities.^{40;41} This causes a decrease in serum calcium followed by an increase in serum parathyroid hormone, which then stimulates bone resorption.^{40;41} While these findings are interesting, further research is needed before any firm conclusions can be drawn.

A major interest of the investigative team was to examine the dose–response relationship between changes in FN and LS BMD and exercise load ratings in postmenopausal women. While we found no significant association between changes in FN and LS BMD and load ratings, these associations were based on general categorical estimates versus estimates specific to each activity.¹ The decision to use categorical estimates was based on the inability to accurately calculate load ratings for those studies that involved multiple types of activities. In addition, the algorithm used requires further testing, improvement and validation.¹ Future research should also focus on developing formulas for accurately calculating load ratings from data typically provided in randomized controlled intervention trials. Ideally, individual studies should collect and report force data in all exercise interventions. However, the accurate measurement of such may be challenging for some activities.¹¹ Until additional dose–response research is conducted, it would appear plausible to suggest that postmenopausal women adhere to the exercise guidelines from the American College of Sports Medicine.¹² These include weight-bearing endurance activities 3 to 5 times per week as well as resistance exercise 2 to 3 times per week.¹² However, it will be particularly important for future dose–response studies to determine whether increased duration of aerobic exercise diminishes the potential skeletal benefits, as suggested by the current regression analyses.

In conclusion, the overall findings of this aggregate data meta-analysis suggest that exercise may result in clinically relevant benefits to FN and LS BMD in postmenopausal women. However, future research regarding the dose-response relationship between exercise and FN and LS BMD are needed.

Details regarding the aforementioned study in postmenopausal women can be found in the manuscript located in Appendix E, pages 287-305.

2. Exercise and BMD at the FN and LS in premenopausal women. Maintaining optimal bone mineral density (BMD) levels during the premenopausal years is important for reducing the risk of osteoporosis and subsequent fractures during the postmenopausal years, with

relative-risk increases ranging from 1.5 to 3.0.⁴² In addition, the prevalence of osteopenia and osteoporosis has been reported to be 15% and 0.6%, respectively, in premenopausal women.⁴³ Furthermore, it has been estimated that the loss of BMD ranges from 0.25% to 1% per year in premenopausal women.⁴² While pharmacologic therapy is usually contraindicated in premenopausal women, reliance on lifestyle factors is almost always recommended.^{42;44} One potentially effective lifestyle approach for achieving this goal is exercise, a low-cost, non-pharmacologic intervention that is available to the vast majority of the population. The purpose of this study was to use the aggregate data meta-analytic approach to determine the overall effects, as well as potential moderators and predictors of, ground and joint reaction force exercise on FN and LS BMD in premenopausal women.

A search of six electronic databases, cross-referencing from retrieved studies, hand searching selected journals, and expert review, resulted in 7 of 1,055 studies representing 17 groups (10 exercise, 7 control) and 521 participants (269 exercise, 252 control) that met the following inclusion criteria: (1) randomized trials with a comparative control group, (2) premenopausal women, (3) participants not engaged in a regular exercise program prior to study enrollment, (4) ground and/or joint reaction force exercise intervention of at least 24 weeks, (5) published and unpublished (master's theses and dissertations) studies since January 1989, and (6) data available for changes in BMD at the FN and/or LS and assessed using dual-energy X-ray absorptiometry (DEXA) or dual-photon absorptiometry (DPA). Any studies not meeting all six criteria were excluded.⁴⁵⁻⁵¹

Using a random-effects model and standardized effect sizes (*g*) classified as either trivial (<0.20), small (≥ 0.20 to <0.50), medium (≥ 0.50 to <0.80), or large (≥ 0.80),³⁸ statistically significant ($p = 0.03$) benefits with non-overlapping CI's were observed for FN BMD (Figure 3). Changes were equivalent to a 1.1% benefit (0.4% increase in the exercise groups, -0.7% decrease in the control groups). The NNT was 5.

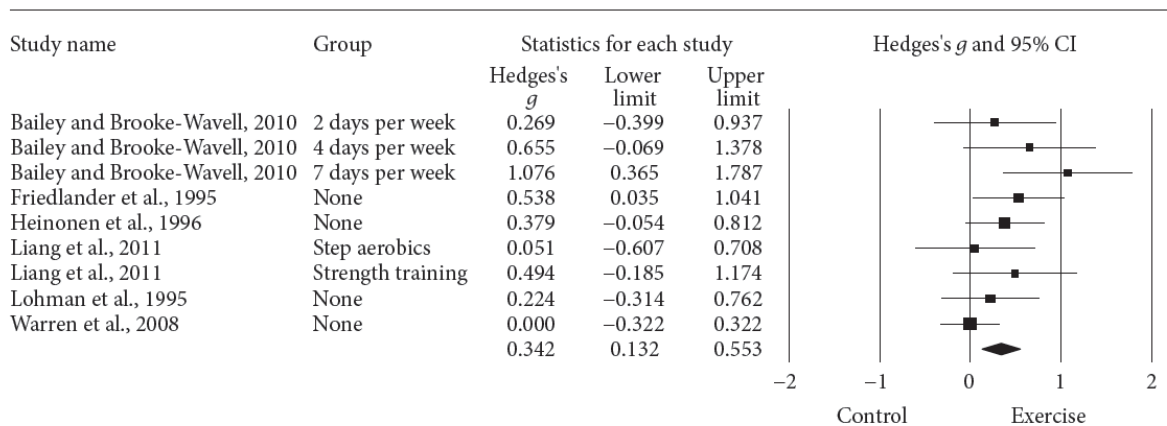


Figure 3. Forest plot for changes in FN BMD among premenopausal women. The black squares represent the standardized mean difference (*g*) while the left and right extremes of the squares represent the corresponding 95% confidence intervals. The middle of the black diamond represents the overall standardized mean difference (*g*) while the left and right extremes of the diamond represent the corresponding 95% confidence intervals.

There was a trend ($p > 0.05$ to ≤ 0.10) for greater benefits in FN BMD for those participating in home versus facility-based exercise. A statistically significant ($p \leq 0.05$) and positive relationship was observed between benefits in FN BMD and the number of sets

performed when resistance training while an inverse relationship was observed for exercise frequency. A trend for statistical significance was observed for greater benefits in FN BMD and (1) shorter exercise interventions, (2) lower initial FN BMD, (3) increases in body weight, and (4) decreases in upper body strength. Load rating was not associated with changes in FN BMD.

With one outlier deleted from the model, statistically significant benefits along with non-overlapping confidence intervals were observed between exercise and changes in LS BMD (Figure 4). The NNT was 9. A trend for a statistically significant association was observed for greater benefits in LS BMD and earlier published studies. No statistically significant association was found between load rating and changes in LS BMD.

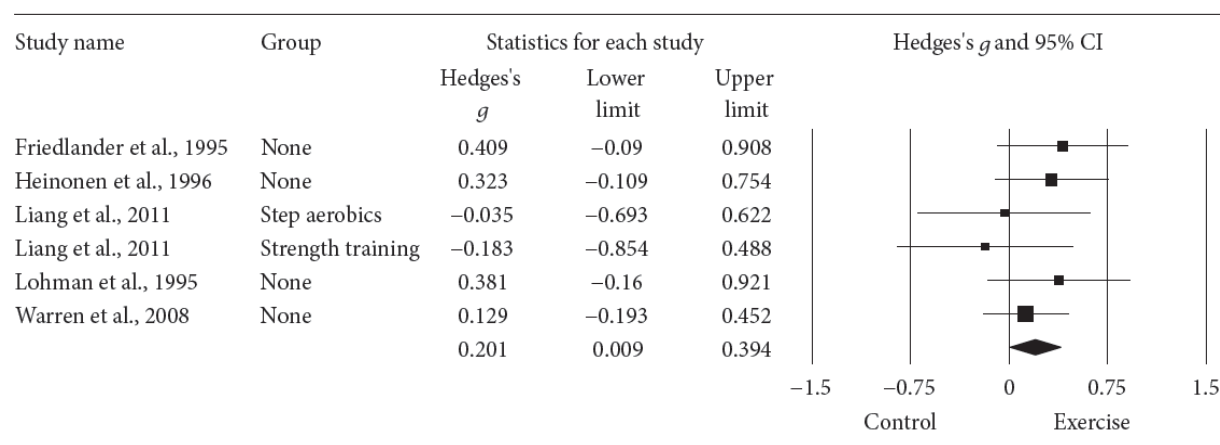


Figure 4. Forest plot for changes in LS BMD among premenopausal women. The black squares represent the standardized mean difference (g) while the left and right extremes of the squares represent the corresponding 95% confidence intervals. The middle of the black diamond represents the overall standardized mean difference (g) while the left and right extremes of the diamond represent the corresponding 95% confidence intervals.

The overall findings suggest that exercise results in small but statistically significant benefits in both FN and LS BMD. In addition, moderator analyses resulted in a trend for greater benefits on FN BMD when exercise took place in the home versus a facility. Since the investigative team is not aware of any consensus in the literature regarding which location is superior, future research in this area appears warranted.

Simple meta-regression analyses resulted in several noteworthy associations that may be appropriate for future investigation. Specifically, there was a trend for greater increases in FN BMD with shorter exercise interventions as well as a statistically significant association between increases in FN BMD and fewer days per week of exercise. One possible explanation for the negative associations observed may have to do with the loss of calcium from excessive exercise.^{40;41} This causes a decrease in serum calcium, followed by an increase in serum parathyroid hormone, which then stimulates bone resorption.^{40;41} However, no association was observed between changes in FN BMD and duration of training as well as exercise load rating. Thus, while these findings are interesting, further dose-response research is needed before any firm conclusions can be drawn. For resistance training, greater increases in FN BMD were associated with a greater number of sets. Since sweating as a result of resistance training is usually not as great as that from aerobic exercise, it may be that

a greater but undetermined amount of resistance training is needed to increase FN BMD in premenopausal women. However, no association was found between the number of exercises performed and changes in FN BMD. Given the former, it would appear appropriate to suggest that future dose-response studies are needed to address this issue. Until that time, it would appear plausible to suggest adherence to current exercise guidelines for optimizing BMD in adults.¹²

The trend for greater benefits in FN BMD and lower baseline BMD at the FN suggests that those with lower FN BMD may derive the greatest benefits as a result of exercise. This finning would seem to be entirely reasonable. The trend for increases in FN BMD to be associated with increases in body weight supports well-established research regarding greater BMD in heavier adult humans. Other than chance, the investigative team has no plausible explanation for the observed association between increases in FN BMD and smaller increases in upper body strength. Finally, there was a trend for greater benefits in LS BMD for those studies published during the earlier years. This observed association may be reflective of improved study designs in more recent years.

In conclusion, the overall findings of the current meta-analysis provide additional support regarding the benefits of exercise, including NNT estimates to aid decision makers regarding the utility of exercise for improving FN and LS BMD in premenopausal women. In addition, this study provides first-time meta-analytic evidence, when limited to randomized controlled trials, of potential moderators and predictors with respect to changes in FN and LS BMD which appears worthy of pursuing in future well-designed randomized controlled trials. The inability of the current meta-analysis to provide a definitive exercise prescription warrants further research.

Details regarding the aforementioned study in premenopausal women can be found in the manuscript located in Appendix E, pages 306-321.

3. Exercise and BMD at the FN and LS in men. While the prevalence of osteopenia and osteoporosis is more common in women than men,⁵² the burden of this problem among men is still substantial. For example, recent data from the US National Center for Health Statistics reported that the age-adjusted prevalence of osteopenia among US men 50 years of age and older was 38% while the age-adjusted prevalence for osteoporosis was 4%.⁵² Using 2010 population estimates from the US Census Bureau,⁵³ this means that approximately 16.8 million US men 50 years of age and older currently have osteopenia while more than 1.7 million have osteoporosis. One potential, low-cost, readily available non-pharmacologic approach for maintaining optimal BMD levels in men is exercise. The purpose of this study was to use the aggregate data meta-analytic approach to examine the effects of exercise on FN and LS BMD in men.

A search of six electronic databases, cross-referencing from retrieved studies, hand searching selected journals, and expert review resulted in 3 of 1,055 studies representing 9 groups (five exercise and four control) and 275 participants (152 exercise, 123 control) that met the following inclusion criteria: (1) randomized trials with a comparative control group, (2) men 18 years of age and older, (3) participants not taking part in regular exercise prior to study

enrollment, (4) ground and/or joint reaction force exercise intervention of at least 24 weeks, (5) published and unpublished (master's theses and dissertations) studies since January 1989, and (6) data available for changes in FN and/or LS BMD as assessed by dual-energy X-ray absorptiometry (DEXA) or dual-photon absorptiometry (DPA).

Using a random-effects model and standardized effect sizes (g) classified as either trivial (<0.20), small (≥ 0.20 to <0.50), medium (≥ 0.50 to <0.80), or large (≥ 0.80),³⁸ a statistically significant improvement was found at the FN (3 g 's, 187 participants, $g=0.583$, $p=0.04$) (Figure 5). However, results were sensitive to influence analysis as well as collapsing multiple groups from the same studies so that only one g represented each study. Given the small sample size, we were unable to conduct any type of moderator or regression analyses.

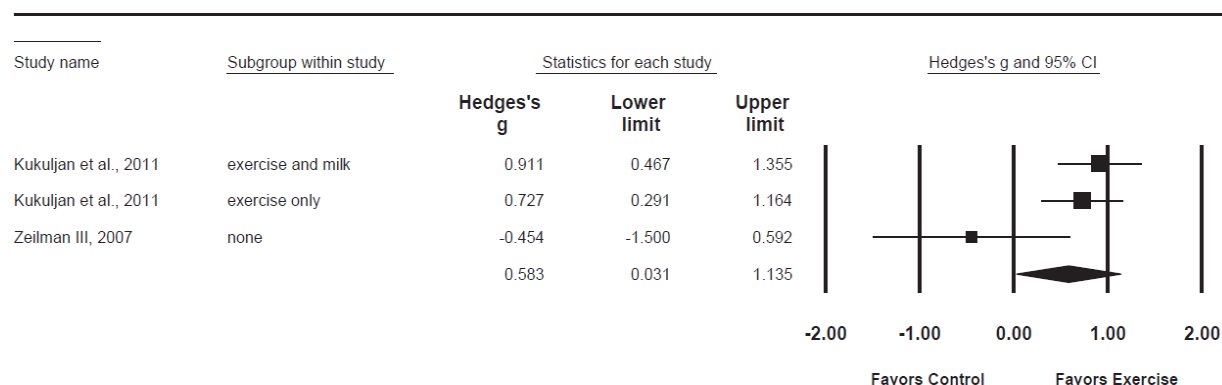


Figure 5. Forest plot for changes in FN BMD in men. The black squares represent the standardized mean difference (g) while the left and right extremes of the squares represent the corresponding 95% confidence intervals. The middle of the black diamond represents the overall standardized mean difference (g) while the left and right extremes of the diamond represent the corresponding 95% confidence intervals.

While not statistically significant, a trend for statistical significance was observed for exercise-induced benefits in LS BMD (5 g 's, 275 participants, $g=0.190$, $p=0.10$) (Figure 6). However, results were sensitive to influence analysis as well as collapsing multiple groups from the same studies so that only one g represented each study. Similar to FN BMD, results were sensitive to influence analysis as well as collapsing multiple groups from the same studies so that only one g represented each study. We were unable to conduct any type of moderator or regression analyses because of the small sample size.

While a statistically significant benefit of exercise was observed in FN BMD and a trend in LS BMD, the findings for both were sensitive to influence analysis and/or collapsing multiple groups from the same study so that only one g represented each study. Thus, given the small number of g 's included and the instability of results, it is believed that there is currently insufficient evidence to recommend exercise as a singular intervention for improving and/or maintaining FN and LS BMD in men. However, similar to recent clinical practice guidelines by the Endocrine Society on osteoporosis in men,⁵⁴ it is suggested that men, especially those at risk for osteoporosis, participate in regular exercise. While the Endocrine Society guidelines suggest that men participate in weight bearing, i.e., ground reaction force exercise, three to four times per week for 30 to 40 min per session, the American College of Sports Medicine Position Statement suggests that adults participate in

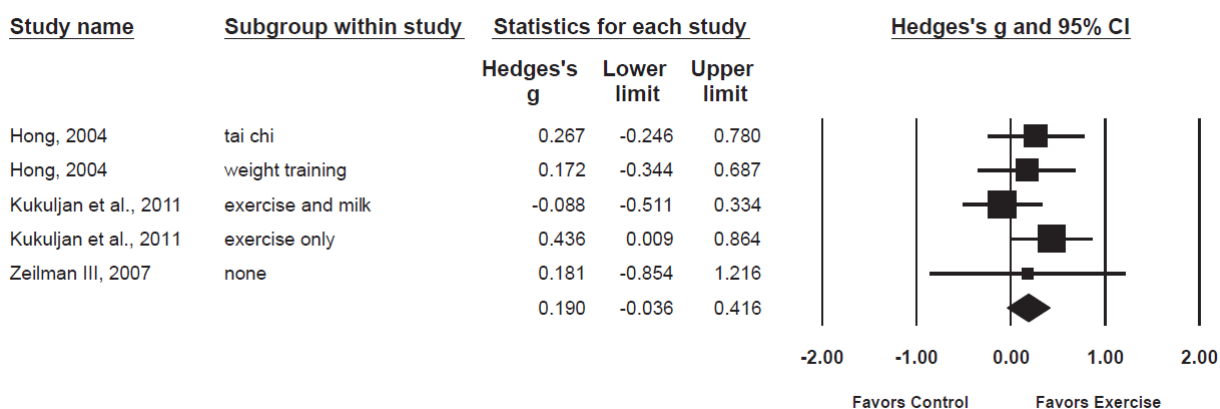


Figure 6. Forest plot for changes in LS BMD in men. The black squares represent the standardized mean difference (g) while the left and right extremes of the squares represent the corresponding 95% confidence intervals. The middle of the black diamond represents the overall standardized mean difference (g) while the left and right extremes of the diamond represent the corresponding 95% confidence intervals

ground reaction force exercise, i.e., weight bearing endurance exercise, 3 to 5 times per week for 30 to 60 min per session as well as joint reaction force exercise, i.e., weight training, 2 to 3 times per week.¹² Despite the current lack of convincing evidence to support the use of exercise for improving and/or maintaining FN and LS BMD in men, it would seem plausible that adherence to the latter would be more appropriate, especially given the other benefits and minimal risk derived from participation in both.^{12;55} Finally, it is clear that additional randomized controlled trials addressing the effects of exercise on FN and LS BMD in men are needed. This recommendation is consistent with the 2008 US Department of Health and Human Services Physical Activity Guidelines for Americans.¹¹

In conclusion, there is currently insufficient evidence at this time to recommend ground and/or joint reaction force exercise for improving and/or maintaining FN and LS BMD in men. Additional well-designed randomized controlled trials in men are needed before any final recommendations can be formulated.

Details regarding the aforementioned study in men can be found in the manuscript located in Appendix E, pages 322-330.

III. KEY RESEARCH ACCOMPLISHMENTS FOR PROJECT PERIOD

- A. Developed an electronic search strategy for potentially eligible studies (Appendix A).
- B. Developed a reference database of intervention studies dealing with the effects of exercise on FN and LS BMD in adults (Appendix B).
- C. Developed code book and coded data for all eligible intervention studies dealing with the effects of exercise on FN and LS BMD in adults (Appendix C).
- D. Published and presented three abstracts dealing with the effects of exercise intervention studies on FN and LS BMD in adults (Appendix D).
- E. Published three meta-analytic papers dealing with the effects of exercise intervention studies on FN and LS BMD in adults (Appendix E).

IV. REPORTABLE OUTCOMES FOR PROJECT PERIOD

A. Published Abstracts of Presentations (Appendix D)

1. **Kelley G**, Kelley K, Kohrt W. (2012). Effects of ground and joint reaction force exercise on lumbar spine and femoral neck bone mineral density in postmenopausal women: a meta-analysis of randomized controlled trials. Arthritis and Rheumatism. 64(10):S1014-S1015. (Pages 281-282 of Appendix)
2. **Kelley GA**, Kelley KS, Kohrt WM. (2013) Exercise and bone mineral density in premenopausal women: A meta-analysis of randomized controlled trials. Medicine and Science in Sports and Exercise. 1206. (Pages 283-284 of Appendix)
3. **Kelley GA**, Kelley KS, Kohrt WM. (2013) Exercise and bone mineral density in men: A meta-analysis of randomized controlled trials. Medicine and Science in Sports and Exercise. 1599. (Page 285 of Appendix)

B. Articles Published (Appendix E)

1. **Kelley G**, Kelley K, Kohrt W. (2012). Effects of ground and joint reaction force exercise on lumbar spine and femoral neck bone mineral density in postmenopausal women: a meta-analysis of randomized controlled trials. BMC Musculoskeletal Disorders. 13(1): Article ID 177, 1-19. (Pages 287-305 of Appendix)
2. **Kelley GA**, Kelley KS, Kohrt WM. Exercise and bone mineral density in premenopausal women: A meta-analysis of randomized controlled trials. International Journal of Endocrinology 2013, Article ID 741639, 1-16. 201. (Pages 306-321 of Appendix)
3. **Kelley GA**, Kelley KS, Kohrt WM. Exercise and bone mineral density in men: A meta-analysis of randomized controlled trials. Bone. 53:103-111. (Pages 322-330 of Appendix)

C. Personnel (Paid)

1. Dr. George A. Kelley, FACSM – Principal Investigator
2. Kristi Sharpe-Kelley, M.Ed. – Research Technician
3. Dr. Wendy Kohrt – Consultant

V. CONCLUSIONS FOR PROJECT PERIOD

A. Implications of Completed Research

The overall results of our research led us to the following major conclusions:

1. Exercise increases and maintains FN and LS BMD in postmenopausal women.
2. Exercise increases and maintains FN and LS BMD in premenopausal women.
3. While promising, there is currently insufficient evidence to recommend exercise as being beneficial for FN and LS BMD in men.

4. Weight-bearing endurance activities 3 to 5 times per week as well as resistance exercise 2 to 3 times per week should benefit FN and LS BMD.¹²

B. Suggestions for Future Research

Based on our findings, we recommend the following areas in which additional research is needed:

1. Additional randomized controlled trials addressing the dose-response effects of exercise on FN and LS BMD in adult men and women of all ages.
2. Additional randomized controlled trials addressing the overall effects of exercise on FN and LS BMD in men.
3. The development of more valid and reliable load rating instruments that can easily be applied in randomized controlled exercise intervention trials.

B. So What?

Osteoporosis and osteopenia are major public health problems among both men and women. The results of our research suggest that exercise can benefit FN and LS BMD in pre and postmenopausal women. These benefits may reduce the risk for subsequent fracture.

VI. REFERENCES

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VII. APPENDICES

- A. Search Strategies for Electronic Database Searches
- B. Reference Lists of Included and Excluded BMD Studies
- C. Base Meta-Analytic Codebook
- D. Published Abstracts of Presentations at Professional Conferences
- E. Publications in Peer-Reviewed Biomedical Journals

APPENDIX A

Database Search Strategies

1. Medline

Query Limiters/Expanders Last Run Via Results

S7 (s3 and s6) Limiters - Date of Publication from: 19890101-20100631;

Human; Age Related: All Adult: 19+ years

Search modes - Find all my search terms Interface - EBSCOhost

Search Screen - Advanced Search

Database - MEDLINE 402

S6 (s4 or s5) Limiters - Date of Publication from: 19890101-20100631;

Human; Age Related: All Adult: 19+ years

Search modes - Find all my search terms Interface - EBSCOhost

Search Screen - Advanced Search

Database - MEDLINE 387298

S5 TX clinical w1 trial* Limiters - Date of Publication from:

19890101-20100631; Human; Age Related: All Adult: 19+ years

Search modes - Find all my search terms Interface - EBSCOhost

Search Screen - Advanced Search

Database - MEDLINE 324417

S4 TX random* w1 control* Limiters - Date of Publication from:

19890101-20100631; Human; Age Related: All Adult: 19+ years

Search modes - Find all my search terms Interface - EBSCOhost

Search Screen - Advanced Search

Database - MEDLINE 211688

S3 (s1 and s2) Limiters - Date of Publication from: 19890101-20100631;

Human; Age Related: All Adult: 19+ years

Search modes - Find all my search terms Interface - EBSCOhost

Search Screen - Advanced Search

Database - MEDLINE 1672

S2 (MH "bone density") or TX bone w1 densit* Limiters - Date of

Publication from: 19890101-20100631; Human; Age Related: All Adult: 19+ years

Search modes - Find all my search terms Interface - EBSCOhost

Search Screen - Advanced Search

Database - MEDLINE 21414

S1 MH exercise or TX exercise Limiters - Date of Publication from:

19890101-20100631; Human; Age Related: All Adult: 19+ years

Search modes - Find all my search terms Interface - EBSCOhost

Search Screen - Advanced Search

Database - MEDLINE 82574

2. Cochrane Database of Controlled Clinical Trials

(exercise):ti,ab,kw and (bone NEAR/1 densit*):ti,ab,kw and (random* NEAR/1 control*):ti,ab,kw and (human):ti,ab,kw, from 1989 to 2010 in Clinical Trials

3. Dissertation Abstracts Online

(kw: exercise and kw: bone and kw: densit*) and kw: random*
years 1989-2010

4. Embase

Set	Items	Description
S1	224518	EXERCISE OR EXERCISE/DE
S2	41847	BONE(W)DENSIT? OR BONE(W)DENSITY/DE
S3	2630	S1 AND S2
S4	294309	RANDOM?(W)CONTROL?
S5	868757	CLINICAL(W)TRIAL?
S6	894597	S4 OR S5
S7	585	S3 AND S6
S8	578	S7/HUMAN
S9	577	S8 AND PY=1989:2010
S10	296	S9 AND DT=ARTICLE
S11	296	S10 NOT DT=EDITORIAL
S13	54	FS=MEDLINE AND S11

5. CINAHL

Query Limiters/Expanders Last Run Via Results

S7 (s3 and s6) Search modes - Find all my search terms Interface - EBSCOhost

Search Screen - Advanced Search

Database - CINAHL with Full Text 224

S6 (s4 or s5) Search modes - Find all my search terms Interface - EBSCOhost

Search Screen - Advanced Search

Database - CINAHL with Full Text 41070

S5 (MH "Clinical Trials+") Limiters - Published Date from:

19890101-20100631; Human; Age Groups: All Adult

Search modes - Find all my search terms Interface - EBSCOhost

Search Screen - Advanced Search

Database - CINAHL with Full Text 35755

S4 TX random* w1 control* Limiters - Published Date from:

19890101-20100631; Human; Age Groups: All Adult

Search modes - Find all my search terms Interface - EBSCOhost

Search Screen - Advanced Search
 Database - CINAHL with Full Text 13913
 S3 (s1 and s2) Limiters - Published Date from: 19890101-20100631; Human;
 Age Groups: All Adult
 Search modes - Find all my search terms Interface - EBSCOhost
 Search Screen - Advanced Search
 Database - CINAHL with Full Text 672
 S2 (NH "bone density") or TX bone w1 densit* Limiters - Published Date
 from: 19890101-20100631; Human; Age Groups: All Adult
 Search modes - Find all my search terms Interface - EBSCOhost
 Search Screen - Advanced Search
 Database - CINAHL with Full Text 2392
 S1 MH exercise or TX exercise Limiters - Published Date from:
 19890101-20100631; Human; Age Groups: All Adult
 Search modes - Find all my search terms Interface - EBSCOhost
 Search Screen - Advanced Search
 Database - CINAHL with Full Text 29586

6. SportDiscus

Query Limiters/Expanders Last Run Via Results

S11 (s7 and s10) Limiters - Published Date: 19890101-20100631
 Search modes - Find all my search terms Interface - EBSCOhost
 Search Screen - Advanced Search
 Database - SPORTDiscus with Full Text 300
 S10 (s8 or s9) Limiters - Published Date: 19890101-20100631
 Search modes - Find all my search terms Interface - EBSCOhost
 Search Screen - Advanced Search
 Database - SPORTDiscus with Full Text 135179
 S9 (teenager* or adolescen* or teen* or adult or senior or aged or
 geriatric or geriatrics or elder or elderly) Limiters - Published Date:
 19890101-20100631
 Search modes - Find all my search terms Interface - EBSCOhost
 Search Screen - Advanced Search
 Database - SPORTDiscus with Full Text 84621
 S8 human Limiters - Published Date: 19890101-20100631
 Search modes - Find all my search terms Interface - EBSCOhost
 Search Screen - Advanced Search
 Database - SPORTDiscus with Full Text 59183
 S7 (s3 and s6) Limiters - Published Date: 19890101-20100631
 Search modes - Find all my search terms Interface - EBSCOhost
 Search Screen - Advanced Search
 Database - SPORTDiscus with Full Text 639
 S6 (s4 or s5) Limiters - Published Date: 19890101-20100631
 Search modes - Find all my search terms Interface - EBSCOhost
 Search Screen - Advanced Search

Database - SPORTDiscus with Full Text 23853

S5 TX clinical w1 trial* Limiters - Published Date: 19890101-20100631

Search modes - Find all my search terms Interface - EBSCOhost

Search Screen - Advanced Search

Database - SPORTDiscus with Full Text 16823

S4 TX random* w1 control* Limiters - Published Date: 19890101-20100631

Search modes - Find all my search terms Interface - EBSCOhost

Search Screen - Advanced Search

Database - SPORTDiscus with Full Text 13437

S3 (s1 and s2) Limiters - Published Date: 19890101-20100631

Search modes - Find all my search terms Interface - EBSCOhost

Search Screen - Advanced Search

Database - SPORTDiscus with Full Text Display

S2 (MH "bone density") or TX bone w1 densit* Limiters - Published Date:
19890101-20100631

Search modes - Find all my search terms Interface - EBSCOhost

Search Screen - Advanced Search

Database - SPORTDiscus with Full Text Display

S1 TX exercise or MH exercise Limiters - Published Date: 19890101-20100631

Search modes - Find all my search terms Interface - EBSCOhost

Search Screen - Advanced Search

Database - SPORTDiscus with Full Text Display

APPENDIX B

Included and Excluded BMD Studies

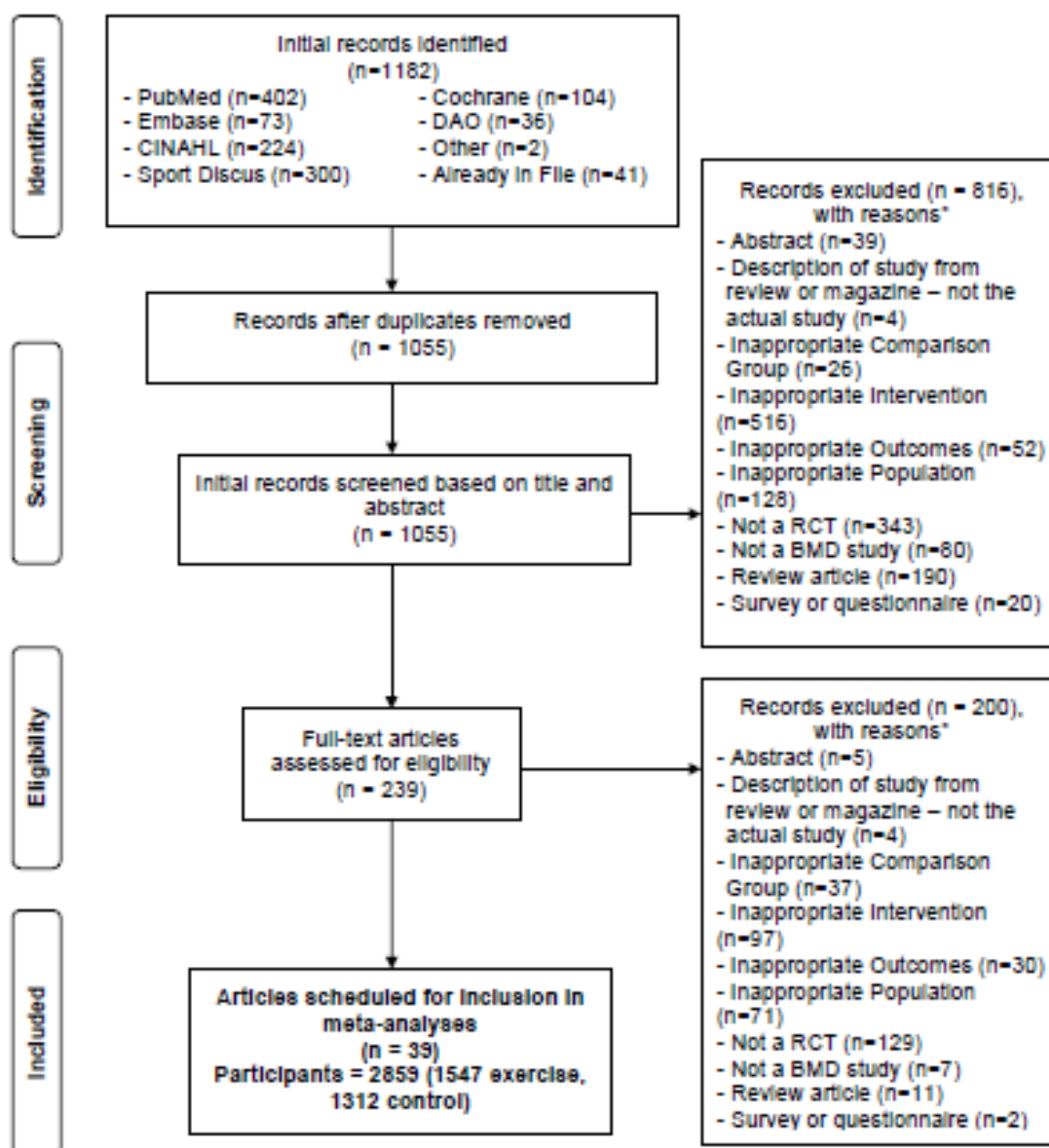


Figure 1. Flow diagram for selection of articles. *, number of reasons exceeds the number of articles because some articles were excluded for more than one reason.

1. Included Studies (n = 39)

- (1) Bailey CA, Brooke-Wavell K. Optimum frequency of exercise for bone health: Randomised controlled trial of a high-impact unilateral intervention. *Bone* 2010;46(4):1043-9.
- (2) Bassey EJ, Rothwell MC, Littlewood JJ, Pye DW. Pre- and postmenopausal women have different BMD responses to the same high-impact exercise. *Journal Of Bone And Mineral Research: The Official Journal Of The American Society For Bone And Mineral Research* 1998 December;13(12):1805-13.
- (3) Bergstrom I, Landgren B, Brinck J, Freyschuss B. Physical training preserves BMD in postmenopausal women with forearm fractures and low BMD. *Osteoporosis International: A Journal Established As Result Of Cooperation Between The European Foundation For Osteoporosis And The National Osteoporosis Foundation Of The USA* 2008 February;19(2):177-83.
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- (5) Bocalini DS, Serra AJ, dos Santos L, Murad N, Levy RF. Strength training preserves the bone mineral density of postmenopausal women without hormone replacement therapy. *Journal of Aging & Health* 2009 April;21(3):519-27.
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- (7) Brooke-Wavell KSF, Jones PRM, Hardman AE. Brisk walking reduces calcaneal bone loss in post-menopausal women. *Clinical Science* 1997;92:75-80.
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- (10) Englund U, Littbrand H+, Sondell A, Pettersson U, Bucht G. A 1-year combined weight-bearing training program is beneficial for BMD and neuromuscular function in older women. *Osteoporosis International: A Journal Established As Result Of Cooperation Between The European Foundation For Osteoporosis And The National Osteoporosis Foundation Of The USA* 2005 September;16(9):1117-23.

- (11) Friedlander AL, Genant HK, Sadowsky S, Byl NN, Gluer CC. A two-year program of aerobics and weight training enhances BMD of young women. *J Bone Miner Res* 1995 April;10(4):574-85.
- (12) Going S, Lohman T, Houtkooper L, Metcalfe L, Flint-Wagner H, Blew R, Stanford V, Cussler E, Martin J, Teixeira P, Harris M, Milliken L, Figueroa-Galvez A, Weber J. Effects of exercise on BMD in calcium-replete postmenopausal women with and without hormone replacement therapy. *Osteoporosis International: A Journal Established As Result Of Cooperation Between The European Foundation For Osteoporosis And The National Osteoporosis Foundation Of The USA* 2003 August;14(8):637-43.
- (13) Grove KA, Londeree BR. Bone density in postmenopausal women: high impact vs low impact exercise. *Medicine and Science in Sports and Exercise* 1992 November;24(11):1190-4.
- (14) Heinonen A, Kanus P, Sievanen H, Oja P, Pasanen M, Rinne M, Uusi-Rasi K, Vuori I. Randomised control trial of effect of high-impact exercise on selected risk factors for osteoporotic fractures. *Lancet* 1996;348:1343-7.
- (15) Heinonen A, Oja P, Sievänen H, Pasanen M, Vuori I. Effect of two training regimens on BMD in healthy perimenopausal women: a randomized controlled trial. *Journal of bone and mineral research : the official journal of the American Society for Bone and Mineral Research* 1998;13:483-90.
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- (20) 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: The Official Journal Of The American Society For Bone And Mineral Research* 1996 February;11(2):218-25.
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- (22) Kukuljan S, Nowson CA, Sanders KM, Nicholson GC, Seibel MJ, Salmon J, Daly RM. Independent and combined effects of calcium-vitamin D3 and exercise on bone structure and strength in older men: an 18-month factorial design randomized controlled trial. *J Clin Endocrinol Metab* 2011 April;96(4):955-63.
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 - (39) Zeilman CJ, III. Inflammatory bowel disease, osteoporosis, exercise, and BMD University of Florida; 2007.

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- (1) Clinical practice guidelines for the diagnosis and management of osteoporosis. Scientific Advisory Board, Osteoporosis Society of Canada. *CMAJ: Canadian Medical Association Journal = Journal De L'association Medicale Canadienne* 1996 October 15;155(8):1113-33. Review article
- (2) Research update. Exercise increases bone marrow density. *Australian Nursing Journal* 1997 February;4(7):30. Description of study from review or magazine or etc. (not the actual study)

- (3) Abstracts of the 4th Scandinavian Congress on Medicine and Science in Sports. Scandinavian Journal Of Medicine & Science In Sports 1998 October;8(5):309-92. Abstract
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APPENDIX C

Codebooks for Meta-Analyses

Study Characteristics

study_id1_new	author	source	year	journal	language	language_other	country	country_2	design	type_c
2	Bailey & Brooke-Wavell	journal	2010	Bone	english		United Kingdom	other	rct	other
302	Bassey et al.	journal	1998	J Bone Miner Res	english		United Kingdom	other	rct	nonintervention
298	Bergstrom et al.	journal	2008	Osteoporos Int	english		Sweden	other	rct	other
1057	Bergstrom et al.	journal	2005	Osteoporos Int	english		Sweden	other	rct	other
744	Bocalini et al.	journal	2009	J Aging Health	english		Brazil	other	rct	nonintervention
1170	Brentano et al.	journal	2008	J Strength Cond Res	english		Brazil	other	rct	nonintervention
26	Brooke-Wavell et al.	journal	1997	Clin Sci	english		United Kingdom	other	rct	other
362	Chilibeck et al.	journal	2002	Can J Physiol Pharmacol	english		Canada	other	rct	other
1085	Choquette et al.	journal	2011	Br J Nutr	english		Canada	other	rct	other
405	Englund et al.	journal	2005	Osteoporos Int	english		Sweden	other	rct	nonintervention
407	Friedlander et al.	journal	1995	J Bone Miner Res	english		United States	usa	rct	attention control
161	Going et al.	journal	2003	Osteoporos Int	english		United States	usa	rct	nonintervention
71	Grove & Londeree/Grove	journal	1992	Med Sci Sports Exerc	english		United States	usa	rct	nonintervention
21	Heinonen et al.	journal	1996	Lancet	english		Finland	other	rct	nonintervention
951	Heinonen et al.	journal	1998	J Bone Miner Res	english		Finland	other	rct	attention control
1019	Hong	dissertation	2004	The Chinese University of Hong Kong	english		China	other	rct	nonintervention
135	Iwamoto et al.	journal	2001	J Orthop Sci	english		Japan	other	rct	other
819	Jessup et al.	journal	2003	Biol Res Nurs	english		United States	usa	rct	other
827	Kemmler et al.	journal	2010	Arch Intern Med	english		Germany	other	rct	attention control
205	Kerr et al.	journal	1996	J Bone Miner Res	english		Australia	other	rct	other
322	Kerr et al.	journal	2001	J Bone Miner Res	english		Australia	other	rct	other
1113	Kukuljan et al.	journal	2011	J Clin Endocrinol Metab	english		Australia	other	rct	nonintervention
1118	Liang et al.	journal	2011	Int J Sports Med	english		United States	usa	rct	nonintervention
85	Liu-Ambrose et al.	journal	2004	J Clin Densitom	english		Canada	other	rct	attention control
184	Lohman et al.	journal	1995	J Bone Miner Res	english		United States	usa	rct	nonintervention
1120	Marques et al.	journal	2011	Exp Gerontol	english		Portugal	other	rct	nonintervention
1121	Marques et al.	journal	2011	Calcif Tissue Int	english		Portugal	other	rct	nonintervention
19	Martin & Notelovitz	journal	1993	J Bone Miner Res	english		United States	usa	rct	other
170	Nelson et al.	journal	1994	JAMA	english		United States	usa	rct	nonintervention
863	Newstead et al.	journal	2004	J Geriatr Phys Ther	english		United States	usa	rct	other
365	Prince et al.	journal	1995	J Bone Miner Res	english		Australia	other	rct	other
174	Rhodes et al.	journal	2000	Br J Sports Med	english		Canada	other	rct	nonintervention
30	Villareal et al.	journal	2011	N Engl J Med	english		United States	usa	rct	other
913	Villareal et al.	journal	2004	Age Ageing	english		United States	usa	rct	other
920	Warren et al.	journal	2008	Med Sci Sports Exerc	english		United States	usa	rct	usual care
239	Weaver et al.	journal	2001	Med Sci Sports Exerc	english		United States	usa	rct	nonintervention
922	Westby et al.	journal	2000	J Rheumatol	english		Canada	other	rct	other
105	Wu et al.	journal	2006	Metabolism	english		Japan	other	rct	other
930	Zeilman III	dissertation	2007	Univ. of Florida	english		United States	usa	rct	other

Study Characteristics

type_c_desc	matching
control group included but also had a control leg (unilateral training)	no
	no
control & ex groups both received calcium & Vitamin D supplements	no
control & ex groups both received calcium supplements	no
asked to maintain their normal daily activity routines	no
asked to keep the same activities during the period of 24 weeks	yes
Nine women in control group exercised option of swimming 2x week for 20 minutes	no
placebo	no
control and exercise groups received a placebo (cellulose)	no
control subjects asked not to increase their physical activity during the study	yes
given the option to continue with current level of PA or attend 2 out of 3, 30 minute stretching classes/wk	no
	yes
	yes
asked to maintain their current level of physical activity	yes
Light stretching exercises once a week (Sham exercise)	no
	yes
control & ex groups both received calcium & Vitamin D supplements	no
subjects received 1000 mg of calcium and 400 IU vitamin D per day (same as exercise group)	no
low-frequency, low intensity (50%-60% mhr) activity for 60 minutes, 1x per week for 10 weeks followed by 10 weeks of rest	yes
alternate limb served as the control	no
all subjects received 600 mg elemental calcium per day	no
	yes
required to submit weekly physical activity logs	no
sham exercise (stretching)	yes
subjects asked to maintain their normal daily routine	no
continue their daily routine and refrain from changing physical activity levels	no
asked to continue their daily routines and not to change physical activity levels during the course of the experiment	no
subject's received the same calcium supplementation as the exercise group	no
asked to maintain their current level of physical activity	no
control & ex groups both received calcium supplements	no
subject's received the same calcium supplementation (tablets) as the exercise group	no
instructed to maintain their normal lifestyle throughout the study; offered training program after the study	no
provided general information about a healthy diet during monthly visits with staff	yes
control group did exercises for flexibility, balance and coordination 2.9 +- 1.5 days/wk; all subjects received calcium & Vit D supplements	no
received AHA brochure recommending 30 minutes of moderate intensity activity on most days of the week	no
	yes
usual care + written materials on osteoporosis & pamphlet on ex & arthritis	no
placebo (2 capsules of dextrin, daily in the morning)	no
both groups took 1200 mg calcium and 400 IU Vitamin D every day; asked to continue ADL and to not start exercising	no

Study Characteristics

matching_des	crossover	sequence	allocation	blind_prime	inc_prime	outcome_rep	analysis	sample_size	groups_e
	no	yes	unclear	yes	unclear	unclear	abp	yes	3
	no	yes	unclear	yes	unclear	unclear	abp	yes	3
	no	yes	unclear	no	yes	no	abp & itt	yes	1
	no	yes	unclear	yes	unclear	unclear	abp	no	1
	no	yes	unclear	yes	unclear	unclear	abp	no	1
subjects divided by hrt use (yes versus no) and then randomly assigned to groups	no	yes	unclear	yes	unclear	unclear	abp	yes	2
	no	yes	unclear	yes	yes	unclear	abp	no	1
	no	yes	unclear	yes	unclear	unclear	abp	yes	1
	no	yes	unclear	yes	unclear	yes	abp	no	1
age	no	yes	unclear	yes	yes	unclear	abp	yes	1
	no	yes	yes	yes	yes	unclear	abp	no	1
hrt	no	yes	unclear	yes	unclear	unclear	abp	no	2
bmd, bodyweight	no	yes	unclear	yes	yes	unclear	abp	no	2
weight, oral contraceptive use	no	yes	unclear	yes	yes	unclear	itt	yes	1
	no	yes	unclear	yes	unclear	unclear	abp	no	2
gender	no	yes	unclear	yes	yes	unclear	abp	yes	4
	no	yes	unclear	yes	unclear	unclear	abp	no	1
	no	yes	unclear	yes	yes	unclear	abp	yes	1
age	no	yes	unclear	yes	yes	yes	abp & itt	yes	1
	no	yes	unclear	yes	unclear	unclear	abp	no	2
	no	yes	unclear	yes	unclear	unclear	abp	no	2
age, calcium intake	no	yes	unclear	yes	yes	unclear	itt	yes	2
	no	yes	unclear	yes	unclear	unclear	abp	no	2
postural stability, baseline total hip areal BMD, bisphosphonate use	no	yes	unclear	yes	yes	unclear	abp	yes	2
	no	yes	unclear	yes	unclear	unclear	abp	no	1
	no	yes	unclear	yes	yes	unclear	itt	yes	2
	no	yes	unclear	yes	yes	unclear	abp & itt	yes	1
	no	yes	unclear	yes	unclear	unclear	abp	no	2
	no	yes	unclear	yes	yes	unclear	itt	no	1
	no	yes	unclear	yes	yes	unclear	abp	yes	1
	no	yes	yes	yes	unclear	unclear	abp	no	1
	no	yes	unclear	yes	unclear	unclear	abp	no	1
gender	no	yes	unclear	yes	yes	unclear	itt	yes	1
	no	yes	unclear	yes	yes	unclear	itt	yes	1
	no	yes	unclear	yes	yes	unclear	itt	yes	1
age, oral contraceptive use	no	yes	unclear	yes	unclear	unclear	abp	no	1
	no	yes	unclear	yes	yes	unclear	itt	yes	1
	no	yes	unclear	yes	yes	unclear	abp	no	1
	no	yes	unclear	yes	yes	unclear	abp	yes	1

Study Characteristics

groups_c	groups_t	funded	notes_sc
1	4	no	
3	6	yes	Postmenopausal women with BMD <2.0 SD or any woman with BMD >1.5 SD excluded
1	2	no	all participants has a previous forearm fracture
1	2	no	all participants were perimenopausal
1	2	no	postmenopausal participants not taking hormone replacement therapy
1	3	no	
1	2	yes	
1	2	yes	
1	2	yes	all participants were overweight, postmenopausal women; study also included an exercise and isoflavone and isoflavone only group
1	2	yes	
1	2	yes	exercise + calcium and exercise + placebo combined; control + calcium and control + placebo combined
2	4	yes	exercise & control group on HRT; exercise & control group not on HRT; all subjects received 800 mg calcium citrate supplements daily
1	3	no	
1	2	yes	
1	3	yes	
2	6	yes	
1	2	no	all participants given 2 grams of calcium and 1 microgram of vitamin D3 each day
1	2	yes	all participants received 1000 mg of calcium and 400 IU vitamin D per day
1	2	yes	all participants received 1500 mg of calcium and 500 IU of cholecalciferol (vitamin D) per day
2	4	yes	
1	3	yes	
2	4	yes	exercise and milk versus milk only group included as well as an exercise only versus control group
1	3	yes	
1	3	yes	
1	2	no	
1	3	yes	
1	2	yes	both itt and abp analysis done but data not reported for abp analysis
1	3	yes	subjects in both exercise and control groups were given 1000 mg/d of supplemental calcium
1	2	yes	
1	2	yes	
1	2	yes	subjects in both exercise and control groups were given 1000 mg/d of supplemental calcium
1	2	no	
1	2	yes	all participants received 1500 mg of calcium and 1000 IU of vitamin D per day; limited to obese participants
1	2	yes	subjects were frail elderly participants 78 years of age and older; partial itt
1	2	yes	
1	2	yes	results poorly reported; same study as id# 202 that we chose not to code
1	2	yes	all participants received 1000 mg of calcium and 400 IU vitamin D per day; partial itt
1	2	yes	exercise subjects also received placebo (2 capsules of dextrin daily, in the morning)
1	2	no	all subjects had inflammatory bowel disease

Group Characteristics

study_id2_new	author2	group_id1	group_desc	i_n_e	f_n_e	drop_e
2	Bailey & Brooke-Wavell	1	2 days per week	21	16	24
2	Bailey & Brooke-Wavell	2	4 days per week	22	13	41
2	Bailey & Brooke-Wavell	3	7 days per week	22	16	27
302	Bassey et al.	1	premenopausal		30	
302	Bassey et al.	2	postmenopausal		45	
302	Bassey et al.	3	postmenopausal-hrt		24	
298	Bergstrom et al.	1		60	48	20
1057	Bergstrom et al.	1		20	12	40
744	Bocalini et al.	1		23	15	35
1170	Brentano et al.	1	strength training		9	
1170	Brentano et al.	2	circuit training		10	
26	Brooke-Wavell et al.	1		43	39	9
362	Chilibeck et al.	1		14	10	29
1085	Choquette et al.	1		25	18	28
405	Englund et al.	1		24	21	13
407	Friedlander et al.	1			32	50
161	Going et al.	1	hrt	86	71	17
161	Going et al.	2	no hrt	91	71	22
71	Grove & Londeree/Grove	1	low impact	5	5	0
71	Grove & Londeree/Grove	2	high impact	5	5	0
21	Heinonen et al.	1		49	39	20
951	Heinonen et al.	1	calisthenics	35	26	26
951	Heinonen et al.	2	endurance	32	23	28
1019	Hong	1	tai chi-men	30	30	0
1019	Hong	2	weight training-men	30	29	3
1019	Hong	3	tai chi-women	30	28	7
1019	Hong	4	weight training-women	30	30	0
135	Iwamoto et al.	1			8	
819	Jessup et al.	1		10	9	10
827	Kemmler et al.	1		123	115	7
205	Kerr et al.	1	weight training (high load, low reps)	28	25	11
205	Kerr et al.	2	weight training (low load, high reps)	28	21	25
322	Kerr et al.	1	weight training	42	24	43
322	Kerr et al.	2	circuit training	42	30	29
1113	Kukuljan et al.	1	exercise and milk	45	43	4
1113	Kukuljan et al.	2	exercise only	46	44	4
1118	Liang et al.	1	strength training	30	15	50
1118	Liang et al.	2	step aerobics	32	16	50
85	Liu-Ambrose et al.	1	weight training	34	32	6

Group Characteristics

85	Liu-Ambrose et al.	2	agility training	36	34	6
184	Lohman et al.	1		59	22	63
1120	Marques et al.	1	resistance training	23	15	35
1120	Marques et al.	2	aerobic training	24	19	21
1121	Marques et al.	1		30	27	10
19	Martin & Notelovitz	1	30 minutes	27	20	26
19	Martin & Notelovitz	2	45 minutes	25	16	36
170	Nelson et al.	1		21	20	5
863	Newstead et al.	1		25	23	8
365	Prince et al.	1	exercise and calcium	42	31	26
174	Rhodes et al.	1		22	20	9
30	Villareal et al.	1		26	22	15
913	Villareal et al.	1		69	42	39
920	Warren et al.	1		72	62	14
239	Weaver et al.	1		77	28	64
922	Westby et al.	1		14	11	21
105	Wu et al.	1		34	31	9
930	Zeilman III	1		8	7	13

Group Characteristics

reason_e	adverse_e
changed circumstance (3); time constraints (1); ankle sprain (1)	
changed circumstance (2); time constraints (2); personal reasons (1); lower limb discomfort(1); recurrence of back pain (1); injury unrelated to exercise (2)	
time constraints (1); lower limb discomfort (3); lower back discomfort (2)	
	no
	no
DEXA during HRT (1); inadequate level of training (11), related to intervention	
vaginal bleeding (1); infection (1); knee problems (1); myoma surgery (1); myocardial infarction (1); needed hrt (2); personal reasons (1)	
compliance to exercise less than 90% (5)	
surgery (1); illness/bereavement (2); fall at home (1); hyperthyroidism (1)	
time (4)	
	no
dementia(1);heart failure(1);unspecified knee pain(1)	
nd (reasons reported but not separately for exercise and control groups), unrelated to intervention	
	no
one person injured at 11 months and all but treadmill data collected at post	yes
previous musculoskeletal problems (2); lower-limb overuse injury (2); pregnancy (1); moved (2); lost interest (3), all unrelated to study protocol	no
moved (1); overuse injury (1); lost interest (7)	no
overuse injury (1); lost interest (8)	no
	no
	no
	no
	no
	yes
time (1); illness (1)	no
time (1); illness (1)	no
dropouts (10); noncompliance (5)	
dropouts (10); noncompliance (6)	
time commitment (1); ill health (1)	no

Group Characteristics

time commitment (2)	no
medical issues unrelated to intervention (3); disinterest (3); personal reasons (2)	no
medical issues unrelated to intervention (2); personal reasons (3)	no
medical problems unrelated to intervention (2); personal reasons (1)	no
myocardial infarction while on vacation (1), unrelated to intervention	no
time and/or moved; injury (1)	yes
	no
wanted to lose weight (1); job (1); family (1); medical (1)	yes
personal (3); medical problems (17)	
additional participants were excluded because they became pregnant or started corticosteroid use	
and (reasons reported but not separately for exercise and control groups)	
family problems (1); illness (1); other (1)	
moved (1)	

adverse_desc

no
no
transient musculoskeletal pain that required minor modifications to the training program (7)
knee problems (1)
back pain (2); tendon tear and tendonitis (1); ankle fracture (1); hematoma (1); transient atrial fibrillation during exercise (1)

Group Characteristics

i_n_c	f_n_c	drop_c	reason_c	i_n_t	f_n_t	gender
20	19	5	changed circumstances (1)	41	35	females
				22	13	females
				22	16	females
	25				55	females
	32				77	females
	22				46	females
52	44	15	started too extensive training (8)	112	92	females
20	15	25	personal reasons (3); needed hrt (2)	40	27	females
12	10	17		35	25	females
	9				18	females
					10	females
41	40	2	surgery (1)	84	79	females
14	12	14	hysterectomy and hrt (1); hrt (1)	28	22	females
26	22	15		51	40	females
24	19	21	lack of interest (2); death (1); started exercise (2)	48	40	females
	31	50	nd (reasons reported but not separately for exercise and control groups)		63	females
73	65	11		159	136	females
70	59	16		161	130	females
6	5	17		11	10	females
						females
49	45	8	accidental back injury (1); moved (1); lost interest (2)	98	84	females
34	27	21	died from cancer (1); lost interest (6)	69	53	females
				32	23	females
30	29	3		60	59	males
				30	29	males
30	30	0		60	58	females
				30	30	females
	20				28	females
10	9	10		20	18	females
123	112	9		246	227	females
28	25	11		28	25	females
28	21	25		28	21	females
42	36	14		84	60	females
				42	30	females
45	43	4	time (2)	90	86	males
44	42	5	time (1); unsatisfied (1)	90	86	males
28	20	29	dropouts (8)	58	35	females
				32	16	females
34	32	6	time commitment (1); ill (1)	68	64	females

Group Characteristics

				36	34	females
47	34	28		106	56	females
24	20	17	surgery (1); unwilling to participate as control (2); personal reasons (1)	47	35	females
				24	19	females
30	22	27	surgery (2); unwilling to participate as control (3); personal reasons (3)	60	49	females
24	19	21		51	39	females
24				49	16	females
19	19	0	no dropouts	40	39	females
28	26	7	time and or moved	53	49	females
42	35	17		84	66	females
22	18	18	refused to participate or unavailable for testing (4)	44	38	females
27	23	15	lacked interest (3); medical reasons (1)	53	45	mixed
50	38	24	death (1); personal (4); medical (4)	119	80	mixed
76	59	22	additional participants were excluded because they became pregnant or started corticosteroid use	148	121	females
64	27	58	nd (reasons reported but not separately for exercise and control groups)	141	55	females
16	10	38		30	21	females
34	33	3	unable to cope with trial (1)	68	64	females
10	9	10	unable to attend post-test evaluation (1)	18	16	males

Group Characteristics

n_m_e	n_f_e	n_m_c	n_f_c	race/ethnicity	age_e	agesd_e	age_r_e_l	age_r_e_u	age_c	agesd_c	age_r_c_l	age_r_c_u
	16		19		30.7	7.4	18	45	32.9	9.4	18.0	45.0
	13				32.2	10.0	18	45				
	16				34.6	7.9	18	45				
	30		25	white/not hispanic or latino	38.4	7.4			36.4	7.6		
	45		32		55.8	3.3			54.9	4.1		
	24		22		53.7	3.2			53.4	4.5		
	48		44		58.9	4.3	45	65	59.6	3.6	45.0	65.0
	12		15		47.3	2.1	44	51	47.0	2.7	41.0	51.0
	15		10		69.0	34.9	57.0	75	67.0	25.3	57.0	75.0
	9		9									
	10											
	39		40		64.9	3.0	60.0	70.0	64.2	3.1	60.0	70.0
	10		12	east indian (1), all others white/not hispanic or latino	56.8	6.3			58.8	6.2		
	18		22	white	58.0	6.0	50	70	59.0	6.0	50.0	70.0
	21		19		72.8	3.6	66	87	73.2	4.9	66.0	87.0
	32		31	white;asian/not hispanic or latino	28.0	6.8	20	35	30.1	4.0	20.0	35.0
	71		65		54.8	4.0	40	65	54.9	5.0	40.0	65.0
	71		59		55.8	4.7	40	65	57.1	5.0	40.0	65.0
	5		5	white/not hispanic or latino	56.6	4.3	50.0	61.0	56.0	4.5	53.0	64.0
	5			white/not hispanic or latino	54.0	1.9	51.0	56.0				
	39		45		39.0	3.0	35.0	45.0	39.0	3.0	35.0	45.0
	26		27		53.1	0.9	52.0	53.0	53.1	0.8	52.0	53.0
	23				52.9	0.9	52.0	53.0				
30		29		asian/not hispanic or latino	68.2	2.4	65	74	68.1	2.7	65.0	74.0
29				asian/not hispanic or latino	68.7	3.0	65	74				
	28		30	asian/not hispanic or latino	69.7	2.8	65	74	69.3	3.0	65.0	74.0
	30			asian/not hispanic or latino	69.6	3.2	65	74				
	8		20	asian/not hispanic or latino	65.3	4.7	53	77	64.9	5.7	53.0	77.0
	9		9	white/not hispanic or latino	69.1	2.8			69.4	4.2		
	115		112	white/not hispanic or latino	68.9	3.9	65		69.2	4.1	65.0	
	25		25		58.4	3.7	40	70	58.4	3.7	40	70
	21		21		55.7	4.7	40	70	55.7	4.7	40	70
	24		36		60.0	5.0			62.0	6.0		
	30				59.0	5.0						
43		43		white	61.7	7.6	50	79	61.7	7.7	50.0	79.0
44		42		white	60.7	7.1	50	79	59.9	7.4	50.0	79.0
	15		20		23.0	4.2	20	35	25.0	4.7	20.0	35.0
	16				25.0	4.4	20	35				
	32		32	white	79.6	2.1	75	85	79.5	3.2	75.0	85.0

Group Characteristics

	34			white	78.9	2.8	75	85				
	22		34	white/not hispanic or latino	34.2	2.6	28.0	39.0	34.4	2.7	28.0	39.0
	15		20	white	67.3	5.2	61	83	67.9	5.9	61.0	83.0
	19			white	70.3	5.5	61	83				
	27		22	white	70.1	5.4	63	83	68.2	5.7	63.0	83.0
	20		19	white/not hispanic or latino	60.3	7.8			56.7	6.9		
	16			white/not hispanic or latino	57.8	7.1						
	20		19	white/not hispanic or latino	61.1	3.7	50.0	70.0	57.3	6.3	50.0	70.0
	23		26	white (34); hispanic (13); asian (1); indian (1)	56.7	3.2	50	65	56.6	4.1	50.0	65.0
	31		35		63.0	5.0	50.0	70.0	62.0	5.0	50.0	70.0
	20		18		68.8	3.2	65	75	68.2	3.5	65.0	75.0
				white (43); black or african american (8); other (2)	70.0	4.0	65		69.0	4.0	65.0	
31	34	21	26	white (95); other (17)	83.0	4.0			83.0	4.0		
	62		59	white (95); other (53)	36.4	5.5	25	44	36.2	5.6	25.0	44.0
	28		27		24.0	3.8	18	31	24.2	3.7	18.0	31.0
	11		10	white/asian: 14/0 exercise, 15/1 control	56.4	10.1			56.0	10.8		
	31		33	asian	55.2	2.8	45	60	54.9	2.9	45.0	60.0
7		9			50.5	10.1	41	70	59.2	6.6	51.0	72.0

Group Characteristics

ht_e	htsd_e	ht_c	htsd_c	ht_metric	drugs_e	drugs_desc_e
164	5	162	6	centimeters		
164	7			centimeters		
163	8			centimeters		
164	1.2	164	1.3	centimeters	no	
161	6	163	6	centimeters	no	
162	5	161	6	centimeters	yes	
					no	
					no	no medication known to interfere with bone metabolism
					no	use of any medication that may alter calcium or bone metabolism
161.9	6.1	162.9	7.3	centimeters	no	none that could affect bone metabolism
164	6.32	165	3.46	centimeters	no	chronic medication use that might influence bone metabolism or calcium balance
161	6	160	6	centimeters		no medication that influences glucose or lipid metabolism
162	6.3	160.5	5.8	centimeters	no	no medications known to affect bone metabolism
163.4	7.1	163.4	6.9	centimeters	no	not using medications that alter bone density
163.2	6.8	163	5.3	centimeters	no	not using medications that alter bone density
					some	no drugs that could affect calcium metabolism and absorption
					some	no drugs that could affect calcium metabolism and absorption
164	6	165	5	centimeters	some	none that could affect the skeleton
161	6	161	5	centimeters	some	
164	5			centimeters	some	
152	7.84	152	5.66	centimeters	no	none that could affect bone metabolism
						no osteoporosis medications but could have been taking other drugs that alter bmd
161.8	6.1	160.5	5.8	centimeters	no	no medication usage (bisphosphonates, hrt, glucocorticoids, laxatives)
165.2	7	165.2	7	centimeters	no	no medication known to affect bone density including estrogen, steroid hormones, or thiazide diuretics
165.2	6.1	165.2	6.1	centimeters	no	no medication known to affect bone density including estrogen, steroid hormones, or thiazide diuretics
163.3	5.4	162.4	6.6	centimeters	no	no hormone replacement therapy or other medications that could affect bone
165.3	5.8			centimeters	no	no hormone replacement therapy or other medications that could affect bone
174.3	6.3	174.4	5.8	centimeters	no	no medication known to affect bone metabolism
174.2	6.6	175	6.6	centimeters	no	no medication known to affect bone metabolism
158	9.9	159	6	centimeters		
158	8.3			centimeters		
160.1	6	158.3	8.4	centimeters	some	bisphosphonates (21); estrogen replacement therapy (4); no medications that would negatively affect bone density

Group Characteristics

157	6.1			centimeters	some	bisphosphonates (23); estrogen replacement therapy (5); no medications that would negatively affect bone density
165	7.2	165.8	5.8	centimeters	no	none that could affect bone metabolism
					no	no medication known to affect bone metabolism
					no	no medication known to affect bone metabolism
					no	no medication known to affect bone metabolism
162.3	7.1	162.1	4.1	centimeters	no	no medications in the last 12 months that could affect calcium metabolism
159	5.1			centimeters	no	no medications in the last 12 months that could affect calcium metabolism
162.8	6.3	164	8.3	centimeters	no	none that could affect bone metabolism
163.3	4.4	161.7	6.6	centimeters	no	no alendronate, tamoxifen, calcitonin, raloxifene, glucocorticoids, residronate
					no	none that could affect bone metabolism
160.9	5.5	159.3	4.5	centimeters		
					no	no drugs that could affect bone health and metabolism
164	10	163	9	centimeters	no	exclusion criteria: use of bone-acting drugs within previous year
166.3	5.6	165.5	6.5	centimeters		
164.55	7.16	165.85	7.18	centimeters	no	no chronic medication that could affect bone metabolism
162	8	163.5	6.8	centimeters	yes	prednisone (all); DMARD; NSAID
155.3	6.3	156.7	6.3	centimeters	no	no medication known to affect the skeleton
					no	not currently taking hormones, osteoporosis medications or steroids

Group Characteristics

drugs_c	drugs_desc_c	hrt_e	hrt_c	gluc_e	gluc_c	rheum_e
		some	some			
		some				
		some				
no		no	no	no	no	no
no		no	no	no	no	no
yes		yes	yes	no	no	no
no		no	no	no	no	no
no	no medication known to interfere with bone metabolism	no	no	no	no	no
no	use of any medication that may alter calcium or bone metabolism	no	no	no	no	
		some	some			
		some				
no	none that could affect bone metabolism	no	no	no	no	no
no	chronic medication use that might influence bone metabolism or calcium balance	no	no	no	no	no
	no medication that influences glucose or lipid metabolism	no	no			
no	no medications known to affect bone metabolism	no	no	no	no	
		no	no			
no	not using medications that alter bone density	yes	yes	no	no	
no	not using medications that alter bone density	no	no	no	no	
no	no drugs that could affect calcium metabolism and absorption	some	some	no	no	
some	no drugs that could affect calcium metabolism and absorption	some		no		
some	none that could affect the skeleton	some	some	no	no	
some		some	some			
		some				
no	none that could affect bone metabolism	no	no	no	no	
	no osteoporosis medications but could have been taking other drugs that alter bmd	no	no			
no	no medication usage (bisphosphonates, hrt, glucocorticoids, laxatives)	no	no	no	no	
no	no medication known to affect bone density including estrogen, steroid hormones, or thiazide diuretics	no	no	no	no	
no	no medication known to affect bone density including estrogen, steroid hormones, or thiazide diuretics	no	no	no	no	
no	no hormone replacement therapy or other medications that could affect bone	no	no	no	no	
		no		no		
no	no medication known to affect bone metabolism	no	no	no	no	
no	no medication known to affect bone metabolism	no	no	no	no	
		some	some			
		some				
some	bisphosphonates (22); estrogen replacement therapy (4); no medications that would negatively affect bone density	some	some	no	no	

Group Characteristics

		some		no		
no	none that could affect bone metabolism	no	no	no	no	
no	no medication known to affect bone metabolism	no	no	no	no	
		no		no		
no	no medication known to affect bone metabolism	no	no	no	no	
no	no medications in the last 12 months that could affect calcium metabolism	no	no	no	no	
		no		no		
no	none that could affect bone metabolism	no	no	no	no	
no	no alendronate, tamoxifen, calcitonin, raloxifene, glucocorticoids, residronate	some	some	no	no	
no	none that could affect bone metabolism	no	no	no	no	
						no
no	no drugs that could affect bone health and metabolism			no	no	
no	exclusion criteria: use of bone-acting drugs within previous year	no	no	no	no	some
		some	some			
no	no chronic medication that could affect calcium metabolism	some	some	no	no	
yes	prednisone (all); DMARD; NSAID			yes	yes	yes
no	no medication known to affect the skeleton	no	no	no	no	
no	not currently taking hormones, osteoporosis medications or steroids	no	no	no	no	

Group Characteristics

rheum_c	osteo_e	osteo_c	osteo_sec_e	osteo_sec_c	osteopen_e	osteopen_c	smoke_e	smoke_c	alcoho_e	alcoho_c	regex_e	regex_c
											yes	yes
											yes	
											yes	
no	no	no	no	no			some	some			yes	yes
no	no	no	no	no			some	some			yes	yes
no	no	no	no	no			some	some			yes	yes
no	some	some	no	no	some	some	some	some			yes	yes
no	no	no	no	no	no	no	some	some			yes	yes
											yes	yes
											yes	yes
											yes	
no	no	no	no	no	no	no	some	some			yes	yes
no	no	no	no	no	some	some					yes	yes
							no	no	some	some	yes	yes
	no	no	no	no	no	no	no	no				
	no	no	no	no	no	no					yes	yes
							no	no			yes	yes
							no	no			yes	yes
											yes	yes
											yes	
							no	no			yes	yes
							no	no			yes	yes
							some	some	no	some	yes	yes
							some		some		yes	
							some	some	no	no	yes	yes
							no		no		yes	
	yes	yes			no	no					yes	yes
							no	no			yes	yes
	some	some	no	no			some	some			yes	yes
	no	no									yes	yes
	no	no									yes	yes
											yes	yes
											yes	
	no	no			some	some	no	no			yes	yes
	no	no			some	some	no	no			yes	yes
	no	no			no	no	no	no			yes	yes
	no				no		no				yes	
	some	some			some	some	some	some			yes	yes

Group Characteristics

[illegible]

Group Characteristics

regex_desc
no more than 1 hour per week of high-impact or weight-bearing exercise
no more than 1 hour per week of high-impact or weight-bearing exercise
no more than 1 hour per week of high-impact or weight-bearing exercise
current or recent (12 months) participation in vigorous, regular exercise more than 1h/wk
current or recent (12 months) participation in vigorous, regular exercise more than 1h/wk
current or recent (12 months) participation in vigorous, regular exercise more than 1h/wk
not already training at the level of or above that of the intervention
most performed no regular physical training; none training at a level above that of the intervention
participation in a regular and structured physical activity for the last 3 months
none engaged in any type of competitive exercise and practiced sports occasionally at a recreational level
none engaged in any type of competitive exercise and practiced sports occasionally at a recreational level
not already taking regular exercise
recent participation in a vigorous exercise program
sedentary (no participation in a systematic/supervised exercise program in the last 5 years
assume subjects were generally inactive since 2 control subjects dropped because they started exercising
no history of vigorous physical activity or currently exercising greater than 3 strenuous hours per week
less than 120 minutes of physical activity per week and no weightlifting or similar activity
less than 120 minutes of physical activity per week and no weightlifting or similar activity
women not active during the last year
women not active during the last year
regular exercise not more than 2 times per week
vigorous exercise no more than 2 times per week
vigorous exercise no more than 2 times per week
no tai chi or other regular exercise
no tai chi or other regular exercise
no tai chi or other regular exercise
no tai chi or other regular exercise
no engagement in sporting activity in the previous 5 years
not participating in regular exercise for the previous 12 months
no participation in exercise studies in the past 2 years or athletic history last decade; average self-rated PA score 4 (range 1-7 with 1 low, 7 high)
not exercising for more than 3 hours per week at a high intensity; no racquet sports or weight training in last 5 years
not exercising for more than 3 hours per week at a high intensity; no racquet sports or weight training in last 5 years
not exercising for more than 2 hours per week at a moderate intensity; no weight training in last 5 years
not exercising for more than 2 hours per week at a moderate intensity; no weight training in last 5 years
no participation in resistance training in the past 12 months and/or high-impact weight bearing activities for greater than 30 minutes three times per week in the preceding 6 months
no participation in resistance training in the past 12 months and/or high-impact weight bearing activities for greater than 30 minutes three times per week in the preceding 6 months
not engaged in regular exercise training in the last 6 months and VO2 max less than or equal to 38 ml/kg/min
not engaged in regular exercise training in the last 6 months and VO2 max less than or equal to 38 ml/kg/min
not exercising regularly more than 2 times per week

Group Characteristics

not exercising regularly more than 2 times per week
no history of participation in athletics, a regular exercise program for up to 2 years prior to the study; leisure or occupational activities requiring regular lifting, carrying or pushing against resistance
not engaged in regular exercise training in the last year
not engaged in regular exercise training in the last year
not engaged in regular exercise training in the last year
not involved in any systematic aerobic or strength training program in the last 12 months
not involved in any systematic aerobic or strength training program in the last 12 months
no strength training and less than 20 minutes of aerobic exercise two times per week
no current involvement in regular aerobic exercise and/or weight training exercise
excluded if exercising more than 1 hour per week in last year; average baseline physical activity equivalent to brisk walking 1.5 hours per day for the 2 most active hours in the day
no regular exercise of more than 30 minutes, 3 times per week; not actively engage in an organized activity program
sedentary lifestyle
sedentary
sedentary
minimally active (not exercising for more than 2 hours per week in the last year)
not currently exercising (but advised to continue with regular physical activities & therapy (physical and occupational) as needed
sedentary (no regular sports activities for at least 2 years)
sedentary (not currently participating in regular exercises such as walking, jogging, cycling, dance aerobics, strength training, etc. and have not done so for the previous 12 months)

Group Characteristics

pachange_e	pachange_c	meno_e	meno_c	meno_yrs_e	meno_yrs_sd_e	meno_yrs_c	meno_yrs_sd_c	calcium_e	calcium_c	vitd_e	vitd_c	fract_e
		premenopausal	premenopausal					no	no	no	no	
		premenopausal						no		no		
		premenopausal						no		no		
no change	no change	premenopausal	premenopausal									
no change	no change	postmenopausal	postmenopausal	6.8	4.2	5.2	4	some	some			
no change	no change	postmenopausal	postmenopausal	6	4.3	6.7	4.1	some	some			
		postmenopausal	postmenopausal					yes	yes	yes	yes	yes
		perimenopausal	perimenopausal					yes	yes			
		postmenopausal	postmenopausal									no
		postmenopausal	postmenopausal									
		postmenopausal										
		postmenopausal	postmenopausal	15.1	5.5	14.6	6.6					
no change	no change	postmenopausal	postmenopausal	8.6	6.96	8.3	5.89	yes	yes	yes	yes	
		postmenopausal	postmenopausal	8	8	10	8					
no change	no change	postmenopausal	postmenopausal	24.7		22.8						
		premenopausal	premenopausal					some	some	yes	yes	
		postmenopausal	postmenopausal					yes	yes			no
		postmenopausal	postmenopausal					yes	yes			no
		postmenopausal	postmenopausal	3.47	2.01	3.9	1.75	no	no			
		postmenopausal		4.1	2.97			no				
no change	no change	premenopausal	premenopausal									
		mixed	mixed									
		mixed										
		postmenopausal	postmenopausal									
		postmenopausal										
	no change	postmenopausal	postmenopausal	16.3	5.9	14.8	6.4	yes	yes	yes	yes	
		postmenopausal	postmenopausal	23.7	11.3	22.1	11.2	yes	yes	yes	yes	
no change	no change	postmenopausal	postmenopausal	20.1		19.4		yes	yes	yes	yes	
		postmenopausal	postmenopausal	7.8	3.5	7.8	3.5	no	no			
		postmenopausal	postmenopausal	6.3	4	6.3	4	no	no			
		postmenopausal	postmenopausal	11	6	12	6	yes	yes			
		postmenopausal		9	5			yes				
no change	no change							yes	yes	yes	yes	no
no change	no change							no	no	no	no	no
		premenopausal	premenopausal					yes	yes			
		premenopausal						yes				
		postmenopausal	postmenopausal	29.8	5	29.7	6.3	no	no	no	no	some

Group Characteristics

		postmenopausal		30.3	6.5			no		no		some
no change	no change	premenopausal	premenopausal					yes	yes			
no change	no change	postmenopausal	postmenopausal	19.7		19.2						
no change		postmenopausal		22								
no change	no change	postmenopausal	postmenopausal	22.3		20						
		postmenopausal	postmenopausal	12.75	8.75	8.5	7	yes	yes	yes	yes	
		postmenopausal		9.5	8.92			yes		yes		
increase	decrease	postmenopausal	postmenopausal	11.6	5	9.8	4.6	some	some			some
		postmenopausal	postmenopausal	10	6.5	9.7	6.5	yes	yes			no
		postmenopausal	postmenopausal	16	5	16	6	yes	yes			
		postmenopausal	postmenopausal									
		postmenopausal	postmenopausal					yes	yes	yes	yes	
		postmenopausal	postmenopausal					yes	yes	yes	yes	
no change	no change	premenopausal	premenopausal					no	no	no	no	
		premenopausal	premenopausal									
	no change	mixed	mixed					yes	yes	yes	yes	no
		postmenopausal	postmenopausal	3.6	1.8	3.7	2.1	no	no	no	no	
								yes	yes	yes	yes	

Group Characteristics

fract_c	fract_par_e	fract_par_c	strength_e	ex_type	ex_type_other	length	freq_ae	freq_r_l_ae	freq_r_u_ae	int_ae	int_r_l_ae	int_r_u_ae
				strength	unilateral hopping	24						
				strength	unilateral hopping	24						
				strength	unilateral hopping	24						
			no change	strength	vertical jumps	20						
			no change	strength	vertical jumps	51						
			no change	strength	vertical jumps	51						
yes			increase	both		52		4	5			
			no change	both		78	5					
no			increase	strength		24						
			increase	strength		24						
			increase	strength		24						
				aerobic		52	4	3.5	4.8	71		
			increase	strength		52						
				both		24	3				40	85
			increase	both	aerobic,strength,balance,coordination	47	2					
			increase	both		104	2				70	85
no			increase	both		52	3			60		
no			increase	both		52	3			60		
				aerobic		52	3					
				aerobic		52	3					
			no change	aerobic		78	2.5					
			no change	strength		78						
			no change	aerobic		78	3.2			72	55	75
			no change	aerobic	tai chi	52	3					
			increase	strength		52						
			no change	aerobic	tai chi	52	3					
			no change	strength		52						
				both		104	7					
			no change	both	also did balance exercises	32	3					
				both		78	2				70	85
			increase	strength		52						
			increase	strength		52						
				strength		104						
				both		104	3					
no			increase	both		72	3					
no			increase	both		72	3					
			increase	strength		52						
			no change	aerobic		52	3					
some				strength		25						

Group Characteristics

			other	agility training	25	2					
			increase	strength	78						
			increase	strength	32						
			no change	aerobic	32	3				50	85
			increase	both	32	2					
				aerobic	52	3			78.65	70	85
				aerobic	52	3			80.3	70	85
some			increase	strength	52						
no				other	52	3					
				aerobic	104				60		
			increase	strength	52						
			increase	both	52	3				65	85
			increase	both	24	2.2			80		
			increase	strength	104						
			increase	both	96						
no				both	52	2.1				60	75
				aerobic	24	3					
				aerobic	32	3					

Group Characteristics

int_met_ae	int_other_ae	int_c_ae	dur_ae	dur_r_l_ae	dur_r_u_ae	prescription_ae
				25	30	prescribed
				25	30	prescribed
mhr	walked at brisk pace when hr not monitored	53.13		14.8	20.4	completed
hrr	also did interval training at 90% of MHR		30			prescribed
			10			prescribed
mhr			40			prescribed
mhr		35.94		20	25	prescribed
mhr		35.94		20	25	prescribed
			20			prescribed
			20			prescribed
			20			completed
vo2		72.00	30			completed
			45			prescribed
			45			prescribed
						completed
				30	45	prescribed
mhr			20			prescribed
						prescribed
						prescribed
						prescribed
			40			prescribed

Group Characteristics

			50			prescribed
hrr				35	40	prescribed
			15			prescribed
mhr		65.08	30			prescribed
mhr		67.66	45			prescribed
						prescribed
mhr		35.94		180	240	prescribed
mhr						prescribed
mhr		67.19	25	15	30	completed
						prescribed
mhr				15	20	completed
other	walk 5 to 6 km/hr		45			prescribed
			50			prescribed

Group Characteristics

mode_ae
walk/other
walk/other
walk
cycle/jog/walk
walk/jog/other
high-impact aerobic workout (low-impact available)
walk/jog/other
walk/jog/other
charleston/heel jack without jump/fast walk/slow walk
jumping jacks/knee-to-elbow jump/running in place
jump training
other
cycle/jog/stairclimb/walk/other
Yang style of tai chi (24 forms)
Yang style of tai chi (24 forms)
walk
walk/stair climb
aerobic dance
stationary cycling as part of a circuit training program
3 sets of 10 to 20 repetitions of single and double foot landings, bench stepping and jumping
3 sets of 10 to 20 repetitions of single and double foot landings, bench stepping and jumping
step/hop/w/run/2-legged hops

Group Characteristics

other
stepping, skipping, graded walking, jogging, dancing, aerobics and step choreographies
weight bearing exercise (moderate to high impact marching in place, stepping exercise, heel drops)
jog/walk
jog/walk
other
walk/other
stair climbing, stationary cycling, walking on a treadmill
walking on treadmill, cycling, rowing
other
walking & marching combined with repetitive arm movements
walking
walking with weighted vest

Group Characteristics

mode_ae_other	comply_ae	comply_r_l_ae	comply_r_u_ae
3 walks/wk plus 25 min aerobic ex in training session mixed with 25 min strengthening workout	95		
3 walks/wk plus 25 min aerobic ex in training session mixed with 25 min strengthening workout			
also did 1-2 days per week of interval training after 3 months (4 minutes of exercise, 3 minutes of recovery)			
steps, arm movements	67	23	95
	61.3		
skip/hop/sc/step box w/weighted vests	79.9		
skip/hop/sc/step box w/weighted vests	79.9		
	80		
	82.6		
	83		
calisthenics			
graded treadmill exercises	80		
	77		
	84		
increased daily step count by 61.3% per day			
wore weighted vest while walking and stair climbing			
	76.3		
	77		
moderate-impact weight bearing exercises in between resistance training exercises	63		
moderate-impact weight bearing exercises in between resistance training exercises	63		

Group Characteristics

ball games, relay races, dance movements, obstacle courses	87		
	77.7	64.2	96.8
	72.4	51.6	85.9
	78.35		
	83.8		
multidirectional jumping (25 to 200 jumps per session) progressing from the floor to 4 inch and then 6 inch steps	75		
	39		
	88	85	92
	73.3		
jump rope	43.7		
	71		
	96		

Group Characteristics

comply_notes_ae	tmin_ae	tmin_adj	supervision_ae	location_ae
			both	home and facility based
			both	home and facility based
			both	home and facility based
			unsupervised	
			unsupervised	
			both	home and facility based
subjects had to attend at least 85% of sessions to be included	90.00		supervised	facility based
for combined program	20.00	13.40	supervised	home and facility based
	80.00	49.04	supervised	facility based
for exercise completers only			supervised	facility based
for exercise completers only			supervised	facility based
	60.00	48.00	supervised	facility based
	60.00	49.56	supervised	facility based
	50.00	41.50	supervised	facility based
			both	
	96.00	76.80	both	
	135.00	103.95	both	home and facility based
	135.00	113.40	both	home and facility based
			unsupervised	home based
			supervised	facility based
	40.00	30.52	supervised	facility based
compliance for combined ae & wt			supervised	facility based
95% CI, 57% to 69%			supervised	facility based
95% CI, 57% to 69%			supervised	facility based
had to attend at least 80% of sessions	120.00		supervised	facility based

Group Characteristics

	100.00	87.00	supervised	facility based
also did strength exercises for the first 6 weeks			supervised	facility based
median versus mean reported; compliance for both ae and st	30.00	21.72	supervised	facility based
	90.00	70.52	supervised	facility based
	135.00	113.13	supervised	facility based
			both	home and facility based
			both	home and facility based
reported as median and interquartile range and combined for aerobic and weight training groups			supervised	facility based
	55.00	40.32	supervised	facility based
	60.00	26.22	unsupervised	home and facility based
compliance for combined aerobic & weight training			unsupervised	home based
number of steps increased in walking group	135.00		supervised	facility based
	150.00	144.00	unsupervised	home based

Group Characteristics

participation_ae	freq_str	freq_r_l_str	freq_r_u_str	int_str	int_r_l_str	int_r_u_str	dur_str	dur_r_l_str	dur_r_u_str	sets_str	sets_l_str	sets_u_str	reps_str
	2									5			10
	4									5			10
	7									5			10
group & self	6						10			5			10
group & self	6						10			5			10
group & self	6						10			5			10
		1	2				25						
	2						25						
	3			85	50	85	60			3			10
	3				45	80	55				2	4	
	3				45	60	55				2	3	
group & self													
	3			70						2			
	3				60	85	30				1	4	
group & self	2						12			2			
group	3						40						
	3				70	80				2			
	3				70	80				2			
group													
group													
group													
	2.6						30			3			16
group & self													
	3									1			30
group & self													
	3									1			30
self	5	5	7							2			15
	3				50	75		30	45				
group	4										1	3	
	3			50.9	40	60		20	30	3			8
	3			15.45	10	20		45	60	3			20
	3						30			3			8
	3						30						
	3				50	85					2	3	
	3				50	85					2	3	
	2.3				65	80	40				1	3	
group													
	2				50	85	50			2			

Group Characteristics

reps_l_str	reps_u_str	rest_str	rest_l_str	rest_u_str	exn_str	equipment_str	prescription_str	type_str
					1	body weight	prescribed	other
					1	body weight	prescribed	other
					1	body weight	prescribed	other
					1		prescribed	other
					1		prescribed	other
					1		prescribed	other
							prescribed	
							prescribed	
		60			12		prescribed	traditional
6	20	120			10	machine and free weights	prescribed	traditional
10	20	0			10	machine and free weights	prescribed	circuit
8	10				12	plate loaded machines (Pulse Fitness Systems & Life Fitness)	prescribed	traditional
4	15					free weights and selective plate machines	prescribed	traditional
8	12					body weight and dumbbells	prescribed	
						body weight, dumbbells, barbells, ankle/wrist weights	prescribed	other
6	8				7	free weights, machine, therabands, physiotherapy balls, weighted vests	prescribed	traditional
6	8				7	free weights, machine, therabands, physiotherapy balls, weighted vests	prescribed	traditional
					8	wrist and ankle weights	completed	other
					7	therabands	prescribed	other
					7	therabands	prescribed	other
					4	body weight	completed	other
8	10					Nautilus-type machines	prescribed	traditional
8	15		20		12	body weight and therabands	prescribed	other
8	10		120	180	11	free weights & resistance machines	prescribed	traditional
20	25		120	180	11	free weights & resistance machines	prescribed	traditional
					9		prescribed	traditional
		10			9		prescribed	circuit
8	20				8	machine and free weights	prescribed	
8	20				8	machine and free weights	prescribed	
8	15				8		completed	circuit
6	15				9	Keiser pneumatic resistance machines & free weights	prescribed	traditional

Group Characteristics

8	12				12	free weights	prescribed	traditional
6	15	120			8	variable resistance machines (Nautilus)	prescribed	traditional
8	15					weighted vests, elastic bands and dumbbells	prescribed	other
			90	120	5	Keiser pneumatic resistance machines	prescribed	traditional
					6	Universal Gym	prescribed	circuit
6	12				9	machines	prescribed	traditional
6	12				8		completed	traditional
8	10					variable resistance machines and free weights	prescribed	traditional
8	12	15			16	Universal super circuit	prescribed	circuit
						hand and cuff weights	completed	other

Group Characteristics

mode_str	mode_other_str	comply_str
yes	hopping on one limb; subjects completed 86 hops per week	84
yes	hopping on one limb; subjects completed 189 hops per week	90
yes	hopping on one limb; subjects completed 312 hops per week	86
yes		
yes		
yes		
yes		95
yes		
yes	emphasis was on eccentric contractions	90
yes		
yes		
yes		77.6
yes	movement centered around 3 core exercises: leg press, bench press, lat pulldown	
yes	also performed exercises for static and dynamic balance	67
yes	Variety Training Program (circuit training); other (traditional)	61.3
yes		79.9
yes		79.9
yes	8 rhythmic muscular strength-endurance calisthenics exercises	66
yes	therabands	73
yes	therabands	80
yes		
yes		
yes	isometric and isotonic exercise in circuit and traditional format, balance, gymnastics, stretching	59.25
yes		87
yes		89
yes		74
yes	subjects performed all exercises for 40 seconds followed by a 10 second break	77
yes	squats or leg press, lunges, hip adduction/abduction, pulldown or seated row, back extension, combination of abdominal and core stability exercises	63
yes	squats or leg press, lunges, hip adduction/abduction, pulldown or seated row, back extension, combination of abdominal and core stability exercises	63
yes		
yes		85

Group Characteristics

166

yes		84
yes		78.4
yes	squats while wearing weighted vests, hip flexors, extensors, abductors, knee flexors and extensors, upper body exercises	72.4
yes		87.5
yes		85
yes		88
yes		73.3
yes		67
yes	participants performed super circuit training	46.7
yes	low load strengthening exercises for the major peripheral muscle groups	71

Group Characteristics

comply_r_l_str	comply_r_u_str	comply_notes_str	supervision_str
65	100		unsupervised
74	100		unsupervised
65	97		unsupervised
		Compliance reported as the median $\pm$ IQR (69% $\pm$ 27%)	both
		Compliance reported as the median $\pm$ IQR (91% $\pm$ 13%)	both
		Compliance reported as the median $\pm$ IQR (91% $\pm$ 13%)	both
			unsupervised
			unsupervised
		compliance was at least 90%	supervised
			supervised
			supervised
			supervised
		also did 1-2 days per week of interval training after 3 months (4 minutes of exercise, 3 minutes of recovery)	supervised
23	95	compliance for combined program	supervised
		compliance for intervention (3 alternating classes: aerobic, circuit, traditional)	supervised
		for exercise completers only	supervised
		for exercise completers only	supervised
			both
			supervised
			supervised
			unsupervised
			supervised
		averaged group (76.3%) and home-based (42.2%) compliance	both
67	98		supervised
69	100		supervised
			supervised
		compliance for combined ae & wt	supervised
		95% CI, 57% to 69%	supervised
		95% CI, 57% to 69%	supervised
		has to attend at least 80% of the sessions	supervised
			supervised

Group Characteristics

			supervised
61.6	95.9		supervised
51.6	85.9	median versus mean reported; compliance for both ae and st	supervised
			supervised
		86% for first 3 months; 85% for last 9 months	both
85	92	reported as median and interquartile range and combined for aerobic and weight training groups	supervised
			supervised
30	100		both
			unsupervised
		compliance for combined aerobic & weight training	unsupervised

Group Characteristics

location_str	participation_str	BPAQ_1	BPAQ_2	load stimulus_bpaq1	load stimulus_bpaq2	load rating_bpaq1	load rating_bpaq2	grf	rfa
home based	self	6.44	0.53	4.88	0.40	122.0	10.0	2.8	
home based	self	8.59	0.7	4.88	0.40	122.0	9.9	2.8	
home based	self	10.74	0.88	4.44	0.36	111.0	9.1	2.8	
home and facility based	group & self	27.24	27.24	13.62	13.62	340.5	340.5	3.01	43.0
home and facility based	group & self	27.24	27.24	13.62	13.62	340.5	340.5	3.96	155.6
home and facility based	group & self	27.24	27.24	13.62	13.62	340.5	340.5	3.96	156.8
			0.72						
			0.72		0.40		10.0		
facility based		0.71	0.56	0.51	0.40	12.7	10.0		
facility based									
facility based									
		0.64	0.64	0.38	0.38	9.4	9.4		
facility based		0.71	0.56	0.51	0.40	12.7	10.0		
facility based			0.56		0.40		10.0		
home and facility based	group & self		0.48		0.40		10.0		
facility based	group	30.59	30.51	23.17	23.11	579.4	577.8		
facility based			0.56		0.40		10.0		
facility based			0.56		0.40		10.0		
		2.35	0.56	1.68	0.40	42.0	10.0	1.3	
		9.13	19.07	6.52	13.62	163.0	340.5	2.9	
		77.02	77	59.25	59.23	1481.2	1480.8	3.85	
		0.71	0.56	0.54	0.42	13.4	10.6		
		2.01	0.56	1.40	0.39	34.9	9.7		
			0.56		0.40		10.0		
facility based	group	0.71	0.56	0.51	0.40	12.7	10.0		
			0.56		0.40		10.0		
facility based	group	0.71	0.56	0.51	0.40	12.7	10.0		
home based			0.88		0.40		10.0		
facility based			0.56		0.40		10.0		
home and facility based	group & self		0.64		0.53		13.3		
facility based		0.71	0.56	0.51	0.40	12.7	10.0		
facility based		0.71	0.56	0.51	0.40	12.7	10.0		
facility based		0.71	0.56	0.51	0.40	12.7	10.0		
facility based			0.56		0.40		10.0		
facility based		77.02	77	55.01	55.00	1375.4	1375.0	5.6	
facility based		77.02	77	55.01	55.00	1375.4	1375.0	5.6	
facility based		0.79	0.62	0.57	0.45	14.2	11.2		
		84.72	84.7	55.01	55.00	1375.3	1375.0	4.2	87.8
facility based	group	0.61	0.48	0.51	0.40	12.7	10.0		

Group Characteristics

			0.48					3	
facility based		0.79	0.62	0.51	0.40	12.8	10.1		
facility based	other	0.71	0.56	0.51	0.40	12.7	10.0		
facility based	group	5.66	16.34	4.72	13.62	117.9	340.4	2.06	
		0.56	0.56	0.40	0.40	10.0	10.0		
		0.56	0.56	0.40	0.40	10.0	10.0		
facility based		0.61	0.48	0.51	0.40	12.7	10.0		
		17.71	19.07						
		0.64	0.64						
facility based		0.71	0.56	0.51	0.40	12.7	10.0		
facility based	group		0.56		0.40		10.0		
facility based			0.48		0.39		9.7		
facility based	group & self	0.61	0.48	0.51	0.40	12.7	10.0		
facility based	self								
home based	self		0.48		0.39		9.8		
		0.56	0.56	0.40	0.40	10.0	10.0		
		0.56	0.56	0.40	0.40	10.0	10.0		

Group Characteristics

elr	els	forces
		ground reaction
		ground reaction
		ground reaction
129.4	5.1772	ground reaction
616.0	24.640704	ground reaction
620.8	24.832368	ground reaction
		both
		both
		joint reaction
		joint reaction
		joint reaction
		ground reaction
		joint reaction
		both
		both
		both
		both
		both
		ground reaction
		ground reaction
		ground reaction
		joint reaction
		ground reaction
		joint reaction
		joint reaction
		joint reaction
		joint reaction
		both
		both
		both
		joint reaction
		joint reaction
		joint reaction
		joint reaction
		both
		both
		joint reaction
368.8	14.7504	ground reaction
		joint reaction

Group Characteristics

		ground reaction
		joint reaction
		joint reaction
		ground reaction
		both
		ground reaction
		ground reaction
		joint reaction
		ground reaction
		ground reaction
		joint reaction
		both
		both
		joint reaction
		both
		both
		ground reaction
		both

[illegible]

participants encouraged to exercise with a partner
participants also performed 10 minutes of static and dynamic balance exercises
20 control subjects walked; one control subject stair climbed; one control subject rowed and hiked
subjects performed flexibility, balance and coordination exercises, added weight training, and then added aerobic exercise
couldn't calculate BPAQ score because no frequency for jumping rope prescribed
subjects with femoral neck or lumbar spine BMD 3.5 SD below young healthy normal controls excluded from study; subjects walked with weighted vest

Outcome Characteristics

study_id3_new	author3	group_id2	outcome_id	outcome_variable	outcome_other	outcome_class	outcome_test
2	Bailey & Brooke-Wavell	1	1	femoral neck		primary	dexa
2	Bailey & Brooke-Wavell	1	2	other	upper femoral neck	secondary	dexa
2	Bailey & Brooke-Wavell	1	3	other	lower femoral neck	secondary	dexa
2	Bailey & Brooke-Wavell	1	4	trochanter(ic)		secondary	dexa
2	Bailey & Brooke-Wavell	1	5	body weight		secondary	other
2	Bailey & Brooke-Wavell	1	6	body mass index		secondary	other
2	Bailey & Brooke-Wavell	1	7	percent body fat		secondary	other
2	Bailey & Brooke-Wavell	2	1	femoral neck		primary	dexa
2	Bailey & Brooke-Wavell	2	2	other	upper femoral neck	secondary	dexa
2	Bailey & Brooke-Wavell	2	3	other	lower femoral neck	secondary	dexa
2	Bailey & Brooke-Wavell	2	4	trochanter(ic)		secondary	dexa
2	Bailey & Brooke-Wavell	2	5	body weight		secondary	other
2	Bailey & Brooke-Wavell	2	6	body mass index		secondary	other
2	Bailey & Brooke-Wavell	2	7	percent body fat		secondary	other
2	Bailey & Brooke-Wavell	3	1	femoral neck		primary	dexa
2	Bailey & Brooke-Wavell	3	2	other	upper femoral neck	secondary	dexa
2	Bailey & Brooke-Wavell	3	3	other	lower femoral neck	secondary	dexa
2	Bailey & Brooke-Wavell	3	4	trochanter(ic)		secondary	dexa
2	Bailey & Brooke-Wavell	3	5	body weight		secondary	other
2	Bailey & Brooke-Wavell	3	6	body mass index		secondary	other
2	Bailey & Brooke-Wavell	3	7	percent body fat		secondary	other
302	Bassey et al.	1	1	lumbar spine		primary	dexa
302	Bassey et al.	1	2	femoral neck		primary	dexa
302	Bassey et al.	1	3	trochanter(ic)		secondary	dexa
302	Bassey et al.	1	4	body weight		secondary	
302	Bassey et al.	1	5	body mass index		secondary	
302	Bassey et al.	1	6	muscular power-lower		secondary	
302	Bassey et al.	1	7	balance-dynamic		secondary	
302	Bassey et al.	2	1	lumbar spine		primary	dexa
302	Bassey et al.	2	2	femoral neck		primary	dexa
302	Bassey et al.	2	3	trochanter(ic)		secondary	dexa
302	Bassey et al.	2	4	body weight		secondary	
302	Bassey et al.	2	5	body mass index		secondary	
302	Bassey et al.	2	6	calcium intake		secondary	
302	Bassey et al.	3	1	lumbar spine		primary	dexa
302	Bassey et al.	3	2	femoral neck		primary	dexa
302	Bassey et al.	3	3	trochanter(ic)		secondary	dexa
302	Bassey et al.	3	4	body weight		secondary	
302	Bassey et al.	3	5	body mass index		secondary	

Outcome Characteristics

302	Bassey et al.	3	6	calcium intake		secondary	
302	Bassey et al.	3	7	balance-dynamic		secondary	
298	Bergstrom et al.	1	1	body mass index		secondary	other
298	Bergstrom et al.	1	2	muscular strength-lower		secondary	other
298	Bergstrom et al.	1	3	lumbar spine	L1-L4	primary	dexa
298	Bergstrom et al.	1	4	lumbar spine	L2-L4	primary	dexa
298	Bergstrom et al.	1	5	hip-total		secondary	dexa
298	Bergstrom et al.	1	6	femoral neck		primary	dexa
298	Bergstrom et al.	1	7	muscular strength-lower		secondary	other
298	Bergstrom et al.	1	8	lumbar spine	L1-L4	primary	dexa
298	Bergstrom et al.	1	9	lumbar spine	L2-L4	primary	dexa
298	Bergstrom et al.	1	10	hip-total		secondary	dexa
298	Bergstrom et al.	1	11	femoral neck		primary	dexa
1057	Bergstrom et al.	1	1	body mass index		secondary	other
1057	Bergstrom et al.	1	2	lumbar spine	L2-L4	primary	dexa
1057	Bergstrom et al.	1	3	femoral neck		primary	dexa
1057	Bergstrom et al.	1	4	muscular strength-lower		secondary	other
744	Bocalini et al.	1	1	femoral neck		primary	dexa
744	Bocalini et al.	1	2	lumbar spine	L1-L4	primary	dexa
744	Bocalini et al.	1	3	muscular strength-lower		secondary	other
744	Bocalini et al.	1	4	muscular strength-upper		secondary	other
744	Bocalini et al.	1	5	body weight		secondary	other
744	Bocalini et al.	1	6	body mass index		secondary	other
744	Bocalini et al.	1	7	percent body fat		secondary	other
1170	Brentano et al.	1	1	body weight		secondary	
1170	Brentano et al.	1	2	other	fat mass	secondary	
1170	Brentano et al.	1	3	aerobic fitness		secondary	other
1170	Brentano et al.	1	4	aerobic fitness		secondary	other
1170	Brentano et al.	1	5	muscular strength-upper		secondary	other
1170	Brentano et al.	1	6	muscular strength-lower		secondary	other
1170	Brentano et al.	1	7	muscular strength		secondary	other
1170	Brentano et al.	1	8	lumbar spine	L2-L4	primary	dexa
1170	Brentano et al.	1	9	femoral neck		primary	dexa
1170	Brentano et al.	1	10	trochanter(ic)		secondary	dexa
1170	Brentano et al.	1	11	ward's triangle		secondary	dexa
1170	Brentano et al.	1	12	intertrochanter(ic)		secondary	dexa
1170	Brentano et al.	2	1	body weight		secondary	
1170	Brentano et al.	2	2	other	fat mass	secondary	
1170	Brentano et al.	2	3	aerobic fitness		secondary	other
1170	Brentano et al.	2	4	aerobic fitness		secondary	other

Outcome Characteristics

1170	Brentano et al.	2	5	muscular strength-upper		secondary	other
1170	Brentano et al.	2	6	muscular strength-lower		secondary	other
1170	Brentano et al.	2	7	muscular strength		secondary	other
1170	Brentano et al.	2	8	lumbar spine	L2-L4	primary	dexa
1170	Brentano et al.	2	9	femoral neck		primary	dexa
1170	Brentano et al.	2	10	trochanter(ic)		secondary	dexa
1170	Brentano et al.	2	11	ward's triangle		secondary	dexa
1170	Brentano et al.	2	12	intertrochanter(ic)		secondary	dexa
26	Brooke-Wavell et al.	1	1	lumbar spine	L2-L4	primary	dexa
26	Brooke-Wavell et al.	1	2	femoral neck		primary	dexa
26	Brooke-Wavell et al.	1	3	calcaneus		secondary	dexa
26	Brooke-Wavell et al.	1	4	body weight		secondary	
26	Brooke-Wavell et al.	1	5	body mass index		secondary	
26	Brooke-Wavell et al.	1	6	calcium intake		secondary	
362	Chilibeck et al.	1	1	body weight		secondary	other
362	Chilibeck et al.	1	2	body mass index		secondary	other
362	Chilibeck et al.	1	3	percent body fat		secondary	dexa
362	Chilibeck et al.	1	4	calcium intake		secondary	other
362	Chilibeck et al.	1	5	vitamin D intake		secondary	other
362	Chilibeck et al.	1	6	lumbar spine	L1-L4	primary	dexa
362	Chilibeck et al.	1	7	femur-proximal		secondary	dexa
362	Chilibeck et al.	1	8	femoral neck		primary	dexa
362	Chilibeck et al.	1	9	trochanter(ic)		secondary	dexa
362	Chilibeck et al.	1	10	ward's triangle		secondary	dexa
362	Chilibeck et al.	1	11	whole body		secondary	dexa
362	Chilibeck et al.	1	12	muscular strength-upper		secondary	other
362	Chilibeck et al.	1	13	muscular strength-lower		secondary	other
1085	Choquette et al.	1	1	body weight		secondary	other
1085	Choquette et al.	1	2	body mass index		secondary	other
1085	Choquette et al.	1	3	other	fat mass	secondary	dexa
1085	Choquette et al.	1	4	lean body mass		secondary	dexa
1085	Choquette et al.	1	5	percent body fat		secondary	dexa
1085	Choquette et al.	1	6	whole body		secondary	dexa
1085	Choquette et al.	1	7	lumbar spine	L2-L4	primary	dexa
1085	Choquette et al.	1	8	hip-total		secondary	dexa
1085	Choquette et al.	1	9	femoral neck		primary	dexa
1085	Choquette et al.	1	10	trochanter(ic)		secondary	dexa
1085	Choquette et al.	1	11	ward's triangle		secondary	dexa
405	Englund et al.	1	1	body weight		secondary	other
405	Englund et al.	1	2	body mass index		secondary	other

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405	Englund et al.	1	3	lean body mass		secondary	dexa
405	Englund et al.	1	4	whole body		secondary	dexa
405	Englund et al.	1	5	arm		secondary	dexa
405	Englund et al.	1	6	lumbar spine		primary	dexa
405	Englund et al.	1	7	femoral neck		primary	dexa
405	Englund et al.	1	8	trochanter(ic)		secondary	dexa
405	Englund et al.	1	9	ward's triangle		secondary	dexa
405	Englund et al.	1	10	muscular strength		secondary	other
405	Englund et al.	1	11	muscular strength		secondary	other
405	Englund et al.	1	12	aerobic fitness		secondary	other
405	Englund et al.	1	13	balance-static		secondary	other
405	Englund et al.	1	14	balance		secondary	other
407	Friedlander et al.	1	1	body weight		secondary	other
407	Friedlander et al.	1	2	percent body fat		secondary	other
407	Friedlander et al.	1	3	lumbar spine		primary	dexa
407	Friedlander et al.	1	4	femoral neck		primary	dexa
407	Friedlander et al.	1	5	trochanter(ic)		secondary	dexa
407	Friedlander et al.	1	6	aerobic fitness		secondary	other
407	Friedlander et al.	1	7	muscular strength-lower		secondary	other
407	Friedlander et al.	1	8	muscular strength-lower		secondary	other
407	Friedlander et al.	1	9	muscular strength-upper		secondary	other
407	Friedlander et al.	1	10	muscular strength-upper		secondary	other
161	Going et al.	1	1	body weight		secondary	other
161	Going et al.	1	2	body mass index		secondary	other
161	Going et al.	1	3	lean body mass		secondary	dexa
161	Going et al.	1	4	percent body fat		secondary	dexa
161	Going et al.	1	5	femoral neck		primary	dexa
161	Going et al.	1	6	trochanter(ic)		secondary	dexa
161	Going et al.	1	7	lumbar spine	L2-L4	primary	dexa
161	Going et al.	1	8	whole body		secondary	dexa
161	Going et al.	2	1	body weight		secondary	other
161	Going et al.	2	2	body mass index		secondary	other
161	Going et al.	2	3	lean body mass		secondary	dexa
161	Going et al.	2	4	percent body fat		secondary	dexa
161	Going et al.	2	5	femoral neck		primary	dexa
161	Going et al.	2	6	trochanter(ic)		secondary	dexa
161	Going et al.	2	7	lumbar spine	L2-L4	primary	dexa
161	Going et al.	2	8	whole body		secondary	dexa
71	Grove & Londeree/Grove	1	1	lumbar spine	L2-L4	primary	dpa
71	Grove & Londeree/Grove	1	2	body weight		secondary	

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71	Grove & Londeree/Grove	1	3	percent body fat		secondary	
71	Grove & Londeree/Grove	1	4	lean body mass		secondary	
71	Grove & Londeree/Grove	1	5	aerobic fitness		secondary	
71	Grove & Londeree/Grove	1	6	calcium intake		secondary	
71	Grove & Londeree/Grove	2	1	lumbar spine	L2-L4	primary	dpa
71	Grove & Londeree/Grove	2	2	body weight		secondary	
71	Grove & Londeree/Grove	2	3	percent body fat		secondary	
71	Grove & Londeree/Grove	2	4	lean body mass		secondary	
71	Grove & Londeree/Grove	2	5	aerobic fitness		secondary	
71	Grove & Londeree/Grove	2	6	calcium intake		secondary	
21	Heinonen et al.	1	1	lumbar spine		primary	dexa
21	Heinonen et al.	1	2	femoral neck		primary	dexa
21	Heinonen et al.	1	3	trochanter(ic)		secondary	dexa
21	Heinonen et al.	1	4	femur-distal		secondary	dexa
21	Heinonen et al.	1	5	patella		secondary	dexa
21	Heinonen et al.	1	6	tibia-proximal		secondary	dexa
21	Heinonen et al.	1	7	calcaneus		secondary	dexa
21	Heinonen et al.	1	8	radius-distal		secondary	dexa
21	Heinonen et al.	1	9	body weight		secondary	
21	Heinonen et al.	1	10	body mass index		secondary	
21	Heinonen et al.	1	11	percent body fat		secondary	
21	Heinonen et al.	1	12	lean body mass		secondary	
21	Heinonen et al.	1	13	aerobic fitness		secondary	
21	Heinonen et al.	1	14	calcium intake		secondary	
21	Heinonen et al.	1	15	muscular strength	trunk	secondary	
21	Heinonen et al.	1	16	muscular strength	trunk	secondary	
21	Heinonen et al.	1	17	muscular strength-lower		secondary	
21	Heinonen et al.	1	18	muscular strength-upper		secondary	
21	Heinonen et al.	1	19	muscular power-lower		secondary	
21	Heinonen et al.	1	20	muscular power-lower		secondary	
21	Heinonen et al.	1	21	balance-dynamic		secondary	
951	Heinonen et al.	1	1	lumbar spine		primary	dexa
951	Heinonen et al.	1	2	femoral neck		primary	dexa
951	Heinonen et al.	1	3	calcaneus		secondary	dexa
951	Heinonen et al.	1	4	radius-distal		secondary	dexa
951	Heinonen et al.	1	5	body weight		secondary	
951	Heinonen et al.	1	6	body mass index		secondary	
951	Heinonen et al.	1	7	percent body fat		secondary	
951	Heinonen et al.	1	8	lean body mass		secondary	
951	Heinonen et al.	1	9	calcium intake		secondary	

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951	Heinonen et al.	1	10	muscular strength-upper	trunk extension	secondary	
951	Heinonen et al.	1	11	muscular strength-upper	trunk flexion	secondary	
951	Heinonen et al.	1	12	muscular strength-lower	leg press	secondary	
951	Heinonen et al.	1	13	muscular strength-upper	elbow flexion	secondary	
951	Heinonen et al.	1	14	aerobic fitness		secondary	
951	Heinonen et al.	2	1	lumbar spine		primary	dexa
951	Heinonen et al.	2	2	femoral neck		primary	dexa
951	Heinonen et al.	2	3	calcaneus		secondary	dexa
951	Heinonen et al.	2	4	radius-distal		secondary	dexa
951	Heinonen et al.	2	5	body weight		secondary	
951	Heinonen et al.	2	6	body mass index		secondary	
951	Heinonen et al.	2	7	percent body fat		secondary	
951	Heinonen et al.	2	8	calcium intake		secondary	
951	Heinonen et al.	2	9	muscular strength-upper	trunk extension	secondary	
951	Heinonen et al.	2	10	muscular strength-upper	trunk flexion	secondary	
951	Heinonen et al.	2	11	muscular strength-lower	leg press	secondary	
951	Heinonen et al.	2	12	muscular strength-upper	elbow flexion	secondary	
951	Heinonen et al.	2	13	aerobic fitness		secondary	
1019	Hong	1	1	hip-total		secondary	dexa
1019	Hong	1	2	femoral neck		primary	dexa
1019	Hong	1	3	intertrochanter(ic)		secondary	dexa
1019	Hong	1	4	lumbar spine	L2-L4	primary	dexa
1019	Hong	1	5	body weight		secondary	other
1019	Hong	1	6	body mass index		secondary	other
1019	Hong	1	7	muscular strength-upper		secondary	other
1019	Hong	1	8	muscular strength-lower		secondary	other
1019	Hong	1	9	balance-static		secondary	other
1019	Hong	1	10	balance-static		secondary	other
1019	Hong	1	11	balance-static		secondary	other
1019	Hong	1	12	lean body mass		secondary	dexa
1019	Hong	2	1	hip-total		secondary	dexa
1019	Hong	2	2	femoral neck		primary	dexa
1019	Hong	2	3	intertrochanter(ic)		secondary	dexa
1019	Hong	2	4	lumbar spine	L2-L4	primary	dexa
1019	Hong	2	5	body weight		secondary	other
1019	Hong	2	6	body mass index		secondary	other
1019	Hong	2	7	muscular strength-upper		secondary	other
1019	Hong	2	8	muscular strength-lower		secondary	other
1019	Hong	2	9	balance-static		secondary	other
1019	Hong	2	10	balance-static		secondary	other

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1019	Hong	2	11	balance-static		secondary	other
1019	Hong	2	12	lean body mass		secondary	dexa
1019	Hong	3	1	hip-total		secondary	dexa
1019	Hong	3	2	femoral neck		primary	dexa
1019	Hong	3	3	intertrochanter(ic)		secondary	dexa
1019	Hong	3	4	lumbar spine	L2-L4	primary	dexa
1019	Hong	3	5	body weight		secondary	other
1019	Hong	3	6	body mass index		secondary	other
1019	Hong	3	7	muscular strength-upper		secondary	other
1019	Hong	3	8	muscular strength-lower		secondary	other
1019	Hong	3	9	balance-static		secondary	other
1019	Hong	3	10	balance-static		secondary	other
1019	Hong	3	11	balance-static		secondary	other
1019	Hong	3	12	lean body mass		secondary	dexa
1019	Hong	4	1	hip-total		secondary	dexa
1019	Hong	4	2	femoral neck		primary	dexa
1019	Hong	4	3	intertrochanter(ic)		secondary	dexa
1019	Hong	4	4	lumbar spine	L2-L4	primary	dexa
1019	Hong	4	5	body weight		secondary	other
1019	Hong	4	6	body mass index		secondary	other
1019	Hong	4	7	muscular strength-upper		secondary	other
1019	Hong	4	8	muscular strength-lower		secondary	other
1019	Hong	4	9	balance-static		secondary	other
1019	Hong	4	10	balance-static		secondary	other
1019	Hong	4	11	balance-static		secondary	other
1019	Hong	4	12	lean body mass		secondary	dexa
135	Iwamoto et al.	1	1	body weight		secondary	other
135	Iwamoto et al.	1	2	body mass index		secondary	other
135	Iwamoto et al.	1	3	lumbar spine	L2-L4	primary	dexa
819	Jessup et al.	1	1	femoral neck		primary	dexa
819	Jessup et al.	1	2	lumbar spine		primary	dexa
819	Jessup et al.	1	3	balance-static		secondary	dexa
819	Jessup et al.	1	4	muscular strength		secondary	other
819	Jessup et al.	1	5	body weight		secondary	other
827	Kemmler et al.	1	1	body weight		secondary	other
827	Kemmler et al.	1	2	percent body fat		secondary	dexa
827	Kemmler et al.	1	3	calcium intake		secondary	other
827	Kemmler et al.	1	4	aerobic fitness		secondary	other
827	Kemmler et al.	1	5	lumbar spine		primary	dexa
827	Kemmler et al.	1	6	femoral neck		primary	dexa

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827	Kemmler et al.	1	7	fractures		secondary	other
205	Kerr et al.	1	1	body weight		secondary	other
205	Kerr et al.	1	2	whole body		secondary	dexa
205	Kerr et al.	1	3	percent body fat		secondary	
205	Kerr et al.	1	4	lean body mass		secondary	
205	Kerr et al.	1	5	trochanter(ic)		secondary	dexa
205	Kerr et al.	1	6	intertrochanter(ic)		secondary	dexa
205	Kerr et al.	1	7	femoral neck		primary	dexa
205	Kerr et al.	1	8	ward's triangle		secondary	dexa
205	Kerr et al.	1	9	radius-ultra-distal		secondary	dexa
205	Kerr et al.	1	10	radius-mid		secondary	dexa
205	Kerr et al.	1	11	radius-1/3		secondary	dexa
205	Kerr et al.	1	12	muscular strength-lower	hip extension	secondary	other
205	Kerr et al.	1	13	muscular strength-lower	hip flexion	secondary	other
205	Kerr et al.	1	14	muscular strength-lower	hip abduction	secondary	other
205	Kerr et al.	1	15	muscular strength-lower	hip adduction	secondary	other
205	Kerr et al.	1	16	muscular strength-lower	leg press	secondary	other
205	Kerr et al.	1	17	muscular strength-upper	wrist curl	secondary	other
205	Kerr et al.	1	18	muscular strength-upper	reverse wrist curl	secondary	other
205	Kerr et al.	1	19	muscular strength-upper	wrist pronation/supination	secondary	other
205	Kerr et al.	1	20	muscular strength-upper	biceps curl	secondary	other
205	Kerr et al.	1	21	muscular strength-upper	triceps push down	secondary	other
205	Kerr et al.	2	1	body weight		secondary	other
205	Kerr et al.	2	2	whole body		secondary	dexa
205	Kerr et al.	2	3	percent body fat		secondary	
205	Kerr et al.	2	4	lean body mass		secondary	
205	Kerr et al.	2	5	trochanter(ic)		secondary	dexa
205	Kerr et al.	2	6	intertrochanter(ic)		secondary	dexa
205	Kerr et al.	2	7	femoral neck		primary	dexa
205	Kerr et al.	2	8	ward's triangle		secondary	dexa
205	Kerr et al.	2	9	radius-ultra-distal		secondary	dexa
205	Kerr et al.	2	10	radius-mid		secondary	dexa
205	Kerr et al.	2	11	radius-1/3		secondary	dexa
205	Kerr et al.	2	12	muscular strength-lower	hip extension	secondary	other
205	Kerr et al.	2	13	muscular strength-lower	hip flexion	secondary	other
205	Kerr et al.	2	14	muscular strength-lower	hip abduction	secondary	other
205	Kerr et al.	2	15	muscular strength-lower	hip adduction	secondary	other
205	Kerr et al.	2	16	muscular strength-lower	leg press	secondary	other
205	Kerr et al.	2	17	muscular strength-upper	wrist curl	secondary	other
205	Kerr et al.	2	18	muscular strength-upper	reverse wrist curl	secondary	other

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205	Kerr et al.	2	19	muscular strength-upper	wrist pronation/supination	secondary	other
205	Kerr et al.	2	20	muscular strength-upper	biceps curl	secondary	other
205	Kerr et al.	2	21	muscular strength-upper	triceps push down	secondary	other
322	Kerr et al.	1	1	body weight		secondary	other
322	Kerr et al.	1	2	percent body fat		secondary	other
322	Kerr et al.	1	3	lean body mass		secondary	other
322	Kerr et al.	1	4	lumbar spine	L1-L4	primary	dexa
322	Kerr et al.	1	5	hip-total		secondary	dexa
322	Kerr et al.	1	6	trochanter(ic)		secondary	dexa
322	Kerr et al.	1	7	intertrochanter(ic)		secondary	dexa
322	Kerr et al.	1	8	femoral neck		primary	dexa
322	Kerr et al.	1	9	radius-ultra-distal		secondary	dexa
322	Kerr et al.	1	10	radius-mid		secondary	dexa
322	Kerr et al.	1	11	radius-1/3		secondary	dexa
322	Kerr et al.	1	12	whole body		secondary	dexa
322	Kerr et al.	2	1	body weight		secondary	other
322	Kerr et al.	2	2	percent body fat		secondary	other
322	Kerr et al.	2	3	lean body mass		secondary	other
322	Kerr et al.	2	4	lumbar spine	L1-L4	primary	dexa
322	Kerr et al.	2	5	hip-total		secondary	dexa
322	Kerr et al.	2	6	trochanter(ic)		secondary	dexa
322	Kerr et al.	2	7	intertrochanter(ic)		secondary	dexa
322	Kerr et al.	2	8	femoral neck		primary	dexa
322	Kerr et al.	2	9	radius-ultra-distal		secondary	dexa
322	Kerr et al.	2	10	radius-mid		secondary	dexa
322	Kerr et al.	2	11	radius-1/3		secondary	dexa
322	Kerr et al.	2	12	whole body		secondary	dexa
1113	Kukuljan et al.	1	1	body weight		secondary	other
1113	Kukuljan et al.	1	2	body mass index		secondary	other
1113	Kukuljan et al.	1	3	calcium intake		secondary	other
1113	Kukuljan et al.	1	4	vitamin D intake		secondary	other
1113	Kukuljan et al.	1	5	lumbar spine	L1-L4	primary	dexa
1113	Kukuljan et al.	1	6	femoral neck		primary	dexa
1113	Kukuljan et al.	1	7	hip-total		secondary	dexa
1113	Kukuljan et al.	2	1	body weight		secondary	other
1113	Kukuljan et al.	2	2	body mass index		secondary	other
1113	Kukuljan et al.	2	3	calcium intake		secondary	other
1113	Kukuljan et al.	2	4	vitamin D intake		secondary	other
1113	Kukuljan et al.	2	5	lumbar spine	L1-L4	primary	dexa
1113	Kukuljan et al.	2	6	femoral neck		primary	dexa

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1113	Kukuljan et al.	2	7	hip-total		secondary	dexa
1118	Liang et al.	1	1	body weight		secondary	other
1118	Liang et al.	1	2	body mass index		secondary	other
1118	Liang et al.	1	3	aerobic fitness		secondary	other
1118	Liang et al.	1	4	os calcis		secondary	dexa
1118	Liang et al.	1	5	wrist		secondary	dexa
1118	Liang et al.	1	6	lower limb		secondary	dexa
1118	Liang et al.	1	7	hip-total		secondary	dexa
1118	Liang et al.	1	8	femoral neck		primary	dexa
1118	Liang et al.	1	9	trochanter(ic)		secondary	dexa
1118	Liang et al.	1	10	ward's triangle		secondary	dexa
1118	Liang et al.	1	11	lumbar spine	L1-L4	primary	dexa
1118	Liang et al.	1	12	percent body fat		secondary	dexa
1118	Liang et al.	1	13	lean body mass		secondary	dexa
1118	Liang et al.	1	14	calcium intake		secondary	other
1118	Liang et al.	1	15	muscular strength-lower		secondary	other
1118	Liang et al.	2	1	body weight		secondary	other
1118	Liang et al.	2	2	body mass index		secondary	other
1118	Liang et al.	2	3	aerobic fitness		secondary	other
1118	Liang et al.	2	4	os calcis		secondary	dexa
1118	Liang et al.	2	5	wrist		secondary	dexa
1118	Liang et al.	2	6	lower limb		secondary	dexa
1118	Liang et al.	2	7	hip-total		secondary	dexa
1118	Liang et al.	2	8	femoral neck		primary	dexa
1118	Liang et al.	2	9	trochanter(ic)		secondary	dexa
1118	Liang et al.	2	10	ward's triangle		secondary	dexa
1118	Liang et al.	2	11	lumbar spine	L1-L4	primary	dexa
1118	Liang et al.	2	12	percent body fat		secondary	dexa
1118	Liang et al.	2	13	lean body mass		secondary	dexa
1118	Liang et al.	2	14	calcium intake		secondary	other
1118	Liang et al.	2	15	muscular strength-lower		secondary	other
85	Liu-Ambrose et al.	1	1	body weight		secondary	
85	Liu-Ambrose et al.	1	2	lean body mass		secondary	dexa
85	Liu-Ambrose et al.	1	3	other	fat mass	secondary	dexa
85	Liu-Ambrose et al.	1	4	hip-total		secondary	dexa
85	Liu-Ambrose et al.	1	5	femoral neck		primary	dexa
85	Liu-Ambrose et al.	1	6	trochanter(ic)		secondary	dexa
85	Liu-Ambrose et al.	1	7	other	tibia - cortical content (50%	secondary	ppct
85	Liu-Ambrose et al.	1	8	other	tibia - cortical area (50% tib	secondary	ppct
85	Liu-Ambrose et al.	1	9	other	tibia - cortical density	secondary	ppct

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85	Liu-Ambrose et al.	1	10	other	tibia - stress strain index (50%	secondary	ppct
85	Liu-Ambrose et al.	1	11	other	tibia - total content (10% tib	secondary	ppct
85	Liu-Ambrose et al.	1	12	other	tibia - total area (10% tibia)	secondary	ppct
85	Liu-Ambrose et al.	1	13	other	tibia - total density (10% tib	secondary	ppct
85	Liu-Ambrose et al.	1	14	other	radius - cortical content (30%	secondary	ppct
85	Liu-Ambrose et al.	1	15	other	radius - cortical area (30% r	secondary	ppct
85	Liu-Ambrose et al.	1	16	other	radius - cortical density (30%	secondary	ppct
85	Liu-Ambrose et al.	1	17	other	radius - stress strain index (3	secondary	ppct
85	Liu-Ambrose et al.	1	18	other	radius - total content (10% r	secondary	ppct
85	Liu-Ambrose et al.	1	19	other	radius - total area (10% radi	secondary	ppct
85	Liu-Ambrose et al.	1	20	other	radius - total density (10% r	secondary	ppct
85	Liu-Ambrose et al.	2	1	body weight		secondary	
85	Liu-Ambrose et al.	2	2	lean body mass		secondary	dexa
85	Liu-Ambrose et al.	2	3	other	fat mass	secondary	dexa
85	Liu-Ambrose et al.	2	4	hip-total		secondary	dexa
85	Liu-Ambrose et al.	2	5	femoral neck		primary	dexa
85	Liu-Ambrose et al.	2	6	trochanter(ic)		secondary	dexa
85	Liu-Ambrose et al.	2	7	other	tibia - cortical content (50%	secondary	ppct
85	Liu-Ambrose et al.	2	8	other	tibia - cortical area (50% tib	secondary	ppct
85	Liu-Ambrose et al.	2	9	other	tibia - cortical density	secondary	ppct
85	Liu-Ambrose et al.	2	10	other	tibia - stress strain index (50	secondary	ppct
85	Liu-Ambrose et al.	2	11	other	tibia - total content (10% tib	secondary	ppct
85	Liu-Ambrose et al.	2	12	other	tibia - total area (10% tibia)	secondary	ppct
85	Liu-Ambrose et al.	2	13	other	tibia - total density (10% tib	secondary	ppct
85	Liu-Ambrose et al.	2	14	other	radius - cortical content (30%	secondary	ppct
85	Liu-Ambrose et al.	2	15	other	radius - cortical area (30% r	secondary	ppct
85	Liu-Ambrose et al.	2	16	other	radius - cortical density (30%	secondary	ppct
85	Liu-Ambrose et al.	2	17	other	radius - stress strain index (3	secondary	ppct
85	Liu-Ambrose et al.	2	18	other	radius - total content (10% r	secondary	ppct
85	Liu-Ambrose et al.	2	19	other	radius - total area (10% radi	secondary	ppct
85	Liu-Ambrose et al.	2	20	other	radius - total density (10% r	secondary	ppct
184	Lohman et al.	1	1	whole body		secondary	dexa
184	Lohman et al.	1	2	lumbar spine	l2-l4	primary	dexa
184	Lohman et al.	1	3	femoral neck		primary	dexa
184	Lohman et al.	1	4	trochanter(ic)		secondary	dexa
184	Lohman et al.	1	5	ward's triangle		secondary	dexa
184	Lohman et al.	1	6	radius		secondary	dexa
184	Lohman et al.	1	7	body weight		secondary	
184	Lohman et al.	1	8	body mass index		secondary	
184	Lohman et al.	1	9	percent body fat		secondary	

Outcome Characteristics

184	Lohman et al.	1	10	lean body mass		secondary	
1120	Marques et al.	1	1	calcium intake		secondary	other
1120	Marques et al.	1	2	vitamin D intake		secondary	other
1120	Marques et al.	1	3	body mass index		secondary	other
1120	Marques et al.	1	4	lean body mass		secondary	dexa
1120	Marques et al.	1	5	percent body fat		secondary	dexa
1120	Marques et al.	1	6	balance-dynamic		secondary	other
1120	Marques et al.	1	7	balance-static		secondary	other
1120	Marques et al.	1	8	muscular strength-lower		secondary	other
1120	Marques et al.	1	9	muscular strength-lower		secondary	other
1120	Marques et al.	1	10	muscular strength-lower		secondary	other
1120	Marques et al.	1	11	muscular strength-lower		secondary	other
1120	Marques et al.	1	12	femoral neck		primary	dexa
1120	Marques et al.	1	13	trochanter(ic)		secondary	dexa
1120	Marques et al.	1	14	intertrochanter(ic)		secondary	dexa
1120	Marques et al.	1	15	hip-total		secondary	dexa
1120	Marques et al.	2	1	calcium intake		secondary	other
1120	Marques et al.	2	2	vitamin D intake		secondary	other
1120	Marques et al.	2	3	body mass index		secondary	other
1120	Marques et al.	2	4	lean body mass		secondary	dexa
1120	Marques et al.	2	5	percent body fat		secondary	dexa
1120	Marques et al.	2	6	balance-dynamic		secondary	other
1120	Marques et al.	2	7	balance-static		secondary	other
1120	Marques et al.	2	8	muscular strength-lower		secondary	other
1120	Marques et al.	2	9	muscular strength-lower		secondary	other
1120	Marques et al.	2	10	muscular strength-lower		secondary	other
1120	Marques et al.	2	11	muscular strength-lower		secondary	other
1120	Marques et al.	2	12	femoral neck		primary	dexa
1120	Marques et al.	2	13	trochanter(ic)		secondary	dexa
1120	Marques et al.	2	14	intertrochanter(ic)		secondary	dexa
1120	Marques et al.	2	15	hip-total		secondary	dexa
1121	Marques et al.	1	1	calcium intake		secondary	other
1121	Marques et al.	1	2	vitamin D intake		secondary	other
1121	Marques et al.	1	3	body mass index		secondary	other
1121	Marques et al.	1	4	percent body fat		secondary	dexa
1121	Marques et al.	1	5	lean body mass		secondary	dexa
1121	Marques et al.	1	6	aerobic fitness		secondary	other
1121	Marques et al.	1	7	muscular strength-upper		secondary	other
1121	Marques et al.	1	8	balance-dynamic		secondary	other
1121	Marques et al.	1	9	balance-static		secondary	other

Outcome Characteristics

1121	Marques et al.	1	10	muscular strength-lower		secondary	other
1121	Marques et al.	1	11	muscular strength-lower		secondary	other
1121	Marques et al.	1	12	muscular strength-lower		secondary	other
1121	Marques et al.	1	13	muscular strength-lower		secondary	other
1121	Marques et al.	1	14	muscular strength-lower		secondary	other
1121	Marques et al.	1	15	muscular strength-lower		secondary	other
1121	Marques et al.	1	16	muscular strength-lower		secondary	other
1121	Marques et al.	1	17	muscular strength-lower		secondary	other
1121	Marques et al.	1	18	muscular strength-lower		secondary	other
1121	Marques et al.	1	19	femoral neck		primary	dexa
1121	Marques et al.	1	20	trochanter(ic)		secondary	dexa
1121	Marques et al.	1	21	intertrochanter(ic)		secondary	dexa
1121	Marques et al.	1	22	hip-total		secondary	dexa
1121	Marques et al.	1	23	lumbar spine	L1-L4	primary	dexa
19	Martin & Notelovitz	1	1	lumbar spine		primary	dpa
19	Martin & Notelovitz	1	2	body weight		secondary	
19	Martin & Notelovitz	1	3	body mass index		secondary	
19	Martin & Notelovitz	1	4	aerobic fitness		secondary	
19	Martin & Notelovitz	2	1	lumbar spine		primary	dpa
19	Martin & Notelovitz	2	2	body weight		secondary	
19	Martin & Notelovitz	2	3	body mass index		secondary	
19	Martin & Notelovitz	2	4	aerobic fitness		secondary	
170	Nelson et al.	1	1	femoral neck		primary	dexa
170	Nelson et al.	1	2	lumbar spine		primary	dexa
170	Nelson et al.	1	3	body weight		secondary	
170	Nelson et al.	1	4	body mass index		secondary	
170	Nelson et al.	1	5	calcium intake		secondary	
170	Nelson et al.	1	6	muscular strength-lower	double leg press	secondary	other
170	Nelson et al.	1	7	muscular strength-lower	knee extension	secondary	other
170	Nelson et al.	1	8	muscular strength-upper	lateral pulldown	secondary	other
170	Nelson et al.	1	9	muscular strength-upper	back extension	secondary	other
170	Nelson et al.	1	10	muscular strength-upper	abdominal flexion	secondary	other
170	Nelson et al.	1	11	balance-dynamic		secondary	other
170	Nelson et al.	1	12	other	physical activity score	secondary	other
863	Newstead et al.	1	1	body weight		secondary	
863	Newstead et al.	1	2	body mass index		secondary	
863	Newstead et al.	1	3	femoral neck		primary	dexa
863	Newstead et al.	1	4	hip-total		secondary	dexa
863	Newstead et al.	1	5	lumbar spine	L1-L4	primary	dexa
365	Prince et al.	1	1	spine		secondary	dexa

Outcome Characteristics

365	Prince et al.	1	2	hip-total		secondary	dexa
365	Prince et al.	1	3	lower limb		secondary	dexa
365	Prince et al.	1	4	trochanter(ic)		secondary	dexa
365	Prince et al.	1	5	intertrochanter(ic)		secondary	dexa
365	Prince et al.	1	6	femoral neck		primary	dexa
365	Prince et al.	1	7	tibia-mid		secondary	dexa
365	Prince et al.	1	8	ultradistal		secondary	dexa
174	Rhodes et al.	1	1	body weight		secondary	
174	Rhodes et al.	1	2	femoral neck		primary	dexa
174	Rhodes et al.	1	3	ward's triangle		secondary	dexa
174	Rhodes et al.	1	4	trochanter(ic)		secondary	dexa
174	Rhodes et al.	1	5	lumbar spine	L2-L4	primary	dexa
174	Rhodes et al.	1	6	muscular strength-upper		secondary	other
174	Rhodes et al.	1	7	muscular strength-upper	bench press	secondary	other
174	Rhodes et al.	1	8	muscular strength-lower	leg press	secondary	other
174	Rhodes et al.	1	9	muscular strength-upper	biceps curl	secondary	other
174	Rhodes et al.	1	10	muscular strength-upper	triceps push down	secondary	other
174	Rhodes et al.	1	11	muscular strength-lower	quadriceps curl	secondary	other
30	Villareal et al.	1	1	body mass index		secondary	other
30	Villareal et al.	1	2	aerobic fitness		secondary	other
30	Villareal et al.	1	3	body weight		secondary	other
30	Villareal et al.	1	4	lean body mass		secondary	dexa
30	Villareal et al.	1	5	other	fat mass	secondary	dexa
30	Villareal et al.	1	6	hip-total		secondary	dexa
30	Villareal et al.	1	7	muscular strength		secondary	other
30	Villareal et al.	1	8	balance-dynamic		secondary	other
30	Villareal et al.	1	9	balance-static		secondary	other
30	Villareal et al.	1	10	whole body		secondary	dexa
30	Villareal et al.	1	11	lumbar spine		primary	dexa
913	Villareal et al.	1	1	body weight		secondary	
913	Villareal et al.	1	2	aerobic fitness		secondary	
913	Villareal et al.	1	3	hip-total		secondary	dexa
913	Villareal et al.	1	4	trochanter(ic)		secondary	dexa
913	Villareal et al.	1	5	femoral neck		primary	dexa
913	Villareal et al.	1	6	lumbar spine	L2-L4	primary	dexa
913	Villareal et al.	1	7	whole body		secondary	dexa
913	Villareal et al.	1	8	calcium intake		secondary	
913	Villareal et al.	1	9	vitamin D intake		secondary	
920	Warren et al.	1	1	muscular strength-upper	bench press	secondary	other
920	Warren et al.	1	2	muscular strength-lower	leg press	secondary	other

Outcome Characteristics

920	Warren et al.	1	3	body weight		secondary	other
920	Warren et al.	1	4	other	fat mass	secondary	dexa
920	Warren et al.	1	5	lean body mass		secondary	dexa
920	Warren et al.	1	6	trochanter(ic)		secondary	dexa
920	Warren et al.	1	7	femoral neck		primary	dexa
920	Warren et al.	1	8	femur		secondary	dexa
920	Warren et al.	1	9	lumbar spine		primary	dexa
239	Weaver et al.	1	1	aerobic fitness		secondary	other
239	Weaver et al.	1	2	muscular strength		secondary	other
239	Weaver et al.	1	3	lean body mass		secondary	dexa
239	Weaver et al.	1	4	lumbar spine	L2-L4	primary	dexa
239	Weaver et al.	1	5	radius		secondary	spa
239	Weaver et al.	1	6	femoral neck		primary	dexa
239	Weaver et al.	1	7	trochanter(ic)-greater		secondary	dexa
239	Weaver et al.	1	8	ward's triangle		secondary	dexa
239	Weaver et al.	1	9	body weight		secondary	dexa
239	Weaver et al.	1	10	calcium intake		secondary	other
922	Westby et al.	1	1	body weight		secondary	
922	Westby et al.	1	2	lumbar spine	L2-L4	primary	dexa
922	Westby et al.	1	3	femoral neck		primary	dexa
105	Wu et al.	1	1	body weight		secondary	
105	Wu et al.	1	2	body mass index		secondary	
105	Wu et al.	1	3	calcium intake		secondary	
105	Wu et al.	1	4	vitamin D intake		secondary	
105	Wu et al.	1	5	whole body		secondary	dexa
105	Wu et al.	1	6	lean body mass		secondary	dexa
105	Wu et al.	1	7	other	fat mass	secondary	dexa
105	Wu et al.	1	8	lumbar spine	L2-L4	primary	dexa
105	Wu et al.	1	9	hip-total		secondary	dexa
105	Wu et al.	1	10	femoral neck		primary	dexa
105	Wu et al.	1	11	trochanter(ic)		secondary	dexa
930	Zeilman III	1	1	body weight		secondary	other
930	Zeilman III	1	2	body mass index		secondary	other
930	Zeilman III	1	3	lumbar spine	L2-L4	primary	dexa
930	Zeilman III	1	4	hip-total		secondary	dexa
930	Zeilman III	1	5	femoral neck		primary	dexa

Outcome Characteristics

outcome_test_desc	reliability	metric	metric_other
Lunar Prodigy Advance, GE Lunar	1.4% (coefficient of variation)	gm_cm_2	
Lunar Prodigy Advance, GE Lunar	1.8% (coefficient of variation)	gm_cm_2	
Lunar Prodigy Advance, GE Lunar	1.3% (coefficient of variation)	gm_cm_2	
Lunar Prodigy Advance, GE Lunar	2.3% (coefficient of variation)	gm_cm_2	
light indoor clothing using digital scales		kilograms	
derived from measures of height and weight		kgmsquared	
		percentage	
Lunar Prodigy Advance, GE Lunar	1.4% (coefficient of variation)	gm_cm_2	
Lunar Prodigy Advance, GE Lunar	1.8% (coefficient of variation)	gm_cm_2	
Lunar Prodigy Advance, GE Lunar	1.3% (coefficient of variation)	gm_cm_2	
Lunar Prodigy Advance, GE Lunar	2.3% (coefficient of variation)	gm_cm_2	
light indoor clothing using digital scales		kilograms	
derived from measures of height and weight		kgmsquared	
		percentage	
Lunar Prodigy Advance, GE Lunar	1.4% (coefficient of variation)	gm_cm_2	
Lunar Prodigy Advance, GE Lunar	1.8% (coefficient of variation)	gm_cm_2	
Lunar Prodigy Advance, GE Lunar	1.3% (coefficient of variation)	gm_cm_2	
Lunar Prodigy Advance, GE Lunar	2.3% (coefficient of variation)	gm_cm_2	
light indoor clothing using digital scales		kilograms	
derived from measures of height and weight		kgmsquared	
		percentage	
	1.4% (coefficient of variation)	gm_cm_2	
	1.4% (coefficient of variation)	gm_cm_2	
	2.0% (coefficient of variation)	gm_cm_2	
		kilograms	
		kgmsquared	
		watts	
one foot, 20 seconds, other foot struck two hydraulic switches		other	
	1.4% (coefficient of variation)	gm_cm_2	
	1.4% (coefficient of variation)	gm_cm_2	
	2.0% (coefficient of variation)	gm_cm_2	
		kilograms	
		kgmsquared	
		milligrams	
	1.4% (coefficient of variation)	gm_cm_2	
	1.4% (coefficient of variation)	gm_cm_2	
	2.0% (coefficient of variation)	gm_cm_2	
		kilograms	
		kgmsquared	

Outcome Characteristics

		milligrams	
one foot, 20 seconds, other foot struck two hydraulic switches		other	
derived from measures of height and weight		kgmsquared	
chair stand test		other	seconds
Lunar Prodigy 10631 GE Medical Systems	1% (precision)	gm_cm_2	
Lunar Prodigy 10631 GE Medical Systems	1% (precision)	gm_cm_2	
Lunar Prodigy 10631 GE Medical Systems		gm_cm_2	
Lunar Prodigy 10631 GE Medical Systems		gm_cm_2	
chair stand test		other	seconds
Lunar Prodigy 10631 GE Medical Systems	1% (precision)	gm_cm_2	
Lunar Prodigy 10631 GE Medical Systems	1% (precision)	gm_cm_2	
Lunar Prodigy 10631 GE Medical Systems		gm_cm_2	
Lunar Prodigy 10631 GE Medical Systems		gm_cm_2	
derived from measures of height and weight		kgmsquared	
Hologic		gm_cm_2	
Hologic		gm_cm_2	
vertical jump		centimeters	
DEA-DTX 200 Osteometer		gm_cm_2	
DEA-DTX 200 Osteometer		gm_cm_2	
1 RM for lower body strength		kilograms	
1 RM for upper body strength		kilograms	
		kilograms	
derived from measures of height and weight		kgmsquared	
calculated using equations from Woo, Ho, and Sham, 2001		percentage	
		kilograms	
		kilograms	
incremental treadmill test (INBRAMED, 10200ATL) to volitional exhaustion		mlkgmin	
incremental treadmill test (INBRAMED, 10200ATL) to volitional exhaustion		other	seconds
1RM maximum (arm curl)		kilograms	
1RM maximum (knee extension)		kilograms	
isometric strength (knee extensors) using an isokinetic dynamometer (Cybex Norm)		other	newton meters
Hologic QDR 4500A		gm_cm_2	
Hologic QDR 4500A		gm_cm_2	
Hologic QDR 4500A		gm_cm_2	
Hologic QDR 4500A		gm_cm_2	
Hologic QDR 4500A		gm_cm_2	
		kilograms	
		kilograms	
incremental treadmill test (INBRAMED, 10200ATL) to volitional exhaustion		mlkgmin	
incremental treadmill test (INBRAMED, 10200ATL) to volitional exhaustion		other	seconds

Outcome Characteristics

1RM maximum (arm curl)		kilograms	
1RM maximum (knee extension)		kilograms	
isometric strength (knee extensors) using an isokinetic dynamometer (Cybex Norm)		other	newton meters
Hologic QDR 4500A		gm_cm_2	
Hologic QDR 4500A		gm_cm_2	
Hologic QDR 4500A		gm_cm_2	
Hologic QDR 4500A		gm_cm_2	
Hologic QDR 4500A		gm_cm_2	
	1.4 (coefficient of variation)	gm_cm_2	
	1.9 (coefficient of variation)	gm_cm_2	
	2.7 (coefficient of variation)	gm_cm_2	
		kilograms	
		kgmsquared	
		milligrams	
light clothing with shoes off		kilograms	
derived from measures of height and weight		kgmsquared	
Hologic QDR-2000	2.95% (coefficient of variation)	percentage	
Food frequency questionnaire; current use of calcium and other nutritional supplements; Block Food Frequency Questionnaire		milligrams	
Food frequency questionnaire; current use of calcium and other nutritional supplements; Block Food Frequency Questionnaire		other	micrograms
Hologic QDR-2000	0.7% (coefficient of variation)	gm_cm_2	
Hologic QDR-2000	1.0% (coefficient of variation)	gm_cm_2	
Hologic QDR-2000		gm_cm_2	
Hologic QDR-2000		gm_cm_2	
Hologic QDR-2000		gm_cm_2	
Hologic QDR-2000	0.5% (coefficient of variation)	gm_cm_2	
1 RM bench press test		kilograms	
1 RM leg press test		kilograms	
electronic scale (SECA707) to plus or minus 0.2 kg		kilograms	
derived from measures of height and weight		kgmsquared	
Lunar Prodigy (GE)	0.9% (coefficient of variation)	kilograms	
Lunar Prodigy (GE)	0.4% (coefficient of variation)	kilograms	
Lunar Prodigy (GE)	0.4% (coefficient of variation)	percentage	
Lunar Prodigy (GE)	0.1% (coefficient of variation)	gm_cm_2	
Lunar Prodigy (GE)		gm_cm_2	
Lunar Prodigy (GE)		gm_cm_2	
Lunar Prodigy (GE)		gm_cm_2	
Lunar Prodigy (GE)		gm_cm_2	
Lunar Prodigy (GE)		gm_cm_2	
standard equipment in stocking feet and underwear		kilograms	
derived from measures of height and weight		kgmsquared	

Outcome Characteristics

Lunar DPX-L	0.9% (coefficient of variation)	kilograms	
Lunar DPX-L	0.7% (coefficient of variation)	gm_cm_2	
Lunar DPX-L	1.0% (coefficient of variation)	gm_cm_2	
Lunar DPX-L	0.6% (coefficient of variation)	gm_cm_2	
Lunar DPX-L	0.8% (coefficient of variation)	gm_cm_2	
Lunar DPX-L	1.5% (coefficient of variation)	gm_cm_2	
Lunar DPX-L	1.2% (coefficient of variation)	gm_cm_2	
1RM handgrip strength using a tensiometer		newtons	
1RM knee extensor strength using a tensiometer		newtons	
30 meter walk			meters/second
timed standing balance on one leg		other	seconds
Berg Balance Scale		other	
standard height and weight measurements taken		kilograms	
skinfold calipers at biceps, triceps, subscapula, anterior-superior iliac spine	.835 (reliability)	percentage	
Hologic QDR-1000	1% (precision)	gm_cm_2	
Hologic QDR-1000	1-2% (precision)	gm_cm_2	
Hologic QDR-1000	1-2% (precision)	gm_cm_2	
Bruce treadmill test using Quinton Q55 treadmill		mlkgmin	
isokinetic knee extension using Cybex340	5.5% (reliability)	other	foot pounds
isokinetic knee flexion using Cybex340	7.5% (reliability)	other	foot pounds
isokinetic trunk extension using the Lumex Trunk Extension Flexion Unit	11.4% (reliability)	other	foot pounds
isokinetic trunk flexion using the Lumex Trunk Extension Flexion Unit	3.5% (reliability)	other	foot pounds
calibrated digital scale (SECA, model 770), accurate to 0.1 kg		kilograms	
derived from measures of height and weight		kgmsquared	
Lunar Model DPX-L		kilograms	
Lunar Model DPX-L		percentage	
Lunar Model DPX-L	2.4% (precision)	gm_cm_2	
Lunar Model DPX-L	2.4% (precision)	gm_cm_2	
Lunar Model DPX-L	1.8% (precision)	gm_cm_2	
Lunar Model DPX-L	0.8% (precision)	gm_cm_2	
calibrated digital scale (SECA, model 770), accurate to 0.1 kg		kilograms	
derived from measures of height and weight		kgmsquared	
Lunar Model DPX-L		kilograms	
Lunar Model DPX-L		percentage	
Lunar Model DPX-L	2.4% (precision)	gm_cm_2	
Lunar Model DPX-L	2.4% (precision)	gm_cm_2	
Lunar Model DPX-L	1.8% (precision)	gm_cm_2	
Lunar Model DPX-L	0.8% (precision)	gm_cm_2	
Lunar DP3	3% (precision error)	gm_cm_2	
		kilograms	

Outcome Characteristics

		percentage	
		kilograms	
		mlkgmin	
		milligrams	
Lunar DP3	3% (precision error)	gm_cm_2	
		kilograms	
		percentage	
		kilograms	
		mlkgmin	
		milligrams	
	0.5-0.8% (coefficient of variation)	gm_cm_2	
	0.5-0.8% (coefficient of variation)	gm_cm_2	
	0.5-0.8% (coefficient of variation)	gm_cm_2	
	0.5-0.8% (coefficient of variation)	gm_cm_2	
	0.5-0.8% (coefficient of variation)	gm_cm_2	
	0.5-0.8% (coefficient of variation)	gm_cm_2	
	0.5-0.8% (coefficient of variation)	gm_cm_2	
		kilograms	
		kgmsquared	
biceps, triceps, subscapularis, and suprailiac with a Harpenden skinfold caliper		percentage	
		kilograms	
estimated VO2 max from a 2 km walking test		mlkgmin	
3-day diet records		milligrams	
trunk extension with an arm dynamometer (Digitest, Muurame, Finland)		kilograms	
trunk flexion with an arm dynamometer (Digitest, Muurame, Finland)		kilograms	
leg extension with a leg press dynamometer (Tamtron, Tampere, Finland)		kilograms	
elbow flexion with an arm dynamometer (Digitest, Muurame, Finland)		kilograms	
leg extensor power with vertical counter-movement jump test/no weight (Newtest, Oulu, Finland)		other	meters/second
leg extensor power with vertical counter-movement jump test (10% more weight) (Newtest, Oulu, Finland)		other	meters/second
figure 8 running test around 2 poles, 10 meters apart		other	seconds
	0.7-1.7% (coefficient of variation)	gm_cm_2	
	0.7-1.7% (coefficient of variation)	gm_cm_2	
	0.7-1.7% (coefficient of variation)	gm_cm_2	
	0.7-1.7% (coefficient of variation)	gm_cm_2	
		kilograms	
		kgmsquared	
		percentage	
		kilograms	
		milligrams	

Outcome Characteristics

trunk extension with an arm dynamometer (Digitest, Muurame, Finland)		kilograms	
trunk flexion with an arm dynamometer (Digitest, Muurame, Finland)		kilograms	
leg extension with a leg press dynamometer (Tamtron, Tampere, Finland)		kilograms	
elbow flexion with an arm dynamometer (Digitest, Muurame, Finland)		kilograms	
maximum oxygen consumption using a bicylce ergometer test		litersmin	
	0.7-1.7% (coefficient of variation)	gm_cm_2	
	0.7-1.7% (coefficient of variation)	gm_cm_2	
	0.7-1.7% (coefficient of variation)	gm_cm_2	
	0.7-1.7% (coefficient of variation)	gm_cm_2	
		kilograms	
		kgmsquared	
		percentage	
		milligrams	
trunk extension with an arm dynamometer (Digitest, Muurame, Finland)		kilograms	
trunk flexion with an arm dynamometer (Digitest, Muurame, Finland)		kilograms	
leg extension with a leg press dynamometer (Tamtron, Tampere, Finland)		kilograms	
elbow flexion with an arm dynamometer (Digitest, Muurame, Finland)		kilograms	
maximum oxygen consumption using a bicylce ergometer test		litersmin	
Hologic QDR-4500		gm_cm_2	
Hologic QDR-4500		gm_cm_2	
Hologic QDR-4500		gm_cm_2	
Hologic QDR-4500		gm_cm_2	
wearing light clothing and without shoes or socks		kilograms	
derived from measures of height and weight		kgmsquared	
hangrip strength using a handgrip dynamometer (Takei Scientific Instruments)		kilograms	
quadriceps device		kilograms	
SMART Balance Master (NeuroCom)		other	1-100
single stance (average of both legs)		other	seconds
single stance (average of dominant leg)		other	seconds
Hologic QDR-4500		kilograms	
Hologic QDR-4500		gm_cm_2	
Hologic QDR-4500		gm_cm_2	
Hologic QDR-4500		gm_cm_2	
Hologic QDR-4500		gm_cm_2	
wearing light clothing and without shoes or socks		kilograms	
derived from measures of height and weight		kgmsquared	
hangrip strength using a handgrip dynamometer (Takei Scientific Instruments)		kilograms	
quadriceps device		kilograms	
SMART Balance Master (NeuroCom)		other	1-100
single stance (average of both legs)		other	seconds

Outcome Characteristics

single stance (average of dominant leg)		other	seconds
Hologic QDR-4500		kilograms	
Hologic QDR-4500		gm_cm_2	
Hologic QDR-4500		gm_cm_2	
Hologic QDR-4500		gm_cm_2	
Hologic QDR-4500		gm_cm_2	
wearing light clothing and without shoes or socks		kilograms	
derived from measures of height and weight		kgmsquared	
hangrip strength using a handgrip dynamometer (Takei Scientific Instruments)		kilograms	
quadriceps device		kilograms	
SMART Balance Master (NeuroCom)		other	1-100
single stance (average of both legs)		other	seconds
single stance (average of dominant leg)		other	seconds
Hologic QDR-4500		kilograms	
Hologic QDR-4500		gm_cm_2	
Hologic QDR-4500		gm_cm_2	
Hologic QDR-4500		gm_cm_2	
Hologic QDR-4500		gm_cm_2	
wearing light clothing and without shoes or socks		kilograms	
derived from measures of height and weight		kgmsquared	
hangrip strength using a handgrip dynamometer (Takei Scientific Instruments)		kilograms	
quadriceps device		kilograms	
SMART Balance Master (NeuroCom)		other	1-100
single stance (average of both legs)		other	seconds
single stance (average of dominant leg)		other	seconds
Hologic QDR-4500		kilograms	
		kilograms	
derived from measures of height and weight		kgmsquared	
Norland XR-26	1.14% (coefficient of variation)	gm_cm_2	
Norland Excell		gm_cm_2	
Norland Excell		gm_cm_2	
AccuSway OR6-7 computerized force platform		gm_cm_2	
mean of 1RM for 8 upper and lower body exercises		kilograms	
standard balance beam scale calibrated daily		kilograms	
digital scale wearing minimal clothing		kilograms	
Hologic QDR 4500		percentage	
4-day dietary protocols		milligrams	
maximal treadmill test		mlkgmin	
Hologic QDR 4500	0.9% (coefficient of variation)	gm_cm_2	
Hologic QDR 4500	1.0% (coefficient of variation)	gm_cm_2	

[illegible]

Outcome Characteristics

1RM maximum		kilograms	
1RM maximum		kilograms	
1RM maximum		kilograms	
		kilograms	
		percentage	
		kilograms	
Hologic QDR 4500	1.0% (coefficient of variation)	gm_cm_2	
Hologic QDR 4500		gm_cm_2	
Hologic QDR 4500	1.3% (coefficient of variation)	gm_cm_2	
Hologic QDR 4500	1.3% (coefficient of variation)	gm_cm_2	
Hologic QDR 4500	1.5% (coefficient of variation)	gm_cm_2	
Hologic QDR 4500	1.6% (coefficient of variation)	gm_cm_2	
Hologic QDR 4500	1.4% (coefficient of variation)	gm_cm_2	
Hologic QDR 4500	1.3% (coefficient of variation)	gm_cm_2	
Hologic QDR 2000	1.0% (coefficient of variation)	gm_cm_2	
		kilograms	
		percentage	
		kilograms	
Hologic QDR 4500	1.0% (coefficient of variation)	gm_cm_2	
Hologic QDR 4500		gm_cm_2	
Hologic QDR 4500	1.3% (coefficient of variation)	gm_cm_2	
Hologic QDR 4500	1.3% (coefficient of variation)	gm_cm_2	
Hologic QDR 4500	1.5% (coefficient of variation)	gm_cm_2	
Hologic QDR 4500	1.6% (coefficient of variation)	gm_cm_2	
Hologic QDR 4500	1.4% (coefficient of variation)	gm_cm_2	
Hologic QDR 4500	1.3% (coefficient of variation)	gm_cm_2	
Hologic QDR 2000	1.0% (coefficient of variation)	gm_cm_2	
digital scale		kilograms	
derived from measures of height and weight		kgmsquared	
3-day food diary (two weekdays and one weekend day)		milligrams	
3-day food diary (two weekdays and one weekend day)		other	micrograms
Lunar Prodigy		gm_cm_2	
Lunar Prodigy		gm_cm_2	
Lunar Prodigy		gm_cm_2	
digital scale		kilograms	
derived from measures of height and weight		kgmsquared	
3-day food diary (two weekdays and one weekend day)		milligrams	
3-day food diary (two weekdays and one weekend day)		other	micrograms
Lunar Prodigy		gm_cm_2	
Lunar Prodigy		gm_cm_2	

Outcome Characteristics

Lunar Prodigy		gm_cm_2	
without clothes in light clothing using a clinical scale (Detecto)		kilograms	
derived from measures of height and weight		kgmsquared	
Balke-Ware treadmill protocol		mlkgmin	
Lunar PIXI #50828	0.585% (coefficient of variation)	gm_cm_2	
Lunar PIXI #50828	2.79% (coefficient of variation)	gm_cm_2	
Hologic QDR 4500W		gm_cm_2	
Hologic QDR 4500W		gm_cm_2	
Hologic QDR 4500W		gm_cm_2	
Hologic QDR 4500W		gm_cm_2	
Hologic QDR 4500W		gm_cm_2	
Hologic QDR 4500W	0.339% (coefficient of variation)	gm_cm_2	
Hologic QDR 4500W		percentage	
Hologic QDR 4500W		kilograms	
3-day dietary intake record		milligrams	
1RM maximum		kilograms	
without clothes in light clothing using a clinical scale (Detecto)		kilograms	
derived from measures of height and weight		kgmsquared	
Balke-Ware treadmill protocol		mlkgmin	
Lunar PIXI #50828	0.585% (coefficient of variation)	gm_cm_2	
Lunar PIXI #50828	2.79% (coefficient of variation)	gm_cm_2	
Hologic QDR 4500W		gm_cm_2	
Hologic QDR 4500W		gm_cm_2	
Hologic QDR 4500W		gm_cm_2	
Hologic QDR 4500W		gm_cm_2	
Hologic QDR 4500W		gm_cm_2	
Hologic QDR 4500W	0.339% (coefficient of variation)	gm_cm_2	
Hologic QDR 4500W		percentage	
Hologic QDR 4500W		kilograms	
3-day dietary intake record		milligrams	
1RM maximum		kilograms	
		kilograms	
Hologic DXA 4500	.30% (coefficient of variation)	kilograms	
Hologic DXA 4500	1.42% (coefficient of variation)	kilograms	
Hologic DXA 4500	<1.2% (coefficient of variation)	gm_cm_2	
Hologic DXA 4500	<1.2% (coefficient of variation)	gm_cm_2	
Hologic DXA 4500	<1.2% (coefficient of variation)	gm_cm_2	
Norland/Stratec XCT 540 densitometer		other	mg/mm
Norland/Stratec XCT 540 densitometer		other	mmsquared
Norland/Stratec XCT 540 densitometer		other	mg/cm ³

Outcome Characteristics

Norland/Stratec XCT 540 densitometer		other	mmcubed
Norland/Stratec XCT 540 densitometer		other	mg/mm
Norland/Stratec XCT 540 densitometer		other	mmsquared
Norland/Stratec XCT 540 densitometer		other	mg/cm ³
Norland/Stratec XCT 540 densitometer		other	mg/mm
Norland/Stratec XCT 540 densitometer		other	mmsquared
Norland/Stratec XCT 540 densitometer		other	mg/cm ³
Norland/Stratec XCT 540 densitometer		other	mmcubed
Norland/Stratec XCT 540 densitometer		other	mg/mm
Norland/Stratec XCT 540 densitometer		other	mmsquared
Norland/Stratec XCT 540 densitometer		other	mg/cm ³
		kilograms	
Hologic DXA 4500	.30% (coefficient of variation)	kilograms	
Hologic DXA 4500	1.42% (coefficient of variation)	kilograms	
Hologic DXA 4500	<1.2% (coefficient of variation)	gm _{cm2}	
Hologic DXA 4500	<1.2% (coefficient of variation)	gm _{cm2}	
Hologic DXA 4500	<1.2% (coefficient of variation)	gm _{cm2}	
Norland/Stratec XCT 540 densitometer		other	mg/mm
Norland/Stratec XCT 540 densitometer		other	mmsquared
Norland/Stratec XCT 540 densitometer		other	mg/cm ³
Norland/Stratec XCT 540 densitometer		other	mmcubed
Norland/Stratec XCT 540 densitometer		other	mg/mm
Norland/Stratec XCT 540 densitometer		other	mmsquared
Norland/Stratec XCT 540 densitometer		other	mg/cm ³
Norland/Stratec XCT 540 densitometer		other	mg/mm
Norland/Stratec XCT 540 densitometer		other	mmsquared
Norland/Stratec XCT 540 densitometer		other	mg/cm ³
Norland/Stratec XCT 540 densitometer		other	mmcubed
Norland/Stratec XCT 540 densitometer		other	mg/mm
Norland/Stratec XCT 540 densitometer		other	mmsquared
Norland/Stratec XCT 540 densitometer		other	mg/cm ³
	1-4	gm _{cm2}	
	1-4	gm _{cm2}	
	1-4	gm _{cm2}	
	1-4	gm _{cm2}	
	1-4	gm _{cm2}	
	1-4	gm _{cm2}	
		kilograms	
		kgmsquared	
		percentage	

Outcome Characteristics

		kilograms	
4-day diet record (three weekdays and 1 weekend day)		milligrams	
4-day diet record (three weekdays and 1 weekend day)		other	micrograms
derived from measures of height and weight		kgmsquared	
Hologic QDR-4500A	1.1% (coefficient of variation)	kilograms	
Hologic QDR-4500A	3.1% (coefficient of variation)	percentage	
8-foot up and go test		other	seconds
one-leg stand		other	seconds
knee extension 180 degrees/second using an isokinetic dynamometer (Biodex System 4 Pro)		percentage	
knee flexion 180 degrees/second using an isokinetic dynamometer (Biodex System 4 Pro)		percentage	
knee extension 60 degrees/second using an isokinetic dynamometer (Biodex System 4 Pro)		percentage	
knee flexion 60 degrees/second using an isokinetic dynamometer (Biodex System 4 Pro)		percentage	
Hologic QDR-4500A	0.9% (coefficient of variation)	gm_cm_2	
Hologic QDR-4500A		gm_cm_2	
Hologic QDR-4500A		gm_cm_2	
Hologic QDR-4500A	1.1% (coefficient of variation)	gm_cm_2	
4-day diet record (three weekdays and 1 weekend day)		milligrams	
4-day diet record (three weekdays and 1 weekend day)		other	micrograms
derived from measures of height and weight		kgmsquared	
Hologic QDR-4500A	1.1% (coefficient of variation)	kilograms	
Hologic QDR-4500A	3.1% (coefficient of variation)	percentage	
8-foot up and go test		other	seconds
one-leg stand		other	seconds
knee extension 180 degrees/second using an isokinetic dynamometer (Biodex System 4 Pro)		percentage	
knee flexion 180 degrees/second using an isokinetic dynamometer (Biodex System 4 Pro)		percentage	
knee extension 60 degrees/second using an isokinetic dynamometer (Biodex System 4 Pro)		percentage	
knee flexion 60 degrees/second using an isokinetic dynamometer (Biodex System 4 Pro)		percentage	
Hologic QDR-4500A	0.9% (coefficient of variation)	gm_cm_2	
Hologic QDR-4500A		gm_cm_2	
Hologic QDR-4500A		gm_cm_2	
Hologic QDR-4500A	1.1% (coefficient of variation)	gm_cm_2	
4-day diet record (three weekdays and 1 weekend day)		milligrams	
4-day diet record (three weekdays and 1 weekend day)		other	micrograms
derived from measures of height and weight		kgmsquared	
Hologic QDR 4500A	3.6% (coefficient of variation)	percentage	
Hologic QDR 4500A	1.1% (coefficient of variation)	kilograms	
6-minute walk test		meters	
handgrip strength with digital dynamometer (Grip-D, Model TKK 5401)		kilograms	
8-foot up and go test		other	seconds
one-leg stand		other	seconds

Outcome Characteristics

chair stand test		other	repetitions
isokinetic right knee extension (180 degrees/second)		other	peak torque/bod
isokinetic left knee extension (180 degrees/second)		other	peak torque/bod
isokinetic right knee flexion (180 degrees/second)		other	peak torque/bod
isokinetic left knee flexion (180 degrees/second)		other	peak torque/bod
isokinetic right knee extension (60 degrees/second)		other	peak torque/bod
isokinetic left knee extension (60 degrees/second)		other	peak torque/bod
isokinetic right knee flexion (60 degrees/second)		other	peak torque/bod
isokinetic left knee flexion (60 degrees/second)		other	peak torque/bod
Hologic QDR 4500A	0.9% (coefficient of variation)	gm_cm_2	
Hologic QDR 4500A		gm_cm_2	
Hologic QDR 4500A		gm_cm_2	
Hologic QDR 4500A	1.1% (coefficient of variation)	gm_cm_2	
Hologic QDR 4500A	0.8% (coefficient of variation)	gm_cm_2	
	2	gm_cm_2	
		kilograms	
		kgmsquared	
		mlkgmin	
	2	gm_cm_2	
		kilograms	
		kgmsquared	
		mlkgmin	
	2.1	gm_cm_2	
	1	gm_cm_2	
		kilograms	
		kgmsquared	
		milligrams	
1 RM		kilograms	
1 RM	.88 (reliability)	kilograms	
1 RM		kilograms	
1 RM		kilograms	
1 RM		kilograms	
tandem walk test over a 20 foot course		other	seconds
Harvard Alumni Questionnaire		other	kj/wk
		kilograms	
derived from measures of height and weight		kgmsquared	
Hologic QDR 1500		gm_cm_2	
Hologic QDR 1500	0.87% (coefficient of variation)	gm_cm_2	
Hologic QDR 1500	1.0% (coefficient of variation)	gm_cm_2	
	1	mg_cm_2	

Outcome Characteristics

	1.5	mg_cm_2	
	1.8	mg_cm_2	
	2.2	mg_cm_2	
	2.2	mg_cm_2	
	2.3	mg_cm_2	
	1.8	mg_cm_2	
	1.8	mg_cm_2	
		kilograms	
Lunar DPX	~1.0% (coefficient of variation)	gm_cm_2	
Lunar DPX	~1.0% (coefficient of variation)	gm_cm_2	
Lunar DPX	~1.0% (coefficient of variation)	gm_cm_2	
Lunar DPX	~1.0% (coefficient of variation)	gm_cm_2	
hand dynamometer		kilograms	
1 RM		kilograms	
1 RM		kilograms	
1 RM		kilograms	
1 RM		kilograms	
1 RM		kilograms	
derived from measures of height and weight		kgmsquared	
graded treadmill walking		mlkgmin	
		kilograms	
Hologic Delphi 4500/w		kilograms	
Hologic Delphi 4500/w		kilograms	
Hologic Delphi 4500/w		gm_cm_2	
1RM (sum of biceps curl, bench press, seated row, knee extension, knee flexion, leg press)		pounds	
time needed to complete and obstacle course			seconds
one-leg stand			seconds
Hologic Delphi 4500/w		gm_cm_2	
Hologic Delphi 4500/w		gm_cm_2	
body weight		kilograms	
maximum oxygen consumption test		mlkgmin	
Hologic QDR-1000/W		gm_cm_2	
Hologic QDR-1000/W		gm_cm_2	
Hologic QDR-1000/W		gm_cm_2	
Hologic QDR-1000/W		gm_cm_2	
Hologic QDR-1000/W		gm_cm_2	
		milligrams	
		IU	
1 RM		pounds	
1 RM		pounds	

Outcome Characteristics

digital stand-on scale (Scale-tronix 5005)		kilograms	
DXA (Lunar Prodigy)	<1.0% (coefficient of variation)	kilograms	
DXA (Lunar Prodigy)	<1.0% (coefficient of variation)	kilograms	
DXA (Lunar Prodigy)	<1.0% (coefficient of variation)	gm_cm_2	
DXA (Lunar Prodigy)	<1.0% (coefficient of variation)	gm_cm_2	
DXA (Lunar Prodigy)	<1.0% (coefficient of variation)	gm_cm_2	
DXA (Lunar Prodigy)	<0.8% (coefficient of variation)	gm_cm_2	
VO2 max (ml/kg/min) on motorized treadmill		mlkgmin	
addiitonal pounds lifted		pounds	
Lunar DXA, version 1.2		kilograms	
Lunar DXA	1% (short term precison); 1.2%	gm_cm_2	
Lunar SP2	1% (short term precison); 1.5%	gm_cm_2	
Lunar DXA	1% (short term precison); 2.3%	gm_cm_2	
Lunar DXA	2% (short term precison); 2.5%	gm_cm_2	
Lunar DXA	2% (short term precison); 3.3%	gm_cm_2	
light clothing on a calibrated electronic scale		kilograms	
food frequency questionnaire		milligrams	
		kilograms	
DPX (Lunar)	2.3% (coefficient of variation)	gm_cm_2	
DPX (Lunar)	5.0% (coefficient of variation)	gm_cm_2	
		kilograms	
derived from measures of height and weight		kgmsquared	
3 day diet records		milligrams	
3 day diet records			micrograms
Hologic QDR-4500A	0.8% (short-term precision)	gm_cm_2	
Hologic QDR-4500A		kilograms	
Hologic QDR-4500A		kilograms	
Hologic QDR-4500A	0.5% (short-term precision); 0.3	gm_cm_2	
Hologic QDR-4500A	1.5% (short-term precision)	gm_cm_2	
Hologic QDR-4500A		gm_cm_2	
Hologic QDR-4500A		gm_cm_2	
		kilograms	
derived from measures of height and weight		kgmsquared	
Lunar Prodigy		gm_cm_2	
Lunar Prodigy		gm_cm_2	
Lunar Prodigy		gm_cm_2	

Outcome Characteristics

analysis_type	n_e	i_e	i_se_e	i_sd_e	f_e	f_se_e	f_sd_e	d_e	d_sd_e	d_se_e	lci_e	uci_e	p_e	p_sd_e	p_se_e	p_lci_e	p_uci_e
abp	16												0.20	1.88		-0.80	1.20
abp	16												-0.50	3.10		-2.20	1.10
abp	16												0.80	2.16		-0.40	1.90
abp	16												0.90	3.10		-0.80	2.50
abp	16	58.10		7.90	57.6			-0.50	3.0964843		-2.2	1.1	-0.86				
abp	16	21.70		3.00													
abp	16	26.10		6.50													
abp	13												0.90	1.82		-0.20	2.00
abp	13												1.50	2.98		-0.30	3.30
abp	13												0.50	1.99		-0.70	1.70
abp	13												0.10	2.90		-1.60	1.90
abp	13	60.30		10.30	59.9			-0.40	3.8060947		-2.7	1.9	-0.66				
abp	13	22.40		3.30													
abp	13	27.80		6.20													
abp	16												1.70	1.88		0.70	2.70
abp	16												2.20	3.00		0.60	3.80
abp	16												1.30	2.06		0.20	2.40
abp	16												-0.80	3.00		-2.40	0.80
abp	16	60.70		10.20	60.3			-0.40	3.28415		-2.1	1.4	-0.66				
abp	16	22.90		3.20													
abp	16	30.10		6.10													
abp	30	1.14		0.12	1.15		0.12	0.01	0.016				1.05				
abp	30	0.97		0.13	0.99		0.13	0.02	0.027				2.06				
abp	30	0.82		0.11	0.85		0.11	0.02	0.033				2.92				
abp	30	60.7		7.90	60.7		7.90	0.00	3.5329874				0.00				
abp	30	22.7		2.50	22.7		2.50	0.00	1.118034				0.00				
abp	30	186.00		45.00				12.90	21.908902	4			6.94				
abp	30	39.00		8.00				3.70	3.8340579	0.7			9.49				
abp	45	1.09		0.09	1.09		0.09	0.00	0.027				-0.18				
abp	45	0.89		0.09	0.88		0.09	-0.02	0.033				-1.68				
abp	45	0.77		0.08	0.76		0.08	-0.01	0.02				-1.18				
abp	45	64.7		7.30	64.7		7.30	0.00	3.2646592				0.00				
abp	45	25		2.60	25		2.60	0.00	1.1627553				0.00				
abp	45	1053		246.00	1053		246.00	0.00	110.01454				0.00				
abp	24	1.15		0.12	1.17		0.12	0.01	0.03				1.22				
abp	24	0.93		0.12	0.93		0.11	0.00	0.03				0.11				
abp	24	0.81		0.13	0.81		0.13	0.00	0.024				-0.01				
abp	24	64.2		5.30	64.2		5.30	0.00	2.3702321				0.00				
abp	24	24.3		2.00	24.3		2.00	0.00	0.8944272				0.00				

Outcome Characteristics

abp	24	1005		324.00	1005		324.00	0.00	144.8972				0.00				
abp	24	40.00		7.00				9.80	5.8787754	1.2			24.50				
abp	48	24.40		2.60													
abp	48	18.70		4.50	14.1		3.50	-4.60	2.0371549				-24.60				
abp	48	0.96		0.08	0.957		0.08	0.00	0.0344354				-0.31				
abp	48	0.98		0.08	0.983		0.08	0.00	0.0367723				-0.10				
abp	48	0.87		0.07	0.878		0.07	0.01	0.0322583				0.57				
abp	48	0.83		0.08	0.829		0.08	0.00	0.0348827				0.00				
itt	59	18.70		4.50	14.1		3.50	-4.60	2.0371549				-24.60				
itt	59	0.96		0.08	0.958		0.08	0.00	0.0355668				-0.42				
itt	59	0.99		0.08	0.984		0.09	0.00	0.0374566				-0.30				
itt	59	0.88		0.07	0.878		0.07	0.00	0.0307734				0.23				
itt	59	0.83		0.07	0.828		0.07	0.00	0.0321994				-0.24				
abp	12	24.05		2.44													
abp	12	1.27		0.14	1.263			-0.01	0.034641	0.01			-0.55				
abp	12	1.02		0.10	1.01		0.10	-0.01	0.0442154				-1.27				
abp	12																
abp	15	0.71	0.00	0.00	0.704	0.001	0.00	0.00	0.0017321				-0.09	0.19	0.05		
abp	15	0.88	0.00	0.00	0.88	0.001	0.00	0.00	0.0017321				-0.13	0.35	0.09		
abp	15	38.00	9.00	34.86	62	5	19.36	24.00	19.364917				63.16				
abp	15	20.00	7.00	27.11	37	6	23.24	17.00	11.874342				85.00				
abp	15	68.00	23.24	90.01	63	11.62	45.00	-5.00	53.24953				-7.35				
abp	15	28.00	15.49	59.99	25	19.36	74.98	-3.00	33.530772				-10.71				
abp	15	31.00	19.36	74.98	27	15.49	59.99	-4.00	33.530772				-12.90				
abp	9	56.70		5.80	56.3		4.50	-0.40	2.6286879				-0.71				
abp	9	18.30		3.20	17.1		2.90	-1.20	1.394991				-6.56				
abp	9	21.67		2.67	26.622		2.23	4.96	1.64325				22.87				
abp	9	562.56		98.35	671.67		72.68	109.11	42.51601				19.40				
abp	9	7.33		0.75	9.389		0.96	2.06	0.52705				28.03				
abp	9	46.67		5.55	65.222		8.92	18.56	5.19281				39.76				
abp	9	112.00		18.41	149.78		23.40	37.78	11.18903				33.73				
abp	9	0.85		0.09	0.84667		0.09	0.00	0.01379				0.11				
abp	9	0.68		0.08	0.68978		0.07	0.01	0.02319				1.26				
abp	9	0.61		0.09	0.61		0.09	0.00	0.0192				0.05				
abp	9	0.56		0.15	0.57911		0.15	0.02	0.04577				3.60				
abp	9	0.93		0.10	0.93922		0.11	0.01	0.03329				0.77				
abp	10	60.60		8.80	59.4		7.60	-1.20	3.8491558				-1.98				
abp	10	21.10		5.70	20.2		4.70	-0.90	2.5215075				-4.27				
abp	10	22.10		2.31	26.233		2.33	4.13	2.824				18.70				
abp	10	573.22		66.52	666.89		75.26	93.67	50.69517				16.34				

Outcome Characteristics

abp	10	6.83		1.30	8.556		1.16	1.72	0.66667				25.20			
abp	10	41.40		7.83	60.111		9.47	18.71	6.37974				45.20			
abp	10	124.11		23.20	146.67		22.28	22.56	12.52109				18.17			
abp	10	0.82		0.08	0.8139		0.08	-0.01	0.01648				-1.13			
abp	10	0.65		0.03	0.6456		0.03	-0.01	0.01722				-0.77			
abp	10	0.53		0.04	0.531		0.05	0.01	0.0152				1.10			
abp	10	0.44		0.04	0.4411		0.04	0.00	0.02164				0.11			
abp	10	0.91		0.06	0.9218		0.06	0.01	0.02359				1.40			
abp	38	1.04		0.18	1.05			0.01	0.02				0.57			
abp	38	0.84		0.11	0.86			0.02	0.04				1.90			
abp	38	0.50		0.09	0.50			0.00	0.02				0.20			
abp	38	67.7		10.90	67.6			-0.10					-0.15			
abp	38	25.8		3.80	25.79			-0.01					-0.04			
abp	38	836		216.00	864		222.00	28.00	98.114219				3.35			
abp	10	72.00	4.30	13.60												
abp	10	27.00	1.70	5.38												
abp	10	44.00	2.00	6.32												
abp	10	1214.00	200.00	632.46												
abp	10	10.00	2.10	6.64												
abp	10	0.89	0.04	0.13	0.885	0.037	0.12	-0.01	0.0565155				-0.60	3.16	1.00	
abp	10	0.90	0.03	0.09	0.901	0.03	0.09	0.00	0.0424264				-0.20	2.21	0.70	
abp	10	0.75	0.03	0.09	0.743	0.027	0.09	0.00	0.0400749				-0.10	2.85	0.90	
abp	10	0.68	0.03	0.09	0.676	0.028	0.09	0.00	0.0404228				0.20	3.48	1.10	
abp	10	0.61	0.04	0.12	0.601	0.034	0.11	-0.01	0.051049				-0.90	3.79	1.20	
abp	10	0.97	0.03	0.10	0.974	0.031	0.10	0.00	0.0438406				0.10	1.26	0.40	
abp	10	22.50	3.10	9.80	39.3	5	15.81	16.80	8.191459				90.00	66.41	21.00	
abp	10	103.70	10.40	32.89	136.3	11.9	37.63	32.60	16.432285				33.00	15.81	5.00	
abp	18	75.40		12.10	74.6		12.90	-0.80	5.6442891				-1.06			
abp	18	29.10		3.90	28.8		4.30	-0.30	1.8745666				-1.03			
abp	18	31.70		8.10	30.7		9.20	-1.00	4.0142247				-3.15			
abp	18	40.80		5.00	41.3		4.80	0.50	2.2				1.23			
abp	18	43.30		5.10	41.9		5.90	-1.40	2.5803101				-3.23			
abp	18	1.13		0.10	1.13		0.11	0.00	0.0479583				0.00			
abp	18	1.16		0.18	1.15		0.18	-0.01	0.0804984				-0.86			
abp	18	0.94		0.13	0.94		0.13	0.00	0.0581378				0.00			
abp	18	0.87		0.11	0.88		0.11	0.01	0.0491935				1.15			
abp	18	0.78		0.14	0.78		0.13	0.00	0.0611555				0.00			
abp	18	0.73		0.15	0.7		0.10	-0.03	0.074162				-4.11			
abp	21	66.90		8.70	67.1		9.40	0.20	4.1043879				0.30			
abp	21	25.20		2.70	25.5		2.70	0.30	1.2074767				1.19			

Outcome Characteristics

abp	21	38.60		3.20	37.2		3.70	-1.40	1.6180235				-3.63			
abp	21	0.97		0.09	0.99		0.09	0.02	0.0402492				2.10			
abp	21	0.67		0.07	0.68		0.07	0.01	0.031305				1.50			
abp	21	0.97		0.18	1		0.21	0.03	0.0919783				3.10			
abp	21	0.74		0.06	0.74		0.07	0.00	0.0306594				0.00			
abp	21	0.63		0.07	0.67		0.08	0.04	0.0349285				6.30			
abp	21	0.57		0.10	0.6		0.11	0.03	0.0479583				5.30			
abp	21	261.13		41.57	280.57		40.79	19.44	18.431941				7.40			
abp	21	240.08		42.16	253.45		46.44	13.37	20.245999				5.60			
abp	21	1.83		0.28	2.11		0.39	0.28	0.1842281				15.30			
abp	21	30.10		25.87	52.9		41.09	22.80	21.077193				75.70			
abp	21	55.14		1.46	55.33		1.56	0.19	0.6822903				0.30			
abp	32	70.14		13.15												
abp	32	34.30		6.10												
abp	32	1.08		0.09				-1.08					1.30	2.80		
abp	32	0.88		0.09				-0.88					0.50	2.60		
abp	32	0.72		0.09				-0.72					2.60	6.10		
abp	32	34.70		7.40				2.30	5.2				8.60	15.70		
abp	32	52.60		16.90				4.80	6.4				16.70	25.40		
abp	32	37.70		11.90				4.60	4.7				21.70	23.70		
abp	32	80.10		30.50				11.70	12.9				26.60	31.60		
abp	32	93.20		22.10				3.80	11.9				8.40	21.50		
abp	71	67.70		12.40												
abp	71	25.30		4.10												
abp	71	38.60		4.50												
abp	71	37.90		6.30												
abp	71	0.89		0.13	0.902			0.01	0.029				1.35			
abp	71	0.75		0.12	0.764			0.01	0.025				1.87			
abp	71	1.14		0.15	1.149			0.01	0.022				0.79			
abp	71	1.12		0.08	1.124			0.00	0.011				0.36			
abp	71	68.90		11.40												
abp	71	25.80		3.40												
abp	71	38.60		4.60												
abp	71	39.30		6.00												
abp	71	0.87		0.13	0.875			0.01	0.036				0.57			
abp	71	0.74		0.11	0.748			0.01	0.024				1.08			
abp	71	1.12		0.18	1.12			0.00	0.029				0.00			
abp	71	1.11		0.08	1.11			0.00	0.013				0.00			
abp	5	1.18		0.10	1.18		0.11	0.00	0.0479583				0.00			
abp	5	69		12.67	69.1		13.70	0.10	5.9813627				0.14			

Outcome Characteristics

abp	5	38.3	6.03	40.7	6.69	2.40	2.9161173	6.27								
abp	5	42.57		40.98		-1.60		-3.75								
abp	5	22.7	2.06	21.7	1.12	-1.00	1.1597586	-4.41								
abp	5	860.6	512.70	860.6	512.70	0.00	229.28641	0.00								
abp	5	1.17	0.10	1.19	0.10	0.02	0.0447214	1.71								
abp	5	72.3	19.20	71.2	20.20	-1.10	8.8638592	-1.52								
abp	5	41.3	4.19	41.5	4.32	0.20	1.9071078	0.48								
abp	5	42.44		41.65		-0.79		-1.86								
abp	5	21.9	2.93	23.6	2.04	1.70	1.4098014	7.76								
abp	5	935	326.70	935	326.70	0.00	146.10468	0.00								
abp	39	1.03	0.14													
abp	39	0.88	0.10					1.60	2.51							
abp	39	0.94	0.11													
abp	39	1.22	0.11													
abp	39	1.04	0.10													
abp	39	1.08	0.10													
abp	39	0.61	0.08													
abp	39	0.63	0.07					-1.50	3.77							
abp	39	62	7.00	62	7.00	0.00	3.1304952	0.00								
abp	39	23.2	2.60	23.2	2.60	0.00	1.1627553	0.00								
abp	39	30.9	3.70	30.9	3.70	0.00	1.6546903	0.00								
abp	39	42.84		42.84		0.00		0.00								
abp	39	36.4	3.10	39.5		3.10	3.61	8.52								
abp	39	1125	240.00	1125	240.00	0.00	107.33126	0.00								
abp	39	58.00	7.30													
abp	39	40.50	7.90													
abp	39	142.10	22.40													
abp	39	21.00	25.90													
abp	39	444.00	38.00													
abp	39	410.00	37.00													
abp	39	6.40	0.50													
abp	26	1.00	0.15													
abp	26	0.85	0.11													
abp	26	0.64	0.09													
abp	26	0.39	0.05													
abp	26	68	9.00													
abp	26	26.3	3.60													
abp	26	31.5	6.30													
abp	26	46.58														
abp	26	890	276.00	890	276.00	0.00	123.43095	0.00								

Outcome Characteristics

abp	26	60.90		11.30												
abp	26	45.00		10.00												
abp	26	133.30		23.60												
abp	26	19.30		3.40												
abp	26	1.83		0.27												
abp	23	1.00		0.13												
abp	23	0.89		0.10												
abp	23	0.63		0.08												
abp	23	0.39		0.05												
abp	23	71		12.00												
abp	23	26.5		4.00												
abp	23	33.3		6.50												
abp	23	942		243.00	942		243.00	0.00	108.6729				0.00			
abp	23	58.00		10.50												
abp	23	45.20		8.40												
abp	23	137.80		22.60												
abp	23	18.10		3.70												
abp	23	1.89		0.32												
abp		0.86		0.11				-0.86					-0.42	2.50		
abp	30	0.69		0.11												
abp	30	1.04		0.13												
abp	30	0.95		0.16				-0.95					1.31	2.30		
abp	30							-0.79	1.81							
abp	30	23.56		3.44	23.4		3.30	-0.13	0.7				-0.55			
abp	30							1.31	1.36							
abp	30							1.55	4.49							
abp	30							1.93	3.51							
abp	30							29.70	45.1							
abp	30							25.30	44.9							
abp	30	44.20		5.30	44.3		5.30	0.10	2.3702321				0.23			
abp		0.89		0.09				-0.89					-1.01	1.30		
abp	29	0.73		0.08												
abp	29	1.06		0.12												
abp	29	0.99		0.16				-0.99					1.10	2.20		
abp	29							-0.46	1.61							
abp	29	24.10		3.42	24		3.50	-0.08	0.59				-0.33			
abp	29							1.00	1.27							
abp	29							1.84	4.2							
abp	29							3.28	4.71							
abp	29							32.90	45							

Outcome Characteristics

abp	29						22.00	58.4									
abp	29	45.80		6.10	45.7		6.10	-0.10	2.7280029				-0.22				
abp		0.67		0.09				-0.67					0.21	2.50			
abp	28	0.57		0.07													
abp	28	0.83		0.12													
abp	28	0.68		0.09				-0.68					0.10	2.30			
abp	28							0.32	1.79								
abp	28	24.40		4.29	25.2		4.40	0.64	0.77				2.62				
abp	28							0.89	1.36								
abp	28							3.23	5.28								
abp	28							1.89	4.05								
abp	28							62.60	124.1								
abp	28							3.57	26								
abp	28	34.90		5.40	35.3		5.40	0.40	2.4149534				1.15				
abp		0.68		0.11				-0.68					0.00	4.50			
abp	30	0.57		0.09													
abp	30	0.82		0.14													
abp	30	0.69		0.12				-0.69					2.00	2.60			
abp	30							-0.09	1.73								
abp	30	24.60		4.00	24.8		3.90	0.23	0.81				0.93				
abp	30							0.65	1.77								
abp	30							0.84	4.66								
abp	30							4.13	5.52								
abp	30							49.50	198.1								
abp	30							10.10	38.2								
abp	30	35.30		5.40	35.6		5.40	0.30	2.4149534				0.85				
abp	8	45.50		6.50													
abp	8	19.70		1.30													
abp	8	0.60		0.07	0.62		0.09	0.03	0.0395702				4.29	2.34			
abp	9	0.67		0.04	0.74		0.05	0.07	0.0223607				10.45				
abp	9	0.77		0.07	0.88		0.08	0.11	0.0349285				14.29				
abp	9	2.49		0.52	1.83		0.26	-0.66	0.3076361				-26.51				
abp	9	24.21		3.84	29.58		5.78	5.37	2.8640251				22.18				
abp	9	78.00		9.20	73.8		7.30	-4.20	4.1281957				-5.38				
abp	123	68.10		10.90													
abp	123	36.30		5.90													
abp	123	828.00		414.00													
abp	123	24.10		4.10													
abp	115	0.92		0.16	0.936		0.17	0.02	0.027				1.77	2.76		1.26	2.28
abp	115	0.71			0.713			0.01	0.024				1.01	3.46		0.37	1.65

Outcome Characteristics

abp	115	0.37	0.68	1	1.37	0.63	0.8138919	170.27								
abp	28	69.40	11.40													
abp	28	0.98	0.10													
abp	28	38.10	7.70													
abp	28	41.50														
abp	23	0.65	0.11			-0.65		1.70	4.10							
abp	23	0.98	0.15			-0.98		1.50	3.00							
abp	23	0.72	0.10			-0.72		0.00	3.10							
abp	23	0.55	0.10			-0.55		2.30	4.00							
abp	25	0.36	0.06			-0.36		2.40	4.30							
abp	25	0.50	0.07			-0.50		0.50	3.20							
abp	25	0.56	0.08			-0.56		0.90	3.50							
abp	23	54.00	14.00	99	22.00	45.00	11.207141	94.00	83.00							
abp	23	45.00	13.00	86	26.00	41.00	15.381807	106.00	97.00							
abp	23	42.00	13.00	85	27.00	43.00	16.315637	114.00	90.00							
abp	23	49.00	14.00	84	17.00	35.00	7.5232971	86.00	89.00							
abp	23	41.00	13.00	73	26.00	32.00	15.381807	95.00	106.00							
abp	25	10.00	2.00	13	2.00	3.00	0.8944272	38.00	40.00							
abp	25	6.00	1.00	8	2.00	2.00	1.183216	49.00	42.00							
abp	25	9.00	2.00	12	2.00	3.00	0.8944272	33.00	26.00							
abp	25	6.00	1.00	10	2.00	4.00	1.183216	67.00	43.00							
abp	25	15.00	3.00	26	6.00	11.00	3.5496479	71.00	26.00							
abp	28	70.80	10.00													
abp	28	1.00	0.12													
abp	28	40.40	7.10													
abp	28	40.50	4.00													
abp	19	0.65	0.10			-0.65		0.30	2.80							
abp	19	1.02	0.15			-1.02		0.30	2.40							
abp	19	0.75	0.12			-0.75		0.20	4.20							
abp	19	0.58	0.16			-0.58		1.90	8.90							
abp	21	0.37	0.06			-0.37		-0.20	5.90							
abp	21	0.53	0.07			-0.53		0.10	1.40							
abp	21	0.60	0.08			-0.60		0.40	2.80							
abp	19	51.00	12.00	98	18.00	47.00	8.8994382	102.00	57.00							
abp	19	43.00	9.00	87	18.00	44.00	10.648944	110.00	49.00							
abp	19	42.00	13.00	82	22.00	40.00	11.75585	128.00	139.00							
abp	19	45.00	8.00	86	18.00	41.00	11.349009	96.00	46.00							
abp	19	46.00	15.00	69	20.00	23.00	9.2195445	50.00	44.00							
abp	21	10.00	2.00	12	2.00	2.00	0.8944272	21.00	20.00							
abp	21	6.00	1.00	8	2.00	2.00	1.183216	38.00	42.00							

Outcome Characteristics

abp	21	9.00	2.00	11	3.00	2.00	1.4832397	25.00	22.00
abp	21	6.00	2.00	9	2.00	3.00	0.8944272	52.00	36.00
abp	21	15.00	3.00	25	6.00	10.00	3.5496479	68.00	36.00
abp	42	72.20	12.00						
abp	42	43.00	6.00						
abp	42	39.50	4.20						
abp	24	0.90	0.16			-0.90		-0.65	2.12
abp	24	0.86	0.12			-0.86		0.57	1.76
abp	24	0.67	0.10			-0.67		0.00	2.33
abp	24	1.01	0.15			-1.01		0.70	2.08
abp	24	0.72	0.11			-0.72		1.04	2.81
abp	24	0.36	0.07			-0.36		-0.71	2.77
abp	24	0.53	0.06			-0.53		-0.35	2.25
abp	24	0.62	0.08			-0.62		-0.07	2.65
abp	24					0.00		-0.62	1.38
abp	42	69.00	11.40						
abp	42	40.00	7.00						
abp	42	39.60	4.30						
abp	30	0.91	0.12			-0.91		-0.32	1.85
abp	30	0.84	0.11			-0.84		-0.65	1.81
abp	30	0.65	0.09			-0.65		-0.02	2.60
abp	30	1.00	0.15			-1.00		-1.07	2.49
abp	30	0.72	0.09			-0.72		0.03	2.22
abp	30	0.36	0.07			-0.36		-0.39	3.19
abp	30	0.53	0.07			-0.53		-1.21	1.84
abp	30	0.62	0.06			-0.62		-0.96	2.50
abp	30					0.00		-0.79	1.73
itt	45	83.20	11.90						
itt	45	27.40	3.70						
itt	45	911.00	360.00						
itt	45	1.20	2.10						
abp	43	1.23	0.16	1.236	0.17	0.00	0.0741741	0.93	2.82
abp	43	0.92	0.07	0.933	0.07	0.01	0.0319906	1.18	2.32
abp	43	1.03	0.08	1.03	0.08	0.00	0.0367723	0.37	2.21
itt	46	85.20	10.90						
itt	46	28.10	3.30						
itt	46	1064.00	449.00						
itt	46	0.80	1.10						
abp	44	1.25	0.14	1.26	0.15	0.01	0.0645368	1.01	2.66
abp	44	0.94	0.08	0.947	0.08	0.01	0.0355668	1.01	2.29

Outcome Characteristics

abp	44	1.02		0.09	1.024		0.09	0.00	0.0413787				0.22	2.01			
abp	15	55.00		9.20													
abp	15	22.00		4.40													
abp	15	33.50		4.80													
abp	15	0.53	0.01	0.04									0.80	3.79		-1.30	2.90
abp	15	0.45	0.01	0.04									-0.50	4.60		-3.00	2.10
abp	15	1.10	0.02	0.08									0.40	2.08		-0.70	1.60
abp	15	0.92	0.02	0.08									0.50	2.62		-1.00	1.90
abp	15	0.85	0.03	0.12									0.50	3.25		-1.30	2.30
abp	15	0.69	0.02	0.08									0.50	4.33		-1.90	2.90
abp	15	0.84	0.03	0.12									1.10	5.42		-1.90	4.10
abp	15	0.99	0.02	0.08									0.90	2.17		-0.30	2.10
abp	15	30.00	1.40	5.42									1.00	10.56		-4.90	6.80
abp	15	39.20	1.20	4.65									-0.20	4.15		-2.50	2.10
abp	15	877.00	123.00	476.38									-0.50	360.25		-200.00	199.00
abp	15	80.00	5.70	22.08									55.00	28.44		39.20	70.70
abp	16	54.70		7.60													
abp	16	23.00		4.20													
abp	16	33.10		6.50													
abp	16	0.53	0.03	0.12									4.40	4.22		2.10	6.60
abp	16	0.48	0.01	0.04									0.80	5.91		-2.40	3.90
abp	16	1.11	0.02	0.08									1.40	2.18		0.18	2.50
abp	16	0.95	0.00										-1.00	2.53		-2.30	0.40
abp	16	0.86	0.03	0.12									-0.70	5.16		-3.50	2.00
abp	16	0.71	0.03	0.12									-0.30	2.91		-1.80	1.30
abp	16	0.83	0.05	0.20									-2.00	5.63		-5.00	1.00
abp	16	1.01	0.03	0.12									1.30	2.44		-0.10	2.50
abp	16	31.00	1.50	6.00									-2.40	11.26		-8.40	3.60
abp	16	38.70	1.10	4.40									0.50	3.57		-1.40	2.40
abp	16	764.00	119.00	476.00									16.30	443.83		-220.00	253.00
abp	16	89.00	5.80	23.20									14.00	29.46		-2.00	29.40
abp	32	59.90		9.40	58.70			-1.20	3.6				-2.00				
abp	32	38.00		4.10	38.4			0.40	1.1				1.05				
abp	32	20.60		5.70	20.5			-0.10	1.3				-0.49				
abp	29	0.67		0.14	0.671			0.00	0.0197171		-0.01	0.009	0.15				
abp	29	0.58		0.11	0.578			0.00	0.0184027		-0.01	0.005	-0.34				
abp	29	0.51		0.11	0.52			0.01	0.0354909		-0	0.023	1.96				
abp	32	214.11		68.83	213.03			-1.08	6.43482		-3.4	1.24	-0.50				
abp	32	198.21		56.65	197.16			-1.05	2.9261789		-3.4	-1.29	-0.53				
abp	32	1069.04		48.01	1068.98			-0.06	15.074675		-5.49	5.38	-0.01				

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abp	32	1260.37		348.00	1246.7			-13.67	58.689996		-34.8	7.49	-1.08			
abp	31	160.11		37.72	159.66			-0.45	3.5305059		-1.75	0.84	-0.28			
abp	31	537.12		79.69	538.72			1.60	17.925155		-4.98	8.17	0.30			
abp	31	304.26		81.84	302.02			-2.24	12.431743		-6.8	2.32	-0.74			
abp	21	57.64		18.59	58.64			1.00	3.6577767		-0.66	2.67	1.73			
abp	21	51.78		14.01	52.23			0.45	2.9767492		-0.91	1.8	0.87			
abp	21	1096.80		76.55	1112.19			15.39	28.811857		2.27	28.5	1.40			
abp	21							4.95	14.158781		-1.5	11.39				
abp	27	57.07		17.87	58.06			0.99	9.1256832		-2.57	4.65	1.73			
abp	27	120.22		31.27	123.26			3.04	32.710898		-9.9	15.98	2.53			
abp	27	478.02		85.77	475.27			-2.75	48.118388		-36.8	1.28	-0.58			
abp	34	62.50		9.30	61.5			-1.00	2.1				-1.60			
abp	34	38.10		4.50	38.4			0.30	1				0.79			
abp	34	23.90		6.30	23.4			-0.50	1.5				-2.09			
abp	33	0.69		0.11	0.70			0.01	0.0183313		0	0.013	0.87			
abp	33	0.60		0.08	0.60			0.00	0.0197414		-0	0.011	0.67			
abp	33	0.53		0.08	0.54			0.01	0.0352525		-0.01	0.02	1.51			
abp	33	229.70		51.83	228.48			-1.22	6.3454536		-3.46	1.04	-0.53			
abp	33	212.39		42.92	210.21			-2.18	6.4159586		-4.46	0.09	-1.03			
abp	33	1076.20		42.26	1081.52			5.32	14.876563		0.04	10.59	0.49			
abp	33	1338.39		270.22	1330.02			-8.37	57.983345		-28.9	12.19	-0.63			
abp	32	165.75		29.37	164.78			-0.97	3.4809048		-2.23	0.28	-0.59			
abp	32	548.68		77.84	544.92			-3.76	17.640282		-10.1	2.6	-0.69			
abp	32	307.22		67.82	307.38			0.16	12.259442		-4.26	4.58	0.05			
abp	31	59.05		11.71	58.34			-0.71	3.6395562		-2.04	0.63	-1.20			
abp	31	52.83		9.62	52.42			-0.41	2.9716227		-1.5	0.68	-0.78			
abp	31	1114.59		32.56	1110.04			-4.55	28.680248		-15.1	5.97	-0.41			
abp	31							-0.60	14.094761		-5.77	4.57				
abp	32	58.39		14.37	55.07			-3.32	9.3193945		-6.68	0.04	-5.69			
abp	32	127.31		32.12	120.95			-6.36	32.936848		-18.2	5.51	-5.00			
abp	32	469.39		91.44	473.01			3.62	86.592707		-27.6	34.84	0.77			
abp	22	1.13		0.08	1.12		0.08	-0.01	0.0358106				-1.24			
abp	22	1.18		0.15	1.20		0.15	0.02	0.0679765				1.35			
abp	22	0.94		0.13	0.93		0.12	-0.01	0.0552069				-0.95			
abp	22	0.75		0.10	0.76		0.10	0.01	0.0438703				1.47			
abp	22	0.88		0.14	0.90		0.14	0.02	0.0619468				1.70			
abp	22	0.69		0.05	0.70		0.05	0.01	0.0239458				1.30			
abp	22	58.4		9.90												
abp	22	21.45														
abp	22	27.4		7.80												

Outcome Characteristics

abp	22	42.4															
itt	23	714.50		358.40													
itt	23	1.80		1.70													
itt	23	28.80		4.60	28.2		3.90	-0.60	2.0194059				-2.08				
itt	23	41.80		8.60	44.6		8.60	2.80	3.8460369				6.70				
itt	23	38.80		4.40	35.2		5.50	-3.60	2.4596748				-9.28				
itt	23	5.50		0.50	4.9		0.30	-0.60	0.2645751				-10.91				
itt	23	26.30		13.20	31.7		12.80	5.40	5.8268345				20.53				
itt	23	76.20		16.00	90.5		15.10	14.30	7.0092796				18.77				
itt	23	50.50		18.30	61.6		14.90	11.10	8.1298216				21.98				
itt	23	123.00		29.80	140.7		31.10	17.70	13.676476				14.39				
itt	23	74.60		23.40	94.4		24.50	19.80	10.764293				26.54				
itt	23	0.68		0.08	0.676		0.09	-0.01	0.0392428				-1.17				
itt	23	0.65		0.10	0.666		0.11	0.02	0.0462061				3.10				
itt	23	1.04		0.17	1.047		0.16	0.01	0.0743398				1.16				
itt	23	0.86		0.12	0.873		0.13	0.01	0.057772				1.63				
itt	24	608.50		248.80													
itt	24	2.30		1.40													
itt	24	27.50		3.80	27.5		3.30	0.00	1.6607227				0.00				
itt	24	37.30		5.20	37.2		5.20	-0.10	2.3255107				-0.27				
itt	24	39.20		4.50	38.4		3.80	-0.80	1.977372				-2.04				
itt	24	5.90		0.90	5.1		0.60	-0.80	0.4449719				-13.56				
itt	24	28.80		14.90	32.9		9.50	4.10	7.580897				14.24				
itt	24	84.50		21.50	81.2		24.90	-3.30	10.89174				-3.91				
itt	24	47.20		12.80	51.7		11.80	4.50	5.5864121				9.53				
itt	24	137.70		36.50	132.5		28.20	-5.20	16.575584				-3.78				
itt	24	71.80		19.00	77.1		19.30	5.30	8.5691306				7.38				
itt	24	0.66		0.11	0.66		0.11	0.00	0.0486518				0.46				
itt	24	0.64		0.10	0.641		0.10	0.00	0.0440613				0.47				
itt	24	1.02		0.14	1.02		0.14	0.00	0.0632882				-0.20				
itt	24	0.85		0.13	0.849		0.12	0.00	0.0556866				0.12				
itt	30	654.90		200.80													
itt	30	1.60		1.20													
itt	30	28.40		3.70	28.4		3.30	0.00	1.6130716				0.00				
itt	30	38.00		2.90	35.9		3.10	-2.10	1.3557286				-5.53				
itt	30	39.30		5.50	40.6		5.80	1.30	2.5436195				3.31				
itt	30	544.80		67.40	555		62.00	10.20	29.409522				1.87				
itt	30	24.70		4.20	27		3.20	2.30	1.9204166				9.31				
itt	30	5.80		1.20	5		0.80	-0.80	0.5932959				-13.79				
itt	30	28.30		14.70	34.2		12.50	5.90	6.4490309				20.85				

Outcome Characteristics

itt	30	17.30		4.40	19.8		3.80	2.50	1.9245779				14.45			
itt	30	82.90		20.60	90.9		20.00	8.00	9.0972523				9.65			
itt	30	77.60		18.60	79.8		24.50	2.20	11.222745				2.84			
itt	30	51.10		15.40	55.1		16.10	4.00	7.0765811				7.83			
itt	30	49.90		14.00	56.8		14.40	6.90	6.3623895				13.83			
itt	30	137.60		27.50	141.9		34.80	4.30	15.64257				3.13			
itt	30	126.50		36.50	135.5		30.90	9.00	16.029036				7.11			
itt	30	68.90		19.10	75.1		20.20	6.20	8.8529091				9.00			
itt	30	72.50		18.00	79.5		20.50	7.00	8.9470666				9.66			
itt	30	0.70		0.09	0.717		0.09	0.02	0.0397869				2.58			
itt	30	0.62		0.08	0.628		0.08	0.01	0.0356735				1.13			
itt	30	0.99		0.14	0.989		0.15	0.00	0.0652518				0.30			
itt	30	0.83		0.10	0.832		0.10	0.00	0.0462969				0.48			
itt	30	0.86		0.10	0.868		0.09	0.01	0.0428089				1.28			
abp	20	1.00		0.13	0.99		0.13	-0.01	0.0578705				-0.48	3.63		
abp	20	68.9		11.50	68.5		11.20	-0.40	5.0842895				-0.58			
abp	20	26.16			26			-0.16					-0.61			
abp	20	23.2		4.40	25		4.10	1.80	1.9230185				7.76			
abp	16	1.05		0.17	1.06		0.17	0.01	0.0771505				0.81	4.53		
abp	16	65.6		11.90	64.5		11.00	-1.10	5.1951901				-1.68			
abp	16	25.95			25.51			-0.44					-1.70			
abp	16	24.2		4.70	26.1		5.00	1.90	2.1886069				7.85			
itt	20	0.85		0.13	0.86			0.01	0.039				0.90	4.50		
itt	20	1.02		0.16	1.03			0.01	0.033				1.00	3.60		
itt	20	64.7		7.70												
itt	20	24.4		2.50												
itt	20	724		350.00	931		378.00	207.00	165.05757				28.59			
itt	20	84.70		14.10	111.6		19.10	26.90	8.8804279				35.20			
itt	20	22.10		6.20	37.8		10.40	15.70	5.5259388				72.40			
itt	20	18.50		4.10	32.4		5.10	13.90	2.2764007				76.30			
itt	20	27.60		6.80	37.8		7.60	10.20	3.3130047				43.50			
itt	20	14.30		5.10	20.4		5.10	6.10	2.2807893				42.60			
itt	20	24.60		5.80	20.4		5.20	-4.20	2.5282405				-14.30			
itt	20	6762.00		1046.00	8610		1109.00	1848.00	485.76929							
abp	23	69.00		12.40												
abp	23	25.90		4.40												
abp	23	0.73	0.01	0.05	0.73	0.01	0.05	0.00	0.0214476				0.00			
abp	23	0.88	0.02	0.10	0.89	0.02	0.10	0.01	0.0428952				1.14			
abp	23	1.01	0.02	0.10	1.02	0.02	0.10	0.01	0.0428952				0.99			
abp	31	862.00		145.00	864.73			2.73					0.32	1.42		

Outcome Characteristics

abp	31	849.00		121.00	851.76			2.76				0.33	1.77			
abp	31	657.00		89.00	649.58			-7.42				-1.13	2.15			
abp	31	629.00		87.00	634.09			5.09				0.81	2.29			
abp	31	1001.00		161.00	1003.30			2.30				0.23	1.79			
abp	31	694.00		103.00	695.94			1.94				0.28	1.92			
abp	31	641.00		92.00	633.31			-7.69				-1.20	2.35			
abp	31	623.00		101.00	616.46			-6.54				-1.05	2.26			
abp	20	68.40		12.00	68.5		12.00	0.10	5.3665631			0.15				
abp	20	0.82		0.11	0.83		0.12	0.01	0.052345			1.22				
abp	20	0.69		0.13	0.7		0.11	0.01	0.0570964			1.45				
abp	20	0.74		0.10	0.75		0.11	0.01	0.0479583			1.35				
abp	20	1.10		0.17	1.13		0.18	0.03	0.078867			2.73				
abp	20	24.60		3.80	26.7		3.60	2.10	1.6661332			8.54				
abp	20	13.40		2.30	17.3		2.80	3.90	1.2401613			29.10				
abp	20	99.50		10.20	118.5		9.30	19.00	4.447696			19.10				
abp	20	4.30		0.90	6.6		0.80	2.30	0.3924283			53.49				
abp	20	22.00		4.20	33		4.40	11.00	1.9328735			50.00				
abp	20	29.50		4.80	33.5		4.30	4.00	2.0923671			13.56				
itt	26	36.90		5.40												
itt	26	17.40		3.50	18.8			1.40	1			8.05				
itt	26	99.20		17.40	98.7			-0.50	3.6			-0.50				
itt	26	57.60		13.70	58.9			1.30	1.6			2.26				
itt	26	41.60		9.40	39.8			-1.80	1.9			-4.33				
itt	26	0.96		0.15	0.971			0.01	0.014			1.36				
itt	26	519.00		187.00	693			174.00	166			33.53				
itt	26	10.90		3.30	9.4			-1.50	1.4			-13.76				
itt	26	13.40		10.40	16.8			3.40	5.9			25.37				
itt	26	1.16		0.12	1.17			0.01	0.023			0.60				
itt	26	1.08		0.16	1.083			0.01	0.027			0.74				
itt	65	72.00		15.00												
itt	65	15.00		3.00												
itt	65	0.84		0.18	0.85		0.19	0.01	0.0833067			1.19				
itt	65	0.65		0.17	0.65		0.17	0.00	0.0760263			0.00				
itt	65	0.70		0.15	0.7		0.17	0.00	0.074162			0.00				
itt	65	1.09		0.26	1.08		0.28	-0.01	0.1223111			-0.92				
itt	65	1.09		0.16	1.09		0.18	0.00	0.0784857			0.00				
itt	65	792.00		282.00	1286		322.00	494.00	140.57311			62.37				
itt	65	147.00		94.00	613		119.00	466.00	53.499533			317.01				
itt	72	88.80	2.10	17.82	93.00			4.20	11.879394	1.4		4.73				
itt	72	295.00	5.80	49.21	323.50			28.50	61.942554	7.3		9.66				

Outcome Characteristics

itt	72	81.60	1.10	9.33	82.90			1.30	5.939697	0.7			1.59			
itt	72	34.90	0.80	6.79	34.30			-0.60	5.0911688	0.6			-1.72			
itt	72	43.30	0.50	4.24	45.00			1.70	2.5455844	0.3			3.93			
itt	72	0.85	0.01	0.08	0.86	0.01	0.08	0.01	0.0379473				1.18			
itt	72	1.07	0.01	0.08	1.07	0.01	0.08	0.00	0.0379473				0.00			
itt	72	1.09	0.01	0.08	1.09	0.01	0.08	0.00	0.0379473							
itt	72	1.29	0.02	0.17	1.29	0.02	0.17	0.00	0.0758947							
abp	45															
abp	22															
abp	28															
abp	28	1.24		0.12									0.97	3.23	0.61	
abp	28	0.69		0.06									-0.77	3.70	0.70	
abp	28	1.01		0.12									-1.49	3.23	0.61	
abp	28	0.79		0.12									-0.99	4.55	0.86	
abp	28	0.97		0.16									-1.33	5.87	1.11	
abp	28	60.15		9.96												
abp	28	914.00		403.21												
itt	14	61.70		10.80												
itt	10	0.97		0.17	0.978		0.17	0.01	0.035				0.93			
itt	10	0.73		0.12	0.717		0.13	-0.01	0.026				-1.24			
abp	31	54.10		7.30	53.1		7.30	-1.00	3.2646592				-1.85			
abp	31	22.40		2.90	22.1		2.90	-0.30	1.2969194				-1.34			
abp	31	723.80		221.50	693		220.30	-30.80	98.796407				-4.26			
abp	31	12.30		13.10	6.3		3.40	-6.00	10.148793				-48.78			
abp	31	0.98		0.10	0.976		0.10	0.00	0.0438748				-0.26	1.58		
abp	31	37.90		4.20	38		4.30	0.10	1.9031553				0.23	2.27		
abp	31	16.80		4.30	16.2		4.20	-0.60	1.9031553				-3.37	6.35		
abp	31	0.88		0.12	0.866		0.11	-0.01	0.0532748				-1.30	2.26		
abp	31	0.78		0.11	0.775		0.11	-0.01	0.0501019				-0.60	2.31		
abp	31	0.67		0.12	0.667		0.11	0.00	0.0508724				-0.39	4.09		
abp	31	0.59		0.10	0.589		0.09	0.00	0.0428089				-0.31	3.44		
abp	6	96.21		0.86	7.82	0.00	0.88	0.02	0.3916102				-1.04			
abp	6	31.40		5.50	31.1		5.60	-0.40	0.7				-1.27			
abp	6	1.11		0.09	1.1293		0.10	0.02	0.0328				2.10			
abp	6	0.77		0.34	0.9312		0.08	0.16	0.3492				20.25			
abp	6	0.86		0.06	0.8548		0.05	-0.01	0.0294				-0.78			

Outcome Characteristics

met_sd_e	p_met_sd_e	n_c	i_c	i_se_c	i_sd_c	f_c	f_se_c	f_sd_c	d_c	d_sd_c	d_se_c	lci_c	uci_c	p_c
	confidence interval	19												-0.30
	confidence interval	19												0.10
	confidence interval	19												-0.70
	confidence interval	19												0.20
confidence interval		19	62.6		9.50	60.7			-1.90	4.88		-4.2	0.5	-3.04
		19	23.9		3.50									
		19	29.7		5.00									
	confidence interval	19												-0.30
	confidence interval	19												0.10
	confidence interval	19												-0.70
	confidence interval	19												0.20
confidence interval		19	62.6		9.50	60.7			-1.90	4.88		-4.2	0.5	-3.04
		19	23.9		3.50									
		19	29.7		5.00									
	confidence interval	19												-0.30
	confidence interval	19												0.10
	confidence interval	19												-0.70
	confidence interval	19												0.20
confidence interval		19	62.6		9.50	60.7			-1.90	4.88		-4.2	0.5	-3.04
		19	23.9		3.50									
		19	29.7		5.00									
change score sd (imputed)		25	1.22		0.10	1.23		0.11	0.01	0.02				1.06
change score sd (imputed)		25	0.99		0.09	1.00		0.11	0.00	0.04				0.40
change score sd (imputed)		25	0.82		0.09	0.82		0.11	0.00	0.04				0.37
pre-post sd		25	62.7		2.00	62.7		2.00	0.00	0.89				0.00
pre-post sd		25	23.2		3.20	23.2		3.20	0.00	1.43				0.00
change score sem		25	194		55.00				8.60	22.50	4.5			4.43
change score sem		25	40		6.00				2.40	3.80	0.76			6.00
change score sd (imputed)		32	1.12		0.12	1.12		0.12	0.00	0.04				-0.09
change score sd (imputed)		32	0.93		0.13	0.92		0.11	-0.01	0.03				-0.54
change score sd (imputed)		32	0.79		0.11	0.79		0.10	-0.01	0.03				-0.76
pre-post sd		32	66.5		7.80	66.5		7.80	0.00	3.49				0.00
pre-post sd		32	25.1		2.60	25.1		2.60	0.00	1.16				0.00
pre-post sd		32	1139		340.00	1139		340.00	0.00	152.05				0.00
change score sd (imputed)		22	1.15		0.12	1.16		0.12	0.02	0.02				1.57
change score sd (imputed)		22	0.89		0.11	0.89		0.11	0.00	0.03				-0.11
change score sd (imputed)		22	0.77		0.11	0.77		0.12	0.00	0.03				-0.52
pre-post sd		22	63.8		9.20	63.8		9.20	0.00	4.11				0.00
pre-post sd		22	24.6		2.57	24.6		2.57	0.00	1.15				0.00

Outcome Characteristics

pre-post sd		22	1190		336.00	1190		336.00	0.00	150.26				0.00
change score sem		22	39		6.60				5.80	6.10	1.3			14.87
		44	24.9		2.30									
pre-post sd		44	18.8		5.60	16.8		5.10	-2.00	2.44				-10.64
pre-post sd		44	1.021		0.11	1.014		0.11	-0.01	0.05				-0.69
pre-post sd		44	1.049		0.12	1.042		0.12	-0.01	0.05				-0.67
pre-post sd		44	0.869		0.08	0.866		0.08	0.00	0.04				-0.35
pre-post sd		44	0.826		0.09	0.832		0.09	0.01	0.04				0.73
pre-post sd		52	18.8		5.60	16.8		5.10	-2.00	2.44				-10.64
pre-post sd		52	1.007		0.11	1.002		0.11	0.00	0.05				-0.50
pre-post sd		52	1.033		0.12	1.028		0.12	0.00	0.05				-0.48
pre-post sd		52	0.875		0.08	0.874		0.08	0.00	0.04				-0.11
pre-post sd		52	0.832		0.09	0.834		0.09	0.00	0.04				0.24
		15	24.61		2.32									
change score sem		15	1.18		0.20	1.15			-0.03	0.04	0.01			-2.54
pre-post sd		15	0.955		0.10	0.942		0.15	-0.01	0.07				-1.36
		15												
pre-post sd	change score sem	10	0.706	0.001	0.00	0.695	0.001	0.00	-0.01	0.00				-1.58
pre-post sd	change score sem	10	0.882	0.002	0.01	0.873	0.002	0.01	-0.01	0.00				-0.98
pre-post sd		10	39	8	25.30	38	7	22.14	-1.00	11.05				-2.56
pre-post sd		10	22	7	22.14	23	5	15.81	1.00	10.49				4.55
pre-post sd		10	69	22.14	70.01	69	18.97	59.99	0.00	30.67				0.00
pre-post sd		10	27	18.97	59.99	28	22.14	70.01	1.00	30.67				3.70
pre-post sd		10	31	9.49	30.01	32	18.87	59.67	1.00	35.19				3.23
pre-post sd		9	61.4		5.90	62.8		5.30	1.40	2.57				2.28
pre-post sd		9	21		4.80	22		4.60	1.00	2.11				4.76
change score sd (imputed)		9	21.033		1.50	21.578		1.73	0.54	1.07				2.59
change score sd (imputed)		9	508.89		49.28	517.89		40.62	9.00	49.82				1.77
change score sd (imputed)		9	7		0.93	7.125		0.88	0.13	0.35				1.79
change score sd (imputed)		9	41.889		7.25	42.622		7.02	0.73	2.41				1.75
change score sd (imputed)		9	110.67		21.14	113.44		22.15	2.78	4.74				2.51
change score sd (imputed)		9	0.8539		0.13	0.86011		0.13	0.01	0.01				0.73
change score sd (imputed)		9	0.691		0.08	0.69678		0.08	0.01	0.01				0.84
change score sd (imputed)		9	0.5707		0.07	0.57367		0.07	0.00	0.00				0.53
change score sd (imputed)		9	0.4737		0.07	0.48389		0.07	0.01	0.02				2.15
change score sd (imputed)		9	0.9454		0.08	0.94933		0.08	0.00	0.01				0.41
pre-post sd		9	61.4		5.90	62.8		5.30	1.40	2.57				2.28
pre-post sd		9	21		4.80	22		4.60	1.00	2.11				4.76
change score sd (imputed)		9	21.033		1.50	21.578		1.73	0.54	1.07				2.59
change score sd (imputed)		9	508.89		49.28	517.89		40.62	9.00	49.82				1.77

Outcome Characteristics

change score sd (imputed)		9	7		0.93	7.125		0.88	0.13	0.35				1.79
change score sd (imputed)		9	41.889		7.25	42.622		7.02	0.73	2.41				1.75
change score sd (imputed)		9	110.67		21.14	113.44		22.15	2.78	4.74				2.51
change score sd (imputed)		9	0.8539		0.13	0.86011		0.13	0.01	0.01				0.73
change score sd (imputed)		9	0.691		0.08	0.69678		0.08	0.01	0.01				0.84
change score sd (imputed)		9	0.5707		0.07	0.57367		0.07	0.00	0.00				0.53
change score sd (imputed)		9	0.4737		0.07	0.48389		0.07	0.01	0.02				2.15
change score sd (imputed)		9	0.9454		0.08	0.94933		0.08	0.00	0.01				0.41
change score sd (imputed)		40	1.04		0.20	1.03		0.20	0.00	0.09				-0.48
change score sd (imputed)		40	0.84		0.11	0.85		0.11	0.01	0.05				1.31
change score sd (imputed)		40	0.53		0.11	0.52		0.11	-0.01	0.05				-1.89
		40	67.9		10.60	68.8			0.90	1.90				1.33
		40	25.6		3.50	25.93			0.33					1.29
pre-post sd		40	841		240.00	853		272.00	12.00	118.66				1.43
		12	73.2	4.8	16.63									
		12	26.6	1.2	4.16									
		12	40	2	6.93									
		12	1019	115	398.37									
		12	8.1	2.2	7.62									
pre-post sd	change score sem	12	0.939	0.033	0.11	0.937	0.031	0.11	0.00	0.05				-0.10
pre-post sd	change score sem	12	0.847	0.03	0.10	0.841	0.03	0.10	-0.01	0.05				-0.70
pre-post sd	change score sem	12	0.721	0.025	0.09	0.718	0.026	0.09	0.00	0.04				-0.40
pre-post sd	change score sem	12	0.662	0.022	0.08	0.661	0.023	0.08	0.00	0.04				-0.20
pre-post sd	change score sem	12	0.566	0.023	0.08	0.571	0.025	0.09	0.01	0.04				0.80
pre-post sd	change score sem	12	0.991	0.016	0.06	0.986	0.016	0.06	-0.01	0.02				-0.50
pre-post sd	change score sem	12	31.4	4.6	15.93	29.3	5.1	17.67	-2.10	7.70				-2.00
pre-post sd	change score sem	12	110.6	9.2	31.87	114	8.9	30.83	3.40	14.06				4.00
pre-post sd		22	79.5		9.20	79		8.40	-0.50	4.01				-0.63
pre-post sd		22	31		2.90	30.8		2.90	-0.20	1.30				-0.65
pre-post sd		22	35.4		7.30	35.2		6.90	-0.20	3.20				-0.56
pre-post sd		22	41.1		3.60	40.9		3.90	-0.20	1.70				-0.49
pre-post sd		22	45.9		5.00	46		4.80	0.10	2.20				0.22
pre-post sd		22	1.13		0.06	1.12		0.06	-0.01	0.03				-0.88
pre-post sd		22	1.07		0.14	1.09		0.13	0.02	0.06				1.87
pre-post sd		22	1		0.08	1		0.08	0.00	0.04				0.00
pre-post sd		22	0.92		0.09	0.91		0.09	-0.01	0.04				-1.09
pre-post sd		22	0.84		0.07	0.84		0.06	0.00	0.03				0.00
pre-post sd		22	0.76		0.10	0.8		0.10	0.04	0.04				5.26
pre-post sd		19	67.7		8.50	67.8		8.50	0.10	3.80				0.15
pre-post sd		19	26.1		3.20	26.4		3.40	0.30	1.49				1.15

Outcome Characteristics

pre-post sd		19	38.8		3.30	37.6		3.40	-1.20	1.50				-3.09
pre-post sd		19	0.98		0.10	1		0.10	0.02	0.04				2.00
pre-post sd		19	0.68		0.07	0.69		0.08	0.01	0.03				1.50
pre-post sd		19	0.95		0.15	0.96		0.15	0.01	0.07				1.00
pre-post sd		19	0.78		0.10	0.78		0.10	0.00	0.04				0.00
pre-post sd		19	0.68		0.11	0.7		0.11	0.02	0.05				2.90
pre-post sd		19	0.64		0.10	0.62		0.12	-0.02	0.05				-3.10
pre-post sd		19	284.19		38.98	277.03		51.71	-7.16	23.77				-2.50
pre-post sd		19	238.02		49.24	235.16		41.21	-2.86	21.69				-1.20
pre-post sd		19	1.79		0.26	1.86		0.31	0.07	0.14				3.90
pre-post sd		19	42.89		44.64	61.22		48.78	18.33	21.28				42.70
pre-post sd		19	54.79		2.30	54.58		2.34	-0.21	1.04				-0.40
		31	65.09		15.42									
		31	33.3		5.90									
	change score sd (imputed)	31	1.06		0.12			0.00	-1.06					0.20
	change score sd (imputed)	31	0.84						-0.84					-1.90
	change score sd (imputed)	31	0.69		0.06				-0.69					0.30
change score sd (imputed)	change score sd (imputed)	31	35.4		6.60				-1.80	6.00				-4.00
change score sd (imputed)	change score sd (imputed)	31	51.2		16.00				0.87	5.80				6.00
change score sd (imputed)	change score sd (imputed)	31	36.3		11.40				2.10	4.90				13.90
change score sd (imputed)	change score sd (imputed)	31	75		28.90				4.40	12.10				15.40
change score sd (imputed)	change score sd (imputed)	31	91.8		26.50				0.03	13.00				4.20
		65	68.3		10.80									
		65	25.6		4.00									
		65	38.5		4.40									
		65	38.6		7.20									
change score sd (imputed)		65	0.89		0.11	0.897			0.01	0.03				0.79
change score sd (imputed)		65	0.77		0.10	0.77			0.00	0.03				0.00
change score sd (imputed)		65	1.17		0.13	1.181			0.01	0.03				0.94
change score sd (imputed)		65	1.13		0.07	1.134			0.00	0.01				0.35
		59	67.8		11.40									
		59	25.5		4.00									
		59	38.3		4.10									
		59	38.5		7.30									
change score sd (imputed)		59	0.85		0.10	0.846			0.00	0.04				-0.47
change score sd (imputed)		59	0.72		0.10	0.719			0.00	0.03				-0.14
change score sd (imputed)		59	1.08		0.15	1.074			-0.01	0.03				-0.56
change score sd (imputed)		59	1.09		0.08	1.086			0.00	0.01				-0.37
pre-post sd		5	1.15		0.12	1.08		0.15	-0.07	0.07				-6.09
pre-post sd		5	70.5		10.12	69.3		9.27	-1.20	4.41				-1.70

Outcome Characteristics

pre-post sd		5	42		6.73	45.1		4.96	3.10	3.13				7.38
		5	40.89			38.05			-2.84					-6.95
pre-post sd		5	23		3.65	22.7		1.21	-0.30	2.61				-1.30
pre-post sd		5	1036.9		523.50	1036.9		523.50	0.00	234.12				0.00
pre-post sd		5	1.15		0.12	1.08		0.15	-0.07	0.07				-6.09
pre-post sd		5	70.5		10.12	69.3		9.27	-1.20	4.41				-1.70
pre-post sd		5	42		6.73	45.1		4.96	3.10	3.13				7.38
		5	40.89			38.05			-2.84					-6.95
pre-post sd		5	23		3.65	22.7		1.21	-0.30	2.61				-1.30
pre-post sd		5	1036.9		523.50	1036.9		523.50	0.00	234.12				0.00
		45	1.02		0.12									
	change score sd (imputed)	45	0.86		0.11									0.60
		45	0.91		0.11									
		45	1.19		0.11									
		45	1.03		0.10									
		45	1.05		0.09									
		45	0.59		0.07									
	change score sd (imputed)	45	0.60		0.07									-0.70
pre-post sd		45	62		7.00	62		7.00	0.00	3.13				0.00
pre-post sd		45	22.9		2.30	22.9		2.30	0.00	1.03				0.00
pre-post sd		45	30.4		4.30	30.4		4.30	0.00	1.92				0.00
		45	43.15			43.15			0.00					0.00
change score sd (imputed)		45	37.6		3.30	37.6		3.30	0.00	1.48				0.00
pre-post sd		45	1102		264.00	1102		264.00	0.00	118.06				0.00
other		45	56.3		8.70									
other		45	39.2		7.00									
other		45	137.5		26.50									
other		45	17.2		3.80									
other		45	437		38.00									
other		45	407		36.00									
other		45	6.6		0.60									
		27	0.92		0.16									
		27	0.82		0.12									
		27	0.60		0.10									
		27	0.36		0.06									
		27	65		8.00									
		27	25.1		2.90									
		27	31.4		5.40									
		27	44.59											
pre-post sd		27	925		236.00	925		236.00	0.00	105.54				0.00

Outcome Characteristics

		34	57.8										
		34	42.8										
		34	126										
		34	17.4										
		34	1.74										
		27	0.92		0.16								
		27	0.82		0.12								
		27	0.60		0.10								
		27	0.36		0.06								
		27	65		8.00								
		27	25.1		2.90								
		27	31.4		5.40								
pre-post sd		27	925		236.00	925		236.00	0.00	105.54			0.00
		34	57.8										
		34	42.8										
		34	126										
		34	17.4										
		34	1.74										
	change score sd (imputed)	29	0.85		0.12				-0.85				-0.30
		29	0.68		0.10								
		29	1.01		0.14								
	change score sd (imputed)	29	0.96		0.15				-0.96				0.75
change score sd (imputed)		29			0.00				-0.34	1.45			
change score sd (imputed)		29	23.89		3.08	24		3.20	0.08	0.56			0.33
change score sd (imputed)		29							1.47	2.03			
change score sd (imputed)		29							1.52	3.51			
change score sd (imputed)		29							1.41	5.21			
change score sd (imputed)		29							25.80	50.00			
change score sd (imputed)		29							28.20	50.50			
pre-post sd		29	45.4		5.70	46		6.20	0.60	2.71			1.32
	change score sd (imputed)	29	0.85		0.12				-0.85				-0.30
		29	0.68		0.10								
		29	1.01		0.14								
	change score sd (imputed)	29	0.96		0.15				-0.96				0.75
change score sd (imputed)		29							-0.34	1.45			
change score sd (imputed)		29	23.89		3.08	24		3.20	0.08	0.56			0.33
change score sd (imputed)		29							1.47	2.03			
change score sd (imputed)		29							1.52	3.51			
change score sd (imputed)		29							1.41	5.21			
change score sd (imputed)		29							25.80	50.00			

Outcome Characteristics

change score sd (imputed)		29						28.20	50.50				
pre-post sd		29	45.4		5.70	46		6.20	0.60	2.71			1.32
	change score sd (imputed)	30	0.7		0.10				-0.70				-2.30
		30	0.59		0.08								
		30	0.85		0.12								
	change score sd (imputed)	30	0.75		0.09				-0.75				0.99
change score sd (imputed)		30			0.00			0.00	-0.19	1.55			
change score sd (imputed)		30	24.93		3.02	25.2		3.10	0.29	0.73			1.16
change score sd (imputed)		30							0.51	1.45			
change score sd (imputed)		30							2.26	4.17			
change score sd (imputed)		30							3.07	4.78			
change score sd (imputed)		30							60.60	179.60			
change score sd (imputed)		30							13.50	35.30			
pre-post sd		30	34.7		3.50	35		3.40	0.30	1.55			0.86
	change score sd (imputed)	30	0.7		0.10				-0.70				-2.30
		30	0.59		0.08								
		30	0.85		0.12								
	change score sd (imputed)	30	0.75		0.09				-0.75				0.99
change score sd (imputed)		30							-0.41	1.56			
change score sd (imputed)		30	24.93		3.02	25.2		3.10	0.29	0.73			1.16
change score sd (imputed)		30							0.51	1.45			
change score sd (imputed)		30							2.26	4.17			
change score sd (imputed)		30							3.07	4.78			
change score sd (imputed)		30							60.60	179.60			
change score sd (imputed)		30							13.50	35.30			
pre-post sd		30	34.7		3.50	35		3.40	0.30	1.55			0.86
		20	45.8		4.00								
		20	19.9		2.10								
pre-post sd	change score sd (imputed)	20	0.611		0.05	0.616		0.04	0.01	0.02			0.96
pre-post sd		9	0.78		0.09	0.74		0.13	-0.04	0.06			-5.13
pre-post sd		9	1.15		0.29	1.14		0.32	-0.01	0.14			-0.87
pre-post sd		9	2.24		0.49	2.31		0.34	0.07	0.24			3.12
pre-post sd		9	26.4		2.66	28.15		3.89	1.75	1.89			6.63
pre-post sd		9	84.2		17.70	84.8		16.70	0.60	7.75			0.71
		123	69.5		12.00								
		123	37.4		5.60								
		123	816		356.00								
		123	22.9		4.20								
change score sd (imputed)	confidence interval	112	0.927		0.15	0.93		0.15	0.00	0.03			0.33
change score sd (imputed)	confidence interval	112	0.703		0.11	0.696		0.11	-0.01	0.02			-1.05

[illegible]

Outcome Characteristics

pre-post sd	change score sd (imputed)												
pre-post sd	change score sd (imputed)												
pre-post sd	change score sd (imputed)												
		42	69.3		14.60								
		42	41		8.00								
		42	39		4.90								
	change score sd (imputed)	36	0.94		0.16			-0.94					-0.01
	change score sd (imputed)	36	0.89		0.15			-0.89					-0.57
	change score sd (imputed)	36	0.7		0.10			-0.70					-0.01
	change score sd (imputed)	36	1.05		0.15			-1.05					-1.18
	change score sd (imputed)	36	0.76		0.11			-0.76					-0.11
	change score sd (imputed)	36	0.36		0.06			-0.36					-0.55
	change score sd (imputed)	36	0.53		0.07			-0.53					-0.47
	change score sd (imputed)	36	0.61		0.08			-0.61					0.05
	change score sd (imputed)	36			0.00			0.00					-0.71
		42	69.3		14.60								
		42	41		8.00								
		42	39		4.90								
	change score sd (imputed)	36	0.94		0.16			-0.94					-0.01
	change score sd (imputed)	36	0.89		0.15			-0.89					-0.57
	change score sd (imputed)	36	0.7		0.10			-0.70					-0.01
	change score sd (imputed)	36	1.05		0.15			-1.05					-1.18
	change score sd (imputed)	36	0.76		0.11			-0.76					-0.11
	change score sd (imputed)	36	0.36		0.06			-0.36					-0.55
	change score sd (imputed)	36	0.53		0.07			-0.53					-0.47
	change score sd (imputed)	36	0.61		0.08			-0.61					0.05
		36			0.00			0.00					-0.71
		45	84.1		9.80								
		45	27.7		3.30								
		45	1039		455.00								
		45	1.4		3.00								
pre-post sd	change score sd (imputed)	43	1.206		0.15	1.221		0.15	0.02	0.07			1.18
pre-post sd	change score sd (imputed)	43	0.919		0.08	0.908		0.07	-0.01	0.03			-0.87
pre-post sd	change score sd (imputed)	43	1.004		0.09	1.004		0.08	0.00	0.04			0.23
		44	81.9		10.70								
		44	26.7		2.90								
		44	996		293.00								
		44	0.7		1.00								
pre-post sd	change score sd (imputed)	42	1.238		0.17	1.235		0.17	0.00	0.08			-0.08
pre-post sd	change score sd (imputed)	42	0.933		0.08	0.923		0.08	-0.01	0.04			-0.68

Outcome Characteristics

pre-post sd	change score sd (imputed)	42	1.01		0.12	1.007		0.11	0.00	0.05				0.15
		20	58.2		6.70									
		20	23		3.80									
		20	33.3		11.70									
	confidence interval	20	0.521	0.02	0.09				-0.52					0.30
	confidence interval	20	0.471	0.12	0.54				-0.47					-0.30
	confidence interval	20	1.1	0.02	0.09				-1.10					0.20
	confidence interval	20	0.953	0.01	0.04				-0.95					-0.10
	confidence interval	20	0.852	0.01	0.04				-0.85					-0.90
	confidence interval	20	0.696	0.01	0.04				-0.70					0.80
	confidence interval	20	0.838	0.01	0.04				-0.84					-0.70
	confidence interval	20	0.986	0.02	0.09				-0.99					1.40
	confidence interval	20	32	0.8	3.58				-32.00					1.30
	confidence interval	20	39.4	0.7	3.13				-39.40					-0.20
	confidence interval	20	913	136	608.21				-913.00					-3.10
	confidence interval	20	88	4.3	19.23				-88.00					17.00
		20	58.2		6.70									
		20	23		3.80									
		20	33.3		11.70									
	confidence interval	20	0.521	0.02	0.09				-0.52					0.30
	confidence interval	20	0.471	0.12	0.54				-0.47					-0.30
	confidence interval	20	1.1	0.02	0.09				-1.10					0.20
	confidence interval	20	0.953	0.01	0.04				-0.95					-0.10
	confidence interval	20	0.852	0.01	0.04				-0.85					-0.90
	confidence interval	20	0.696	0.01	0.04				-0.70					0.80
	confidence interval	20	0.838	0.01	0.04				-0.84					-0.70
	confidence interval	20	0.986	0.02	0.09				-0.99					1.40
	confidence interval	20	32	0.8	3.58				-32.00					1.30
	confidence interval	20	39.4	0.7	3.13				-39.40					-0.20
	confidence interval	20	913	136	608.21				-913.00					-3.10
	confidence interval	20	88	4.3	19.23				-88.00					17.00
change score sd (imputed)		32	65.2		12.60	64.2			-1.00	2.00				-1.53
change score sd (imputed)		32	39.7		5.40	40			0.30	1.00				0.76
change score sd (imputed)		32	24.5		8.40	24.1			-0.40	1.40				-1.63
confidence interval		31	0.69		0.12	0.693			0.00	0.02		-0	0.01	0.43
confidence interval		31	0.59		0.10	0.589			0.00	0.02		-0.01	0.006	-0.17
confidence interval		31	0.52		0.09	0.522			0.00	0.04		-0.01	0.015	0.38
confidence interval		30	219.93		47.18	217.15			-2.78	6.40		-5.17	-0.39	-1.26
confidence interval		30	205.46		40.74	203.62			-1.84	6.48		-4.26	0.58	-0.90
confidence interval		30	1067.2		42.39	1062.25			-4.99	15.02		-10.6	0.62	-0.47

Outcome Characteristics

confidence interval		30	1361.4		310.47	1339.45		-21.95	58.52		-43.8	-0.1	-1.61
confidence interval		28	161.79		29.15	161.55		-0.24	3.52		-1.6	1.13	-0.15
confidence interval		28	586.41		147.56	589.22		2.81	17.86		-4.11	9.74	0.48
confidence interval		28	287.14		72.66	284.21		-2.93	12.40		-7.74	1.88	-1.02
confidence interval		23	55.66		13.47	54.99		-0.67	3.65		-2.25	0.91	-1.20
confidence interval		23	50.62		10.43	50.16		-0.46	2.97		-1.74	0.83	-0.91
confidence interval		23	1092.1		0.00	1088.56		-3.54	28.76		-16	8.89	-0.32
confidence interval		23			0.00			-1.00	14.13		-7.11	5.11	
confidence interval		28	51.56		15.69	53.41		1.85	9.34		-1.77	5.47	3.59
confidence interval		28	112.13		39.98	119.31		7.18	33.01		-5.62	19.98	6.40
confidence interval		28	481.82		108.02	473.07		-8.75	86.81		-42.4	24.91	-1.82
change score sd (imputed)		32	65.2		12.60	64.2		-1.00	2.00				-1.53
change score sd (imputed)		32	39.7		5.40	40		0.30	1.00				0.76
change score sd (imputed)		32	24.5		8.40	24.1		-0.40	1.40				-1.63
confidence interval		31	0.69		0.12	0.693		0.00	0.02		-0	0.01	0.43
confidence interval		31	0.59		0.10	0.589		0.00	0.02		-0.01	0.006	-0.17
confidence interval		31	0.52		0.09	0.522		0.00	0.04		-0.01	0.015	0.38
confidence interval		30	219.93		47.18	217.15		-2.78	6.40		-5.17	-0.39	-1.26
confidence interval		30	205.46		40.74	203.62		-1.84	6.48		-4.26	0.58	-0.90
confidence interval		30	1067.2		42.39	1062.25		-4.99	15.02		-10.6	0.62	-0.47
confidence interval		30	1361.4		310.47	1339.45		-21.95	58.52		-43.8	-0.1	-1.61
confidence interval		28	161.79		29.15	161.55		-0.24	3.52		-1.6	1.13	-0.15
confidence interval		28	586.41		147.56	589.22		2.81	17.86		-4.11	9.74	0.48
confidence interval		28	287.14		72.66	284.21		-2.93	12.40		-7.74	1.88	-1.02
confidence interval		23	55.66		13.47	54.99		-0.67	3.65		-2.25	0.91	-1.20
confidence interval		23	50.62		10.43	50.16		-0.46	2.97		-1.74	0.83	-0.91
confidence interval		23	1092.1		0.00	1088.56		-3.54	28.76		-16	8.89	-0.32
confidence interval		23			0.00			-1.00	14.13		-7.11	5.11	
confidence interval		28	51.56		15.69	53.41		1.85	9.34		-1.77	5.47	3.59
confidence interval		28	112.13		39.98	119.31		7.18	33.01		-5.62	19.98	6.40
confidence interval		28	481.82		108.02	473.07		-8.75	86.81		-42.4	24.91	-1.82
pre-post sd		34	1.15		0.07	1.14	0.07	-0.01	0.03				-0.96
pre-post sd		34	1.23		0.11	1.22	0.11	-0.01	0.05				-0.49
pre-post sd		34	0.96		0.13	0.93	0.13	-0.02	0.06				-2.30
pre-post sd		34	0.77		0.10	0.76	0.11	0.00	0.05				-0.39
pre-post sd		34	0.90		0.16	0.89	0.17	-0.01	0.07				-0.89
pre-post sd		34	0.71		0.06	0.72	0.06	0.01	0.03				1.27
		34	62.9		10.20								
		34	22.88										
		34	32.2		7.00								

Outcome Characteristics

		34	42.65										
		24	636.9		280.90								
		24	2		1.90								
pre-post sd		24	28.1		3.50	27.3		2.00	-0.80	1.91			-2.85
pre-post sd		24	39.4		5.00	38.2		3.20	-1.20	2.54			-3.05
pre-post sd		24	38.4		4.60	37.8		3.70	-0.60	2.05			-1.56
pre-post sd		24	6		0.80	6.3		1.20	0.30	0.59			5.00
pre-post sd		24	26.9		16.20	22.3		13.60	-4.60	7.13			-17.10
pre-post sd		24	81.3		18.60	79.1		19.30	-2.20	8.50			-2.71
pre-post sd		24	50.6		15.00	49.9		11.10	-0.70	6.96			-1.38
pre-post sd		24	134.4		27.30	129.6		28.60	-4.80	12.56			-3.57
pre-post sd		24	68.6		20.00	66.6		20.20	-2.00	8.99			-2.92
pre-post sd		24	0.678		0.06	0.676		0.07	0.00	0.03			-0.29
pre-post sd		24	0.628		0.04	0.621		0.05	-0.01	0.02			-1.11
pre-post sd		24	0.99		0.09	0.98		0.11	-0.01	0.05			-1.01
pre-post sd		24	0.831		0.07	0.824		0.08	-0.01	0.04			-0.84
		24	636.9		280.90								
		24	2		1.90								
pre-post sd		24	28.1		3.50	27.3		2.00	-0.80	1.91			-2.85
pre-post sd		24	39.4		5.00	38.2		3.20	-1.20	2.54			-3.05
pre-post sd		24	38.4		4.60	37.8		3.70	-0.60	2.05			-1.56
pre-post sd		24	6		0.80	6.3		1.20	0.30	0.59			5.00
pre-post sd		24	26.9		16.20	22.3		13.60	-4.60	7.13			-17.10
pre-post sd		24	81.3		18.60	79.1		19.30	-2.20	8.50			-2.71
pre-post sd		24	50.6		15.00	49.9		11.10	-0.70	6.96			-1.38
pre-post sd		24	134.4		27.30	129.6		28.60	-4.80	12.56			-3.57
pre-post sd		24	68.6		20.00	66.6		20.20	-2.00	8.99			-2.92
pre-post sd		24	0.678		0.06	0.676		0.07	0.00	0.03			-0.29
pre-post sd		24	0.628		0.04	0.621		0.05	-0.01	0.02			-1.11
pre-post sd		24	0.99		0.09	0.98		0.11	-0.01	0.05			-1.01
pre-post sd		24	0.831		0.07	0.824		0.08	-0.01	0.04			-0.84
		30	625.7		265.60								
		30	1.9		2.00								
pre-post sd		30	28.2		3.70	27.7		2.50	-0.50	1.81			-1.77
pre-post sd		30	37.7		4.40	37.9		3.10	0.20	2.10			0.53
pre-post sd		30	40.6		5.30	40.6		4.00	0.00	2.44			0.00
pre-post sd		30	515		68.40	535.5		67.30	20.50	30.36			3.98
pre-post sd		30	24.8		3.90	25.4		1.30	0.60	2.79			2.42
pre-post sd		30	6.3		1.20	5.9		0.90	-0.40	0.55			-6.35
pre-post sd		30	33.5		14.60	31.2		12.30	-2.30	6.42			-6.87

Outcome Characteristics

pre-post sd		30	15.5		3.60	17.7		5.00	2.20	2.36				14.19
pre-post sd		30	81.1		26.00	92		19.40	10.90	12.02				13.44
pre-post sd		30	80.3		19.50	84.6		19.70	4.30	8.77				5.35
pre-post sd		30	50.2		16.10	53		9.50	2.80	8.61				5.58
pre-post sd		30	51.5		14.90	51.1		10.70	-0.40	7.04				-0.78
pre-post sd		30	142.7		42.70	140.7		33.80	-2.00	19.18				-1.40
pre-post sd		30	134.1		31.90	132.9		31.90	-1.20	14.27				-0.89
pre-post sd		30	69.9		21.90	77.8		25.80	7.90	11.32				11.30
pre-post sd		30	71.7		20.60	73.9		19.30	2.20	9.01				3.07
pre-post sd		30	0.678		0.06	0.671		0.05	-0.01	0.03				-1.03
pre-post sd		30	0.625		0.05	0.628		0.03	0.00	0.02				0.48
pre-post sd		30	0.981		0.11	0.977		0.08	0.00	0.05				-0.41
pre-post sd		30	0.822		0.07	0.823		0.06	0.00	0.03				0.12
pre-post sd		30	0.868		0.08	0.863		0.07	-0.01	0.04				-0.58
pre-post sd	change score sd (imputed)	19	1.11		0.18	1.10		0.16	-0.01	0.08				-0.61
pre-post sd		19	72.9		15.50	74.6		18.00	1.70	7.88				2.33
pre-post sd		19	27.74			28.39			0.65					2.34
pre-post sd		19	23.1		4.40	21.2		4.40	-1.90	1.97				-8.23
pre-post sd	change score sd (imputed)	19	1.11		0.18	1.10		0.16	-0.01	0.08				-0.61
pre-post sd		19	72.9		15.50	74.6		18.00	1.70	7.88				2.33
pre-post sd		19	27.74			28.39			0.65					2.34
pre-post sd		19	23.1		4.40	21.2		4.40	-1.90	1.97				-8.23
change score sd (imputed)	change score sd (imputed)	19	0.83		0.11	0.81			-0.02	0.04				-2.50
change score sd (imputed)	change score sd (imputed)	19	0.99		0.15	0.97			-0.02	0.04				-1.80
		19	62.2		8.90									
		19	23.1		2.20									
pre-post sd		19	707		278.00	908		247.00	201.00	121.22				28.43
pre-post sd		19	80.5		12.50	84.8		11.70	4.30	5.47				3.50
pre-post sd		19	24.5		8.20	25.8		8.50	1.30	3.75				14.00
pre-post sd		19	19.4		4.60	22.2		4.90	2.80	2.14				19.20
pre-post sd		19	28.2		6.40	25.8		8.30	-2.40	3.77				-8.60
pre-post sd		19	15.8		3.90	15.3		5.60	-0.50	2.69				-3.20
pre-post sd		19	24.1		8.10	25.8		8.90	1.70	3.88				8.50
pre-post sd		19	7186		1180.00	5393		697.00	-1793.00	630.70				-24.95
		26	68.1		10.50									
		26	26.1		3.90									
pre-post sd		26	0.79	0.02	0.10	0.78	0.02	0.10	-0.01	0.05				-1.27
pre-post sd		26	0.92	0.02	0.10	0.92	0.02	0.10	0.00	0.05				0.00
pre-post sd		26	1.03	0.02	0.10	1.04	0.02	0.10	0.01	0.05				0.97
	change score sd (imputed)	35	880.00		116.00	878.01			-1.99					-0.23

Outcome Characteristics

	change score sd (imputed)	35	841.00		101.00	841.50		0.50				0.06
	change score sd (imputed)	35	667.00		90.00	657.99		-9.01				-1.35
	change score sd (imputed)	35	634.00		77.00	637.17		3.17				0.50
	change score sd (imputed)	35	982.00		122.00	983.67		1.67				0.17
	change score sd (imputed)	35	701.00		92.00	699.74		-1.26				-0.18
	change score sd (imputed)	35	653.00		92.00	643.07		-9.93				-1.52
	change score sd (imputed)	35	636.00		107.00	646.49		10.49				-1.65
pre-post sd		18	61.7		12.90	60.7	13.20	-1.00	5.84			-1.62
pre-post sd		18	0.78		0.09	0.73	0.10	-0.05	0.04			-6.41
pre-post sd		18	0.63		0.10	0.59	0.12	-0.04	0.05			-6.35
pre-post sd		18	0.69		0.12	0.67	0.11	-0.02	0.05			-2.90
pre-post sd		18	1.01		0.17	1.01	0.17	0.00	0.08			0.00
pre-post sd		18	24.3		4.20	24.4	3.80	0.10	1.83			0.41
pre-post sd		18	13.6		2.20	13.8	2.60	0.20	1.14			1.47
pre-post sd		18	98.6		9.50	99.2	8.60	0.60	4.14			0.61
pre-post sd		18	4.2		1.00	4.1	0.90	-0.10	0.44			-2.38
pre-post sd		18	23		4.80	22	4.40	-1.00	2.09			-4.35
pre-post sd		18	28.5		4.20	28	4.00	-0.50	1.84			-1.75
		27	37.3		4.70							
change score sd (imputed)		27	16.3		3.80	15.4		-0.90	1.50			-5.52
change score sd (imputed)		27	101		16.30	100.9		-0.10	3.50			-0.10
change score sd (imputed)		27	57.3		11.50	56.5		-0.80	2.50			-1.40
change score sd (imputed)		27	43.8		9.90	45		1.20	5.10			2.74
change score sd (imputed)		27	0.962		0.13	0.955		-0.01	0.02			-0.73
change score sd (imputed)		27	505		143.00	499		-6.00	101.00			-1.19
change score sd (imputed)		27	11.6		3.30	11.6	60.28	0.00	1.00			0.00
change score sd (imputed)		27	10.7		10.60	8.4		-2.30	9.40			-21.50
change score sd (imputed)		27	1.207		0.18	1.208		0.00	0.04			0.08
change score sd (imputed)		27	1.096		0.15	1.099		0.00	0.03			0.27
		47	70		14.00							
		47	15		3.00							
pre-post sd		47	0.79		0.17	0.75	0.15	-0.04	0.07			-5.06
pre-post sd		47	0.59		0.14	0.58	0.12	-0.01	0.06			-1.69
pre-post sd		47	0.66		0.13	0.63	0.11	-0.03	0.06			-4.55
pre-post sd		47	1.01		0.24	0.97	0.23	-0.04	0.11			-3.96
pre-post sd		47	1.08		0.16	1.03	0.17	-0.05	0.07			-4.63
pre-post sd		47	783		223.00	1254	330.00	471.00	161.76			60.15
pre-post sd		47	130		86.00	610	111.00	480.00	50.34			369.23
change score sem		76	88	2	17.44	85.20		-2.80	10.46	1.2		-3.18
change score sem		76	290	6.3	54.92	299.30		9.30	63.64	7.3		3.21

Outcome Characteristics

change score sem		76	81.4	1.2	10.46	82.70			1.30	5.23	0.6			1.60
change score sem		76	34.3	0.8	6.97	34.80			0.50	4.36	0.5			1.46
change score sem		76	42.3	0.6	5.23	43.20			0.90	1.74	0.2			2.13
pre-post sd		76	0.87	0.01	0.09	0.87	0.01	0.09	0.00	0.04				0.00
pre-post sd		76	1.09	0.01	0.09	1.09	0.01	0.09	0.00	0.04				0.00
pre-post sd		76	1.1	0.01	0.09	1.1	0.01	0.09	0.00	0.04				0.00
pre-post sd		76	1.3	0.02	0.17	1.29	0.02	0.17	-0.01	0.08				-0.77
		39												
change score sem		27												
		27												
	change score sem	27	1.27		0.13				-1.27					2.22
	change score sem	27	0.7		0.06				-0.70					0.80
	change score sem	27	1.03		0.13				-1.03					0.21
	change score sem	27	0.8		0.12				-0.80					0.69
	change score sem	27	1		0.13				-1.00					-0.80
		27	64.95		9.79									
		27	1020		479.91									
		16	63.4		13.60									
change score sd (imputed)		10	1.004		0.14	0.986		0.14	-0.02	0.04				-1.89
change score sd (imputed)		10	0.755		0.06	0.745		0.07	-0.01	0.04				-1.46
pre-post sd		33	51.4		7.10	51		7.30	-0.40	3.23				-0.78
pre-post sd		33	20.9		2.20	20.8		2.30	-0.10	1.01				-0.48
pre-post sd		33	671.5		190.90	625.4		190.00	-46.10	85.18				-6.87
pre-post sd	change score sd (imputed)	33	9.2		5.90	7		3.90	-2.20	2.93				-23.91
pre-post sd	change score sd (imputed)	33	1.002		0.10	0.994		0.09	-0.01	0.04				-0.74
pre-post sd	change score sd (imputed)	33	36.9		3.70	37.2		3.90	0.30	1.71				0.77
pre-post sd	change score sd (imputed)	33	15.1		4.50	15		4.50	-0.10	2.01				0.17
pre-post sd	change score sd (imputed)	33	0.907		0.13	0.904		0.13	0.00	0.06				-0.27
pre-post sd	change score sd (imputed)	33	0.787		0.13	0.781		0.12	-0.01	0.06				-0.66
pre-post sd	change score sd (imputed)	33	0.676		0.11	0.672		0.10	0.00	0.05				-0.25
pre-post sd	change score sd (imputed)	33	0.599		0.12	0.594		0.12	-0.01	0.05				-0.69
change score sd (imputed)		9	89.635		14.70	90.99569		12.66	1.36	5.85				1.52
change score sd (imputed)		9	29		5.10	29.5		4.30	0.50	2.10				1.72
change score sd (imputed)		9	1.2296		0.22	1.2396		0.29	0.01	0.08				0.81
change score sd (imputed)		9	1.0622		0.17	1.0722		0.15	0.01	0.05				0.94
change score sd (imputed)		9	0.9273		0.33	1.0148		0.12	0.09	0.25				9.43

Outcome Characteristics

p_sd_c	p_se_c	p_lci_c	p_uci_c	met_sd_c	p_met_sd_c	sd_pooled	te	te_se	te_var	te_lci	te_uci	p_sd_pooled
1.76		-1.20	0.50		confidence interval							1.82
2.90		-1.30	1.50		confidence interval							2.99
2.18		-1.70	0.40		confidence interval							2.17
2.90		-1.20	1.60		confidence interval							2.99
				confidence interval		4.16	1.40	1.41	1.99			
1.76		-1.20	0.50		confidence interval							1.79
2.90		-1.30	1.50		confidence interval							2.93
2.18		-1.70	0.40		confidence interval							2.10
2.90		-1.20	1.60		confidence interval							2.90
				confidence interval		4.48	1.50	1.61	2.60			
1.76		-1.20	0.50		confidence interval							1.82
2.90		-1.30	1.50		confidence interval							2.95
2.18		-1.70	0.40		confidence interval							2.13
2.90		-1.20	1.60		confidence interval							2.95
				confidence interval		4.23	1.50	1.43	2.06			
				change score sd (imputed)		0.02	0.00	0.00	0.00			
				change score sd (imputed)		0.03	0.02	0.01	0.00			
				change score sd (imputed)		0.04	0.02	0.01	0.00			
				pre-post sd		2.68	0.00	0.73	0.53			
				pre-post sd		1.27	0.00	0.34	0.12			
				change score sem		22.18	4.30	6.01	36.07			
				change score sem		3.82	1.30	1.03	1.07			
				change score sd (imputed)		0.03	0.00	0.01	0.00			
				change score sd (imputed)		0.03	-0.01	0.01	0.00			
				change score sd (imputed)		0.02	0.00	0.01	0.00			
				pre-post sd		3.36	0.00	0.78	0.60			
				pre-post sd		1.16	0.00	0.27	0.07			
				pre-post sd		129.06	0.00	29.84	890.68			
				change score sd (imputed)		0.03	0.00	0.01	0.00			
				change score sd (imputed)		0.03	0.00	0.01	0.00			
				change score sd (imputed)		0.03	0.00	0.01	0.00			
				pre-post sd		3.32	0.00	0.98	0.96			
				pre-post sd		1.02	0.00	0.30	0.09			

Outcome Characteristics

				pre-post sd		147.48	0.00	43.53	1894.99			
				change score sem		5.98	4.00	1.77	3.12			
				pre-post sd		2.24	-2.60	0.47	0.22			
				pre-post sd		0.04	0.00	0.01	0.00			
				pre-post sd		0.04	0.01	0.01	0.00			
				pre-post sd		0.03	0.01	0.01	0.00			
				pre-post sd		0.04	-0.01	0.01	0.00			
				pre-post sd		2.24	-2.60	0.43	0.18			
				pre-post sd		0.04	0.00	0.01	0.00			
				pre-post sd		0.05	0.00	0.01	0.00			
				pre-post sd		0.03	0.00	0.01	0.00			
				pre-post sd		0.04	0.00	0.01	0.00			
				change score sem		0.04	0.02	0.01	0.00			
				pre-post sd		0.06	0.00	0.02	0.00			
0.63	0.20			pre-post sd	change score sem	0.00	0.01	0.00	0.00			0.42
0.35	0.11			pre-post sd	change score sem	0.00	0.01	0.00	0.00			0.35
				pre-post sd		16.61	25.00	6.78	46.00			
				pre-post sd		11.35	16.00	4.63	21.48			
				pre-post sd		45.76	-5.00	18.68	349.00			
				pre-post sd		32.44	-4.00	13.24	175.40			
				pre-post sd		34.19	-5.00	13.96	194.80			
				pre-post sd		2.60	-1.80	1.23	1.50			
				pre-post sd		1.79	-2.20	0.84	0.71			
				change score sd (imputed)		1.39	4.41	0.65	0.43			
				change score sd (imputed)		46.31	100.11	21.83	476.68			
				change score sd (imputed)		0.45	1.93	0.21	0.04			
				change score sd (imputed)		4.05	17.82	1.91	3.64			
				change score sd (imputed)		8.59	35.00	4.05	16.40			
				change score sd (imputed)		0.01	-0.01	0.01	0.00			
				change score sd (imputed)		0.02	0.00	0.01	0.00			
				change score sd (imputed)		0.01	0.00	0.01	0.00			
				change score sd (imputed)		0.03	0.01	0.02	0.00			
				change score sd (imputed)		0.03	0.00	0.01	0.00			
				pre-post sd		3.31	-2.60	1.52	2.31			
				pre-post sd		2.34	-1.90	1.07	1.15			
				change score sd (imputed)		2.18	3.59	1.00	1.01			
				change score sd (imputed)		50.29	84.67	23.11	533.86			

Outcome Characteristics

				change score sd (imputed)		0.54	1.60	0.25	0.06			
				change score sd (imputed)		4.93	17.98	2.26	5.13			
				change score sd (imputed)		9.67	19.78	4.44	19.75			
				change score sd (imputed)		0.02	-0.02	0.01	0.00			
				change score sd (imputed)		0.02	-0.01	0.01	0.00			
				change score sd (imputed)		0.01	0.00	0.01	0.00			
				change score sd (imputed)		0.02	-0.01	0.01	0.00			
				change score sd (imputed)		0.02	0.01	0.01	0.00			
				pre-post sd		0.07	0.01	0.01	0.00			
				pre-post sd		0.05	0.00	0.01	0.00			
				pre-post sd		0.04	0.01	0.01	0.00			
				change score sd (imputed)		1.36	-1.00	0.31	0.10			
						0.00	-0.34					
				pre-post sd		109.14	16.00	24.72	611.26			
3.12	0.90			pre-post sd	change score sem	0.05	-0.01	0.02	0.00			3.14
2.77	0.80			pre-post sd	change score sem	0.04	0.00	0.02	0.00			2.54
2.77	0.80			pre-post sd	change score sem	0.04	0.00	0.02	0.00			2.81
3.46	1.00			pre-post sd	change score sem	0.04	0.00	0.02	0.00			3.47
2.46	0.71			pre-post sd	change score sem	0.04	-0.01	0.02	0.00			3.13
1.39	0.40			pre-post sd	change score sem	0.03	0.01	0.01	0.00			1.33
31.87	9.20			pre-post sd	change score sem	7.93	18.90	3.39	11.52			50.43
10.39	3.00			pre-post sd	change score sem	15.17	29.20	6.50	42.20			13.11
				pre-post sd		4.81	-0.30	1.53	2.34			
				pre-post sd		1.58	-0.10	0.50	0.25			
				pre-post sd		3.59	-0.80	1.14	1.30			
				pre-post sd		1.94	0.70	0.62	0.38			
				pre-post sd		2.38	-1.50	0.76	0.57			
				pre-post sd		0.04	0.01	0.01	0.00			
				pre-post sd		0.07	-0.03	0.02	0.00			
				pre-post sd		0.05	0.00	0.01	0.00			
				pre-post sd		0.04	0.02	0.01	0.00			
				pre-post sd		0.05	0.00	0.01	0.00			
				pre-post sd		0.06	-0.07	0.02	0.00			
				pre-post sd		3.96	0.10	1.26	1.58			
				pre-post sd		1.35	0.00	0.43	0.18			

Outcome Characteristics

				pre-post sd		1.56	-0.20	0.50	0.25			
				pre-post sd		0.04	0.00	0.01	0.00			3.38
				pre-post sd		0.03	0.00	0.01	0.00			4.51
				pre-post sd		0.08	0.02	0.03	0.00			2.09
				pre-post sd		0.04	0.00	0.01	0.00			4.19
				pre-post sd		0.04	0.02	0.01	0.00			6.28
				pre-post sd		0.05	0.05	0.02	0.00			7.25
				pre-post sd		21.13	26.60	6.69	44.76			19.34
				pre-post sd		20.94	16.23	6.63	43.96			14.34
				pre-post sd		0.16	0.21	0.05	0.00			8.54
				pre-post sd		21.17	4.47	6.70	44.94			244.77
				pre-post sd		0.87	0.40	0.28	0.08			3.38
2.50					change score sd (imputed)	0.00	-0.02					2.66
5.70					change score sd (imputed)	0.00	-0.04					4.41
3.10					change score sd (imputed)	0.00	-0.03					4.86
17.00				change score sd (imputed)	change score sd (imputed)	5.61	4.10	1.41	2.00			16.35
24.40				change score sd (imputed)	change score sd (imputed)	6.11	3.93	1.54	2.37			24.91
26.50				change score sd (imputed)	change score sd (imputed)	4.80	2.50	1.21	1.46			25.12
50.90				change score sd (imputed)	change score sd (imputed)	12.51	7.30	3.15	9.94			42.21
29.50				change score sd (imputed)	change score sd (imputed)	12.45	3.77	3.14	9.85			25.75
				change score sd (imputed)		0.03	0.01	0.00	0.00			
				change score sd (imputed)		0.03	0.01	0.00	0.00			
				change score sd (imputed)		0.03	0.00	0.00	0.00			
				change score sd (imputed)		0.01	0.00	0.00	0.00			
				change score sd (imputed)		0.04	0.01	0.01	0.00			
				change score sd (imputed)		0.03	0.01	0.00	0.00			
				change score sd (imputed)		0.03	0.01	0.00	0.00			
				change score sd (imputed)		0.01	0.00	0.00	0.00			
				pre-post sd		0.06	0.07	0.04	0.00			
				pre-post sd		5.26	1.30	3.32	11.05			

				pre-post sd		3.03	-0.70	1.91	3.66			
				pre-post sd		0.00	1.24					
				pre-post sd		2.02	-0.70	1.28	1.64			
				pre-post sd		231.71	0.00	146.55	21476.54			
				pre-post sd		0.06	0.09	0.04	0.00			
				pre-post sd		7.00	0.10	4.43	19.61			
				pre-post sd		2.59	-2.90	1.64	2.69			
				pre-post sd		0.00	2.05					
				pre-post sd		2.10	2.00	1.33	1.76			
				pre-post sd		195.14	0.00	123.42	15231.41			
2.70					change score sd (imputed)	0.00	0.00					2.61
2.36					change score sd (imputed)	0.00	0.00					3.09
				pre-post sd		3.13	0.00	0.68	0.47			
				pre-post sd		1.09	0.00	0.24	0.06			
				pre-post sd		1.80	0.00	0.39	0.16			
							0.00					
				pre-post sd		2.68	3.10	0.59	0.34			
				pre-post sd		113.22	0.00	24.77	613.52			
				other		9.79	-0.60	2.14	4.59	-4.8	3.6	
				other		10.03	2.60	2.19	4.81	-1.6	6.9	
				other		19.82	7.50	4.34	18.81	-0.9	16	
				other		49.91	17.20	10.92	119.21	-4.3	38.6	
				other		34.98	21.00	7.65	58.57	6	36	
				other		46.64	36.00	10.20	104.12	24	56	
				other		1.63	-0.30	0.36	0.13	-0.7	0.4	
							-3.00					
							-1.20					
							-0.10					
							-1.99					
				pre-post sd		114.66	0.00	31.51	992.58			

Outcome Characteristics

						4.50	-0.30	1.17	1.38	-2.7	2	
						4.31	-0.20	1.12	1.26	-2	2	
						6.66	-0.30	1.73	3.01	-3.6	3.1	
						1.76	0.10	0.46	0.21	-0.9	1	
						0.10	0.03	0.03	0.00	-0.01	0.08	
							-6.00					
							-1.40					
							-1.90					
					pre-post sd	106.99	0.00	30.36	921.62			
						4.54	0.10	1.22	1.50	-2.4	2.5	
						4.35	-1.00	1.17	1.38	-3.3	1.3	
						6.80	-2.60	1.84	3.37	-6.2	1	
						1.89	-0.90	0.51	0.26	-1.9	0.1	
						0.09	0.06	0.03	0.00	0.01	0.11	
1.80					change score sd (imputed)	0.00	-0.01					2.18
1.80					change score sd (imputed)	0.00	0.01					2.07
					change score sd (imputed)	1.64	-0.45	0.43	0.18			
					change score sd (imputed)	0.64	-0.21	0.17	0.03			
					change score sd (imputed)	1.72	-0.16	0.45	0.20			
					change score sd (imputed)	4.04	0.03	1.05	1.11			
					change score sd (imputed)	4.43	0.52	1.15	1.33			
					change score sd (imputed)	47.57	3.90	12.39	153.46			
					change score sd (imputed)	47.73	-2.90	12.43	154.52			
					pre-post sd	2.54	-0.50	0.66	0.44			
1.80					change score sd (imputed)	0.00	-0.04					1.57
1.80					change score sd (imputed)	0.00	-0.03					2.01
					change score sd (imputed)	1.53	-0.12	0.40	0.16			
					change score sd (imputed)	0.58	-0.16	0.15	0.02			
					change score sd (imputed)	1.69	-0.47	0.44	0.20			
					change score sd (imputed)	3.87	0.32	1.02	1.03			
					change score sd (imputed)	4.97	1.87	1.30	1.70			
					change score sd (imputed)	47.57	7.10	12.49	156.03			

Outcome Characteristics

				change score sd (imputed)		54.59	-6.20	14.34	205.55			
				pre-post sd		2.72	-0.70	0.71	0.51			
2.40					change score sd (imputed)	0.00	0.03					2.45
2.70					change score sd (imputed)	0.00	0.07					2.52
					change score sd (imputed)	1.67	0.51	0.44	0.19			
				change score sd (imputed)		0.75	0.35	0.20	0.04			
				change score sd (imputed)		1.41	0.38	0.37	0.14			
				change score sd (imputed)		4.74	0.97	1.24	1.55			
				change score sd (imputed)		4.44	-1.18	1.17	1.36			
				change score sd (imputed)		155.34	2.00	40.82	1666.08			
				change score sd (imputed)		31.16	-9.93	8.19	67.06			
				pre-post sd		2.01	0.10	0.53	0.28			
2.40					change score sd (imputed)	0.00	0.02					3.61
2.70					change score sd (imputed)	0.00	0.06					2.65
				change score sd (imputed)		1.65	0.32	0.43	0.18			
				change score sd (imputed)		0.77	-0.06	0.20	0.04			
				change score sd (imputed)		1.62	0.14	0.42	0.17			
				change score sd (imputed)		4.42	-1.42	1.14	1.30			
				change score sd (imputed)		5.16	1.06	1.33	1.78			
				change score sd (imputed)		189.08	-11.10	48.82	2383.33			
				change score sd (imputed)		36.78	-3.40	9.50	90.18			
				pre-post sd		2.03	0.00	0.52	0.27			
3.39				pre-post sd	change score sd (imputed)	0.03	0.02	0.01	0.00			3.14
				pre-post sd		0.05	0.11	0.02	0.00			
				pre-post sd		0.10	0.12	0.05	0.00			
				pre-post sd		0.27	-0.73	0.13	0.02			
				pre-post sd		2.43	3.62	1.14	1.31			
				pre-post sd		6.21	-4.80	2.93	8.57			
3.07		-0.24	0.91	change score sd (imputed)	confidence interval	0.03	0.01	0.00	0.00	0.006	0.021	2.92
3.47		-1.70	-0.40	change score sd (imputed)	confidence interval	0.02	0.02	0.00	0.00	0.008	0.021	3.47

Outcome Characteristics

1.98					change score sd (imputed)	0.00	0.04					2.04
1.97					change score sd (imputed)	0.00	0.03					1.89
2.74					change score sd (imputed)	0.00	0.03					2.59
2.57					change score sd (imputed)	0.00	0.04					2.39
2.60					change score sd (imputed)	0.00	0.04					2.69
3.03					change score sd (imputed)	0.00	0.00					2.93
2.24					change score sd (imputed)	0.00	0.00					2.24
2.42					change score sd (imputed)	0.00	-0.01					2.51
1.69					change score sd (imputed)	0.00	0.00					1.57
1.98					change score sd (imputed)	0.00	0.03					1.92
1.97					change score sd (imputed)	0.00	0.05					1.90
2.74					change score sd (imputed)	0.00	0.05					2.68
2.57					change score sd (imputed)	0.00	0.05					2.53
2.60					change score sd (imputed)	0.00	0.04					2.44
3.03					change score sd (imputed)	0.00	0.00					3.10
2.24					change score sd (imputed)	0.00	0.00					2.07
2.42					change score sd (imputed)	0.00	-0.01					2.46
1.69					change score sd (imputed)	0.00	0.00					1.71
2.83				pre-post sd	change score sd (imputed)	0.07	-0.01	0.02	0.00			2.82
2.13				pre-post sd	change score sd (imputed)	0.03	0.02	0.01	0.00			2.22
1.67				pre-post sd	change score sd (imputed)	0.04	0.00	0.01	0.00			1.96
2.30				pre-post sd	change score sd (imputed)	0.07	0.02	0.02	0.00			2.49
2.31				pre-post sd	change score sd (imputed)	0.04	0.02	0.01	0.00			2.30

Outcome Characteristics

1.92				pre-post sd	change score sd (imputed)	0.05	0.01	0.01	0.00			1.97
4.06		-1.60	2.20		confidence interval	0.00	-0.01					3.95
5.45		-2.80	2.30		confidence interval	0.00	0.02					5.11
2.03		-0.70	1.20		confidence interval	0.00	0.00					2.05
2.35		-1.20	1.00		confidence interval	0.00	0.03					2.47
2.35		-2.00	0.20		confidence interval	0.00	0.01					2.77
3.21		-0.70	2.30		confidence interval	0.00	0.01					3.73
4.38		-2.80	1.30		confidence interval	0.00	-0.01					4.85
2.99		-0.20	2.60		confidence interval	0.00	-0.01					2.67
10.68		-3.70	6.30		confidence interval	0.00	2.00					10.63
2.78		-1.50	1.10		confidence interval	0.00	0.20					3.43
584.38		-277.00	270.00		confidence interval	0.00	36.00					501.68
29.91		2.70	30.70		confidence interval	0.00	8.00					29.30
4.06		-1.60	2.20		confidence interval	0.00	-0.01					4.13
5.45		-2.80	2.30		confidence interval	0.00	-0.01					5.66
2.03		-0.70	1.20		confidence interval	0.00	-0.01					2.10
2.35		-1.20	1.00		confidence interval	0.00	0.01					2.43
2.35		-2.00	0.20		confidence interval	0.00	-0.01					3.85
3.21		-0.70	2.30		confidence interval	0.00	-0.01					3.08
4.38		-2.80	1.30		confidence interval	0.00	0.01					4.97
2.99		-0.20	2.60		confidence interval	0.00	-0.03					2.76
10.68		-3.70	6.30		confidence interval	0.00	1.00					10.94
2.78		-1.50	1.10		confidence interval	0.00	0.70					3.15
584.38		-277.00	270.00		confidence interval	0.00	149.00					527.02
29.91		2.70	30.70		confidence interval	0.00	-1.00					29.72
				change score sd (imputed)		2.91	-0.20	0.73	0.53			
				change score sd (imputed)		1.05	0.10	0.26	0.07			
				change score sd (imputed)		1.35	0.30	0.34	0.11			
				confidence interval		0.02	0.00	0.01	0.00			
				confidence interval		0.02	0.00	0.00	0.00			
				confidence interval		0.04	0.01	0.01	0.00			
				confidence interval		6.42	1.70	1.63	2.66			
				confidence interval		4.97	0.79	1.26	1.60			
				confidence interval		15.05	4.93	3.82	14.63			

Outcome Characteristics

				confidence interval		58.61	8.28	14.89	221.82			
				confidence interval		3.53	-0.21	0.92	0.84			
				confidence interval		17.89	-1.21	4.67	21.76			
				confidence interval		12.42	0.69	3.24	10.48			
				confidence interval		3.66	1.67	1.10	1.22			
				confidence interval		2.97	0.91	0.90	0.81			
				confidence interval		28.78	18.93	8.69	75.47			
				confidence interval		14.14	5.95	4.27	18.22			
				confidence interval		9.23	-0.86	2.49	6.20			
				confidence interval		32.86	-4.14	8.86	78.57			
				confidence interval		70.53	6.00	19.02	361.91			
				change score sd (imputed)		2.05	0.00	0.51	0.26			
				change score sd (imputed)		1.00	0.00	0.25	0.06			
				change score sd (imputed)		1.45	-0.10	0.36	0.13			
				confidence interval		0.02	0.00	0.00	0.00			
				confidence interval		0.02	0.01	0.00	0.00			
				confidence interval		0.04	0.01	0.01	0.00			
				confidence interval		6.37	1.56	1.61	2.58			
				confidence interval		6.45	-0.34	1.63	2.64			
				confidence interval		14.95	10.31	3.77	14.22			
				confidence interval		58.24	13.58	14.69	215.82			
				confidence interval		3.50	-0.73	0.91	0.82			
				confidence interval		17.74	-6.57	4.59	21.08			
				confidence interval		12.33	3.09	3.19	10.18			
				confidence interval		3.65	-0.04	1.00	1.01			
				confidence interval		2.97	0.05	0.82	0.67			
				confidence interval		28.71	-1.01	7.90	62.44			
				confidence interval		14.11	0.40	3.88	15.08			
				confidence interval		9.33	-5.17	2.41	5.83			
				confidence interval		32.97	-13.54	8.53	72.80			
				confidence interval		86.69	12.37	22.43	503.27			
				pre-post sd		0.03	0.00	0.01	0.00			
				pre-post sd		0.06	0.02	0.02	0.00			
				pre-post sd		0.06	0.01	0.02	0.00			
				pre-post sd		0.05	0.01	0.01	0.00			
				pre-post sd		0.07	0.02	0.02	0.00			
				pre-post sd		0.03	0.00	0.01	0.00			
							4.50					
							1.43					
							4.80					

Outcome Characteristics

							0.25					
				pre-post sd		1.96	0.20	0.57	0.33			
				pre-post sd		3.24	4.00	0.95	0.90			
				pre-post sd		2.26	-3.00	0.66	0.44			
				pre-post sd		0.46	-0.90	0.14	0.02			
				pre-post sd		6.52	10.00	1.90	3.63			
				pre-post sd		7.81	16.50	2.28	5.19			
				pre-post sd		7.56	11.80	2.21	4.86			
				pre-post sd		13.12	22.50	3.83	14.66			
				pre-post sd		9.90	21.80	2.89	8.34			
				pre-post sd		0.03	-0.01	0.01	0.00			
				pre-post sd		0.04	0.03	0.01	0.00			
				pre-post sd		0.06	0.02	0.02	0.00			
				pre-post sd		0.05	0.02	0.01	0.00			
				pre-post sd		1.79	0.80	0.52	0.27			
				pre-post sd		2.43	1.10	0.70	0.49			
				pre-post sd		2.02	-0.20	0.58	0.34			
				pre-post sd		0.52	-1.10	0.15	0.02			
				pre-post sd		7.36	8.70	2.12	4.51			
				pre-post sd		9.77	-1.10	2.82	7.95			
				pre-post sd		6.31	5.20	1.82	3.32			
				pre-post sd		14.71	-0.40	4.25	18.02			
				pre-post sd		8.78	7.30	2.54	6.43			
				pre-post sd		0.04	0.01	0.01	0.00			
				pre-post sd		0.03	0.01	0.01	0.00			
				pre-post sd		0.06	0.01	0.02	0.00			
				pre-post sd		0.05	0.01	0.01	0.00			
				pre-post sd		1.72	0.50	0.44	0.20			
				pre-post sd		1.77	-2.30	0.46	0.21			
				pre-post sd		2.49	1.30	0.64	0.41			
				pre-post sd		29.89	-10.30	7.72	59.56			
				pre-post sd		2.39	1.70	0.62	0.38			
				pre-post sd		0.57	-0.40	0.15	0.02			
				pre-post sd		6.43	8.20	1.66	2.76			

Outcome Characteristics

				pre-post sd		2.15	0.30	0.56	0.31			
				pre-post sd		10.66	-2.90	2.75	7.57			
				pre-post sd		10.07	-2.10	2.60	6.76			
				pre-post sd		7.88	1.20	2.03	4.14			
				pre-post sd		6.71	7.30	1.73	3.00			
				pre-post sd		17.50	6.30	4.52	20.42			
				pre-post sd		15.17	10.20	3.92	15.35			
				pre-post sd		10.16	-1.70	2.62	6.89			
				pre-post sd		8.98	4.80	2.32	5.38			
				pre-post sd		0.03	0.03	0.01	0.00			
				pre-post sd		0.03	0.00	0.01	0.00			
				pre-post sd		0.06	0.01	0.02	0.00			
				pre-post sd		0.04	0.00	0.01	0.00			
				pre-post sd		0.04	0.02	0.01	0.00			
3.40				pre-post sd	change score sd (imputed)	0.07	0.00	0.02	0.00			3.52
				pre-post sd		6.59	-2.10	2.11	4.46			
							-0.81					
				pre-post sd		1.94	3.70	0.62	0.39			
3.40				pre-post sd	change score sd (imputed)	0.08	0.02	0.03	0.00			3.95
				pre-post sd		6.79	-2.80	2.30	5.31			
							-1.09					
				pre-post sd		2.07	3.80	0.70	0.49			
3.80				change score sd (imputed)	change score sd (imputed)	0.04	0.03	0.01	0.00			4.17
3.50				change score sd (imputed)	change score sd (imputed)	0.03	0.03	0.01	0.00			3.55
							-2.50					
							-1.30					
				pre-post sd		145.39	6.00	46.58	2169.50			
				pre-post sd		7.42	22.60	2.38	5.65			
				pre-post sd		4.74	14.40	1.52	2.31			
				pre-post sd		2.21	11.10	0.71	0.50			
				pre-post sd		3.54	12.60	1.14	1.29			
				pre-post sd		2.49	6.60	0.80	0.64			
				pre-post sd		3.26	-5.90	1.04	1.09			
				pre-post sd		560.97	3641.00	179.71	32297.11			
				pre-post sd		0.04	0.01	0.01	0.00			
				pre-post sd		0.04	0.01	0.01	0.00			
				pre-post sd		0.04	0.00	0.01	0.00			
1.26					change score sd (imputed)	0.00	4.72					1.34

Outcome Characteristics

0.96					change score sd (imputed)	0.00	2.26					1.40
1.30					change score sd (imputed)	0.00	1.59					1.75
1.37					change score sd (imputed)	0.00	1.92					1.86
1.24					change score sd (imputed)	0.00	0.63					1.52
1.21					change score sd (imputed)	0.00	3.20					1.58
1.55					change score sd (imputed)	0.00	2.24					1.97
1.34					change score sd (imputed)	0.00	-17.03					1.83
					pre-post sd	5.60	1.10	1.82	3.31			
					pre-post sd	0.05	0.06	0.02	0.00			
					pre-post sd	0.06	0.05	0.02	0.00			
					pre-post sd	0.05	0.03	0.02	0.00			
					pre-post sd	0.08	0.03	0.03	0.00			
					pre-post sd	1.75	2.00	0.57	0.32			
					pre-post sd	1.19	3.70	0.39	0.15			
					pre-post sd	4.31	18.40	1.40	1.96			
					pre-post sd	0.41	2.40	0.13	0.02			
					pre-post sd	2.01	12.00	0.65	0.43			
					pre-post sd	1.98	4.50	0.64	0.41			
					change score sd (imputed)	1.28	2.30	0.35	0.12			
					change score sd (imputed)	3.55	-0.40	0.98	0.95			
					change score sd (imputed)	2.11	2.10	0.58	0.34			
					change score sd (imputed)	3.88	-3.00	1.07	1.13			
					change score sd (imputed)	0.02	0.02	0.00	0.00			
					change score sd (imputed)	136.78	180.00	37.58	1412.45			
					change score sd (imputed)	1.21	-1.50	0.33	0.11			
					change score sd (imputed)	7.88	5.70	2.17	4.69			
					change score sd (imputed)	0.03	0.01	0.01	0.00			
					change score sd (imputed)	0.03	0.01	0.01	0.00			
					pre-post sd	0.08	0.05	0.02	0.00			
					pre-post sd	0.07	0.01	0.01	0.00			
					pre-post sd	0.07	0.03	0.01	0.00			
					pre-post sd	0.12	0.03	0.02	0.00			
					pre-post sd	0.08	0.05	0.01	0.00			
					pre-post sd	149.80	23.00	28.68	822.67			
					pre-post sd	52.20	-14.00	10.00	99.90			
					change score sem	11.17	7.00	1.84	3.38			
					change score sem	62.82	19.20	10.33	106.74			

Outcome Characteristics

				change score sem		5.59	0.00	0.92	0.84			
				change score sem		4.73	-1.10	0.78	0.60			
				change score sem		2.17	0.80	0.36	0.13			
				pre-post sd		0.04	0.01	0.01	0.00			
				pre-post sd		0.04	0.00	0.01	0.00			
				pre-post sd		0.04	0.00	0.01	0.00			
				pre-post sd		0.08	0.01	0.01	0.00			
1.97	0.38				change score sem	0.00	0.03					2.69
4.94	0.95				change score sem	0.00	0.01					4.35
4.05	0.78				change score sem	0.00	0.02					3.66
4.42	0.85				change score sem	0.00	0.01					4.49
5.56	1.07				change score sem	0.00	0.03					5.72
				change score sd (imputed)		0.04	0.03	0.02	0.00			
				change score sd (imputed)		0.03	0.00	0.01	0.00			
				pre-post sd		3.24	-0.60	0.81	0.66			
				pre-post sd		1.16	-0.20	0.29	0.08			
				pre-post sd		92.02	15.30	23.02	529.73			
				pre-post sd	change score sd (imputed)	7.37	-3.80	1.84	3.40			
1.55				pre-post sd	change score sd (imputed)	0.04	0.01	0.01	0.00			1.56
2.39				pre-post sd	change score sd (imputed)	1.81	-0.20	0.45	0.20			2.33
6.75				pre-post sd	change score sd (imputed)	1.96	-0.50	0.49	0.24			6.56
2.64				pre-post sd	change score sd (imputed)	0.06	-0.01	0.01	0.00			2.46
1.99				pre-post sd	change score sd (imputed)	0.05	0.00	0.01	0.00			2.15
3.74				pre-post sd	change score sd (imputed)	0.05	0.00	0.01	0.00			3.91
2.80				pre-post sd	change score sd (imputed)	0.05	0.00	0.01	0.00			3.13
				change score sd (imputed)		0.37	-0.04	0.09	0.04			
				change score sd (imputed)		1.70	-0.90	0.90	0.81			
				change score sd (imputed)		0.07	0.01	0.04	0.00			
				change score sd (imputed)		0.22	0.15	0.12	0.01			
				change score sd (imputed)		0.20	-0.09	0.10	0.01			

Outcome Characteristics

p_te	p_te_se	p_te_var	p_te_lci	p_te_uci	te_met	te_met_p	g_met	g	g_var	g_se
0.50	0.62	0.38				percent change score sds	relative values	0.27	0.12	0.34
-0.60	1.02	1.03				percent change score sds	relative values	-0.20	0.12	0.34
1.50	0.74	0.54				percent change score sds	relative values	0.68	0.12	0.35
0.70	1.02	1.03				percent change score sds	relative values	0.23	0.12	0.34
2.18					change score sds		absolute values	0.33	0.12	0.34
1.20	0.64	0.41				percent change score sds	relative values	0.65	0.14	0.37
1.40	1.06	1.12				percent change score sds	relative values	0.47	0.13	0.37
1.20	0.76	0.57				percent change score sds	relative values	0.56	0.13	0.37
-0.10	1.04	1.09				percent change score sds	relative values	-0.03	0.13	0.36
2.37					change score sds		absolute values	0.33	0.13	0.36
2.00	0.62	0.38				percent change score sds	relative values	1.08	0.13	0.36
2.10	1.00	1.00				percent change score sds	relative values	0.70	0.12	0.35
2.00	0.72	0.52				percent change score sds	relative values	0.92	0.13	0.36
-1.00	1.00	1.00				percent change score sds	relative values	-0.33	0.12	0.34
2.38					change score sds		absolute values	0.35	0.12	0.34
-0.01					change score sds		absolute values	-0.06	0.07	0.27
1.65					change score sds		absolute values	0.47	0.08	0.27
2.56					change score sds		absolute values	0.57	0.08	0.28
0.00					change score sds		absolute values	0.00	0.07	0.27
0.00					change score sds		absolute values	0.00	0.07	0.27
2.50					change score sds		absolute values	0.19	0.07	0.27
3.49					change score sds		absolute values	0.34	0.07	0.27
-0.09					change score sds		absolute values	-0.03	0.05	0.23
-1.14					change score sds		absolute values	-0.31	0.05	0.23
-0.42					change score sds		absolute values	-0.12	0.05	0.23
0.00					change score sds		absolute values	0.00	0.05	0.23
0.00					change score sds		absolute values	0.00	0.05	0.23
0.00					change score sds		absolute values	0.00	0.05	0.23
-0.36					change score sds		absolute values	-0.15	0.09	0.30
0.22					change score sds		absolute values	0.07	0.09	0.30
0.51					change score sds		absolute values	0.14	0.09	0.30
0.00					change score sds		absolute values	0.00	0.09	0.30
0.00					change score sds		absolute values	0.00	0.09	0.30

Outcome Characteristics

0.00					change score sds		absolute values	0.00	0.09	0.30
9.63					change score sds		absolute values	0.66	0.09	0.30
-13.96					change score sds		absolute values	-1.15	0.05	0.23
0.37					change score sds		absolute values	0.10	0.04	0.21
0.57					change score sds		absolute values	0.13	0.04	0.21
0.92					change score sds		absolute values	0.23	0.04	0.21
-0.73					change score sds		absolute values	-0.16	0.04	0.21
-13.96					change score sds		absolute values	-1.15	0.04	0.21
0.08					change score sds		absolute values	0.02	0.04	0.19
0.18					change score sds		absolute values	0.04	0.04	0.19
0.34					change score sds		absolute values	0.09	0.04	0.19
-0.48					change score sds		absolute values	-0.11	0.04	0.19
1.99					change score sds		absolute values	0.60	0.16	0.40
0.09					change score sds		absolute values	0.00	0.15	0.39
							other	0.25	0.15	0.39
1.49	0.17	0.03			change score sds	percent change score sds	absolute values	5.99	0.88	0.94
0.85	0.14	0.02			change score sds	percent change score sds	absolute values	3.47	0.41	0.64
65.72					change score sds		absolute values	1.46	0.21	0.46
80.45					change score sds		absolute values	1.36	0.20	0.45
-7.35					change score sds		absolute values	-0.11	0.17	0.41
-14.42					change score sds		absolute values	-0.12	0.17	0.41
-16.13					change score sds		absolute values	-0.14	0.17	0.41
-2.99					change score sds		absolute values	-0.66	0.23	0.48
-11.32					change score sds		absolute values	-1.17	0.26	0.51
20.28					change score sds		absolute values	3.03	0.48	0.69
17.63					change score sds		absolute values	2.06	0.34	0.58
26.25					change score sds		absolute values	4.10	0.69	0.83
38.01					change score sds		absolute values	4.19	0.71	0.84
31.22					change score sds		absolute values	3.88	0.64	0.80
-0.62					change score sds		absolute values	-0.37	0.23	0.48
0.42					change score sds		absolute values	0.14	0.22	0.47
-0.48					change score sds		absolute values	-0.18	0.22	0.47
1.44					change score sds		absolute values	0.27	0.22	0.47
0.36					change score sds		absolute values	0.12	0.22	0.47
-4.26					change score sds		absolute values	-0.75	0.23	0.48
-9.03					change score sds		absolute values	-0.78	0.23	0.48
16.11					change score sds		absolute values	1.57	0.28	0.53
14.57					change score sds		absolute values	1.61	0.28	0.53

Outcome Characteristics

23.42					change score sds		absolute values	2.81	0.42	0.65
43.45					change score sds		absolute values	3.48	0.53	0.73
15.66					change score sds		absolute values	1.95	0.31	0.56
-1.86					change score sds		absolute values	-0.97	0.24	0.49
-1.61					change score sds		absolute values	-0.64	0.22	0.47
0.58					change score sds		absolute values	0.23	0.21	0.46
-2.04					change score sds		absolute values	-0.46	0.22	0.47
0.98					change score sds		absolute values	0.44	0.22	0.46
1.06					change score sds		absolute values	0.17	0.05	0.23
0.59					change score sds		absolute values	0.11	0.05	0.23
2.09					change score sds		absolute values	0.29	0.05	0.23
-1.47										
-1.33										
1.92					change score sds		absolute values	0.15	0.05	0.23
-0.50	1.34	1.81			change score sds	percent change score sds	absolute values	-0.09	0.18	0.43
0.50	1.09	1.18			change score sds	percent change score sds	absolute values	0.09	0.18	0.43
0.30	1.20	1.44			change score sds	percent change score sds	absolute values	0.02	0.18	0.43
0.40	1.49	2.21			change score sds	percent change score sds	absolute values	0.03	0.18	0.43
-1.70	1.34	1.80			change score sds	percent change score sds	absolute values	-0.26	0.18	0.43
0.60	0.57	0.33			change score sds	percent change score sds	absolute values	0.17	0.18	0.43
92.00	21.59	466.24			change score sds	percent change score sds	absolute values	2.29	0.30	0.55
29.00	5.61	31.52			change score sds	percent change score sds	absolute values	1.85	0.26	0.51
-0.43					change score sds		absolute values	-0.06	0.10	0.32
-0.39					change score sds		absolute values	-0.06	0.10	0.32
-2.59					change score sds		absolute values	-0.22	0.10	0.32
1.71					change score sds		absolute values	0.35	0.10	0.32
-3.45					change score sds		absolute values	-0.62	0.11	0.33
0.88					change score sds		absolute values	0.26	0.10	0.32
-2.73					change score sds		absolute values	-0.42	0.10	0.32
0.00					change score sds		absolute values	0.00	0.10	0.32
2.24					change score sds		absolute values	0.44	0.10	0.32
0.00					change score sds		absolute values	0.00	0.10	0.32
-9.37					change score sds		absolute values	-1.15	0.12	0.34
0.15					change score sds		absolute values	0.02	0.10	0.32
0.04					change score sds		absolute values	0.00	0.10	0.32

Outcome Characteristics

-0.53					change score sds		absolute values	-0.13	0.10	0.32
0.10	1.07	1.15	-1.3	2.2	change score sds	percent change treatment e	absolute values	0.00	0.10	0.32
0.00	1.43	2.04	-1.9	2.8	change score sds	percent change treatment e	absolute values	0.00	0.10	0.32
2.10	0.66	0.44	-0.4	3.4	change score sds	percent change treatment e	absolute values	0.24	0.10	0.32
0.00	1.33	1.76	-3.8	2.6	change score sds	percent change treatment e	absolute values	0.00	0.10	0.32
3.40	1.99	3.96	-1.2	7.3	change score sds	percent change treatment e	absolute values	0.46	0.10	0.32
8.40	2.30	5.27	1.8	12.9	change score sds	percent change treatment e	absolute values	0.97	0.11	0.33
9.90	6.12	37.48	0.2	21.9	change score sds	percent change treatment e	absolute values	1.23	0.12	0.35
6.80	4.54	20.62	-2.7	15.7	change score sds	percent change treatment e	absolute values	0.76	0.11	0.33
11.40	2.70	7.31	6.9	16.7	change score sds	percent change treatment e	absolute values	1.26	0.12	0.35
33.00	77.50	6006.25	-298.1	184.9	change score sds	percent change treatment e	absolute values	0.21	0.10	0.32
0.70	1.07	1.15	-1.4	2.8	change score sds	percent change treatment e	absolute values	0.45	0.10	0.32
1.10	0.67	0.45				percent change score sds	relative values	0.41	0.06	0.25
2.40	1.11	1.23				percent change score sds	relative values	0.54	0.07	0.26
2.30	1.23	1.50				percent change score sds	relative values	0.47	0.07	0.26
12.60	4.12	16.98			change score sds	percent change score sds	absolute values	0.72	0.07	0.26
10.70	6.28	39.42			change score sds	percent change score sds	absolute values	0.64	0.07	0.26
7.80	6.33	40.06			change score sds	percent change score sds	absolute values	0.51	0.07	0.26
11.20	10.64	113.15			change score sds	percent change score sds	absolute values	0.58	0.07	0.26
4.20	6.49	42.10			change score sds	percent change score sds	absolute values	0.30	0.06	0.25
0.56					change score sds		absolute values	0.17	0.03	0.17
1.87					change score sds		absolute values	0.49	0.03	0.17
-0.15					change score sds		absolute values	-0.08	0.03	0.17
0.00					change score sds		absolute values	0.00	0.03	0.17
1.05					change score sds		absolute values	0.25	0.03	0.18
1.22					change score sds		absolute values	0.35	0.03	0.18
0.56					change score sds		absolute values	0.22	0.03	0.18
0.37					change score sds		absolute values	0.33	0.03	0.18
6.09					change score sds		absolute values	1.08	0.46	0.68
1.85					change score sds		absolute values	0.22	0.40	0.63

Outcome Characteristics

-1.11					change score sds		absolute values	-0.21	0.40	0.63
3.19										
-3.10					change score sds		absolute values	-0.31	0.40	0.64
0.00					change score sds		absolute values	0.00	0.40	0.63
7.80					change score sds		absolute values	1.43	0.50	0.71
0.18					change score sds		absolute values	0.01	0.40	0.63
-6.90					change score sds		absolute values	-1.01	0.45	0.67
5.09										
9.07					change score sds		absolute values	0.86	0.44	0.66
0.00					change score sds		absolute values	0.00	0.40	0.63
							other	0.32	0.05	0.22
1.00	0.57	0.33			change score sds	percent change score sds	relative values	0.38	0.05	0.22
							other	0.15	0.05	0.22
							other	0.22	0.05	0.22
							other	0.23	0.05	0.22
							other	0.75	0.05	0.23
							other	0.43	0.05	0.22
-0.80	0.68	0.46				percent change score sds	relative values	-0.26	0.05	0.22
0.00					change score sds		absolute values	0.00	0.05	0.22
0.00					change score sds		absolute values	0.00	0.05	0.22
0.00					change score sds		absolute values	0.00	0.05	0.22
0.00										
8.52					change score sds		absolute values	1.14	0.06	0.24
0.00					change score sds		absolute values	0.00	0.05	0.22
0.00					treatment effect confidence interval		absolute values	-0.06	0.05	0.22
0.00					treatment effect confidence interval		absolute values	0.26	0.05	0.22
0.00					treatment effect confidence interval		absolute values	0.37	0.05	0.22
0.00					treatment effect confidence interval		absolute values	0.34	0.05	0.22
0.00					treatment effect confidence interval		absolute values	0.59	0.05	0.22
0.00					treatment effect confidence interval		absolute values	0.76	0.05	0.23
0.00					treatment effect confidence interval		absolute values	-0.18	0.05	0.22
							other	0.04	0.08	0.27
							other	-0.11	0.08	0.27
							other	0.05	0.08	0.27
							other	-0.12	0.08	0.28
0.00										
0.00										
0.00										
0.00										
0.00					change score sds		absolute values	0.00	0.08	0.27

Outcome Characteristics

0.00					treatment effect confidence interval		absolute values	-0.07	0.07	0.26
0.00					treatment effect confidence interval		absolute values	-0.05	0.07	0.26
0.00					treatment effect confidence interval		absolute values	-0.04	0.07	0.26
0.00					treatment effect confidence interval		absolute values	0.06	0.07	0.26
0.00					treatment effect confidence interval		absolute values	0.30	0.07	0.26
							other	-0.14	0.08	0.28
							other	0.25	0.08	0.28
							other	-0.03	0.08	0.28
							other	-0.38	0.08	0.29
0.00										
0.00										
0.00										
0.00					change score sds		absolute values	0.00	0.08	0.28
0.00					treatment effect confidence interval		absolute values	0.02	0.07	0.27
0.00					treatment effect confidence interval		absolute values	-0.23	0.07	0.27
0.00					treatment effect confidence interval		absolute values	-0.38	0.07	0.27
0.00					treatment effect confidence interval		absolute values	-0.47	0.07	0.27
0.00					treatment effect confidence interval		absolute values	0.63	0.08	0.28
-0.12	0.57	0.32				percent change score sds	relative values	-0.05	0.07	0.26
0.56	0.54	0.29				percent change score sds	relative values	0.27	0.07	0.26
					change score sds		absolute values	-0.27	0.07	0.26
-0.89					change score sds		absolute values	-0.33	0.07	0.26
					change score sds		absolute values	-0.09	0.07	0.26
					change score sds		absolute values	0.01	0.07	0.26
					change score sds		absolute values	0.12	0.07	0.26
					change score sds		absolute values	0.08	0.07	0.26
					change score sds		absolute values	-0.06	0.07	0.26
-1.10					change score sds		absolute values	-0.19	0.07	0.26
-0.71	0.41	0.17				percent change score sds	relative values	-0.45	0.07	0.27
0.35	0.53	0.28				percent change score sds	relative values	0.17	0.07	0.26
					change score sds		absolute values	-0.08	0.07	0.26
-0.67					change score sds		absolute values	-0.27	0.07	0.26
					change score sds		absolute values	-0.27	0.07	0.26
					change score sds		absolute values	0.08	0.07	0.26
					change score sds		absolute values	0.37	0.07	0.26
					change score sds		absolute values	0.15	0.07	0.26

Outcome Characteristics

					change score sds		absolute values	-0.11	0.07	0.26
-1.54					change score sds		absolute values	-0.25	0.07	0.26
2.51	0.64	0.41				percent change score sds	relative values	1.01	0.08	0.28
-0.89	0.66	0.44				percent change score sds	relative values	-0.35	0.07	0.26
					change score sds		absolute values	0.30	0.07	0.26
1.46					change score sds		absolute values	0.46	0.07	0.27
					change score sds		absolute values	0.27	0.07	0.26
					change score sds		absolute values	0.20	0.07	0.26
					change score sds		absolute values	-0.26	0.07	0.26
					change score sds		absolute values	0.01	0.07	0.26
					change score sds		absolute values	-0.31	0.07	0.26
0.28					change score sds		absolute values	0.05	0.07	0.26
2.30	0.93	0.87				percent change score sds	relative values	0.63	0.07	0.26
1.01	0.68	0.47				percent change score sds	relative values	0.38	0.07	0.26
					change score sds		absolute values	0.19	0.07	0.26
-0.23					change score sds		absolute values	-0.08	0.07	0.26
					change score sds		absolute values	0.09	0.07	0.26
					change score sds		absolute values	-0.32	0.07	0.26
					change score sds		absolute values	0.20	0.07	0.26
					change score sds		absolute values	-0.06	0.07	0.26
					change score sds		absolute values	-0.09	0.07	0.26
-0.01					change score sds		absolute values	0.00	0.07	0.26
3.33	1.31	1.73			change score sds	percent change score sds	relative values	1.03	0.19	0.44
15.58					change score sds		absolute values	2.22	0.36	0.60
15.16					change score sds		absolute values	1.12	0.26	0.51
-29.63					change score sds		absolute values	-2.53	0.40	0.63
15.55					change score sds		absolute values	1.42	0.28	0.53
-6.10					change score sds		absolute values	-0.74	0.24	0.49
1.44	0.39	0.15			treatment effect confidence interval	percent change score sds	absolute values	0.52	0.02	0.13
2.06	0.46	0.21			treatment effect confidence interval	percent change score sds	absolute values	0.65	0.02	0.14

[illegible]

Outcome Characteristics

-0.64	0.54	0.29				percent change score sds	relative values	-0.31	0.07	0.27
1.14	0.50	0.25				percent change score sds	relative values	0.60	0.07	0.27
0.01	0.68	0.46				percent change score sds	relative values	0.00	0.07	0.26
1.88	0.63	0.40				percent change score sds	relative values	0.78	0.07	0.27
1.15	0.71	0.50				percent change score sds	relative values	0.42	0.07	0.27
-0.16	0.77	0.60				percent change score sds	relative values	-0.05	0.07	0.26
0.12	0.59	0.35				percent change score sds	relative values	0.05	0.07	0.26
-0.12	0.66	0.44				percent change score sds	relative values	-0.05	0.07	0.26
0.09	0.41	0.17				percent change score sds	relative values	0.06	0.07	0.26
-0.31	0.48	0.23				percent change score sds	relative values	-0.16	0.06	0.25
-0.08	0.47	0.22				percent change score sds	relative values	-0.04	0.06	0.25
-0.01	0.66	0.44				percent change score sds	relative values	0.00	0.06	0.25
0.11	0.63	0.39				percent change score sds	relative values	0.04	0.06	0.25
0.14	0.60	0.36				percent change score sds	relative values	0.06	0.06	0.25
0.16	0.77	0.59				percent change score sds	relative values	0.05	0.06	0.25
-0.74	0.51	0.26				percent change score sds	relative values	-0.35	0.06	0.25
-1.01	0.61	0.37				percent change score sds	relative values	-0.41	0.06	0.25
-0.08	0.42	0.18				percent change score sds	relative values	-0.05	0.06	0.25
-0.25	0.61	0.37			change score sds	percent change score sds	relative values	-0.09	0.05	0.22
2.04	0.48	0.23			change score sds	percent change score sds	relative values	0.91	0.05	0.23
0.14	0.42	0.18			change score sds	percent change score sds	relative values	0.07	0.05	0.22
1.10	0.54	0.29			change score sds	percent change score sds	relative values	0.44	0.05	0.22
1.69	0.50	0.25			change score sds	percent change score sds	relative values	0.73	0.05	0.22

Outcome Characteristics

0.07	0.42	0.18			change score sds	percent change score sds	relative values	0.04	0.05	0.22
0.50	1.35	1.82				percent change score sds	relative values	0.12	0.12	0.34
-0.20	1.74	3.04				percent change score sds	relative values	-0.04	0.12	0.34
0.20	0.70	0.49				percent change score sds	relative values	0.10	0.12	0.34
0.60	0.84	0.71				percent change score sds	relative values	0.24	0.12	0.34
1.40	0.95	0.89				percent change score sds	relative values	0.49	0.12	0.35
-0.30	1.27	1.62				percent change score sds	relative values	-0.08	0.12	0.34
1.80	1.66	2.74				percent change score sds	relative values	0.36	0.12	0.34
-0.50	0.91	0.83				percent change score sds	relative values	-0.18	0.12	0.34
-0.30	3.63	13.19				percent change score sds	relative values	-0.03	0.12	0.34
0.00	1.17	1.37				percent change score sds	relative values	0.00	0.12	0.34
2.60	171.36	29362.90				percent change score sds	relative values	0.01	0.12	0.34
38.00	10.01	100.14				percent change score sds	relative values	1.27	0.14	0.37
4.10	1.39	1.92				percent change score sds	relative values	0.97	0.13	0.35
1.10	1.90	3.60				percent change score sds	relative values	0.19	0.11	0.34
1.20	0.70	0.49				percent change score sds	relative values	0.56	0.12	0.34
-0.90	0.82	0.67				percent change score sds	relative values	-0.36	0.11	0.34
0.20	1.29	1.67				percent change score sds	relative values	0.05	0.11	0.34
-1.10	1.03	1.07				percent change score sds	relative values	-0.35	0.11	0.34
-1.30	1.67	2.78				percent change score sds	relative values	-0.26	0.11	0.34
-0.10	0.93	0.86				percent change score sds	relative values	-0.04	0.11	0.34
-3.70	3.67	13.47				percent change score sds	relative values	-0.33	0.11	0.34
0.70	1.06	1.12				percent change score sds	relative values	0.22	0.11	0.34
19.40	176.77	31246.38				percent change score sds	relative values	0.04	0.11	0.34
-3.00	9.97	99.34				percent change score sds	relative values	-0.10	0.11	0.34
-0.47					change score sds		absolute values	-0.07	0.06	0.25
0.30					change score sds		absolute values	0.09	0.06	0.25
1.15					change score sds		absolute values	0.22	0.06	0.25
-0.29					change score sds		absolute values	-0.10	0.07	0.26
-0.18					change score sds		absolute values	-0.05	0.07	0.26
1.58					change score sds		absolute values	0.22	0.07	0.26
0.76					change score sds		absolute values	0.26	0.07	0.26
0.37					change score sds		absolute values	0.16	0.06	0.25
0.46					change score sds		absolute values	0.32	0.07	0.26

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Outcome Characteristics

0.00										
0.76					change score sds		absolute values	0.10	0.09	0.29
9.74					change score sds		absolute values	1.21	0.10	0.32
-7.72					change score sds		absolute values	-1.30	0.10	0.32
-15.91					change score sds		absolute values	-1.91	0.12	0.35
37.63					change score sds		absolute values	1.51	0.11	0.33
21.47					change score sds		absolute values	2.08	0.13	0.36
23.36					change score sds		absolute values	1.54	0.11	0.33
17.96					change score sds		absolute values	1.69	0.12	0.34
29.46					change score sds		absolute values	2.17	0.14	0.37
-0.87					change score sds		absolute values	-0.17	0.09	0.29
4.21					change score sds		absolute values	0.75	0.09	0.30
2.17					change score sds		absolute values	0.34	0.09	0.29
2.47					change score sds		absolute values	0.43	0.09	0.30
2.85					change score sds		absolute values	0.44	0.09	0.29
2.78					change score sds		absolute values	0.44	0.09	0.29
-0.48					change score sds		absolute values	-0.10	0.08	0.29
-18.56					change score sds		absolute values	-2.06	0.13	0.36
31.34					change score sds		absolute values	1.16	0.10	0.31
-1.20					change score sds		absolute values	-0.11	0.08	0.29
10.92					change score sds		absolute values	0.81	0.09	0.30
-0.20					change score sds		absolute values	-0.03	0.08	0.29
10.30					change score sds		absolute values	0.82	0.09	0.30
0.75					change score sds		absolute values	0.12	0.08	0.29
1.58					change score sds		absolute values	0.29	0.08	0.29
0.81					change score sds		absolute values	0.14	0.08	0.29
0.96					change score sds		absolute values	0.17	0.08	0.29
1.77					change score sds		absolute values	0.29	0.07	0.26
-6.06					change score sds		absolute values	-1.28	0.08	0.28
3.31					change score sds		absolute values	0.52	0.07	0.26
-2.11					change score sds		absolute values	-0.34	0.07	0.26
6.89					change score sds		absolute values	0.70	0.07	0.27
-7.44					change score sds		absolute values	-0.69	0.07	0.27
27.71					change score sds		absolute values	1.26	0.08	0.28

Outcome Characteristics

0.26					change score sds		absolute values	0.14	0.07	0.26
-3.79					change score sds		absolute values	-0.27	0.07	0.26
-2.52					change score sds		absolute values	-0.21	0.07	0.26
2.25					change score sds		absolute values	0.15	0.07	0.26
14.60					change score sds		absolute values	1.07	0.08	0.28
4.53					change score sds		absolute values	0.36	0.07	0.26
8.01					change score sds		absolute values	0.66	0.07	0.27
-2.30					change score sds		absolute values	-0.17	0.07	0.26
6.59					change score sds		absolute values	0.53	0.07	0.26
3.61					change score sds		absolute values	0.73	0.07	0.27
0.65					change score sds		absolute values	0.13	0.07	0.26
0.71					change score sds		absolute values	0.12	0.07	0.26
0.36					change score sds		absolute values	0.07	0.07	0.26
1.86					change score sds		absolute values	0.40	0.07	0.26
0.13	1.13	1.27			change score sds	percent change score sds	absolute values	0.04	0.10	0.32
-2.91					change score sds		absolute values	-0.31	0.10	0.32
-2.95										
15.98					change score sds		absolute values	1.86	0.15	0.38
1.42	1.34	1.80			change score sds	percent change score sds	absolute values	0.21	0.12	0.34
-4.01					change score sds		absolute values	-0.40	0.12	0.34
-4.04										
16.08					change score sds		absolute values	1.79	0.16	0.40
3.40	1.34	1.79			change score sds	percent change score sds	absolute values	0.71	0.11	0.33
2.80	1.14	1.29			change score sds	percent change score sds	absolute values	0.81	0.11	0.33
0.00										
0.00										
0.16					change score sds		absolute values	0.04	0.10	0.32
31.70					change score sds		absolute values	2.98	0.22	0.47
58.40					change score sds		absolute values	2.97	0.22	0.46
57.10					change score sds		absolute values	4.91	0.41	0.64
52.10					change score sds		absolute values	3.48	0.26	0.51
45.80					change score sds		absolute values	2.60	0.19	0.43
-22.80					change score sds		absolute values	-1.77	0.14	0.38
24.95					change score sds		absolute values	6.36	0.62	0.79
1.27					change score sds		absolute values	0.27	0.08	0.29
1.14					change score sds		absolute values	0.22	0.08	0.29
0.02					change score sds		absolute values	0.00	0.08	0.29
0.54	0.33	0.11				percent change score sds	relative values	0.40	0.06	0.25

Outcome Characteristics

0.27	0.35	0.12				percent change score sds	relative values	0.19	0.06	0.25
0.22	0.43	0.19				percent change score sds	relative values	0.12	0.06	0.25
0.31	0.46	0.21				percent change score sds	relative values	0.16	0.06	0.25
0.06	0.38	0.14				percent change score sds	relative values	0.04	0.06	0.25
0.46	0.39	0.15				percent change score sds	relative values	0.29	0.06	0.25
0.32	0.48	0.24				percent change score sds	relative values	0.16	0.06	0.25
0.60	0.45	0.20				percent change score sds	relative values	0.32	0.06	0.25
1.77					change score sds		absolute values	0.19	0.11	0.33
7.63					change score sds		absolute values	1.21	0.12	0.35
7.80					change score sds		absolute values	0.89	0.12	0.34
4.25					change score sds		absolute values	0.59	0.11	0.33
2.73					change score sds		absolute values	0.38	0.11	0.33
8.13					change score sds		absolute values	1.12	0.12	0.35
27.63					change score sds		absolute values	3.03	0.23	0.48
18.49					change score sds		absolute values	4.18	0.34	0.58
55.87					change score sds		absolute values	5.68	0.53	0.73
54.35					change score sds		absolute values	5.84	0.55	0.74
15.31					change score sds		absolute values	2.23	0.17	0.41
13.57					change score sds		absolute values	1.77	0.11	0.32
-0.41					change score sds		absolute values	-0.11	0.08	0.27
3.65					change score sds		absolute values	0.98	0.08	0.29
-7.07					change score sds		absolute values	-0.76	0.08	0.28
2.08					change score sds		absolute values	1.18	0.09	0.30
34.71					change score sds		absolute values	1.30	0.09	0.30
-13.76					change score sds		absolute values	-1.22	0.09	0.30
46.87					change score sds		absolute values	0.71	0.08	0.28
0.52					change score sds		absolute values	0.19	0.08	0.28
0.47					change score sds		absolute values	0.16	0.08	0.28
6.25					change score sds		absolute values	0.62	0.04	0.20
1.69					change score sds		absolute values	0.14	0.04	0.19
4.55					change score sds		absolute values	0.44	0.04	0.19
3.04					change score sds		absolute values	0.26	0.04	0.19
4.63					change score sds		absolute values	0.65	0.04	0.20
2.22					change score sds		absolute values	0.15	0.04	0.19
-52.22					change score sds		absolute values	-0.27	0.04	0.19
7.91					change score sds		absolute values	0.62	0.03	0.17
6.45					change score sds		absolute values	0.30	0.03	0.17

Outcome Characteristics

-0.01					change score sds		absolute values	0.00	0.03	0.16
-3.18					change score sds		absolute values	-0.23	0.03	0.17
1.80					change score sds		absolute values	0.37	0.03	0.17
1.18					change score sds		absolute values	0.26	0.03	0.17
0.00					change score sds		absolute values	0.00	0.03	0.16
0.00					change score sds		absolute values	0.00	0.03	0.16
0.77					change score sds		absolute values	0.13	0.03	0.16
							other	0.51	0.05	0.22
							other	0.55	0.09	0.29
							other	0.52	0.08	0.27
-1.25	0.72	0.53				percent change score sds	relative values	-0.46	0.07	0.27
-1.57	1.17	1.38				percent change score sds	relative values	-0.36	0.07	0.27
-1.70	0.99	0.97				percent change score sds	relative values	-0.46	0.07	0.27
-1.68	1.21	1.46				percent change score sds	relative values	-0.37	0.07	0.27
-0.53	1.54	2.38				percent change score sds	relative values	-0.09	0.07	0.27
2.82					change score sds		absolute values	0.77	0.21	0.46
0.22					change score sds		absolute values	0.06	0.20	0.45
-1.07					change score sds		absolute values	-0.18	0.06	0.25
-0.86					change score sds		absolute values	-0.17	0.06	0.25
2.61					change score sds		absolute values	0.16	0.06	0.25
-24.87	0.00				change score sds	percent change score sds	absolute values	-0.51	0.06	0.25
0.48	0.39	0.15			change score sds	percent change score sds	absolute values	0.12	0.06	0.25
-0.54	0.58	0.34			change score sds	percent change score sds	absolute values	-0.11	0.06	0.25
-3.54	1.64	2.69			change score sds	percent change score sds	absolute values	-0.25	0.06	0.25
-1.03	0.62	0.38			change score sds	percent change score sds	absolute values	-0.18	0.06	0.25
0.06	0.54	0.29			change score sds	percent change score sds	absolute values	0.02	0.06	0.25
-0.14	0.98	0.96			change score sds	percent change score sds	absolute values	0.00	0.06	0.25
0.38	0.78	0.61			change score sds	percent change score sds	absolute values	0.04	0.06	0.25
-2.56					change score sds		absolute values	-0.47	0.29	0.53
-3.00					change score sds		absolute values	-0.50	0.29	0.53
1.28					change score sds		absolute values	0.18	0.28	0.53
19.31					change score sds		absolute values	0.63	0.29	0.54
-10.20					change score sds		absolute values	-0.45	0.28	0.53

Outcome Characteristics

es_direction	notes_oc
positive	included exercise leg of control group versus control leg of exercise group in analysis
positive	included exercise leg of control group versus control leg of exercise group in analysis
positive	included exercise leg of control group versus control leg of exercise group in analysis
positive	included exercise leg of control group versus control leg of exercise group in analysis
negative	
negative	no final data provided
negative	no final data provided
positive	included exercise leg of control group versus control leg of exercise group in analysis
positive	included exercise leg of control group versus control leg of exercise group in analysis
positive	included exercise leg of control group versus control leg of exercise group in analysis
positive	included exercise leg of control group versus control leg of exercise group in analysis
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negative	no final data provided
negative	no final data provided
positive	included exercise leg of control group versus control leg of exercise group in analysis
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Outcome Characteristics

positive	
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negative	no final data provided
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Outcome Characteristics

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Outcome Characteristics

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Outcome Characteristics

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Outcome Characteristics

positive	no data for control group
positive	no data for control group
positive	no data for control group
negative	no final data provided
negative	no final data provided
positive	no final data provided
positive	
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positive	no final data provided
positive	reported data as itt analysis but provided data as abp
positive	reported data as itt analysis but provided data as abp
positive	reported data as itt analysis but provided data as abp
negative	no final data provided
negative	no final data provided
positive	no final data provided
positive	no final data provided
positive	reported data as itt analysis but provided data as abp
positive	reported data as itt analysis but provided data as abp

Outcome Characteristics

positive	reported data as itt analysis but provided data as abp
negative	no final data provided
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Outcome Characteristics

positive	no final data provided
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Outcome Characteristics

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Outcome Characteristics

negative	
negative	
positive	
positive	adjusted for baseline height and weight
positive	adjusted for baseline height and weight
positive	adjusted for baseline height and weight
positive	adjusted for baseline height and weight
positive	g calculated from p-value
positive	g calculated from p-value
positive	g calculated from p-value
positive	
positive	
positive	
positive	
positive	
negative	no final data provided
positive	no final data provided
negative	no final data provided
positive	partial itt
positive	partial itt
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APPENDIX D

Published Abstracts of Presentations at Professional Conferences

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Arthritis & Rheumatism, Volume 64, November 2012 Abstract Supplement

Abstracts of the American College of
Rheumatology/Association of Rheumatology Health Professionals
Annual Scientific Meeting
Washington, DC November 9-14, 2012.



Effects Of Ground And Joint Reaction Force Exercise On Bone Mineral Density In Postmenopausal Women: A Meta-Analysis Of Randomized Controlled Trials.

Kelley¹, George A., Kelley¹, Kristi S., Kohrt², Wendy M.

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Background/Purpose:

Previous randomized controlled trials have led to conflicting findings regarding the effects of ground and/or joint reaction force exercise on femoral neck (FN) and lumbar spine (LS) bone mineral density (BMD) in postmenopausal women. The purpose of this study was to use the aggregate data meta-analytic approach to resolve these discrepancies.

Methods:

The *a priori* inclusion criteria were: (1) randomized controlled trials, (2) ground and/or joint reaction force exercise > 24 weeks, (3) comparative control group, (4) postmenopausal women, (5) participants not regularly active, (6) published and unpublished studies in any language since January 1, 1989, (7) BMD data available at the FN and/or LS. Studies were located by searching six electronic databases, cross-referencing, hand searching and expert review. Dual selection of studies and data abstraction were performed. Hedge's standardized effect size (*g*) was calculated for each FN and LS BMD result and pooled using random-effects models. Z-score alpha values, 95% confidence intervals (CI) and number-needed-to-treat (NNT) were calculated for pooled results.

Heterogeneity was examined using *Q* and *I*². Mixed-effects ANOVA and simple meta-regression were used to examine changes in FN and LS BMD according to selected categorical and continuous variables. Statistical significance was set at an alpha value ≤ 0.05 and a trend at >0.05 to ≤ 0.10.

Results:

Statistically significant exercise minus control group improvements were found for both FN (28 *g*'s, 1632 participants, *g* = 0.288, 95% CI = 0.102, 0.474, *p* = 0.002, *Q* = 90.5, *p* < 0.0001, *I*² = 70.1%, NNT = 6) and LS (28 *g*'s, 1504 participants, *g* = 0.179, 95% CI = -0.003, 0.361, *p* = 0.05, *Q* = 77.7, *p* < 0.0001, *I*² = 65.3%, NNT = 6) BMD. None of the mixed-effects ANOVA analyses were statistically significant. For both FN and LS BMD, statistically significant, or a trend for statistically significant and positive associations were observed for intensity of training and compliance (joint reaction force exercise only) as well as changes in static balance. Inverse associations were observed for compliance (combined ground and joint reaction force exercise) as well as changes in body mass index, body weight and percent body fat. When limited to the LS, statistically significant, or a trend for statistically significant and positive associations were found for age, years postmenopausal and changes in lean body

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mass while inverse associations were observed for duration of training (minutes per session, ground reaction force exercise only), total minutes of training per week (ground reaction force exercise only), compliance (combined ground and joint reaction force exercise) and changes in aerobic fitness.

Conclusion:

Exercise benefits FN and LS BMD in postmenopausal women. Several of the observed associations appear worthy of further investigation in well-designed randomized controlled trials.

To cite this abstract, please use the following information:

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DOI: 10.1002/art.40139**

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Presentation Abstract

Session: C-33-Exercise is Medicine - Implications for Body Composition

Thursday, May 30, 2013, 7:30 AM -12:30 PM

Presentation: 1206 - **Exercise and Bone Mineral Density in Premenopausal Women: A Meta-Analysis of Randomized Controlled Trials**

Location: Hall C, Poster Board: 151

Pres. Time: Thursday, May 30, 2013, 8:00 AM - 9:30 AM

Category: 1200. Exercise is Medicine – Focuses on the impact of physical activity on health and the prevention and treatment of disease and disability in clinical settings

Author(s): George A. Kelley, FACSM¹, Kristi S. Kelley¹, Wendy M. Kohrt, FACSM². ¹West Virginia University, Morgantown, WV. ²University of Colorado Denver, Aurora, CO.

Abstract: Maintaining optimal bone mineral density (BMD) during the premenopausal years is important for reducing the risk of osteoporosis and subsequent fractures during the postmenopausal years. Previous randomized controlled trials addressing the effects of joint and/or ground reaction force exercise on femoral neck (FN) and lumbar spine (LS) BMD in premenopausal women have led to conflicting and less than overwhelming results. **PURPOSE:** Examine the effects of exercise on FN and LS BMD in premenopausal women. **METHODS:** Meta-analysis of randomized controlled exercise trials ≥ 24 weeks in premenopausal women. Standardized effect sizes (g) were calculated for each result and pooled using random-effects models, Z-score alpha values, 95% confidence intervals (CI) and number-needed-to-treat (NNT). Heterogeneity was examined using Q and I-squared. Moderator and predictor analyses using mixed-effects ANOVA and simple meta-regression were conducted. Statistical significance was set at $p \leq 0.05$. **RESULTS:** Statistically significant improvements were found for both FN (7 g 's, 466 participants, $g=0.342$, 95% CI=0.132, 0.553, $p=0.001$, $Q=10.8$, $p=0.22$, $I\text{-squared}=25.7\%$, NNT=5) and LS (6 g 's, 402 participants, $g=0.201$, 95% CI=0.009, 0.394, $p=0.04$, $Q=3.3$, $p=0.65$, $I\text{-squared}=0\%$, NNT=9) BMD. A trend for greater benefits in FN BMD was observed for studies published in countries other than the United States and for those who participated in home versus facility-based exercise. Statistically significant, or a trend for statistically significant, associations were observed for 7 different moderators and predictors, 6 for FN BMD and 1 for LS BMD. **CONCLUSIONS:** Exercise benefits FN and LS BMD in premenopausal women. The observed moderators and predictors deserve further investigation in well-designed randomized controlled trials.

Disclosures: **G.A. Kelley:** None.

[Print this Page](#)

Presentation Abstract

Session: D-33-Physical Activity Interventions/Promotion in Adults

Thursday, May 30, 2013, 1:00 PM - 6:00 PM

Presentation: 1599 - **Exercise and Bone Mineral Density in Men: A Meta-Analysis of Randomized Controlled Trials**

Location: Hall C, Poster Board: 191

Pres. Time: Thursday, May 30, 2013, 3:30 PM - 5:00 PM

Category: 5501. Physical Activity/Health Promotion Interventions - physical activity interventions

Keywords: exercise; bone; meta-analysis

Author(s): George A. Kelley, FACSM¹, Kristi S. Kelley¹, Wendy M. Kohrt, FACSM². ¹West Virginia University, Morgantown, WV. ²University of Colorado Denver, Aurora, CO.

Abstract: Osteoporosis and osteopenia are major public health problems in men 50 years of age and older. Previous research regarding the effects of exercise on bone mineral density (BMD) in men has reached conflicting results. **PURPOSE:** Use the meta-analytic approach to examine the effects of ground and/or joint reaction force exercise on femoral neck (FN) and lumbar spine (LS) BMD in men. **METHODS:** Randomized controlled exercise trials ≥ 24 weeks were included. Standardized effect sizes (g) were calculated and pooled using random-effects models, Z-score alpha values and 95% confidence intervals (CI). Heterogeneity was examined using Q and *I-squared*. Statistical significance was set at a two-tailed alpha value (p) of ≤ 0.05 and a trend at >0.05 to ≤ 0.10 . **RESULTS:** A moderate and statistically significant improvement was found at the FN (3 g 's, 187 participants, $g=0.583$, 95% CI=0.031, 1.135, $p=0.04$, $Q=5.6$, $p=0.06$, *I-squared*=64%) while a small trend was observed at the LS (5 g 's, 275 participants, $g=0.190$, 95% CI = -0.036, 0.416, $p=0.10$, $Q=3.0$, $p=0.55$, *I-squared*=0%). Results were sensitive to influence analysis as well as collapsing multiple groups from the same studies so that only one g represented each study. **CONCLUSIONS:** There is currently insufficient evidence to recommend ground and/or joint reaction force exercise for improving and/or maintaining FN and LS BMD in men. Additional well-designed randomized controlled trials are needed before any final recommendations can be formulated.

Disclosures: **G.A. Kelley:** None.

APPENDIX E

Publications in Peer-Reviewed Biomedical Journals

RESEARCH ARTICLE

Open Access

Effects of ground and joint reaction force exercise on lumbar spine and femoral neck bone mineral density in postmenopausal women: a meta-analysis of randomized controlled trials

George A Kelley^{1*}, Kristi S Kelley¹ and Wendy M Kohrt²

Abstract

Background: Low bone mineral density (BMD) and subsequent fractures are a major public health problem in postmenopausal women. The purpose of this study was to use the aggregate data meta-analytic approach to examine the effects of ground (for example, walking) and/or joint reaction (for example, strength training) exercise on femoral neck (FN) and lumbar spine (LS) BMD in postmenopausal women.

Methods: The *a priori* inclusion criteria were: (1) randomized controlled trials, (2) exercise intervention ≥ 24 weeks, (3) comparative control group, (4) postmenopausal women, (5) participants not regularly active, i.e., less than 150 minutes of moderate intensity (3.0 to 5.9 metabolic equivalents) weight bearing endurance activity per week, less than 75 minutes of vigorous intensity (> 6.0 metabolic equivalents) weight bearing endurance activity per week, resistance training < 2 times per week, (6) published and unpublished studies in any language since January 1, 1989, (7) BMD data available at the FN and/or LS. Studies were located by searching six electronic databases, cross-referencing, hand searching and expert review. Dual selection of studies and data abstraction were performed. Hedge's standardized effect size (g) was calculated for each FN and LS BMD result and pooled using random-effects models. Z-score alpha values, 95% confidence intervals (CI) and number-needed-to-treat (NNT) were calculated for pooled results. Heterogeneity was examined using Q and I^2 . Mixed-effects ANOVA and simple meta-regression were used to examine changes in FN and LS BMD according to selected categorical and continuous variables. Statistical significance was set at an alpha value ≤ 0.05 and a trend at > 0.05 to ≤ 0.10 .

Results: Small, statistically significant exercise minus control group improvements were found for both FN (28 g's, 1632 participants, $g = 0.288$, 95% CI = 0.102, 0.474, $p = 0.002$, $Q = 90.5$, $p < 0.0001$, $I^2 = 70.1\%$, NNT = 6) and LS (28 g's, 1504 participants, $g = 0.179$, 95% CI = -0.003, 0.361, $p = 0.05$, $Q = 77.7$, $p < 0.0001$, $I^2 = 65.3\%$, NNT = 6) BMD. Clinically, it was estimated that the overall changes in FN and LS would reduce the 20-year relative risk of osteoporotic fracture at any site by approximately 11% and 10%, respectively. None of the mixed-effects ANOVA analyses were statistically significant. Statistically significant, or a trend for statistically significant, associations were observed for changes in FN and LS BMD and 20 different predictors.

Conclusions: The overall findings suggest that exercise may result in clinically relevant benefits to FN and LS BMD in postmenopausal women. Several of the observed associations appear worthy of further investigation in well-designed randomized controlled trials.

Keywords: Exercise, Bone, Osteoporosis, Women, Postmenopausal, Aging, Meta-analysis, Systematic review

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Background

Osteoporosis is a major public health problem affecting an estimated 200 million women worldwide [1]. Congruent with osteoporosis is an increased risk for osteoporosis-related fractures, especially in women during the postmenopausal years, generally considered to begin around 50 years of age [2]. Comparatively, the lifetime risk of an osteoporosis-related fracture in women is equivalent to the risk of developing cardiovascular disease [3]. The two most common sites for osteoporosis-related fractures are the hip and the spine, with an estimated worldwide prevalence of 1.1 million and 862,000, respectively, in women 50 years of age and older in the year 2000 [2]. In the United States, the total annual costs associated with osteoporosis-related fractures were more than \$19 billion in 2005 with a predicted increase to \$25.3 billion in 2025 [4]. The majority of the costs in 2005 were attributed to fractures of the hip (72%) followed by the spine (6%) [4].

Prevention of osteoporosis has focused on maximizing bone mineral density (BMD) during childhood and adolescence and maintaining BMD during adulthood [5,6]. Preventive measures include adequate calcium and vitamin D intake as well as avoiding cigarette smoking and excessive alcohol intake [5,6]. In addition, ground reaction (for example, jogging) and joint reaction (for example, strength training) force exercise has been recommended across the lifespan [5-8]. However, the results of previous randomized controlled exercise intervention trials have reached conflicting and underwhelming conclusions regarding the effects of ground reaction and/or joint reaction force exercise on BMD at the femoral neck (FN) and lumbar spine (LS) in postmenopausal women [9-33]. For example, using the vote-counting approach, only 29% of the exercise versus control group differences in FN BMD have been reported as statistically significant and in the direction of benefit while even fewer (11%) have been reported at the LS [9-33]. Based on these findings, one might reach the general conclusion that ground and joint reaction force exercise have little or no effect on FN and LS BMD. However, reliance on a vote-counting approach based on statistical significance can be extremely misleading since the absence of a statistically significant effect does not mean that an effect is absent [34]. In contrast, meta-analysis allows one to go beyond statistical significance and focus on the magnitude of effect. It is a quantitative approach for combining the results of studies. The strengths of meta-analysis include: (1) increased power, (2) improved estimates of effect size (ES), and (3) the potential to resolve disagreements between studies [35].

While a number of meta-analyses have been conducted on the effects of exercise on FN and LS BMD in adults [36-54], fewer have focused, or partitioned data, according to randomized controlled trials in postmenopausal women [37,39,48-51,53]. One meta-analysis that included studies

published up to December, 1995 found a statistically significant exercise minus control group benefit of 0.73% in LS BMD as a result of joint and/or ground reaction force exercise in postmenopausal women [39]. Another meta-analysis that included studies published up to January, 1998 reported a statistically significant benefit in FN and LS BMD ranging from 0.9% to 1.6% as a result of impact and non-impact exercise among postmenopausal women [53]. However, both meta-analyses were limited to studies published more than 14 years ago. Since that time, additional randomized controlled trials with inconsistent findings have been published [10-12,14-17,19-22,24-27,30,32,33]. In addition, guidelines for the improved conduct of meta-analysis have been developed [47].

A modality-specific, joint reaction force meta-analysis that included studies published up to December 2004 found a statistically significant benefit of 0.006 g/cm² in LS BMD and a non-significant benefit of 0.010 g/cm² in FN BMD as a result of high-intensity resistance exercise in postmenopausal women [49]. Another modality-specific meta-analysis by the same research group which included studies published through December 2006 reported a non-statistically significant benefit in FN and LS BMD in postmenopausal women as a result of walking [50]. These findings suggest that walking, a lower impact, ground reaction force exercise, may have little benefit on FN and LS BMD in postmenopausal women. The same research group also published another meta-analysis that included studies published to 2008 [51]. When limited to randomized controlled trials and a random-effects model, a statistically significant benefit of 0.004 g/cm² was found for FN BMD with no statistically significant benefit observed at the LS as a result of exercise in postmenopausal women [51]. More recently, a Cochrane systematic review by Howe et al. reported a statistically significant exercise minus control group benefit of 0.85% in LS BMD but no significant change in FN BMD (-0.08%) as a result of joint and/or ground reaction force exercise in postmenopausal women [37]. However, this systematic review did not appear to be limited to studies in which participants had been previously participating in exercise levels below that currently recommended for bone health [8]. Consequently, the benefits of exercise could have been underestimated. Another meta-analysis reported a statistically significant benefit of 0.014 g/cm² and 0.012 g/cm², respectively, for both FN and LS BMD in females 60 years of age and older [48]. However, similar to the work of Howe et al. [37], participants did not appear to be limited to those who were participating in exercise levels below that currently recommended for bone health [8]. In addition, all studies were coded by one person, thereby increasing the risk for coding errors [47]. A potential reason for the

discrepancy in findings for FN BMD between the Howe et al. [37] and Marques et al. [48] reviews may be accounted for by the fact that the latter meta-analysis limited studies to those in adults 60 years of age and older. This raises the possibility that older postmenopausal women may have more to gain from a regular exercise program. Finally, because the number of analyses aimed at trying to establish the association between selected covariates and changes in FN and LS BMD was limited for all of the previously described meta-analyses, potentially important covariates could have been missed.

A need exists for an updated and thorough meta-analysis on the effects of different ground and joint reaction force exercises, either alone or in combination, on FN and LS BMD in postmenopausal women not participating in exercise levels currently recommended for bone health [8]. Therefore, the purpose of this study was to use the aggregate data meta-analytic approach to determine the effects of ground and/or joint reaction force exercise on BMD at the FN and LS in postmenopausal women not participating in exercise levels currently recommended for bone health [8].

Methods

Study eligibility criteria

The *a priori* inclusion criteria for this meta-analysis were as follows: (1) randomized controlled trials, (2) exercise intervention ≥ 24 weeks, (3) comparative control group (attention control, non-intervention, etc.), (4) postmenopausal women, as defined by the authors, (5) participants not currently participating in any type of regular joint and/or ground reaction force exercise, as defined by the authors, (6) published and unpublished (master's theses and dissertations) studies in any language since January 1, 1989 and (7) BMD (relative value of bone mineral per measured bone area or volume) assessed at the FN and/or LS using dual-energy x-ray absorptiometry (DEXA) or dual-photon absorptiometry (DPA). Given the heterogeneity of reporting by the authors with respect to previous exercise in participants, we revised our inclusion criteria *post hoc* so that only participants who performed less than 150 minutes of moderate intensity (3.0 to 5.9 metabolic equivalents) weight bearing endurance activity per week, less than 75 minutes of vigorous intensity (> 6.0 metabolic equivalents) weight bearing endurance activity per week, resistance training < 2 times per week, were included [7]. Studies were limited to those in which exercise was performed for at least 6 months since it has been suggested that one can generally expect exercise-induced changes in BMD to occur after approximately this length of time [55]. Resistance training studies were included only if lower body exercises were part of the exercise program. The year 1989 was chosen as the starting point for the inclusion of studies because it appeared to

be the first year in which a randomized controlled intervention trial on exercise and BMD in postmenopausal women was conducted [56]. Studies were limited to those in which BMD at the FN and LS were assessed using either DPA or DEXA since they are/have been the most common instruments for assessing BMD in the clinical setting. Only those groups that met the inclusion criteria were included from each study. Any studies not meeting all of the above criteria were excluded from the meta-analysis.

Data sources

Studies were retrieved using the following six electronic databases: (1) Medline (within EBSCO host), (2) Embase, (3) Cochrane Central Register of Controlled Trials (CENTRAL), (4) Dissertation Abstracts Online (DAO), (5) CINAHL (within EBSCOhost), and (6) SPORTDiscus (within EBSCOhost). The last search was conducted in August, 2011. All electronic searches were conducted by the second author with assistance from a Health Sciences librarian at West Virginia University. While the search strategies used varied according to the different databases searched, three key words, or forms of keywords, germane to all searches were 'exercise', 'bone' and 'randomized'. An example of the search strategy used for one of the electronic database searches (SPORTDiscus) is shown in Additional file 1. In addition to electronic searches, cross-referencing from retrieved studies and previous review articles, both systematic and narrative, was performed. Furthermore, hand searches of selected journals were conducted.

Study selection

All studies were selected by the first two authors, independent of each other. Disagreements regarding the final list of studies to include were resolved by consensus. If consensus could not be reached, the third author acted as an arbitrator. After an initial list of included studies was developed, the third author reviewed the list for completeness. All included studies as well as a list of excluded studies, including reasons for exclusion, were stored in Reference Manager (version 12.0.1) [57].

Data abstraction

Prior to data abstraction, a detailed codebook that could hold more than 245 items per study was developed by all three members of the research team in Microsoft Excel 2007 [58]. The major categories of variables that were coded included: (1) study characteristics, (2) subject characteristics, (3) exercise program characteristics, (4) primary outcomes and (5) secondary outcomes. The primary outcomes for this study were BMD at the FN and LS. Secondary outcomes included other measures of BMD (Ward's triangle, total hip, trochanteric, intertrochanteric, whole body, radius) as well as number of

fractures, aerobic fitness, dynamic and static balance, body weight, body mass index (BMI), lean body mass (LBM), fat mass, percent body fat, upper and lower body muscular strength, and calcium and vitamin D intake. Missing primary outcome data were requested from the author(s). Multiple publication bias was avoided by only including data from the most recently published study.

As part of the coding process, the effective load rating for the exercise intervention from each study was calculated using a recently developed, age-adjusted formula [59]. This included the frequency of exercise per week along with the effective load rating, calculated as the product of peak vertical ground reaction force and the rate of force application [59]. Given the multiple types of exercises used in many of the studies, it was not possible to calculate effective load ratings specific to each activity within each study. Therefore, the broad categories recommended by previous work were used [59]. These included numerical effective load ratings equivalent to low (walking, etc.), moderate (tennis, etc.) and high (jumping, etc.) forces [59]. Effective load ratings were also provided for strength training [59]. All studies were coded by the first two authors, independent of each other. They then met and reviewed every entry for accuracy and consistency. Discrepancies were resolved by consensus. If consensus could not be reached, the third author served as an arbitrator.

Risk of bias

The Cochrane Collaboration risk of bias instrument was used to assess bias across five categories: (1) sequence generation, (2) allocation concealment, (3) blinding to group assignment, (4) incomplete outcome data and (5) incomplete outcome reporting [60]. Each item was classified as having either a high, low, or unclear risk of bias [60]. Assessment for risk of bias was limited to the primary outcomes of interest, i.e. FN and LS BMD. Given the objective nature of BMD assessment, all studies were considered to be at a low risk of bias with respect to blinding unless the study reported some reason for such. For incomplete outcome reporting, studies were considered to be at an unclear risk for bias if studies did not report a study protocol identification number to confirm assessed outcomes. No study was excluded based on the results of the risk of bias assessment [61]. All assessments were performed by the first two authors, independent of each other. Both authors then met and reviewed every item for agreement. Disagreements were resolved by consensus.

Statistical analysis

Calculation of effect sizes for primary and secondary outcomes from each study

Given the different methods of reporting results for primary outcomes, i.e., FN and LS BMD, the standardized mean difference effect size (g), adjusted for small sample

bias, was calculated from each study in order to create a common metric for the pooling of findings [62]. Since all studies were parallel, randomized controlled trials [9-33], the g for each outcome from each study was calculated as the difference in change scores between the exercise and control groups divided by the pooled SD of the change scores [62]. For studies in which change outcome SDs for the exercise and control groups were not reported, these were estimated for the exercise and control groups using pre-and post-intervention means and SDs according to the approach of Follmann et al. [63]. For studies that did not allow for such calculations using the aforementioned methods, g was calculated using the reported 95% confidence intervals (95% CIs). After calculating g from each study, its variance was estimated using previously developed procedures [62]. The beneficial effects of exercise on FN and LS BMD were denoted by a positive g .

Secondary outcomes from each study were calculated using either g (Ward's triangle, total hip, trochanteric, whole body, radius, calcaneus, aerobic fitness, dynamic and static balance, upper and lower body muscular strength) or the original metric (body weight in kilograms, BMI in kilogram per meters-squared, LBM in kilograms, fat mass in kilograms and percent of body weight, calcium intake in milligrams, vitamin D intake in micrograms).

Pooled estimates for FN and LS BMD

Random-effects, method-of-moments models that incorporate heterogeneity into the overall estimate were used to pool results for FN and LS BMD as well as secondary outcomes from each study [64]. Multiple groups from the same study were analyzed independently as well as collapsing multiple groups so that only one ES represented each outcome from each study. For the one study that included both per-protocol and intention-to-treat analyses, the more conservative intention-to-treat results were used [10]. While the same study assessed LS BMD at both the L1-L4 and L2-L4 sites [10], data are reported using the L1-L4 sites based on the International Society for Clinical Densitometry 2007 Position Stand recommending that L1-L4 be used for LS BMD measurement [65]. A z -score two-tailed alpha value of ≤ 0.05 was considered to be statistically significant. Alpha values > 0.05 but ≤ 0.10 were considered as a trend. To determine the precision of these estimates, two-tailed 95% confidence intervals (CIs) were also calculated. Analysis of secondary outcomes was considered exploratory because they were not part of the inclusion criteria, and thus, may represent a biased sample.

In terms of magnitude, values for those outcomes in which g was used may be classified as either trivial (< 0.20), small (≥ 0.20 to < 0.50), medium (≥ 0.50 to < 0.80), or large (≥ 0.80) [66]. A g of 0.20, for example, means that exercise

would result in a 0.20 SD benefit over those who did not exercise. Given that the interpretation of g can be difficult with respect to clinical and practical relevance [67], the number needed to treat (NNT) was estimated for FN and LS BMD from pooled g 's using procedures described by Kraemer and Kupfer [68]. For continuous data, the event is the increase in BMD of magnitude g . In addition, the NNT was used to provide a gross estimate of the number of US women 50 years of age and older who could achieve benefit in FN and LS BMD by initiating and maintaining a regular exercise program. This estimate was based on US Census Data for the number of women 50 years of age and older in the US (53,410,602) [69] and Healthy People 2020 Objective PA-2.4 for increasing by 10% the number of adults who meet current physical activity guidelines for aerobic and muscle-strengthening activity [70]. Based on the most recently available physical activity estimates for US adult females, this means an increase in physical activity from 14.9% to approximately 16.4%, a 1.49% increase [71].

Stability and validity of changes in g for FN and LS BMD

Heterogeneity of results between studies was examined using Q as well as an extension of the Q statistic, I^2 [72]. Statistical significance for Q was set at an alpha value of ≤ 0.10 . For I^2 values of 25% to $<50\%$, 50% to $<75\%$, and $\geq 75\%$ may be considered to represent small, medium, and large amounts of inconsistency, respectively [72]. To determine treatment effects in a new trial, 95% prediction intervals were also calculated [73,74].

Publication bias was examined using the trim and fill approach of Duval and Tweedie [75]. Potential publication bias was considered noteworthy if a statistically significant finding was no longer significant after imputing potentially missing studies.

In order to examine the effects of each g from each study on the overall findings, results were analyzed with each study deleted from the model once. In addition, standardized residuals ≥ 3.0 were considered as outliers but not arbitrarily deleted from the model. Cumulative meta-analysis, ranked by year, was used to examine the accumulation of evidence over time on FN and LS BMD [76].

Moderator analysis for FN and LS BMD

Between-group differences (Q_b) in FN and LS BMD for categorical variables were examined using mixed effects ANOVA-like models for meta-analysis [77]. This consisted of a random effects model for combining studies within each subgroup and a fixed effect-model across subgroups [77]. Study-to-study variance (tau-squared) was considered not equal for all subgroups. This value was computed within subgroups but not pooled across subgroups. Planned categorical variables to examine *a priori* and in which each category had at least 3 g 's included: country in which the study was conducted

(USA, other), type of control group (non-intervention, other), matching procedures (yes, no), risk of bias assessment (sequence generation, allocation concealment, blinding, incomplete outcome data, outcome reporting bias according to low, high or unclear risk), type of analysis (per-protocol, intention-to-treat), provision of sample size estimates (yes, no), external funding for the study (yes, no), adverse events (yes, no), whether participants were allowed or required to have osteoporosis, whether they were allowed to be current cigarette smokers and/or consume alcohol (yes, no), changes in exercise habits beyond the exercise intervention (increase, decrease, no change), no prior exercise allowed versus some prior exercise but less than that recommended by the American College of Sports Medicine (yes, no) [8], whether calcium and/or vitamin D supplements were given during the study (yes, no), type of exercise (aerobic, strength, both), exercise delivery (supervised, unsupervised, both), type of reaction forces (ground, joint, both) and instrumentation (Hologic, Lunar). The two-tailed alpha value for a statistically significant difference between groups (Q_b) was set at $p \leq 0.05$ with values >0.05 but ≤ 0.10 considered as a trend. All moderator analyses were considered exploratory [78].

Meta-regression for FN and LS BMD

Simple mixed-effects, method of moments meta-regression was used to examine the potential association between changes in FN and LS BMD and continuous variables with at least 3 g 's [77]. Because of expected missing data for different variables from different studies, only simple meta-regression was planned and performed. Potential predictor variables, established *a priori*, included year of publication, percentage of drop-outs, age in years and years postmenopausal. For exercise training, variables for aerobic-only groups included length (weeks), frequency (days per week), intensity, expressed as a percentage of maximum oxygen consumption ($\%VO_{2max}$), percentage of maximal heart rate (MHR) or heart rate reserve (HRR), duration (minutes per session), minutes of training per week and compliance, defined as the percentage of exercise sessions attended. For strength training only groups, variables included: length (weeks), frequency (days per week), intensity, expressed as a percentage of one-repetition maximum ($\% 1RM$), number of sets, repetitions and exercises, rest between sets (seconds) and compliance (%). For those groups that performed both aerobic and strength training concurrently, variables included: length in weeks, frequency (days per week) and percent compliance. Other potential predictors included: load ratings and baseline BMD as well as changes in aerobic fitness, dynamic and static balance, calcium and vitamin D intake, lower and upper body strength, BMI in kg/m^2 ,

body weight, LBM, percent body fat and fat mass. The alpha value for a statistically significant association was set at ≤ 0.05 . Alpha values > 0.05 but ≤ 0.10 were considered as a trend for an association. All meta-regression analyses were considered exploratory [78].

Results

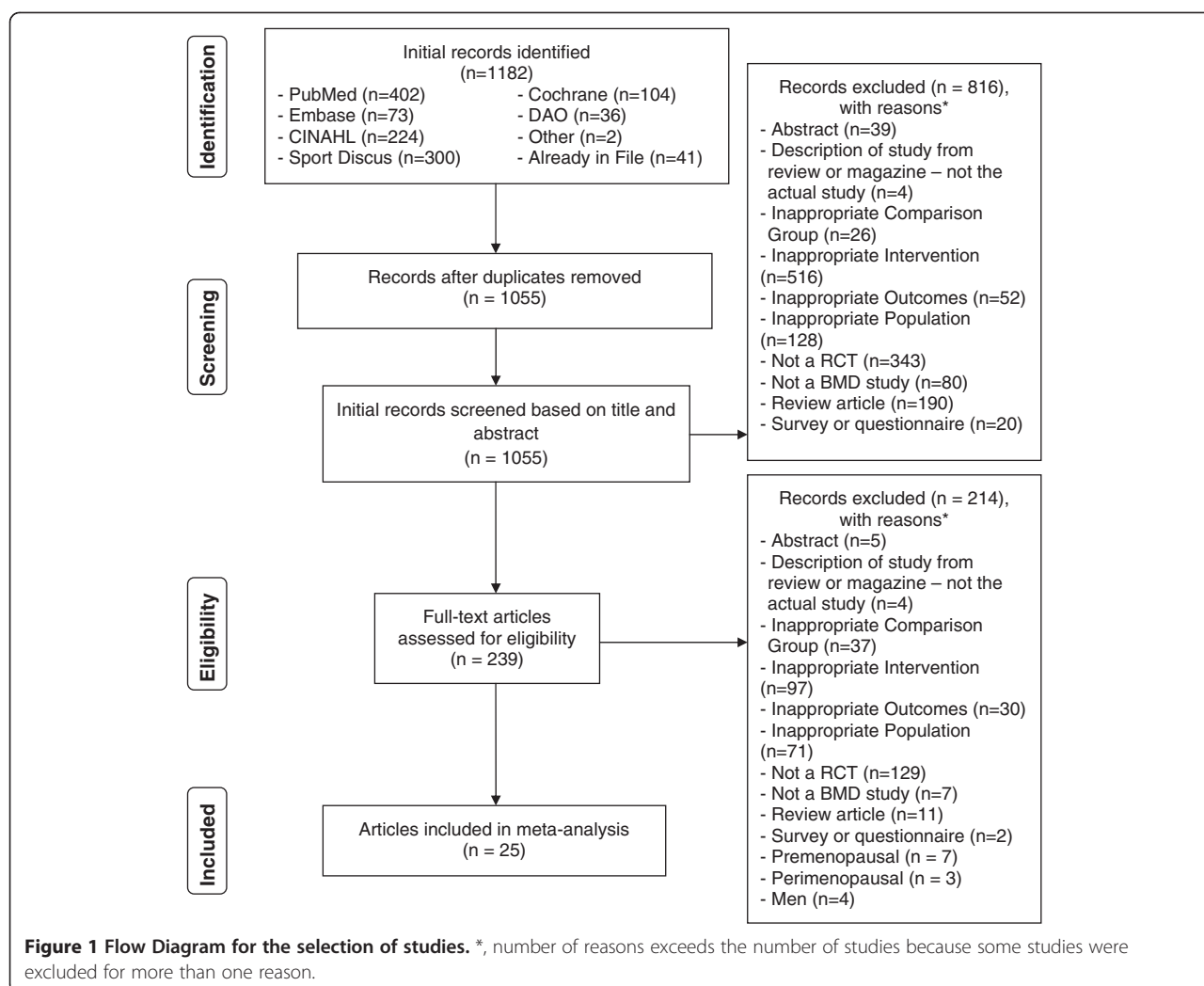
Study characteristics

A general description of the characteristics of each study is shown in Additional file 2. Of the 1,182 citations reviewed, 25 studies representing 63 groups (35 exercise, 28 control) and final assessment of FN and/or LS BMD in 1775 participants, were included [9-33]. One study's initial exercise inclusion criteria exceeded the exercise eligibility criteria for the current meta-analysis [23]. However, a decision was made to include this study because it was apparent upon further reading that the exercise levels of the participants met the eligibility criteria for the current meta-analysis [23]. Missing primary outcome data were successfully retrieved from three studies [10-12]. The number of exercise participants assessed was 991 while the number of controls assessed was 826. The total (1817) exceeds 1775 because one study had participants exercise one side of the body while the other side served as a control [23]. A description of the search process, including the reasons for excluded studies, is shown in Figure 1. The number of intervention and control groups exceeded the number of studies because some studies included more than one intervention and/or control group that met the inclusion criteria for the current meta-analysis. All studies were published in the English language between the years 1992 and 2011 [9-33]. Twenty-four (96%) were published in journals [9-18,20-33] while one was a dissertation [19]. With respect to country in which the study was conducted, six were performed in the United States [17,18,21,28-30], three in Australia [23,24,31], four in Canada [14,15,25,32], two each in either Brazil [11,12], Japan [20,33], Portugal [26,27], Sweden [10,16], or the United Kingdom [9,13], and one each in China [19] and Germany [22]. For types of controls, 11 studies (44%) used a non-intervention control group [9,11,12,16-19,26,27,29,32], while 14 others (56%) used a variety of comparative controls [10,13-15,20-25,28,30,31,33]. Seven of 25 studies (28%) [12,16-19,22,25] reported using the following matching procedures: (1) age [16,22], (2) use of menopausal hormone therapy [12,17], (3) gender [19], (4) BMD and bodyweight [18], (5) postural stability, baseline BMD at the total hip and bisphosphonate use [25]. None of the studies reported using a crossover design. For sample size justification, 12 studies (48%) reported data regarding such [9,10,12,14,16,19,21,22,25-27,30]. Nineteen studies (76%) reported receiving some type of external funding to conduct their study [9,13-17,19,21-31,33].

The dropout rate ranged from 0% to 43% for the 30 exercise groups for which data were available ($\bar{x} \pm SD = 17 \pm 12\%$, $Mdn = 12\%$) and 0% to 27% for the 24 control groups in which data were available for ($\bar{x} \pm SD = 13 \pm 7\%$, $Mdn = 15\%$). Twelve studies (52%) provided one or more of the following reasons for participants dropping out or for the investigative team to drop participants from the study: (1) personal health problems apparently unrelated to the intervention [13,16,17,26,27,29,30,33], (2) time [14,25,30], (3) lack of compliance to the exercise intervention [10,11], (4) personal issues not related to one's health [11,13,26,27,33], (5) lack of interest [26] and (6) moved [30]. Five studies (20%) reported that one or more participants experienced musculoskeletal pain and/or minor musculoskeletal injuries as a result of the exercise intervention [9,18,24,29,30]. For the other studies, a lack of complete data were available regarding any possible pain and/or injuries as a result of the interventions. No serious adverse events were reported.

Initial physical characteristics of the participants are shown in Table 1. Fourteen studies (56%) reported data on race/ethnicity with the majority of participants consisting of either whites [14,15,18,21,22,25-30] or Asians [19,20,33]. For medication usage, two studies (8%) included groups in which all participants were taking menopausal hormone therapy [9,17] while four studies (16%) reported that some participants in their groups were taking hormone therapy [12,18,25,30]. One study (4%) reported that some participants were taking bisphosphonates [25] while none reported the use of glucocorticoids. With regards to osteoporosis, one study (4%) was limited to participants with osteoporosis [20] while three (12%) reported that some participants had osteoporosis [10,22,25]. Six studies (24%) reported that some participants had osteopenia [10,14,25-27,30]. Ten studies (40%) reported that some participants smoked cigarettes [9,10,13,19,22,25-28,30], while two (8%) reported that some consumed alcohol [15,30]. One study (4%) reported that participants in the exercise intervention group increased their physical exercise outside the intervention while the control group decreased their physical activity [29]. Ten studies (40%) reported giving calcium to participants [10,14,17,20-22,24,28,30,31] whereas another two (8%) provided calcium to some participants [9,29]. Vitamin D was reportedly provided to participants in six studies (24%) [10,14,20-22,28]. A total of three studies (12%) reported that one or more participants had previous fractures [10,25,29].

Characteristics of the exercise programs from each group and each study are described in Additional file 2. As can be seen, the exercise interventions varied widely. Fourteen groups (40%) participated in exercise interventions that focused on joint reaction forces (for example, strength training) while 12 (34%) focused on ground reaction forces



(for example, aerobic exercises such as walking and jumping). Another nine groups (26%) included exercises that provided both joint and ground reaction forces. With the exception of four groups (11%) that performed either jumping or agility training, the remaining 31 (89%) focused on aerobic and/or strength training exercises. The load rating for the 28 groups in which data were available for calculation ranged from 9.4 to 340.5 ($\bar{x} \pm SD = 57.3 \pm 117.7$, $Mdn = 10$). The length of training across all groups ranged from 24 to 104 weeks ($\bar{x} \pm SD = 50.7 \pm 23.3$, $Mdn = 52$). A group summary of the characteristics for those studies that included aerobic and/or strength training is shown in Table 2.

Bone mineral density assessment information is shown in Additional file 2. With the exception of two earlier studies that used dual photon absorptiometry [18,28], all others used dual-energy x-ray absorptiometry to assess BMD at the FN and LS [9-17,19-27,29-33]. The two most common instruments used to assess FN and LS BMD were Hologic (48%) and Lunar (40%). For those studies that provided data

[9,13,14,16,20,22-27,30,32], coefficients of variation for the assessment of BMD ranged from 0.8% to 1.9% and 0.6% to 1.5%, respectively, for FN and LS BMD.

Risk of bias assessment

Risk of bias results are shown in Figure 2. As can be seen, the majority of studies were considered to be at low risk with respect to sequence generation and blinding and unclear risk for allocation concealment and incomplete outcome reporting. Approximately half of the studies were considered to be at either low or unclear risk for incomplete outcome data.

Primary outcomes

FN BMD

Overall, there was a statistically significant benefit of ground and/or joint reaction force exercise on FN BMD (Table 3, Figure 3). In addition, non-overlapping CIs were observed. The NNT was 6 with an estimated 127,968 postmenopausal US women experiencing

Table 1 Initial physical characteristics of participants

Variable	Exercise				Control			
	Groups (#)	$\bar{x} \pm SD$	Mdn	Range	Groups (#)	$\bar{x} \pm SD$	Mdn	Range
Age (yrs)	33	62.9 $\pm$ 7.3	60	54 - 80	27	62.2 $\pm$ 6.7	60	53 - 80
Height (cm)	22	161.5 $\pm$ 3.3	162	152 - 165	19	161.4 $\pm$ 3.2	162	152 - 165
Postmenopausal (yrs)	26	13.8 $\pm$ 8	11	3 - 30	21	12.9 $\pm$ 7.1	10	4 - 30
Body weight (kg)	28	66.4 $\pm$ 6.6	68	46 - 78	23	67.2 $\pm$ 7.9	68	46 - 84
Body mass index (kg/m ²)	21	25.6 $\pm$ 2.2	26	20 - 29	18	25.6 $\pm$ 2.6	26	20 - 31
Lean body mass (kg)	18	39.2 $\pm$ 2.2	39	35 - 43	13	39.1 $\pm$ 1.9	39	35 - 42
Fat mass (kg)	6	22.1 $\pm$ 5.3	21	17 - 32	4	24.0 $\pm$ 8.5	23	15 - 35
Body fat (%)	15	39.3 $\pm$ 3.2	39	31 - 44	12	39.1 $\pm$ 3.5	39	31 - 46
Calcium intake (mg)	12	846 $\pm$ 179	832	609 - 1214	10	868 $\pm$ 213	829	626 - 1190
Vitamin D (mcg)	5	5.6 $\pm$ 5.1	2	2 - 12	4	5.3 $\pm$ 3.9	5	2 - 9
BMD (g/cm ²)								
- Femoral neck	27	0.749 $\pm$ 0.094	0.720	0.580 - 0.925	24	0.766 $\pm$ 0.095	0.770	0.590 - 0.927
- Lumbar spine	28	0.957 $\pm$ 0.158	0.966	0.595 - 1.180	24	1.00 $\pm$ 0.100	1.00	0.600 - 1.200
- Ward's triangle	8	0.591 $\pm$ 0.089	0.575	0.441 - 0.730	6	0.605 $\pm$ 0.097	0.598	0.474 - 0.760
- Total hip	13	0.802 $\pm$ 0.093	0.840	0.670 - 0.940	11	0.843 $\pm$ 0.092	0.869	0.690 - 1.00
- Trochanteric	20	0.659 $\pm$ 0.085	0.650	0.510 - 0.806	16	0.682 $\pm$ 0.085	0.685	0.520 - 0.840
- Intertrochanteric	11	0.959 $\pm$ 0.076	0.986	0.820 - 1.035	7	0.979 $\pm$ 0.068	0.990	0.850 - 1.00
- Whole body	8	1.033 $\pm$ 0.073	0.99	0.970 - 1.130	7	1.043 $\pm$ 0.070	1.002	0.980 - 1.130
- Radius - 1/3	4	0.600 $\pm$ 0.028	0.610	0.560 - 0.620	3	0.603 $\pm$ 0.012	0.610	0.590 - 0.610
- Radius - mid	4	0.523 $\pm$ 0.015	0.530	0.500 - 0.530	3	0.520 $\pm$ 0.017	0.530	0.500 - 0.530
- Radius - ultradistal	4	0.363 $\pm$ 0.005	0.360	0.360 - 0.370	3	0.363 $\pm$ 0.006	0.360	0.360 - 0.370

Notes: Groups (#), number of groups in which data were available; $\bar{x} \pm SD$, mean $\pm$ standard deviation; Mdn, Median; BMD, bone mineral density; Baseline data for aerobic fitness, balance and muscular strength not reported because of the different metrics used in the studies.

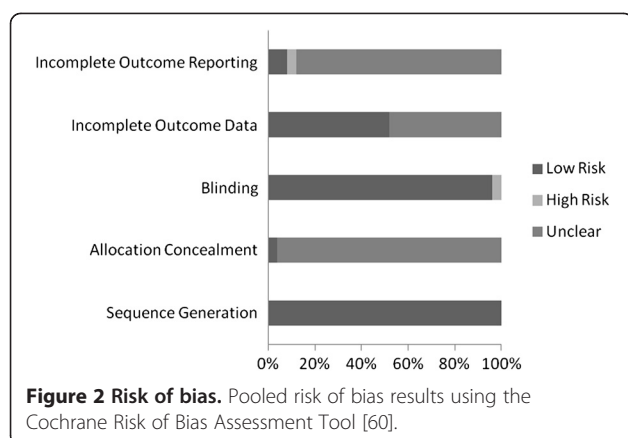
benefit in FN BMD if they began and maintained a regular exercise program. A moderate but statistically significant amount of heterogeneity was observed as well as overlapping prediction intervals. No adjustment for

publication bias was needed. With each study deleted from the model once, results remained statistically significant across all deletions (Figure 4). The difference in *g* between the largest and smallest values with each

Table 2 Training program characteristics for aerobic, strength and aerobic + strength training interventions

Variable	Aerobic				Strength				Aerobic + Strength			
	Groups (#)	$\bar{x} \pm SD$	Mdn	Range	Groups (#)	$\bar{x} \pm SD$	Mdn	Range	Groups (#)	$\bar{x} \pm SD$	Mdn	Range
Length (weeks)	9	52 $\pm$ 22	52	24-104	14	46 $\pm$ 21	52	24-104	10	58 $\pm$ 29	52	24-104
Frequency (days/week)	8	3 $\pm$ 1	3	3-4	14	3 $\pm$ 1	3	3-6	9	3 $\pm$ 1	3	2-7
Intensity*	4	55 $\pm$ 14	59	36-68	6	63 $\pm$ 26	73	15-85	-	-	-	-
Duration (min/sessions)	6	34 $\pm$ 12	38	10-30	-	-	-	-	-	-	-	-
Minutes (per week)	6	103 $\pm$ 37	113	60-135	-	-	-	-	-	-	-	-
Minutes (per week adjusted)	5	79 $\pm$ 33	71	48-113	-	-	-	-	-	-	-	-
Sets (#)	NA	NA	NA	NA	12	3 $\pm$ 1	3	1-5	5	2 $\pm$ 0.4	2	2-3
Repetitions (#)	NA	NA	NA	NA	9	12 $\pm$ 8	10	8-30	-	-	-	-
Rest between sets (sec.)	NA	NA	NA	NA	4	75 $\pm$ 57	90	0-120	-	-	-	-
Exercises (#)	NA	NA	NA	NA	14	8 $\pm$ 4	9	1-12	5	8 $\pm$ 3	7	4-12
Compliance (%)	7	75 $\pm$ 16	80	39-84	10	83 $\pm$ 5	85	74-90	7	76 $\pm$ 11	77	59-95

Groups (#), number of groups in which data were available; $\bar{x} \pm SD$, mean $\pm$ standard deviation; Mdn, Median; *, intensity expressed as a percentage of maximum oxygen consumption for aerobic groups and percentage of one-repetition maximum for strength training groups; -, insufficient data to calculate; NA, not applicable.



study deleted from the model was 0.081 (26.0%). With two outliers removed [11,21], results remained statistically significant ($g=0.207$, 95% CI = 0.076, 0.338, $p=0.002$) and heterogeneity, while statistically significant ($Q=42.2$, $p=0.02$), was reduced to 40.7%.

Improvements in FN BMD also remained statistically significant when data were collapsed so that only one g represented each study ($g=0.343$, 95% CI = 0.129, 0.556, $p=0.002$, $Q=85.5$, $p<0.0001$, $I^2=76.6\%$). Cumulative meta-analysis, ranked by year, demonstrated that results have been statistically significant, or there has been a trend for statistical significance, since 2000 (Figure 5).

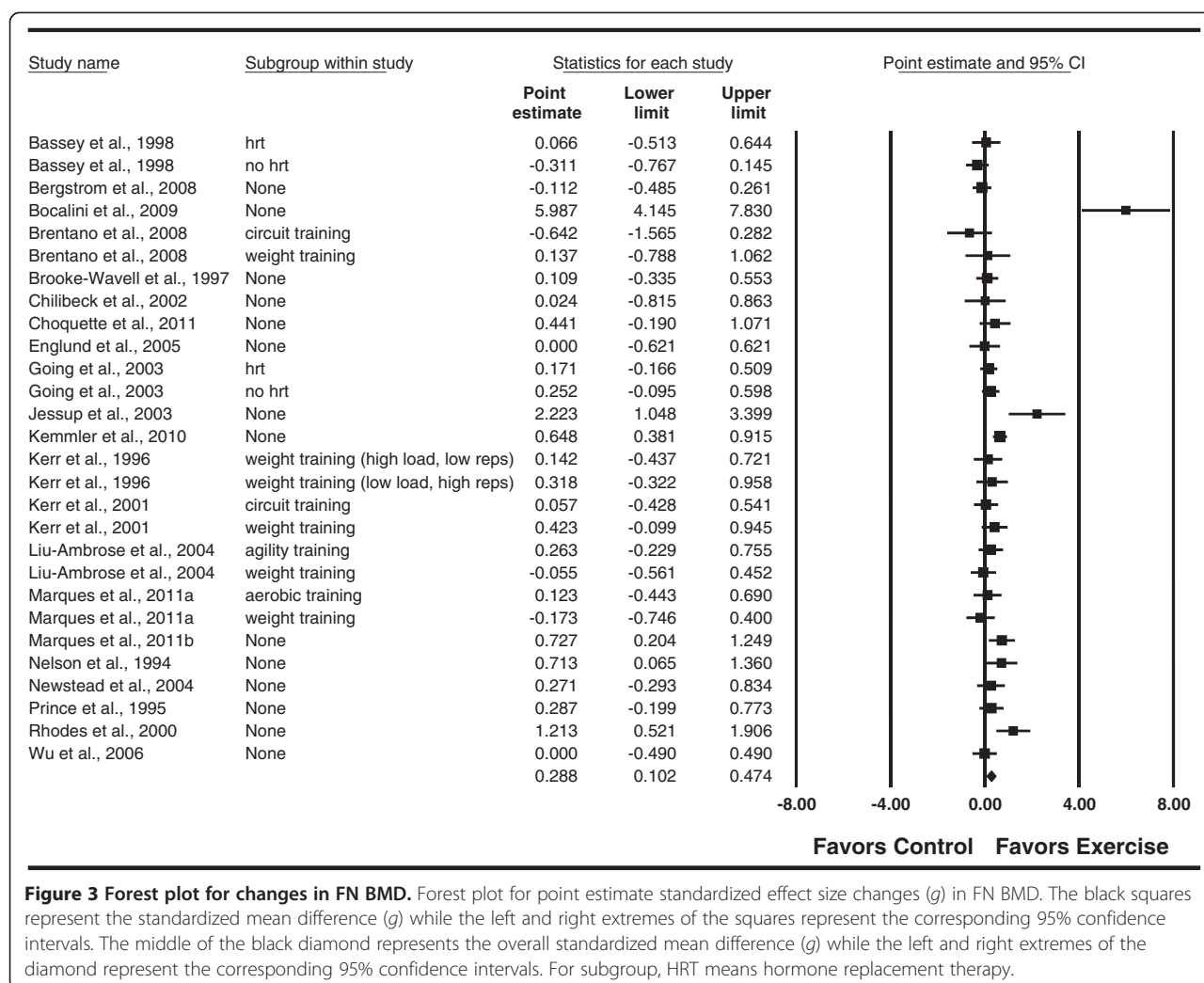
Moderator analysis for changes in FN BMD is shown in Additional file 3. As can be seen, no statistically significant between-group differences (Q_b) were found for those *a priori* comparisons for which sufficient data were available.

Meta-regression analyses for changes in FN BMD are shown in Additional file 4. As can be seen, there was a statistically significant association between increases in FN BMD and decreased compliance (combined aerobic and strength training groups only), decreases in BMI, decreases in body weight and decreases in percent body fat. A trend for a statistically significant association was observed for increases in FN BMD and increases in

Table 3 Changes in primary and secondary outcomes

Variable ^a	Studies (#)	ES (#)	Participants (#)	$\bar{x}$ (95% CI)	Z(p)	Q(p)	I ² (%)	95% PI
Primary								
- Femoral neck	21	28	1632	0.288 (0.102, 0.474)	3.03(0.002)*	90.5($p<0.0001$)*	70.1	-0.568, 1.142
- Lumbar spine	21	28	1504	0.179 (-0.003, 0.361)	1.93(0.05)*	77.7($p<0.0001$)*	65.3	-0.614, 0.972
Secondary								
- Ward's triangle	6	8	252	0.260 (-0.405, 0.613)	0.40(0.69)	28.1($p<0.0001$)*	75.1	-1.567, 1.775
- Total hip	10	14	734	0.232 (0.073, 0.391)	2.86(0.004)*	17.6(0.18)	26.0	-0.149, 0.613
- Trochanteric	14	21	1085	0.222 (0.107, 0.337)	3.79($p<0.0001$)*	18.3(0.57)	0	0.099, 0.345
- Intertrochanteric	6	10	399	0.241 (0.058, 0.425)	2.58(0.01)*	8.3(0.50)	0	0.024, 0.458
- Whole body	6	7	246	0.121 (-0.055, 0.298)	1.35(0.18)	2.7(0.85)	0	-0.110, 0.352
- Radius - 1/3	2	4	182	0.048 (-0.329, 0.424)	0.25(0.81)	5.8(0.12)	48.2	-1.365, 1.461
- Radius - mid	2	4	182	0.153 (-0.262, 0.568)	0.72(0.47)	7.0(0.07)**	57.2	-1.496, 1.802
- Radius - ultradistal	2	4	182	0.263 (-0.239, 0.765)	1.03(0.31)	10.1(0.02)*	70.3	-1.886, 2.412
- Aerobic fitness	5	8	198	1.146 (0.31, 1.930)	2.86(0.004)*	47.0($p<0.0001$)*	85.1	-1.539, 3.831
- Dynamic balance	4	5	95	1.39 (0.766, 2.014)	4.37($p<0.0001$)*	18.9(0.001)*	78.9	-0.856, 3.636
- Static balance	5	7	112	0.841 (0.228, 1.454)	2.69(0.007)*	40.9($p<0.0001$)*	85.3	-1.254, 2.936
- Body weight (kg)	11	17	594	-0.03 (-0.4, 0.4)	-0.15(0.88)	13.0(0.67)	0	-0.5, 0.4
- Body mass index (kg/m ²)	8	11	511	-0.2 (-0.8, 0.4)	-0.69(0.49)	109.9($p<0.0001$)*	90.9	-2.3, 1.9
- Lean body mass (kg)	7	10	461	0.4 (-0.06, 0.9)	1.72(0.09)**	23.8(0.005)*	62.1	-1.0, 1.9
- Fat mass (kg)	4	6	230	-0.5 (-1.2, 0.2)	-1.48(0.14)	11.0(0.05)*	54.6	-2.4, 1.4
- Body fat (%)	5	7	211	-1.7 (-2.8, -0.8)	-3.58($p<0.0001$)*	13.1(0.04)*	54.1	-4.4, 0.8
- Strength (upper body)	7	9	300	2.01 (1.08, 2.95)	4.24($p<0.0001$)*	97.8($p<0.0001$)*	97.8	-1.33, 5.36
- Strength (lower body)	9	12	482	1.58 (0.91, 2.24)	4.67($p<0.0001$)*	120.9($p<0.0001$)*	90.9	-1.00, 4.10
- Calcium intake (mg)	5	7	319	10.1 (-15.8, 35.9)	0.76(0.45)	0.3(1.0)	0	-23.9, 44.0
- Vitamin D (mcg)	-	-	-	-	-	-	-	-

Notes: ^aUnless noted otherwise, all outcomes are reported as standardized effect size (g); ES, effect size; #, number; Z(p), z-score and alpha value; Q(p), Cochran's Q statistic and alpha value; I² (%), I-squared; PI, prediction intervals. *, statistically significant ($p\leq 0.05$); **trend for statistical significance ($p>0.05$ to ≤ 0.10); -, Insufficient data reported (< 3 ES's).



intensity (strength only), increased compliance (strength training group only) and increases in static balance.

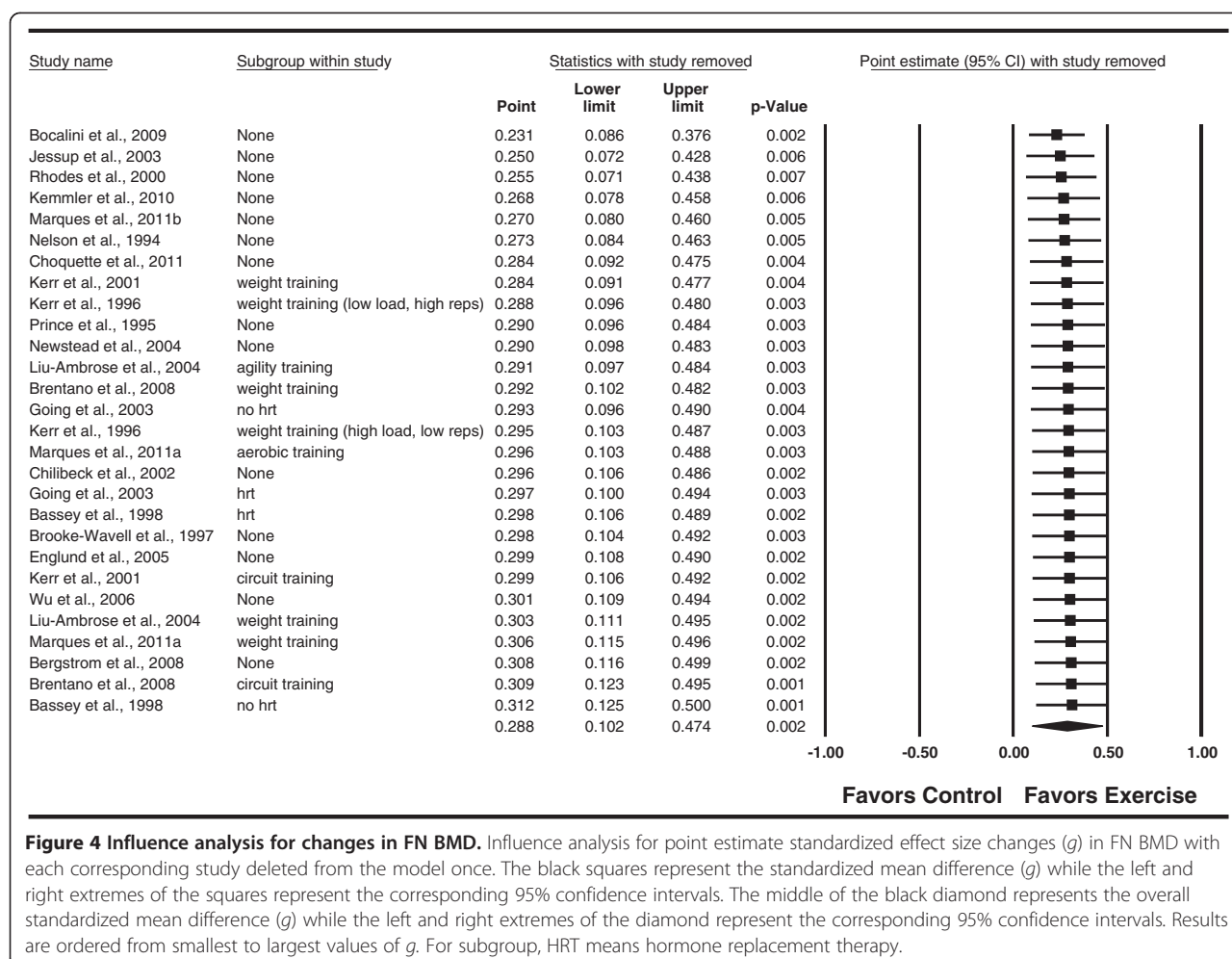
LS BMD

Overall, there was a statistically significant benefit in LS BMD but slightly overlapping 95% CIs (Table 3, Figure 6). The NNT was 6 with an estimated 80,219 postmenopausal US women maintaining and/or increasing their LS BMD if they began and maintained a regular exercise program. A moderate and statistically significant amount of heterogeneity was observed as well as overlapping prediction intervals. No adjustment for publication bias was needed. With the exception of one study [11], an outlier, results remained statistically significant or there was a trend for statistical significance when each study was deleted from the model once (Figure 7). The difference in *g* between the largest and smallest values was 0.084 (41%) when each study was deleted. With the one outlier deleted from the model, the alpha value for *g* increased to 0.12 and heterogeneity,

while still statistically significant ($Q = 42.2$, $p = 0.02$), was reduced to 48.5%. The benefits in LS BMD remained statistically significant when data were collapsed so that only one *g* represented each study ($g = 0.231$, 95% CI = 0.026, 0.435, $p = 0.03$, $Q = 71.1$, $p < 0.0001$, $I^2 = 71.9\%$). Cumulative meta-analysis, ranked by year, demonstrated that results have been statistically significant, or there has been a trend for statistical significance, since 2009 (Figure 8).

Moderator analysis for changes in LS BMD is shown in Additional file 3. As can be seen, no statistically significant between-group differences (Q_b) were found for those *a priori* comparisons in which sufficient data were available.

Meta-regression analyses for changes in LS BMD are shown in Additional file 4. As shown, there was a statistically significant association between increases in LS BMD and older age, greater number of years postmenopausal, fewer minutes of training per session (aerobic groups only), fewer minutes of training per week, greater



intensity of training (strength only), increased compliance (strength only), decreased compliance (combined aerobic and strength training only), increases in static balance, decreases in BMI, body weight and percent body fat. A trend for a statistically significant association was found between increases in LS BMD and smaller increases in aerobic fitness as well as increases in lean body mass.

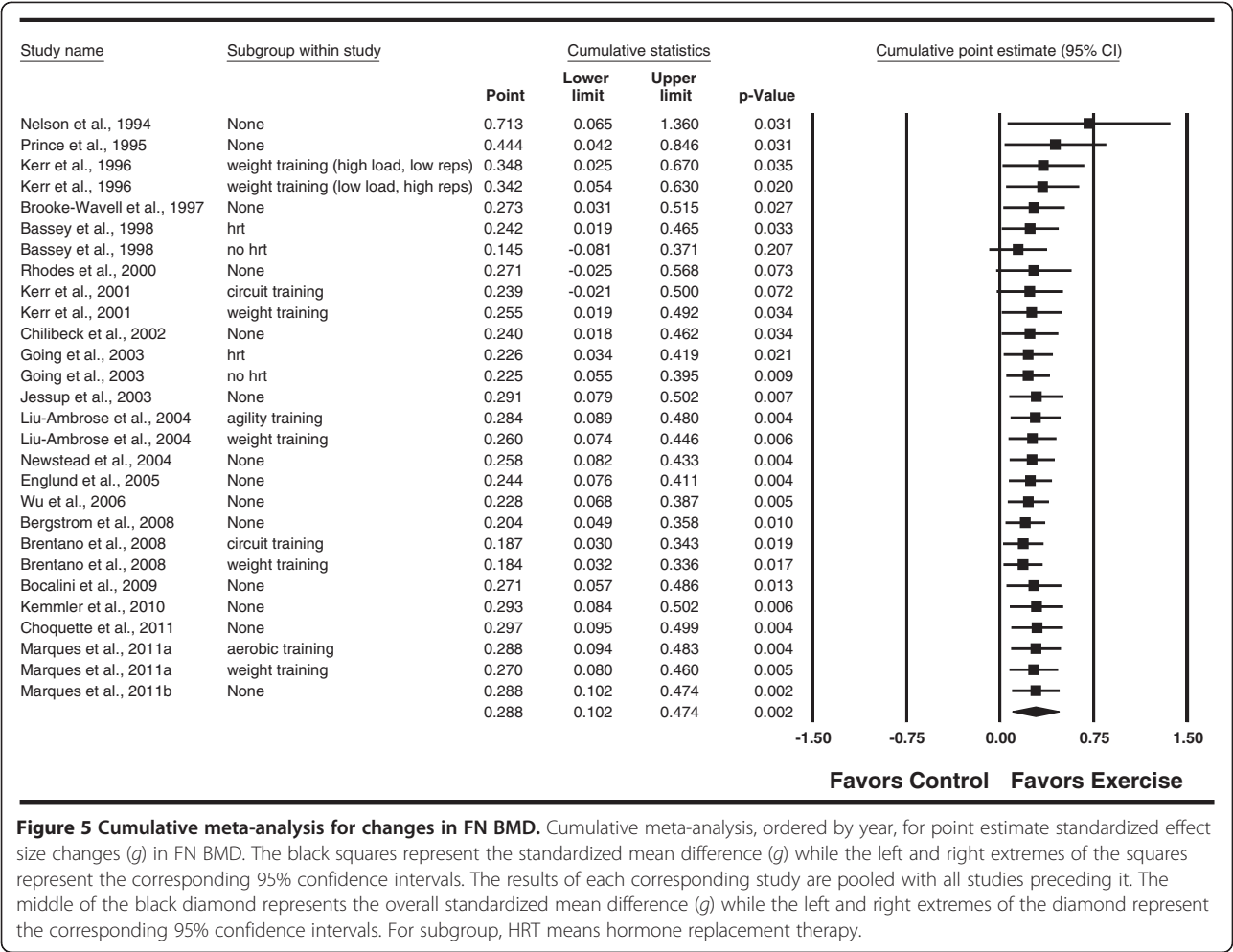
Secondary outcomes

Changes in secondary outcomes are shown in Table 3. As can be seen there was a statistically significant benefit in BMD at the total hip, trochanteric and intertrochanteric regions. A non-significant and small to nil amount of heterogeneity was observed for all three outcomes. In addition, non-overlapping prediction intervals were observed for the trochanteric region. Furthermore, large, statistically significant improvements as well as statistically significant and large amounts of heterogeneity were found for aerobic fitness, dynamic and static balance. For body composition, a trend for statistically significant

increases in LBM along with a statistically significant and moderate amount of heterogeneity was observed. A statistically significant decrease as well as a statistically significant and moderate amount of heterogeneity was also observed for percent body fat. For both upper and lower body strength, large, statistically significant increases were observed as well as large and statistically significant amounts of heterogeneity. Insufficient data were available to examine differences in fractures between the exercise and control groups.

Discussion

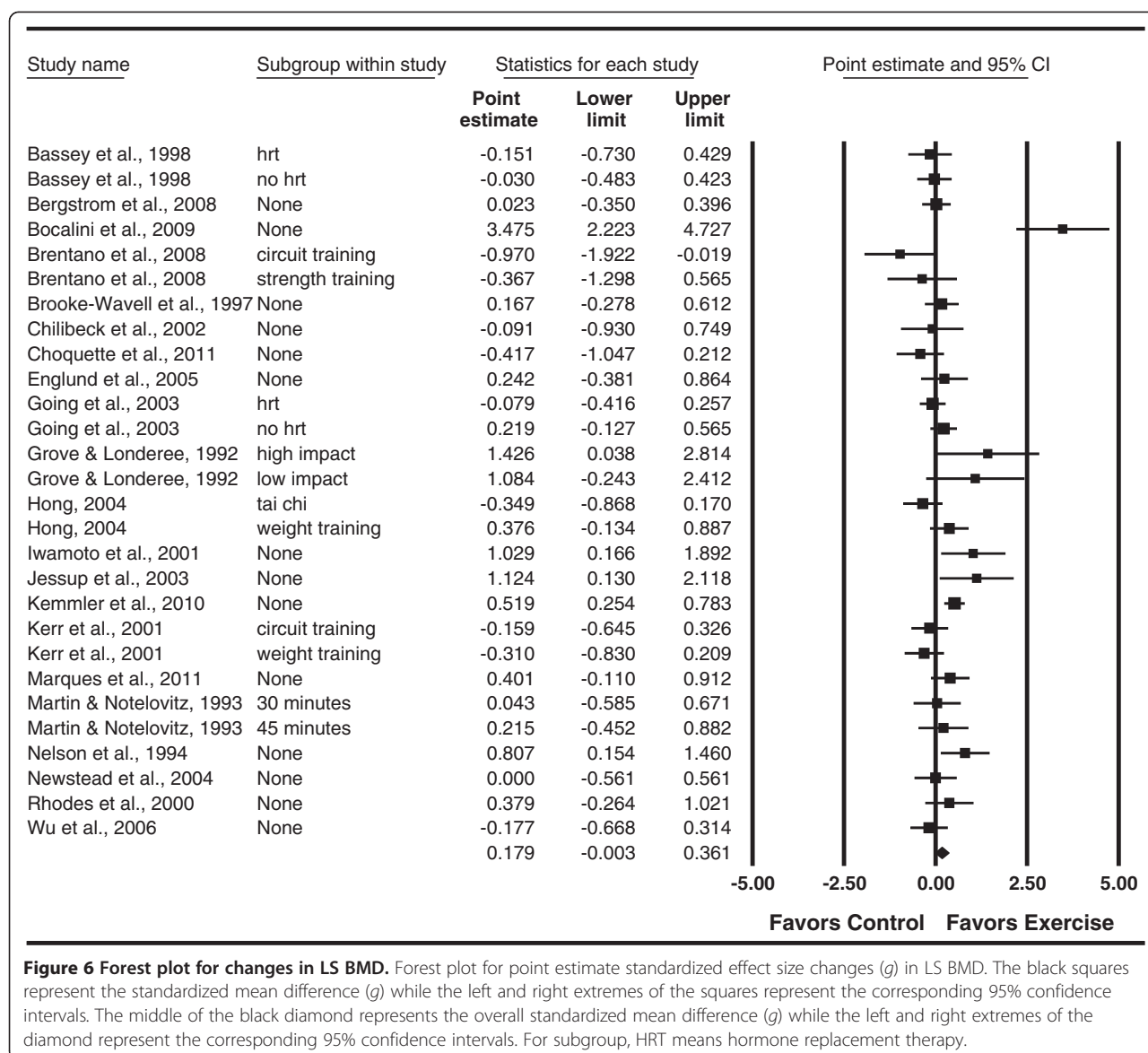
The purpose of this study was to use the aggregate data meta-analytic approach to determine the effects of ground and/or joint reaction force exercise on BMD at the FN and LS in postmenopausal women participating in exercise levels below that currently recommended for bone health [8]. The overall results suggest that ground and joint reaction force exercise may result in clinically important benefits in FN and LS BMD, with results more convincing for FN BMD. These findings are



similar to those from three [48,51,53] of four [37,48,51,53] previous meta-analyses for FN BMD and four [37,39,48,53] of five [37,39,48,51,53] previous meta-analyses for LS BMD, all of which included both ground and joint reaction force exercises from randomized controlled trials in postmenopausal women. Further support for the overall findings of the current meta-analysis were strengthened by the robustness of results when data were collapsed so that only one g represented each study as well as when examined for publication bias. When each study was deleted from the model once, results remained statistically significant for FN BMD across all deletions but were no longer statistically significant for LS BMD ($p = 0.12$) when one study was deleted from the model [11]. From a stability perspective, the statistical significance of findings has been consistent over a longer period of time for BMD at the FN (2000) versus LS (2009). Thus, the changes in BMD appear to be more convincing for FN versus LS BMD. This may have to do with the possibility that the exercise protocols employed were more specific to the FN versus LS.

While random-effects models that incorporate heterogeneity into the analysis were used, it is still important to point out that heterogeneity was observed for both FN and LS BMD. The existence of heterogeneity in meta-analysis is not only common [79], but also important, as there is no need to combine studies exactly alike since their findings, within statistical error, would be the same [80]. In addition, prediction intervals for estimating the expected results of a new trial included zero for both FN and LS BMD. However, these values should not be confused with confidence intervals since prediction intervals are based on a random mean effect while confidence intervals are not [73]. Nevertheless, these prediction intervals may be beneficial for future researchers interested in conducting randomized controlled intervention trials addressing the effects of ground and/or joint reaction force exercise on FN and LS BMD in postmenopausal women.

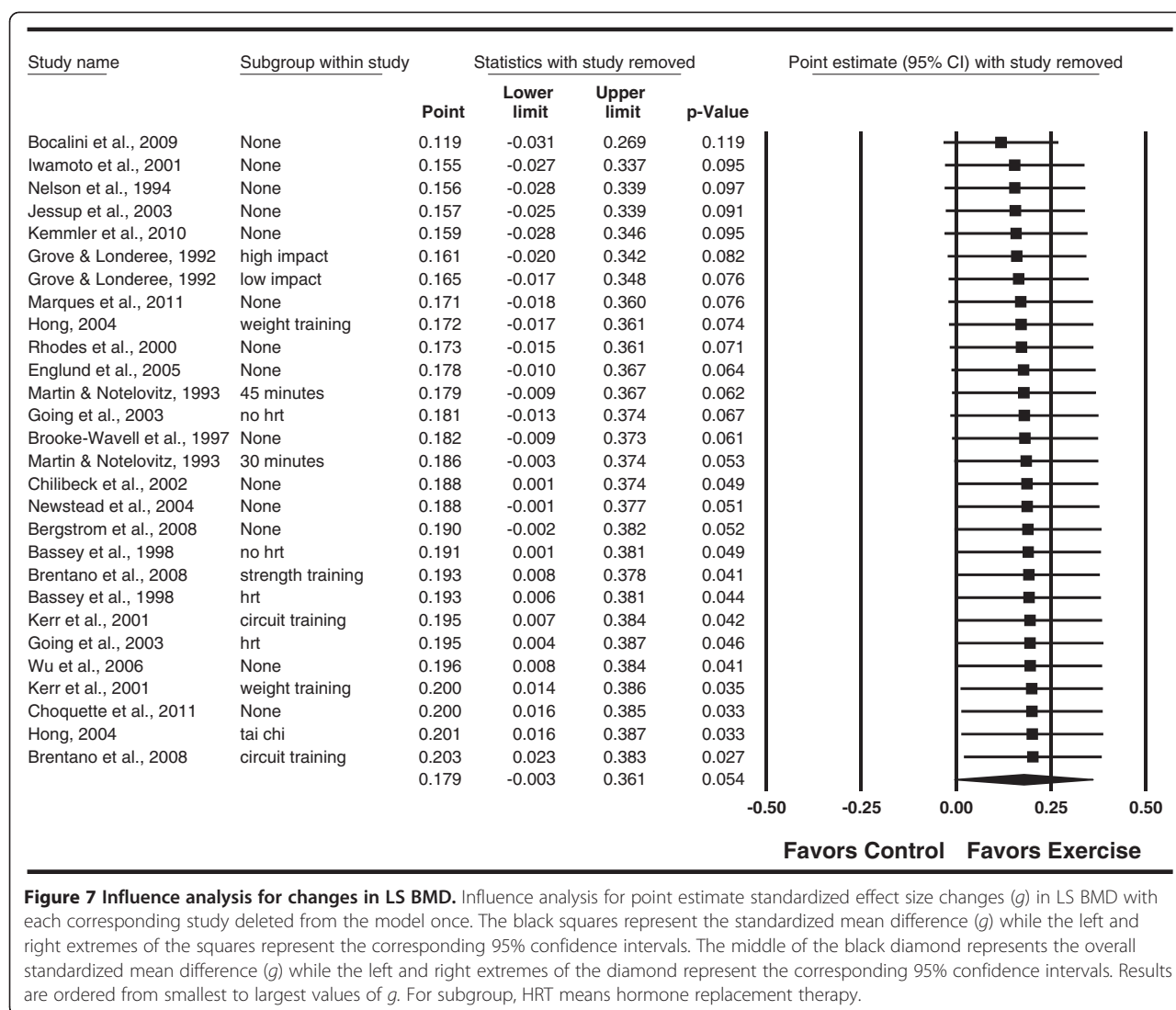
While the magnitude of change in FN and LS BMD might be considered small at the FN and trivial at the LS, they appear to be clinically important. For example, based on previous prediction models [81], the exercise-



induced changes in BMD observed at the FN and LS in the current meta-analysis would reduce the 20-year relative risk of osteoporotic fracture at any site by approximately 11% and 10%, respectively. However, the observed benefits of exercise on FN ($g=0.29$) and LS ($g=0.18$) BMD in the current meta-analysis were smaller than those previously reported for pharmacologic interventions (alendronate, calcitonin, etidronate, hormone therapy, raloxifene, risedronate) at both the hip (range of $g=0.64$ to 5.74) and LS (range of $g=0.90$ to 8.90) [82]. The exercise-induced benefits on FN and LS BMD also appear to be similar to or smaller than those observed for calcium and vitamin D supplementation (g for calcium = 0.45 at the hip and 1.57 at the LS; g for vitamin D = 0.47 at the hip and 0.20 at the LS) [82]. However, the use of pharmacological and nutritional

interventions should be considered with respect to several factors. These include: (1) the potential adverse effects of pharmacologic agents [83], (2) that participants included in previous pharmacological and nutritional intervention studies had generally lower initial levels of BMD than participants included in the current exercise meta-analysis [83], and (3) that exercise results in numerous other benefits not realized with pharmacologic and nutritional interventions [84], for example, increases in balance and a subsequent reduction in falls [85]. Given the former, the current recommendations of lifestyle changes such as exercise and adequate calcium and vitamin D intake prior to pharmacological intervention appear to be appropriate [6].

The focus of the present meta-analysis has been on the use of the traditional alpha value for statistical significance

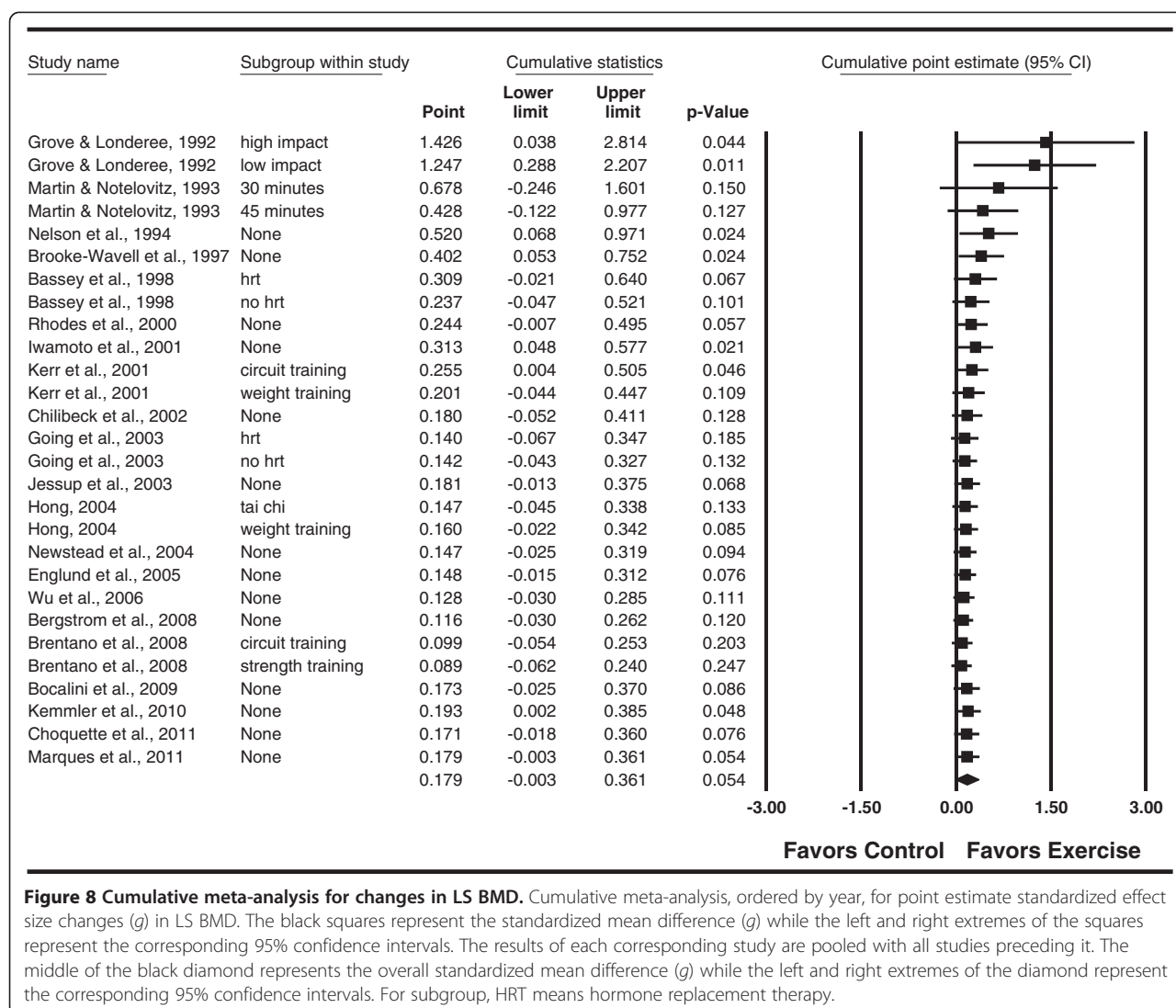


($p \leq 0.05$) and 95% CI. However, it has been suggested that rather than focus on the term statistically significant and alpha value cutpoints, one should report the exact alpha value and use 90% CI to determine clinical relevance within the range of the 90% interval [86]. Using the 90% CI approach, the interval no longer included zero (0) for changes in LS BMD (0.026 to 0.332) and ranged from 0.132 to 0.444 for changes in FN BMD.

No statistically significant between-group differences were found when mixed-effects ANOVA was conducted for changes in FN and LS BMD partitioned by a large number of categorical variables. However, while no statistically significant between-group differences were noted, changes in FN BMD were smaller for ground ($g = 0.088$) versus joint ($g = 0.420$) and combined joint and ground reaction force exercise ($g = 0.398$).

Several interesting associations were found when simple meta-regression was performed for changes in FN and LS

BMD. For ease of reading, statistically significant findings ($p < 0.05$) as well as trends for statistical significance (> 0.05 but ≤ 0.10) are discussed collectively. For both FN and LS BMD, greater increases were associated with both greater intensity and compliance in the strength training (joint-reaction force) groups. These findings suggest that greater loads per repetition as well as greater adherence may provide greater benefit to FN and LS BMD. Greater improvements in both FN and LS BMD were also associated with increases in static balance. These associations may be especially important for reducing the risk of falling as well as subsequent fracture risk. Greater increases in both FN and LS BMD were also associated with decreases in BMI, body weight and percent body fat. In addition, increases in LS BMD were associated with increases in LBM. All of these associations may be reflective of greater exercise effort. The inverse association between increases in both FN and LS BMD with poorer compliance to



aerobic and strength training protocols may be nothing more than the play of chance. Alternatively, studies with poorer compliance may have yielded greater benefits in FN and LS BMD because of the greater overall volume of training prescribed. For LS BMD, the positive association between increases in LS BMD and older age as well as a greater number of years postmenopausal may be the result of lower initial levels of BMD. However, we found no association between baseline LS BMD and changes in LS BMD. The negative associations between increases in LS BMD with shorter duration and total minutes of training per week for aerobic exercise studies may help to reinforce the belief that shorter duration activities such as jumping may be more beneficial to LS BMD than activities such as walking [7]. One potential reason for this negative association may be the result of calcium loss from excessive sweating in longer duration and/or higher intensity activities [87,88]. This causes a decrease in serum calcium

followed by an increase in serum parathyroid hormone, which then stimulates bone resorption [87,88]. While these findings are interesting, further research is needed before any firm conclusions can be drawn.

In addition to changes in FN and LS BMD, statistically significant improvements were found for several secondary outcomes. These included increases in BMD (total hip, trochanteric, intertrochanteric), aerobic fitness, dynamic and static balance, lean body mass and both upper and lower body strength. Statistically significant decreases in percent body fat were also found. These findings reinforce the many benefits that can be derived from exercise programs [84]. The former notwithstanding, the results for secondary outcomes should be interpreted with caution since they were only included if FN and/or LS BMD data were reported. Consequently, secondary outcomes in meta-analysis may not comprise a representative sample.

A major interest of the investigative team was to examine the dose–response relationship between changes in FN and LS BMD and exercise load ratings in postmenopausal women. While we found no significant association between changes in FN and LS BMD and load ratings, these associations were based on general categorical estimates versus estimates specific to each activity [59]. The decision to use categorical estimates was based on the inability to accurately calculate load ratings for those studies that involved multiple types of activities. In addition, the algorithm used requires further testing, improvement and validation [59]. Future research should also focus on developing formulas for accurately calculating load ratings from data typically provided in randomized controlled intervention trials. Ideally, individual studies should collect and report force data in all exercise interventions. However, the accurate measurement of such may be challenging for some activities [7]. Until additional dose–response research is conducted, it would appear plausible to suggest that postmenopausal women adhere to the exercise guidelines from the American College of Sports Medicine [8]. These include weight-bearing endurance activities 3 to 5 times per week as well as resistance exercise 2 to 3 times per week [8]. However, it will be particularly important for future dose–response studies to determine whether increased duration of aerobic exercise diminishes the potential skeletal benefits, as suggested by the current regression analyses.

The results of this meta-analysis should be viewed with respect to several potential limitations. First, because studies are not randomly assigned to covariates, they are considered to be observational in nature. Therefore, the results of moderator and regression analyses conducted in this or any other meta-analysis do not support causal inferences [78]. Second, because a large number of statistical tests were conducted, some statistically significant results could have been nothing more than the play of chance. However, as suggested by Rothman [89], no adjustment was made for multiple tests because of the concern about missing possibly important findings. Third, because of a lack of data, a common occurrence in meta-analysis, the research team was unable to examine several variables, thereby compromising the thoroughness of the study. With the former in mind, it is suggested that future randomized controlled trials addressing the effects of ground and/or joint reaction force exercise on FN and LS BMD in postmenopausal women include information regarding study design (allocation concealment, incomplete outcome data, verification that all outcomes planned to be assessed are reported), participant characteristics (adverse events, whether the participants had osteoporosis, cigarette smoking, alcohol consumption, change in exercise habits outside the intervention) and exercise intervention characteristics

(intensity, how exercise was delivered). Fourth, future studies should provide more specific information regarding their exercise cutpoints for enrolling participants in their studies. The heterogeneity of reporting found in the current meta-analysis is not surprising. In a systematic review of the different definitions of sedentary for screening participants for entrance into physical activity intervention trials, Bennett et al. [90], found that the definition of sedentary ranged from less than 20 to less than 150 minutes per week minutes of physical activity and that few studies reported the type and intensity of physical activity used to screen participants. While such varied definitions may make it difficult to generalize findings, the current meta-analysis, to the best of the authors' knowledge, is the first one on exercise and BMD in women to limit the inclusion of studies to those in which participants were not currently meeting exercise recommendations for bone health [8]. Fifth, given the potential advantage of high resolution peripheral quantitative computed tomography (HR-pQCT) for detecting microarchitectural changes in bone [91], it would appear plausible to suggest that future exercise intervention studies should use this technology so as to better understand the exercise-induced changes that may occur in bone. Finally, consistent with recommendations from the 2008 Physical Activity Guidelines Report, there continues to be a need for large randomized controlled trials to determine whether fracture incidence is decreased as a result of ground and/or joint reaction force exercise [7].

Conclusions

The overall findings of this aggregate data meta-analysis suggest that exercise may result in clinically relevant benefits to FN and LS BMD in postmenopausal women. Several observed and important associations appear worthy of further investigation in well-designed randomized controlled trials.

Additional files

Additional file 1: Example of search strategy for one database search (SPORTDiscus). This additional file describes the search strategy used searching the SPORTDiscus database for randomized controlled trials dealing with the effects of exercise on bone mineral density in adults.

Additional file 2: General characteristics of included studies. This additional file provides a description of the general characteristics of studies that met the inclusion criteria for the meta-analysis.

Additional file 3: Table of moderator analyses results for FN and LS BMD. This additional file provides a table of results for all moderator analyses that were conducted for categorical variables and changes in femoral neck and lumbar spine bone mineral density.

Additional file 4: Table of meta-regression results for changes in FN and LS BMD. This additional file provides a table of results for all regression analyses that were conducted for changes in femoral neck and lumbar spine bone mineral density.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

GAK was responsible for the conception and design, acquisition of data, analysis and interpretation of data, drafting the initial manuscript and revising it critically for important intellectual content. KSK was responsible for the conception and design, acquisition of data, and reviewing all drafts of the manuscript. WMK was responsible for the conception and design, interpretation of data and reviewing all drafts of the manuscript. All authors read and approved the final manuscript.

Authors' information

GAK has more than 15 years of successful experience in the design and conduct of all aspects of meta-analysis, including the effects of chronic exercise on bone mineral density in adult humans. KSK has more than 12 years of successful experience in conducting meta-analysis, including the effects of chronic exercise on bone mineral density in adult humans. WMK is a leading authority on the effects of exercise on bone mineral density.

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Review Article

Exercise and Bone Mineral Density in Premenopausal Women: A Meta-Analysis of Randomized Controlled Trials

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Objective. Examine the effects of exercise on femoral neck (FN) and lumbar spine (LS) bone mineral density (BMD) in premenopausal women. **Methods.** Meta-analysis of randomized controlled exercise trials ≥ 24 weeks in premenopausal women. Standardized effect sizes (g) were calculated for each result and pooled using random-effects models, Z score alpha values, 95% confidence intervals (CIs), and number needed to treat (NNT). Heterogeneity was examined using Q and I^2 . Moderator and predictor analyses using mixed-effects ANOVA and simple metaregression were conducted. Statistical significance was set at $P \leq 0.05$. **Results.** Statistically significant improvements were found for both FN (7 g 's, 466 participants, $g = 0.342$, 95% CI = 0.132, 0.553, $P = 0.001$, $Q = 10.8$, $P = 0.22$, $I^2 = 25.7\%$, NNT = 5) and LS (6 g 's, 402 participants, $g = 0.201$, 95% CI = 0.009, 0.394, $P = 0.04$, $Q = 3.3$, $P = 0.65$, $I^2 = 0\%$, NNT = 9) BMD. A trend for greater benefits in FN BMD was observed for studies published in countries other than the United States and for those who participated in home versus facility-based exercise. Statistically significant, or a trend for statistically significant, associations were observed for 7 different moderators and predictors, 6 for FN BMD and 1 for LS BMD. **Conclusions.** Exercise benefits FN and LS BMD in premenopausal women. The observed moderators and predictors deserve further investigation in well-designed randomized controlled trials.

1. Introduction

Bone is a living tissue that undergoes continuous remodeling as a result of bone resorption and formation whereby osteoclasts remove bone and osteoblasts create new bone [1]. A dynamic tissue, bone, adapts to the associated mechanical stresses, such as exercise, that are placed on it [2]. Currently, mechanotransduction is the predominant mechanism through which mechanical stimuli such as exercise are believed to benefit bone [3, 4]. While not entirely understood, this appears to involve the detection of mechanical stimuli by osteocytes and the transduction of this mechanical strain by osteocytes to osteoclasts and osteoblasts where bone resorption and remodeling take place [4, 5], the end result being enhanced bone formation. At the cellular level, exercise may reduce the secretion of sclerostin by the osteocyte, thereby

upregulating Wnt signaling and osteoblastogenesis, that is, bone formation [6–8]. To support this contention, both cross-sectional and longitudinal studies have shown that physically active premenopausal women have lower sclerostin levels than those who are sedentary [9, 10]. In a cross-sectional study of 1,235 randomly selected premenopausal women, those who participated in more than 120 minutes of physical activity per week were shown to have serum sclerostin levels that were 36.8% lower than sedentary controls [9]. In a longitudinal follow-up study with 120 of these same women who took part in either an 8-week, 4 days per week, exercise ($n = 58$) or control ($n = 62$) condition, serum sclerostin levels were 33.9% lower in the exercise versus control group [9].

Maintaining optimal bone mineral density (BMD) levels during the premenopausal years is important for reducing the risk of osteoporosis and subsequent fractures during the

postmenopausal years, with relative-risk increases ranging from 1.5 to 3.0 [11]. In addition, the prevalence of osteopenia and osteoporosis has been reported to be 15% and 0.6%, respectively, in premenopausal women [12]. Furthermore, it has been estimated that the loss of BMD ranges from 0.25% to 1% per year in premenopausal women [11]. While pharmacologic therapy is usually contraindicated in premenopausal women, reliance on lifestyle factors is almost always recommended [11, 13]. One potentially effective lifestyle approach for achieving this goal is exercise, a low-cost, nonpharmacologic intervention that is available to the vast majority of the population. Unfortunately, previous randomized controlled trials addressing the effects of joint and/or ground reaction force exercise on femoral neck (FN) and lumbar spine (LS) BMD in premenopausal women have led to conflicting and less than overwhelming results, with only 30% and 29% of findings reported as statistically significant at the FN and LS, respectively [14–20]. Using the traditional vote-counting approach [21], one might conclude that exercise does not benefit FN or LS BMD. However, a vote-counting approach based on statistical significance can be extremely misleading since the absence of a statistically significant effect does not mean absence of an effect [21]. In contrast, meta-analysis is a quantitative approach that enables one to go beyond statistical significance and focus on the magnitude of effect [22].

While a number of meta-analyses have been conducted on the effects of exercise on BMD in adults [23–45], none have focused exclusively on FN and/or LS BMD when limited to randomized controlled trials in premenopausal women. However, three meta-analyses have reported subgroup findings when limited to randomized controlled trials [37, 41, 44]. First, Wallace and Cumming reported a statistically significant and positive effect of both impact (1.5%) and nonimpact (1.2%) exercises on LS BMD [44]. A nonsignificant improvement of approximately 0.9% was found at the FN after impact exercise while an insufficient number of studies were available to examine nonimpact exercise [44]. A second meta-analysis that was limited to high-intensity resistance training reported a statistically significant benefit of 0.013 g/cm² for LS BMD and a nonsignificant effect of 0.001 g/cm² for FN BMD [37]. Based on a random-effects model and across all interventions, a third meta-analysis by the same research group reported a statistically significant benefit of 0.007 g/cm² at the LS and 0.012 g/cm² at the FN as a result of different impact modalities [41]. While the results of these meta-analyses are important, none were limited to randomized controlled trials. This is potentially problematic because randomized controlled trials are the only way to control for confounders that are not known or measured as well as the observation that nonrandomized controlled trials tend to overestimate the effects of healthcare interventions [46, 47]. In addition, none of these meta-analyses conducted moderator analyses for other variables when limited to randomized controlled trials [37, 41, 44]. Furthermore, none of the studies [37, 41, 44] provided any quantitative assessment of clinical relevance with respect to the number needed to treat (NNT) [48]. Given the former,

the purpose of this study was to use the aggregate data meta-analytic approach to determine the overall effects, as well as potential moderators and predictors, of ground and joint reaction force exercise on FN and LS BMD in premenopausal women.

2. Methods

2.1. Study Eligibility Criteria. Studies were included if they met the following criteria: (1) randomized trials with a comparative control group (for example, nonintervention), (2) premenopausal women, as defined by the authors, (3) participants not engaged in a regular exercise program prior to study enrollment, (4) ground and/or joint reaction force exercise intervention of at least 24 weeks, (5) published and unpublished (master's theses and dissertations) studies since January 1989, and (6) data available for changes in BMD at the FN and/or LS and assessed using dual-energy X-ray absorptiometry (DEXA) or dual-photon absorptiometry (DPA). Any studies not meeting all six criteria were excluded.

Studies were limited to randomized controlled trials because trials are the only way to control for confounders that are not known or measured as well as the observation that nonrandomized controlled trials tend to overestimate the effects of healthcare interventions [46, 47]. The rationale for limiting studies to those in which the exercise intervention was at least 24 weeks in duration was based on the fact that bone remodeling, a continuous process in which damaged bone is repaired, ion homeostasis is maintained, and bone is reinforced for increased stress, typically takes around 24 weeks [49, 50]. Thus, it is unlikely that any true exercise-induced skeletal changes in BMD would occur prior to this. Because of the site specificity of exercise on BMD [51], resistance training studies were limited to those that included lower body exercise. The year 1989 was chosen as the start date for inclusion since it appeared to be the first time that a randomized controlled trial on exercise and BMD in adult humans was conducted [52].

2.2. Data Sources. Studies were retrieved from a large, previously developed database that included 1055 unique citations (see flow diagram in Supplementary File 1, available online at <http://dx.doi.org/10.1155/2013/741639>). Citations for the original database were retrieved from (1) six electronic sources (PubMed, Embase, SportDiscus, Cochrane Central Register of Controlled Clinical Trials, CINAHL, Dissertation Abstracts International), (2) cross-referencing from retrieved studies, including previous reviews, and (3) hand searching selected journals. Keywords germane to all searches were “exercise,” “bone,” and “randomized.” In consultation with a Health Sciences librarian at West Virginia University, all searches were conducted by the second author (K. Kelly). The last search was conducted in August of 2011. In accordance with recent guidelines [53], an example of the search strategy used for one of the electronic databases (CINAHL) is shown in Supplementary File 2. Based on previous research suggesting that searching for unpublished data is probably not worth the effort, no attempt was made to retrieve such [54].

2.3. Study Selection. All studies were selected by the first two authors (G. Kelley and K. Kelley), independent of each other. They then reviewed their selections for accuracy and consistency. Discrepancies were resolved by consensus. If consensus could not be reached, the third author (W. Kohrt) was consulted and asked to provide a recommendation. The final list of selected studies was reviewed for thoroughness and completeness by the third author (W. Kohrt), an expert on exercise and BMD. A list of included and excluded studies, including the reasons for exclusion, was stored in version 12 of Reference Manager [55].

2.4. Data Extraction. Prior to data extraction, electronic codebooks were developed using Microsoft Excel 2007 [56]. Initial codebooks were developed by the first author (G. Kelley) with input from the second and third authors. Each codebook was then reviewed and tested by all three authors. Codebooks were then revised by the first author (G. Kelley) and reviewed and tested by all authors until final codebooks for data extraction were available after three iterations. The major categories of variables coded included (1) study characteristics (year of publication, risk of bias, etc.), (2) group characteristics (age, height, etc.) and (3) outcome characteristics (changes in FN and LS BMD, secondary outcomes, etc.). Codebooks could hold up to 324 items from each study.

The primary outcomes for this study, determined *a priori*, were changes in FN and LS BMD assessed by DEXA or DPA. Secondary outcomes, also established *a priori*, included changes in other BMD sites (whole body, Ward's triangle, intertrochanter, trochanter, total hip, radius, ulna, calcaneus, and os calcis), body weight, body mass index, lean body mass, percent body fat, fat mass, muscular strength (upper and/or lower), muscular power, cardiorespiratory fitness, balance (static and dynamic), calcium intake, vitamin D intake, and fractures.

All data were extracted by the first two authors (G. Kelley and K. Kelley), independent of each other. They then met and reviewed every selection for accuracy and consistency. Discrepancies were resolved by consensus. If consensus could not be reached, the third author (W. Kohrt) served as an arbitrator. Trials published as duplicate reports (parallel publications) were only included once, using all associated trial reports to maximally extract trial information, but ensuring that the trial data were not duplicated in the review.

2.5. Risk of Bias Assessment. Risk of bias was assessed using the risk of bias assessment tool from the Cochrane Collaboration [57]. This tool addresses specific domains, namely, sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, and selective outcome reporting. Each domain is classified as having either a high, low, or unclear risk of bias [57]. Given the objective nature of BMD assessment, all studies were considered low risk with respect to blinding. For selective outcome reporting, all studies were considered to be at an unclear risk for bias unless a study protocol identification number was provided. If a study

protocol identification number was provided, an *a priori* decision was made to locate the project on the respective clinical trials website to see if the number and type of outcomes reported in the study matched the number and type of outcomes reported on the website. Risk of bias was assessed by the first two authors (G. Kelley and K. Kelley). They then met and reviewed every item for agreement. Disagreements were resolved by consensus.

2.6. Statistical Analysis

2.6.1. Calculation of Effect Sizes from Each Study. The primary outcomes for this study, that is, changes in FN and LS BMD, were calculated using the standardized effect size g [58]. The standardized effect size was chosen over the original metric because of the different methods used to report data, for example, absolute versus relative changes in BMD, as well as the potential for excluding eligible studies because of the inability to retrieve necessary data. Each g was calculated as follows [58]:

$$g_i = \frac{\bar{X}_e - \bar{X}_c}{SD_{\text{pooled}}}, \quad (1)$$

where $\bar{X}_e$ represents the changes score difference in the exercise group, $\bar{X}_c$ represents the change score difference in the control group, and SD_{pooled} represents the pooled standard deviation from the change score standard deviations of the exercise and control groups. If absolute data were not available, relative (percent change) data were used.

For those studies that did not report original metric change score standard deviations, these were calculated from 95% confidence intervals if they were reported. If change score standard deviations and 95% confidence intervals were not available, change score standard deviations for each group (exercise and control) were calculated using the estimation approach of Follmann et al. [59]:

$$SD = \sqrt{(SD_{\text{initial}}^2 + SD_{\text{final}}^2) - 2(SD_{\text{initial}} * SD_{\text{final}} * \text{Corr}_{\text{initial,final}})}, \quad (2)$$

where SD_{pre}^2 is the square of the standard deviation for the initial score, SD_{post}^2 is the square of the standard deviation for the final score, and $\text{Corr}_{\text{pre,post}}$ is the correlation between initial and final scores. Based on the association between initial and final scores, the imputed correlation for this study was 0.90. After original metric change score standard deviations were calculated from each study, the pooled standard deviation for g was calculated as follows [58]:

$$SD_{\text{pooled}} = \sqrt{\frac{(n_e - 1)SD_e^2 + (n_c - 1)SD_c^2}{n_e + n_c - 2}}, \quad (3)$$

where SD_{pooled} is the pooled standard deviation for g , n_e is the sample size in the exercise group, n_c is the sample size in the control group, SD_e^2 is the square of the standard deviation in the exercise group, and SD_c^2 is the square of the standard

deviation in the control group. Each g was then corrected for small sample bias by multiplying g by a constant [58]:

$$g_i^* = c_i g_i, \quad (4)$$

where

$$c_i \approx 1 - \frac{3}{4(n_e + n_c - 2) - 1}. \quad (5)$$

The variance for each g was then calculated as follows [58]:

$$\text{Var}_{g_i} = \frac{n_e + n_c}{n_e n_c} + \frac{g_i^2}{2(n_e + n_c)}, \quad (6)$$

where Var_{g_i} is the variance for g , n_e is the sample size in the exercise group, and n_c is the sample size in the control group. For pooling purposes, each g was then weighted by the inverse of the variance as follows [58]:

$$w_i = \frac{1}{\text{Var}_{g_i}}, \quad (7)$$

where w_i represents the weight and Var_{g_i} is the variance for each g .

Effect sizes for secondary outcomes (whole body BMD, Ward's triangle, intertrochanter, trochanter, total hip, radius, ulna, calcaneus, os calcis, upper and low body muscular strength, muscular power, and static and dynamic balance) were also calculated using g . Generally, the magnitude of effect for g may be classified as trivial (<0.20), small (≥ 0.20 to <0.50), medium (≥ 0.50 to <0.80), or large (≥ 0.80) [60]. A g of 0.30, for example, means that exercise would result in a 0.30 SD benefit over those who did not exercise. The original metric was used to calculate all other secondary outcomes: cardiorespiratory fitness ($\text{VO}_{2\text{max}}$ in $\text{mL/kg}^{-1}/\text{min}^{-1}$), body weight (kg), body mass index (kg/m^2), lean body mass (kg), percent body fat (%), fat mass (kg) calcium intake (mg/day), vitamin D intake (IU), and number of fractures.

2.6.2. Effect Size Pooling. All effect sizes were pooled using a random-effects, method of moments model [61]. This approach weights studies by the inverse of the variance and incorporates heterogeneity into the model [61]. For both primary and secondary outcomes, pooling was limited to those outcomes with at least 3 effect sizes. Multiple groups from the same study were analyzed independently as well as collapsing multiple groups so that only one effect size represented each outcome from each study. A two-tailed Z score alpha value of ≤ 0.05 was considered to be statistically significant while alpha values >0.05 but ≤ 0.10 were considered as a trend. Precision was determined using two-tailed 95% confidence intervals (CIs). For outcomes with statistically significant results, estimation of treatment effects in a new trial was calculated using 95% prediction intervals (PIs) [62–64]. To enhance clinical relevance, the NNT was also estimated [48]. Analysis of secondary outcomes was considered exploratory because they were not part of the inclusion criteria, and thus, may represent a biased sample. After initial pooling, studies

with statistically significant residuals (outliers) were deleted from all further analysis. The alpha value for statistically significant residuals was set at $P \leq 0.05$. Because of a lack of data (<3 effect sizes), analysis of secondary outcomes was limited to changes in body weight and BMD at Ward's triangle and the trochanteric regions.

Statistical heterogeneity of pooled results based on fixed-effects models was examined using the Q statistic and I^2 , an extension of Q that more accurately reflects statistical heterogeneity [65]. The alpha value for statistical significance for Q was set at $P \leq 0.10$. For I^2 , values of 25% to $<50\%$ may be considered small, 50% to $<75\%$ medium, and $\geq 75\%$ large [65]. For this study, I^2 values $>50\%$ were considered as excessive heterogeneity. Potential bias due to small-study effects was examined using the approach of Egger et al. and an alpha value for statistical significance of $P \leq 0.05$ [66]. Small-study effects include such things as publication bias and the overestimation of treatment effects in studies of lower quality. For primary outcomes, influence analysis was conducted in order to examine the effects of each study on the overall results. In addition, cumulative meta-analysis, ranked by year, was also conducted [67].

2.6.3. Moderator Analysis. Mixed-effects, ANOVA-like models for meta-analysis were used to compare between-group differences (Q_b) in FN and LS BMD according to selected categorical variables, assuming that each category included at least 2 g 's. A random-effects model was used to combine studies within each subgroup while a fixed-effect model was used to combine subgroups and yield the overall g . Between-study variance (τ^2) was not assumed to be equal for all subgroups. *A priori* variables to examine included type of control group (nonintervention, other), matching (yes, no), risk of bias for sequence generation, allocation concealment, blinding, incomplete outcome data, selective outcome reporting (low versus high risk), type of analysis (intention to treat, per protocol), provision of sample size estimates (yes, no), whether the study was funded (yes, no), adverse events (yes, no), race/ethnicity, drugs, other than hormone therapy, which could positively or negatively affect BMD (yes, no), hormone therapy, including oral contraceptives (yes, no), rheumatoid arthritis (yes, no), cigarette smoking (yes, no), alcohol consumption (yes, no), changes in physical activity habits outside the exercise intervention (yes, no), whether calcium or vitamin D supplements were given during the study (yes, no), previous fractures (yes, no), type of exercise (aerobic, strength, both), exercise supervision status (supervised, unsupervised, both), location in which exercise took place (facility, home, both), exercise participation (self, group, both), reaction forces (ground, joint, both), and instrument used to assess BMD (Lunar, Hologic). However, because of a lack of data ($<2g$'s per category), moderator analysis was limited to type of control group, type of analysis, sample size estimates, funding (FN only), calcium administration during the study (FN only), type of exercise (aerobic, strength), exercise supervision (FN only), location in which exercise took place (facility versus home, FN only), exercise participation (group versus self, FN only),

reaction forces (ground versus joint), and instrument used to assess BMD (FN only). *Post hoc*, an examination for potential differences in FN and LS BMD when partitioned according to whether studies were at a low versus unclear risk for incomplete outcome data was conducted. Because of a lack of data for categorizing, a statistical examination for other forms of bias (sequence generation, allocation concealment, blinding, selective outcome reporting) was not possible. The alpha level for statistical significance for Q_b was set at $P \leq 0.05$.

2.6.4. Metaregression. Simple mixed-effects, method of moments metaregression was used to examine the association between changes in FN and LS BMD and selected continuous variables, assuming that at least 3 g 's were available for each analysis. Potential predictors established *a priori* included percentage of dropouts in the exercise intervention groups, age, length, frequency and intensity of training, duration of training (aerobic exercise only), compliance to the exercise protocol, total minutes of training (unadjusted and adjusted for compliance, aerobic exercise only), number of sets, repetitions and exercises (strength training only), load rating of the exercise interventions, calculated from previous research [51], baseline BMD and changes in cardiorespiratory fitness, balance (static and dynamic), calcium intake, muscular strength (upper and lower), body weight, BMI, lean body mass, fat mass, and percent body fat. However, because of a lack of data ($<3g$'s), metaregression analysis was limited to dropouts, age, length of training, frequency of training, duration of training, compliance, unadjusted total minutes of training, adjusted total minutes of training (FN only), load rating, number of sets and exercises (FN only), changes in upper and lower body strength, bodyweight (FN only), and baseline BMD. Analyses were limited to simple metaregression versus multiple metaregression because of missing data for different variables from different studies. The alpha level for statistical significance was set at $P \leq 0.05$.

2.6.5. Software Used for Statistical Analysis. Data were analyzed using Comprehensive Meta-Analysis (version 2.2) [68], Microsoft Excel 2007 [56], and SSC-Stat (version 2.18) [69].

3. Results

3.1. Study Characteristics. After screening 1055 citations, seven studies representing 17 groups (10 exercise, 7 control) and 521 participants (269 exercise, 252 control) met the criteria for inclusion [14–20]. A flow diagram for the selection of studies is shown in Supplementary File 1, a general description of the characteristics of each study in Table 1, and baseline characteristics of the participants in Table 2. A list of excluded studies, including the reasons for exclusion, is available upon request from the corresponding author. For the included studies, the number of exercise groups exceeded the number of control groups because two studies included more than one exercise group [14, 17]. All

studies were published in English-language journals between 1995 and 2011 [14–20]. Five studies were conducted in the United States [15, 17–20], one in Australia [14] and one in Finland [16]. For type of control groups, four studies used a nonintervention control group [16–18, 20] while three others used alternative approaches (usual care, attention control) [14, 15, 19]. With respect to matching, one study matched participants according to body weight and oral contraceptive use [16] while another matched according to age and oral contraceptive use [20]. None of the studies used a crossover design [14–20]. For sample size justification, three studies supplied power estimates to support such [14, 16, 19]. Five studies used the per-protocol approach [14, 15, 17, 18, 20] while the remaining two used intention to treat [16, 19] to analyze their data.

For external funding, five [15–17, 19, 20] of 7 studies reported receiving some type of external funding to conduct their project. The dropout rate ranged from 13.9% to 63.6% in the exercise groups ($\bar{x} \pm SD = 40.3\% \pm 17.8\%$, $Mdn = 46\%$) and 5.0% to 57.8% in the control groups ($\bar{x} \pm SD = 28.5\% \pm 19.7\%$, $Mdn = 28\%$). For the 4 studies that reported dropout data separately for exercise and control groups [14, 16, 17, 19] reasons for dropping out or being dropped in the exercise groups included changed circumstances, time constraints, injuries or pain which may or may not have been associated with the exercise intervention, personal issues, pregnancy, moving, loss of interest, uptake of medications that could affect BMD, and noncompliance with the exercise intervention. For control groups, reasons included changed circumstances, injury, moving, loss of interest, pregnancy, and uptake of medications that could affect BMD. For the one study that provided information, no serious adverse events were reported [16].

3.2. Participant Characteristics. Initial physical characteristics of the participants are shown in Table 2. For the three studies that reported data on race/ethnicity [15, 18, 19], participants included primarily Whites. Other racial/ethnic groups included Asians as well as Hispanics and/or Latinos. Two studies reported that none of the subjects were taking any type of hormone therapy, including hormonal contraceptives [15, 18] while the other five reported that some were [14, 16, 17, 19, 20]. For drugs other than hormone therapy that could affect BMD, two studies reported no use of such [18, 20] while one reported that some were [16]. Three studies reported that none of the participants had osteopenia or osteoporosis [15, 17, 20] while two reported no secondary osteoporosis [15, 20]. With respect to cigarette smoking, two studies reported that none of the participants were currently smoking cigarettes [16, 17]. Three studies in which data were available reported no change in the participants' levels of exercise beyond the exercise intervention itself [16, 18, 19]. Two studies reported that calcium was given to all participants [17, 18]; one reported that some participants received calcium [15] while two others reported no calcium supplementation [14, 19]. For vitamin D intake, one study reported administering vitamin D to all participants [15]

TABLE 1: General characteristics of studies.

Study	Country	Participants	Exercise intervention	BMD Assessment
Bailey and Brooke-Wavell, 2010 [14]	United Kingdom	85 healthy, premenopausal women 18 to 45 yrs of age assigned to 0 ($n = 20$), 2 ($n = 21$), 4 ($n = 22$), or 7 ($n = 22$) days/wk of exercise	2, 4, or 7 days/wk of 5 sets of 10 hops on one limb with 15 seconds of walking between each set for 6 months	DEXA (GE Lunar Prodigy Advance) at the FN
Friedlander et al., 1995 [15]	United States	63 women 20 to 35 yrs of age assigned to either an exercise ($n = 32$) or stretching ($n = 31$) group	3 days/wk, 1 h/session, alternating classes of circuit training, strength training, and aerobic exercise (70–85% of $\dot{V}O_{2\max}$), for 2 yrs	DEXA (Hologic QDR 1000) at the LS & FN
Heinonen et al., 1996 [16]	Finland	84 healthy, sedentary premenopausal women 35 to 40 yrs of age assigned to either a training ($n = 39$) or control ($n = 45$) group	3 days/wk, 1 h/session (15 min warm-up, 20 min high-impact jump training, 15 min calisthenics, 10 min cool down), for 18 months	DEXA (Norland XR-26) at the LS & FN
Liang et al., 2011 [17]	United States	51 healthy, untrained women 20 to 35 yrs of age assigned to a strength training ($n = 15$), step aerobics ($n = 16$), or control ($n = 20$) group	3 days/wk, 40 min/session, strength: 1–3 sets, 8–15 reps, 65–80% 1RM, 8 exercises; step aerobics: step, hop, walk, run in place, 20 cm step height, 15–300 hop cycles/session, for 12 months	DEXA (Hologic QDR 4500W)
Lohman et al., 1995 [18]	United States	56 premenopausal women 28 to 39 yrs of age assigned to either an exercise ($n = 22$) or control ($n = 34$) group	3 days/wk, 1 h/session, 3 sets, 8–12 reps, 70–80% 1RM, 12 weight lifting exercises, 18 months	DEXA (Lunar DPX) at the LS & FN
Warren et al., 2008 [19]	United States	148 healthy, sedentary, overweight premenopausal women 25 to 44 yrs of age assigned to either an exercise ($n = 72$) or control ($n = 76$) group	2 days/wk, strength training, 3 sets, 8–10 reps, for 2 yrs	DEXA (Lunar Prodigy) at the LS & FN
Weaver et al., 2001 [20]	United States	55 women 18 to 31 yrs of age assigned to either an exercise ($n = 28$) or control ($n = 27$) group	3 days/wk of super circuit resistance training, 8 upper and 8 lower body exercises with a cycle ergometer between each station, 8–12 reps, 70% 1RM, plus 60 min of jumping rope/wk, for 24 months	DEXA (DXA Lunar) at the LS & FN

BMD: bone mineral density; DEXA: dual-energy X-ray absorptiometry; FN: femoral neck; LS: lumbar spine; yrs: years; min: minute(s); h: hour(s); wks: weeks; wk: week; RM: repetition maximum; reps: repetitions; $\dot{V}O_{2\max}$: maximum oxygen consumption; description of groups is limited to those that met the inclusion criteria for the current meta-analysis; description of BMD assessment is limited to the primary outcomes of the current meta-analysis (FN and LS). Number of participants is limited to those in which final BMD assessments were available.

while two others reported no administration of vitamin D [14, 19].

3.3. Exercise Intervention Characteristics. A description of the training program characteristics is shown in Table 1. As can be seen, the exercise interventions varied. Across all intervention groups, length of training ranged from 24 to 104 weeks ($\bar{x} \pm SD = 63.6 \pm 32.8$, $Mdn = 65$) while frequency ranged from 2 to 7 days per week ($\bar{x} \pm SD = 3.1 \pm 1.4$, $Mdn = 3$). Compliance, defined as percentage of exercise sessions attended, ranged from 44% to 90% ($\bar{x} \pm SD = 71.7\% \pm 17.7\%$, $Mdn = 83\%$). For those groups in which data were available, four participated in either supervised or unsupervised exercise while one participated in both. For location where exercise took place, six participated in facility-based exercise, three in home-based exercise, and one did both. With respect to exercise participation, three groups participated in group-based exercise, four participated in exercise on their own, and one did both. Five exercise groups participated in ground reaction force exercise, three in joint reaction force exercise, and two in both. The exercise load rating ranged from 9.1 to 1481 ($\bar{x} \pm SD = 388.2 \pm 618.6$, $Mdn = 10.1$) for the nine groups that reported data for such.

3.4. BMD Assessment Characteristics. A description of FN and LS BMD assessment is shown in Table 1. For those studies in which data were available, three reported using Lunar dual-energy X-ray absorptiometry [14, 19, 20] while two others used a Hologic instrument [15, 17]. Coefficients of variation ranged from 0.5% to 4% at the FN and 0.3% to 4% at the LS.

3.5. Risk of Bias Assessment. Overall results for risk of bias are shown in Figure 1 while study level results are shown in Supplementary file 3. As can be seen, all studies were considered to be at a low risk for bias with respect to sequence generation and blinding [14–20]. In contrast, allocation concealment was categorized as unclear in 86% of the studies and low risk in 14%. Results for incomplete outcome data were mixed, with 43% considered to be at low risk for bias and 57% classified as unclear. Finally, because none of the studies provided a clinical trials registry number, selective outcome reporting was considered to be unclear for all of the studies [14–20].

3.6. Changes in Primary Outcomes

3.6.1. Changes in FN BMD. Ten g 's representing 521 participants from seven studies [14–20] resulted in a small but statistically significant benefit in FN BMD ($g = 0.280$, 95% CI = 0.036, 0.524, $P = 0.03$, $Q = 17.8$, $P = 0.04$, $I^2 = 49.6\%$). However, one outlier was detected and deleted from all further FN BMD analyses [20]. With the one outlier deleted from the model, results remained small, statistically significant, and with a nonsignificant and small amount of heterogeneity observed (Table 3 and Figure 2). Changes were equivalent to a 1.1% benefit (0.4% increase in the exercise groups, –0.7% decrease in the control groups). The NNT was 5 while the 95% PI was –0.116 to 0.800. Statistically

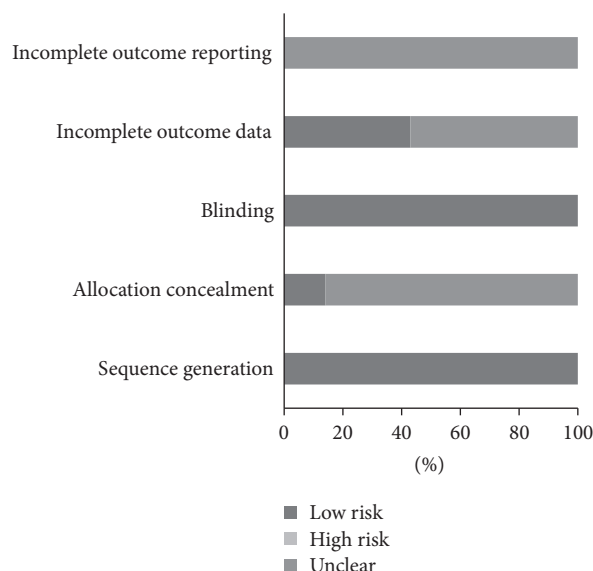


FIGURE 1: Risk of bias. Pooled risk of bias results using the Cochrane Risk of Bias Assessment Tool [57].

significant small-study effects were observed ($P = 0.05$). With each study deleted from the model once, results remained statistically significant (Figure 3). Cumulative meta-analysis demonstrated that results have been statistically significant, or there has been a trend for statistical significance, since inception of the publication of the first two studies in 1995 (Figure 4) [15, 18]. When results were collapsed so that only one g represented each study, increases in FN BMD remained small, statistically significant, and with a nonsignificant and small amount of heterogeneity ($g = 0.323$, 95% CI = 0.109, 0.537, $P = 0.003$, $Q = 7.3$, $P = 0.20$, $I^2 = 31.4\%$). Because g was used, no missing data for FN BMD needed to be requested from the original study authors. The calculation of g was based on relative values from five studies [14–17, 20] and absolute values from the other two [18, 19]. Original metric change outcome SD's for exercise and control groups were estimated from change score SD's in three studies [15, 16, 20], one of which was transformed from sample sizes and standard errors of the means [20], 95% confidence intervals from two studies [14, 17], and initial and final standard deviations in two others [18, 19].

3.6.2. Moderator Analysis for FN BMD. The moderator analyses for FN BMD are shown in Supplementary File 4. As can be seen, there was a trend for greater benefits in FN BMD for those studies published in countries other than the United States. In addition, there was a trend for greater benefits in those participating in home versus facility-based exercise. No other statistically significant differences for FN BMD were observed, including when reporting of incomplete outcome data were partitioned according to low versus unclear risk ($Q_b = 0.55$, $P = 0.46$).

3.6.3. Regression Analysis for FN BMD. Simple metaregression results for changes in FN BMD are shown in Supplementary File 5. As can be seen, there was a statistically significant

TABLE 2: Initial physical characteristics of participants.

Variable	Groups (#)	Participants (#)	Exercise			Groups (#)	Participants (#)	Control		
			$\bar{x} \pm SD$	Mdn	Range			$\bar{x} \pm SD$	Mdn	Range
Age (yrs)	10	269	30.7 $\pm$ 5.5	31	23–39	7	252	32.8 $\pm$ 5.2	34	24–39
Body weight (kg)	10	269	62.1 $\pm$ 8.1	60	55–82	7	252	65.3 $\pm$ 7.5	63	58–81
BMD (g/cm ²)										
Femoral neck	7	224	0.927 $\pm$ 0.085	0.840	0.85–1.070	6	233	0.938 $\pm$ 0.105	0.909	0.840–1.090
Lumbar spine	7	224	1.118 $\pm$ 0.120	1.080	0.991–1.290	6	233	1.145 $\pm$ 0.138	1.145	0.986–1.30
Ward's triangle	4	81	0.882 $\pm$ 0.062	0.863	0.883–0.970	3	81	0.911 $\pm$ 0.082	0.896	0.833–0.970
Trochanteric	6	196	0.775 $\pm$ 0.099	0.735	0.688–0.939	5	206	0.786 $\pm$ 0.10	0.765	0.690–0.909

Groups (#): number of groups in which data were available; participants (#): number of participants nested within groups; $\bar{x} \pm SD$: mean $\pm$ standard deviation; Mdn: median; BMD: bone mineral density.

and positive relationship between benefits in FN BMD and the number of sets performed when resistance training while an inverse relationship was observed for exercise frequency. A trend for statistical significance was observed for greater benefits in FN BMD and (1) shorter exercise interventions, (2) lower initial FN BMD, (3) increases in body weight, and (4) decreases in upper body strength.

3.6.4. Changes in LS BMD. Seven gs representing 457 participants from six studies [15–20] resulted in a trivial and non-significant difference in LS BMD ($g = 0.115$, 95% CI = $-0.108, 0.339$, $P = 0.31$, $Q = 8.5$, $P = 0.20$, $I^2 = 29.5\%$). However, the same outlier as for FN BMD was detected and deleted from all further LS BMD analyses [20]. With the one outlier deleted, results were small but statistically significant and heterogeneity (I^2) was reduced to 0% (Table 3 and Figure 5). The NNT was 9 while the 95% PI was -0.071 to 0.473 . Calculation of percent change was not possible because of missing data from two studies [16, 19]. No statistically significant small-study effects were observed ($P = 0.034$). With each study deleted from the model once, results were no longer statistically significant or there was no longer a trend for statistical significance when two were deleted from the model (Figure 6) [15, 16]. Cumulative meta-analysis demonstrated that results have been statistically significant since inception of the second study in 1995 (Figure 7) [18]. When results were collapsed so that only one g represented each study, increases in LS BMD remained small, statistically significant, and with no apparent statistical heterogeneity ($g = 0.201$, 95% CI = $0.009, 0.394$, $P = 0.04$, $Q = 3.2$, $P = 0.52$, $I^2 = 0\%$). Because g was used, no missing data for LS BMD needed to be requested from the original study authors. The calculation of g was based on relative values from four studies [15–17, 20] and absolute values from the other two [18, 19]. Original metric change outcome SD's for exercise and control groups were estimated from change score SD's in three studies [15, 16, 20], one of which was transformed from standard errors of the means [20], 95% confidence intervals from two studies [17], and initial and final standard deviations in two others [18, 19].

3.6.5. Moderator Analysis for LS BMD. Moderator analyses for LS BMD are shown in Supplementary File 4. As can be seen, no statistically significant differences were observed, including when the reporting of incomplete outcome data were partitioned according to low versus unclear risk ($Q_b = 0.43$, $P = 0.51$).

3.6.6. Regression Analysis for LS BMD. Simple metaregression results for changes in LS BMD are shown in Supplementary File 5. As shown, no statistically significant associations were observed. A trend for a statistically significant association was observed for greater benefits in LS BMD and earlier published studies.

3.7. Changes in Secondary Outcomes. The overall results for secondary outcomes are shown in Table 3. No statistically significant differences were found for BMD at Ward's triangle and the trochanteric regions as well as for bodyweight. Small but statistically significant increases were observed for both upper and lower body strength. A trend for a statistically significant and moderate amount of heterogeneity was observed for changes in lower body strength. For both upper and lower body strength, the NNT was 4 while the 95% PI was -0.879 to 1.850 for upper body strength and -0.492 to 1.388 for lower body strength. Small-study effects were non-significant for changes in strength in both the upper ($P = 0.33$) and lower ($P = 0.70$) body. When results were collapsed so that only one g represented each study, increases in lower body strength remained small, statistically significant, and with no apparent heterogeneity ($g = 0.429$, 95% CI = $0.237, 0.622$, $P = 4.37$, $Q = 1.4$, $P = 0.71$, $I^2 = 0\%$). No study level analysis was needed for changes in upper body strength because none of the studies included multiple groups.

4. Discussion

The primary purpose of meta-analysis is to reach general conclusions regarding a body of research [70]. The primary purpose of this study was to use the aggregate data meta-analytic approach to determine the effects of exercise on

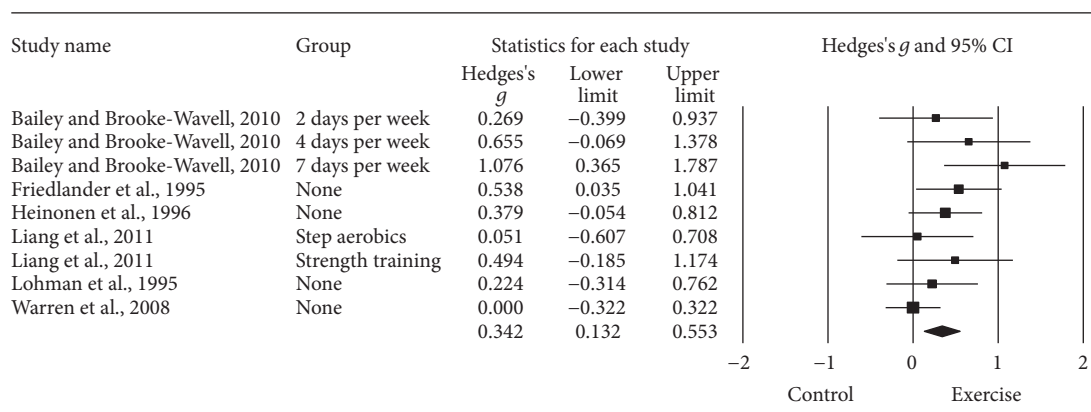


FIGURE 2: Forest plot for changes in FN BMD. Forest plot for point estimate standardized effect size changes (*g*) in FN BMD. The black squares represent the standardized mean difference (*g*) while the left and right extremes of the squares represent the corresponding 95% confidence intervals. The middle of the black diamond represents the overall standardized mean difference (*g*) while the left and right extremes of the diamond represent the corresponding 95% confidence intervals. Negative results favor control groups while positive results favor exercise groups.

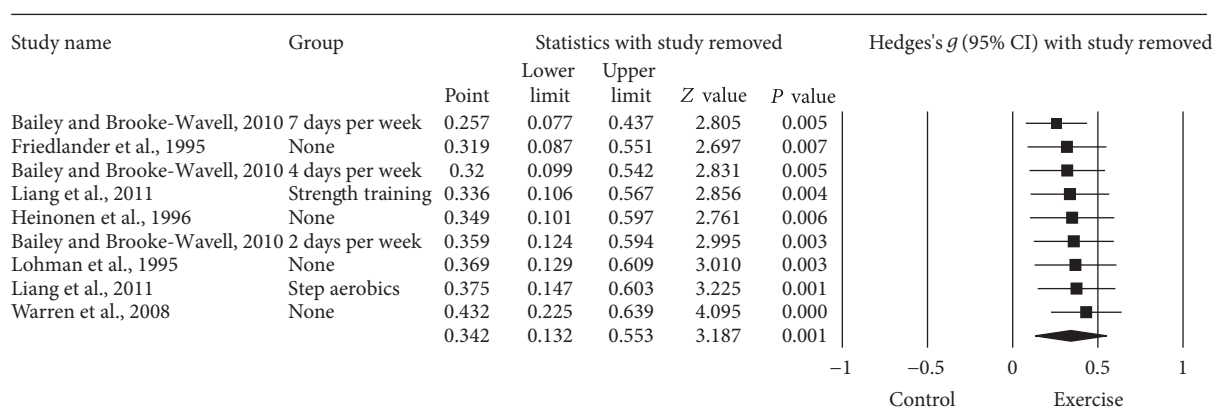


FIGURE 3: Influence analysis for changes in FN BMD. Influence analysis for point estimate standardized effect size changes (*g*) in FN BMD with each corresponding study deleted from the model once. The black squares represent the standardized mean difference (*g*) while the left and right extremes of the squares represent the corresponding 95% confidence intervals. The middle of the black diamond represents the overall standardized mean difference (*g*) while the left and right extremes of the diamond represent the corresponding 95% confidence intervals. Results are ordered from smallest to largest values of *g*. Negative results favor control groups while positive results favor exercise groups.

TABLE 3: Changes in primary and secondary outcomes.

Variable ^a	Studies (#)	ES (#)	Participants (#)	$\bar{x}$ (95% CI)	Z (P)	Q (P)	I ² (%)
Primary							
Femoral neck	7	9	466	0.342 (0.132, 0.553)	3.19 (0.001)*	10.8 (0.22)	25.7
Lumbar spine	5	6	402	0.201 (0.009, 0.394)	2.05 (0.04)*	3.3 (0.65)	0
Secondary							
Ward's triangle	3	4	162	0.088 (-0.207, 0.383)	0.59 (0.56)	2.9(0.41)	0
Trochanteric	7	10	521	0.085 (-0.097, 0.267)	0.92 (0.36)	10.5 (0.31)	14.1
Body weight (kg)	5	5	296	0.4 (-0.5, 1.3)	0.93 (0.35)	2.1 (0.72)	0
Strength (upper body)	3	3	295	0.49 (0.28, 0.70)	4.56 (0.0001)*	1.2 (0.56)	0
Strength (lower body)	4	5	346	0.45 (0.14, 0.75)	2.88 (0.004)*	8.78 (0.07)**	54.4

^aUnless noted otherwise, all outcomes are reported as standardized effect size (*g*); ES: effect size; #: number; participants (#): number of exercise and control participants nested within ES's and studies; Z (P): Z score and alpha value; Q (P): Cochran's Q statistic and alpha value; I² (%): I squared; *statistically significant ($P \leq 0.05$); **trend for statistical significance ($P > 0.05$ to ≤ 0.10).

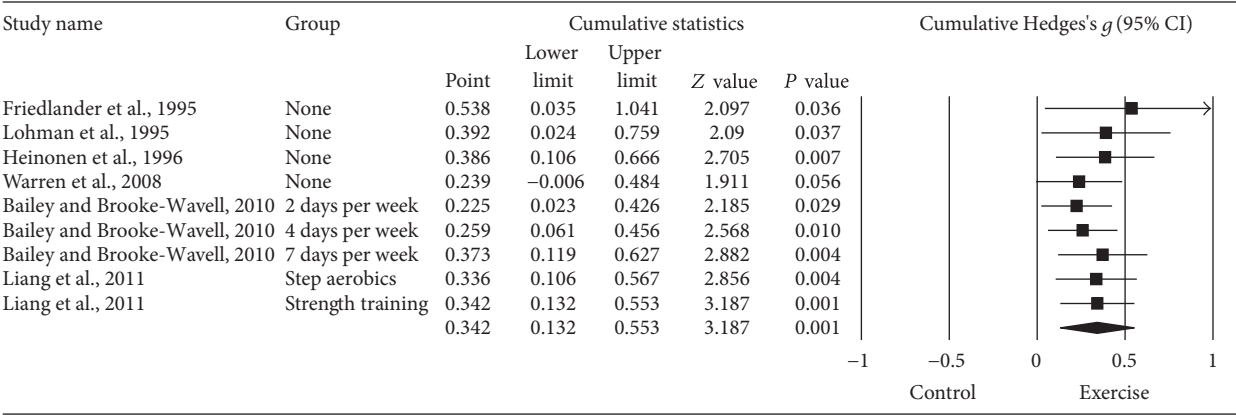


FIGURE 4: Cumulative meta-analysis for changes in FN BMD. Cumulative meta-analysis, ordered by year, for point estimate standardized effect size changes (*g*) in FN BMD. The black squares represent the standardized mean difference (*g*) while the left and right extremes of the squares represent the corresponding 95% confidence intervals. The results of each corresponding study are pooled with all studies preceding it. The middle of the black diamond represents the overall standardized mean difference (*g*) while the left and right extremes of the diamond represent the corresponding 95% confidence intervals. Negative results favor control groups while positive results favor exercise groups.

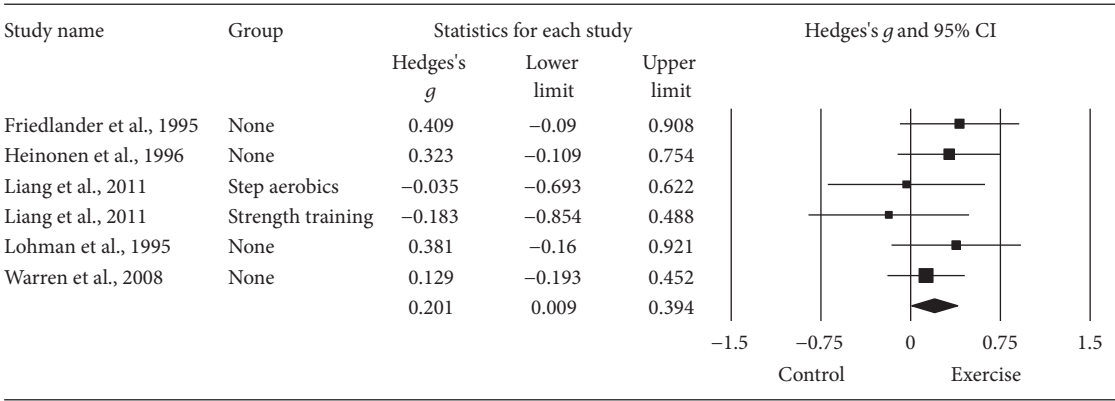


FIGURE 5: Forest plot for changes in LS BMD. Forest plot for point estimate standardized effect size changes (*g*) in LS BMD. The black squares represent the standardized mean difference (*g*) while the left and right extremes of the squares represent the corresponding 95% confidence intervals. The middle of the black diamond represents the overall standardized mean difference (*g*) while the left and right extremes of the diamond represent the corresponding 95% confidence intervals. Negative results favor control groups while positive results favor exercise groups.

FN and LS BMD in premenopausal women and to examine potential moderators and predictors of such changes. To the best of the investigative team's knowledge, this is the first meta-analysis on exercise and BMD in premenopausal women limited to randomized controlled trials. The overall findings suggest that exercise results in small, as defined by Cohen's categorization for the magnitude of effect for *g* [60], but statistically significant benefits in both FN and LS BMD. These findings are similar to the statistically significant results reported for LS BMD in two earlier meta-analyses but differ with respect to FN BMD [37, 44]. One possible reason for the lack of statistically significant findings for FN BMD in the two previous meta-analyses may have to do with the small number of results that were pooled. Specifically, one meta-analysis pooled results from three randomized controlled trials [44] while a second pooled results from five randomized

controlled trials [37]. A second possible reason may have to do with the differing inclusion criteria across meta-analyses. In contrast, the overall findings of the current investigation are in agreement with the overall findings of the James and Carroll meta-analysis [41].

To the best of the investigative team's knowledge, this is the first meta-analysis to report NNT for exercise and BMD studies in premenopausal women. The current findings suggest that less than 10 women would need to exercise in order to derive benefit in BMD at the FN and LS. However, whether the magnitude of effect is large enough to reduce the risk of site-specific fractures in those women who improve their FN and LS BMD is not known.

While the exercise-induced benefits observed for FN and LS BMD were considered small and statistically significant, the direct clinical importance of such changes is

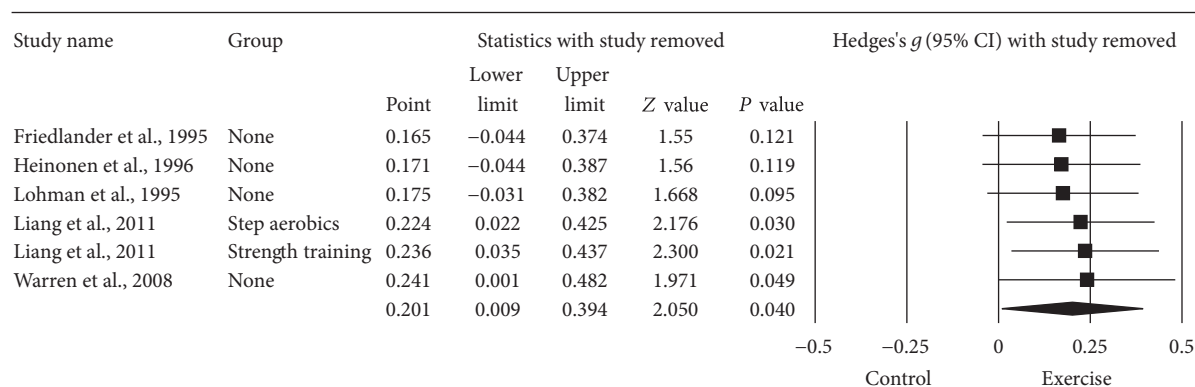


FIGURE 6: Influence analysis for changes in LS BMD. Influence analysis for point estimate standardized effect size changes (g) in LS BMD with each corresponding study deleted from the model once. The black squares represent the standardized mean difference (g) while the left and right extremes of the squares represent the corresponding 95% confidence intervals. The middle of the black diamond represents the overall standardized mean difference (g) while the left and right extremes of the diamond represent the corresponding 95% confidence intervals. Results are ordered from smallest to largest values of g . Negative results favor control groups while positive results favor exercise groups.

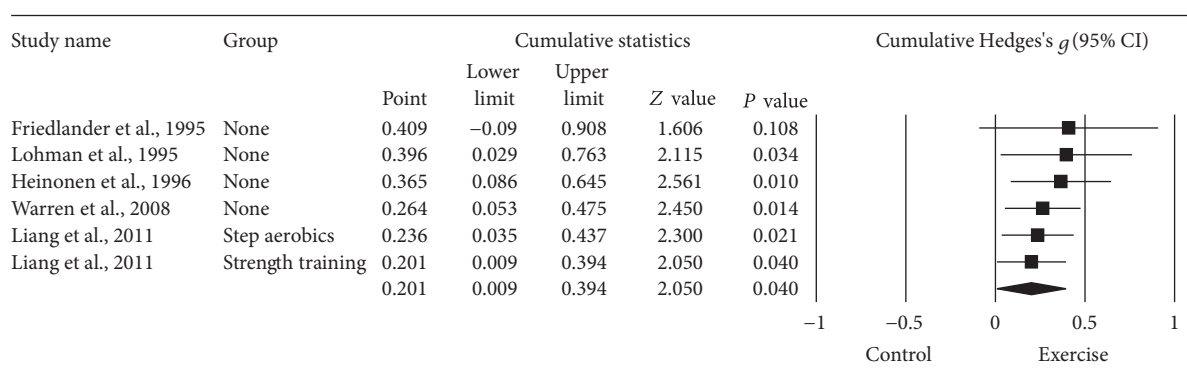


FIGURE 7: Cumulative meta-analysis for changes in LS BMD. Cumulative meta-analysis, ordered by year, for point estimate standardized effect size changes (g) in LS BMD. The black squares represent the standardized mean difference (g) while the left and right extremes of the squares represent the corresponding 95% confidence intervals. The results of each corresponding study are pooled with all studies preceding it. The middle of the black diamond represents the overall standardized mean difference (g) while the left and right extremes of the diamond represent the corresponding 95% confidence intervals. Negative results favor control groups while positive results favor exercise groups.

not known. Previous meta-analytic work in postmenopausal women reported that a 1% improvement in spine BMD was associated with a small but statistically significant 0.03 decrease in the relative risk of vertebral fracture as a result of antiresorptive therapy [71]. However, this study was limited to postmenopausal women using antiresorptive agents. Since the effects of exercise on BMD may be different from antiresorptive therapy, these findings may need to be interpreted with caution when applied to exercise. While additional research is needed, it would seem plausible that any exercise-induced benefit on FN and LS BMD in premenopausal women might be beneficial, especially when viewed from a population-wide perspective.

While the overall results suggest that exercise benefits FN and LS BMD in premenopausal women, these findings should be viewed with respect to several factors. First, the 95% PI for treatment effects if a new trial was conducted crossed zero (0) for both FN and LS BMD. It has been suggested

that nonoverlapping PI allows for more robust meta-analytic conclusions [64]. Second, small-study effects were observed for ES changes in FN BMD. This suggests that ES benefits may be inflated. Third, influence analysis for ES changes in LS BMD resulted in P values > 0.10 when two studies were deleted separately from the model. This suggests a possible lack of robustness across studies. Finally, while BMD has been shown to account for approximately 60% to 70% of the variation in bone strength, it does not account for other aspects of bone quality such as microarchitecture [72, 73]. Thus, the potential benefits of effects of exercise on bone strength, when limited to BMD, may be underestimated. However, a recent systematic review with meta-analysis was only able to locate one randomized controlled trial addressing the effects of exercise on bone outcomes other than BMD (bone strength index, stress-strain index, maximal moment of inertia, cross-sectional moment of inertia, and section moduli) in premenopausal women [74]. Overall,

no statistically significant effect of a 12-month progressive impact exercise program was found at the proximal tibia and femoral shaft [75]. However, greater compliance was associated with improvements ranging from 0.5% to 2.5% at the proximal tibia [75]. Clearly, additional well-designed randomized controlled trials are needed to address the effects of exercise on bone outcomes other than BMD.

Moderator analyses resulted in a trend for greater benefits on FN BMD when exercise took place in the home versus a facility. Since the investigative team is not aware of any consensus in the literature regarding which location is superior, future research in this area appears warranted. In addition to several other non-significant findings, no statistically significant differences were observed when data were partitioned according to type of exercise as well as type of reaction forces induced by exercise.

In subgroup analyses, a recent meta-analysis by James and Carroll reported changes in FN and LS BMD for high-impact only protocols as well as combined impact/resistance training protocols in premenopausal women [41]. A significant improvement in FN but not LS was found as a result of high-impact protocols while combined impact/resistance training resulted in significant improvements in LS but not FN BMD [41]. When limited to ground reaction force exercise, the results of the current meta-analysis are similar to the high-impact protocol results of James and Carroll [41] (FN, $g = 0.454$, 95% CI = 0.143, 0.764, $P = 0.004$; LS, $g = 0.215$, 95% CI = -0.146, 0.576, $P = 0.243$). However, because of the small sample size, investigators in the current meta-analysis were unable to perform subgroup analyses for combined ground and joint reaction force exercise. While these findings are interesting, it is probably not appropriate to make a decision about whether ground and joint reaction force exercise studies should be pooled based on running separate analyses for each. The primary reasons for this include the small sample sizes as well as the inability to control for other potentially confounding variables. Rather, these potential differences would need to be tested in well-designed randomized controlled trials.

Simple metaregression analyses resulted in several noteworthy associations that may be appropriate for future investigation. Specifically, there was a trend for greater increases in FN BMD with shorter exercise interventions as well as a statistically significant association between increases in FN BMD and fewer days per week of exercise. One possible explanation for the negative associations observed may have to do with the loss of calcium from excessive exercise [76, 77]. This causes a decrease in serum calcium, followed by an increase in serum parathyroid hormone, which then stimulates bone resorption [76, 77]. However, no association was observed between changes in FN BMD and duration of training as well as exercise load rating. Thus, while these findings are interesting, further dose-response research is needed before any firm conclusions can be drawn. For resistance training, greater increases in FN BMD were associated with a greater number of sets. Since sweating as a result of resistance training is usually not as great as that from aerobic exercise, it may be that a greater but undetermined amount of resistance training is needed to increase FN

BMD in premenopausal women. However, no association was found between the number of exercises performed and changes in FN BMD. Given the former, it would appear appropriate to suggest that future dose-response studies are needed to address this issue. Until that time, it would appear plausible to suggest adherence to current exercise guidelines for optimizing BMD in adults [78].

The trend for greater benefits in FN BMD and lower baseline BMD at the FN suggests that those with lower FN BMD may derive the greatest benefits as a result of exercise. This finding would seem to be entirely reasonable. The trend for increases in FN BMD to be associated with increases in body weight supports well-established research regarding greater BMD in heavier adult humans. Other than chance, the investigative team has no plausible explanation for the observed association between increases in FN BMD and smaller increases in upper body strength. Finally, there was a trend for greater benefits in LS BMD for those studies published during the earlier years. This observed association may be reflective of improved study designs in more recent years.

While the results for moderator and regression analyses are interesting, they should be viewed with respect to the following potential limitations. First, because of missing data for different variables from different studies, multiple metaregression analysis was not performed. Thus, controlling for potential confounding factors was not possible. Second, because of the large number of statistical tests conducted, one or more of the significant findings may have been nothing more than the play of chance. However, no adjustment was made for alpha values because such adjustments tend to be overly conservative [79]. In addition, the investigative team did not want to miss any potentially important findings that might be worthy of further investigation [79]. Third, since potential moderators and predictors are not randomly assigned in meta-analysis, such analyses are considered to be observational [80]. Therefore, causal inferences cannot be derived [80]. However, such differences and associations do provide direction for future research.

For secondary outcomes, statistically significant increases in both upper and lower body strength were observed. This suggests that exercise, particularly resistance training exercise, can improve both upper and lower body strength in premenopausal women. This observation demonstrates two of the many benefits that can be derived from a regular exercise program [81]. However, results for secondary outcomes in any meta-analysis need to be interpreted with caution since the inclusion of such are not mandatory for inclusion in a meta-analysis. Thus, secondary outcomes may represent a potentially biased sample of results.

Several suggestions in relation to the conduct and reporting of future randomized controlled trials on the effects of exercise in premenopausal women appear appropriate.

The first issue has to do with the risk of bias findings. For example, while all of the studies were considered to be at a low risk of bias with respect to randomized sequence generation, all but one study [15] was considered to be at an unclear risk for adequate allocation concealment. While randomized sequence generation is important, it might be

ineffective if it is not protected by adequate concealment of the allocation from those responsible for enrolling and assigning participants [82]. To support this contention, Pildal et al. [83] reported that binary effect estimates from randomized controlled trials with inadequate allocation concealment were approximately 18% more beneficial than estimates from trials with adequate concealment. However, a more specific analysis by Wood et al. [84] found that intervention effect estimates were inflated when inadequate allocation concealment was present in trials with a subjective outcome but not when the outcome was objective. Given that the primary outcomes in the current meta-analysis were objective measures, that is, changes in FN and LS BMD, inadequate sequence generation may not have posed much of a threat. Notwithstanding the former, it would still seem plausible to suggest that future studies perform appropriate allocation concealment procedures and report this information in their published work.

Because of the objective nature of BMD assessment, all studies were considered to be at a low risk of bias for blinding. While this may indeed be the case, it is also possible that such a classification may not have been appropriate. For example, Pildal et al. [83] reported that a lack of blinding in randomized controlled trials was associated with exaggerated odds ratios averaging 9%. However, this potential form of bias has been reported to be greater for trials with more subjective versus objective outcomes [84]. Thus, blinding as a potential form of bias may not have posed much of a threat in the current meta-analysis. This is important since it is extremely difficult to adequately blind participants enrolled in exercise intervention studies. Regardless, it would seem appropriate to recommend that investigators do the best that they can to blind all relevant parties to group assignment.

Incomplete (missing) outcome data due to drop outs during a study and/or exclusions from a study may result in biased effect estimates [82]. For the current meta-analysis, three studies were considered to be at a low risk for bias [15, 16, 19] while four were classified as unclear risk [14, 17, 18, 20]. However, since no statistically significant differences between the two were found for changes in FN and LS BMD, this potential form of bias did not seem to have an effect in the current meta-analysis.

Selective outcome reporting may be considered as a subset of findings that are reported based on their results [85]. The major concern is that results which are not statistically significant may be withheld. As a result, meta-analyses may overestimate treatment effects. To support this potential form of bias, at least three studies have shown that outcomes with statistically significant findings are more likely to be reported than outcomes with non-significant results [86–88]. For the current meta-analysis, all of the studies were classified as being at an unclear risk of bias for selective outcome reporting. This was based on the fact that none of the studies provided a clinical trials registry number so that the investigative team could retrieve and review the original study protocol. Given the inability to determine such, this potential form of bias cannot be ruled out for the current meta-analysis. It is strongly suggested that future studies report their clinical trials registry number so this potential

form of bias can be determined. However, recent research by Hartling et al. [89], has suggested that the search and identification for study protocols to assess selective outcome reporting bias may not be feasible or productive. Given the former, they suggest that in the absence of study protocols that the outcomes reported in the methods section of a paper should be compared with those reported in the results [89].

Future randomized controlled trials should also report more detailed information, by group, for race/ethnicity, dropouts, adverse events, cigarette smoking, alcohol consumption, pharmacological intake, parental history of osteoporosis and fractures, changes in physical activity habits outside the exercise intervention as well as baseline and final changes in cardiorespiratory fitness, static and dynamic balance, calcium and vitamin D levels, fat mass, and lean body mass. In addition, it is suggested that future studies analyze and report data using both per-protocol and intention-to-treat analyses. This would allow one to determine both the efficacy (per-protocol analysis) and effectiveness (intention-to-treat analysis) of exercise on FN and LS BMD in premenopausal women.

5. Conclusions

The primary and accomplished aim of this study was to use the meta-analytic approach to determine the overall effects of ground and joint reaction exercise on FN and LS BMD in premenopausal women when limited to randomized controlled trials. The overall findings of the current meta-analysis provide additional support regarding the benefits of exercise, including NNT estimates to aid decision makers regarding the utility of exercise for improving FN and LS BMD in premenopausal women. In addition, this study provides first-time meta-analytic evidence, when limited to randomized controlled trials, of potential moderators and predictors with respect to changes in FN and LS BMD, which appears worthy of pursuing in future well-designed randomized controlled trials. The inability of the current meta-analysis to provide a definitive exercise prescription warrants further research. In addition, the results should be interpreted with some trepidation given that the quality of evidence could be improved.

Acknowledgment

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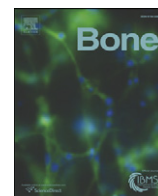
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Original Full Length Article

Exercise and bone mineral density in men: A meta-analysis of randomized controlled trials

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ABSTRACT

Objective: Use the meta-analytic approach to examine the effects of ground and/or joint reaction force exercise on femoral neck (FN) and lumbar spine (LS) bone mineral density (BMD) in men.

Methods: Randomized controlled exercise trials ≥ 24 weeks were included. Standardized effect sizes (g) were calculated and pooled using random-effects models, z -score alpha values and 95% confidence intervals (CI). Heterogeneity was examined using Q and I^2 . Statistical significance was set at a two-tailed alpha value (p) of ≤ 0.05 and a trend at >0.05 to ≤ 0.10 .

Results: A moderate and statistically significant improvement was found at the FN (3 g's, 187 participants, $g = 0.583$, 95% CI = 0.031, 1.135, $p = 0.04$, $Q = 5.6$, $p = 0.06$, $I^2 = 64\%$) while a small trend was observed at the LS (5 g's, 275 participants, $g = 0.190$, 95% CI = -0.036 , 0.416, $p = 0.10$, $Q = 3.0$, $p = 0.55$, $I^2 = 0\%$). Results were sensitive to influence analysis as well as collapsing multiple groups from the same studies so that only one g represented each study.

Conclusions: There is currently insufficient evidence to recommend ground and/or joint reaction force exercise for improving and/or maintaining FN and LS BMD in men. Additional well-designed randomized controlled trials are needed before any final recommendations can be formulated.

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Introduction

Low bone mass (osteopenia) and osteoporosis increase the risk for fracture. For example, it has been estimated that the worldwide incidence of osteoporosis-related fractures is 8.9 million per year, about one every 3 s [1]. The two most common sites for osteoporosis-related fracture are the hip and spine [1].

While the prevalence of osteopenia and osteoporosis is more common in women than men [2], the burden of this problem among men is still substantial. For example, recent data from the US National Center for Health Statistics reported that the age-adjusted prevalence of osteopenia among US men 50 years of age and older was 38% while the age-adjusted prevalence for osteoporosis was 4% [2]. Using the 2010 population estimates from the US Census Bureau [3], this means that approximately 16.8 million US men 50 years of age and older currently have osteopenia while more than 1.7 million have osteoporosis. In addition, fracture-related mortality rates are higher in men than women

[4]. For example, men with hip fractures have mortality rates that are two to three times higher than women [5–7]. The issue of fracture-related mortality in men is especially important given that the lifetime risk for any osteoporotic fracture has been estimated to be between 13% and 22% in men 50 years of age and older [8] and 42% in osteoporotic men 60 years of age and older [9]. To compound this problem, it is estimated that by the year 2025, the worldwide incidence of hip fractures occurring in men will increase from 0.5 million in 1990 [10] to 1.16 million in 2025 [11].

Maintaining optimal bone mineral density (BMD) levels in men during the adult years is important for reducing the risk of fracture. While men traditionally reach peak spine BMD by the age of 18 years and peak hip BMD several years later [12], bone loss during the adult years occurs as a result of bone resorption exceeding formation, with reported estimates between 0.5% and 1.0% per year starting as early as 30 years of age [13–16]. One potential, low-cost, readily available non-pharmacologic approach for maintaining optimal BMD levels in men is exercise. Unfortunately, while some consider systematic reviews with meta-analysis as the highest level of evidence for reaching decisions regarding the effectiveness of an intervention on an outcome [17], especially when limited to randomized controlled trials [18], the investigative team is aware of only one meta-analysis, conducted more than a decade ago, focused on the effects of exercise on BMD in men [19]. Included in the meta-analysis were 6 controlled trials and

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only 2 randomized controlled trials in which BMD was assessed at any region [19]. While the results were not statistically significant, the overall benefits of exercise were approximately 2%; a 1.6% increase among exercisers and a 0.4% decrease in controls [19]. When partitioned according to age, a statistically significant benefit of 6.7% (4.2% increase in exercisers, 2.5% decrease in controls) was found in men > 31 years of age with no difference in men ≤ 31 years of age [19]. In addition, a statistically significant benefit of 10.7% (5.8% increase in exercisers, 4.9% decrease in controls) was observed at the lumbar spine (LS) as well as a 5% benefit at the femur (4.0% increase in exercise groups, 1.9% decrease in controls) [19]. While statistically significant benefits were observed, both randomized and nonrandomized controlled trials were included with only two of the eight studies (25%) reported as randomized controlled trials [19]. In addition, results for the femur were pooled across all femur sites assessed, not just the femoral neck (FN) [19]. The inclusion of nonrandomized controlled trials is potentially problematic because randomized controlled trials are the only way to control for confounders that are not known or measured and nonrandomized controlled trials tend to overestimate the effects of healthcare interventions [20,21]. In addition, since the FN is the most common hip fracture site [22], a focus on this location versus all hip sites combined is important. Furthermore, since this study was conducted more than a decade ago and the median time before a meta-analysis should be updated has been estimated at 5.5 years [23], this work is in need of updating. Given the former, the purpose of this study was to use the aggregate data meta-analytic approach to examine the effects of exercise on FN and LS BMD in men.

Methods

Study eligibility criteria

The a priori inclusion criteria for studies were as follows: (1) randomized trials with a comparative control group (non-intervention, usual care, attention control), (2) men 18 years of age and older, (3) participants not taking part in regular exercise prior to study enrollment, (4) ground and/or joint reaction force exercise intervention of at least 24 weeks, (5) published and unpublished (master's theses and dissertations) studies since January 1989, and (6) data available for changes in FN and/or LS BMD as assessed by dual-energy X-ray absorptiometry (DEXA) or dual-photon absorptiometry (DPA). Studies not meeting all of the above criteria were excluded. Based on exercise-induced changes in BMD, studies were limited to those in which the exercise intervention lasted at least 24 weeks [24]. Since the investigative team was interested in the independent effects of exercise on FN and LS BMD, studies with multiple interventions, for example exercise and milk, were included as long as there was an adequate comparison group, for example, milk only [25]. Resistance training studies were limited to those that included lower body exercise. The year 1989 was chosen as the start date for inclusion since it appeared to be the first time that a randomized controlled trial on exercise and BMD in adult humans was conducted [26].

Data sources

Studies were identified from a large, previously developed reference database that included 1055 exclusive citations (Fig. 1). Records for the original reference database were retrieved from six electronic sources (PubMed, Embase, SportDiscus, Cochrane Central Register of Controlled Clinical Trials, CINAHL, Dissertation Abstracts International). In addition, cross-referencing from retrieved studies, including previous reviews was conducted. Furthermore, hand searching of selected journals took place. A list of journals that were hand searched is available upon request from the corresponding author. Keywords relevant to all searches included various forms of the following: "exercise", "bone" and "randomized". All searches were conducted by the second

author with assistance from a Health Sciences librarian at West Virginia University. The last search was conducted in August of 2011. Based on the recent Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines [27], an example of the search strategy used for one of the electronic databases is shown in Supplementary File 1.

Study selection

Potentially eligible studies were selected autonomously by the first two authors. They then met and reviewed all selections for accuracy. Differences were resolved by consensus. If consensus could not be reached, the third author served as a conciliator. In addition, the final list of selected studies was reviewed for thoroughness and comprehensiveness by the third author, an expert on exercise and BMD. A list of included and excluded studies, including the reasons for exclusion, was stored in Reference Manager, version 12.0.1 [28].

Data abstraction

Prior to data abstraction electronic codebooks were developed using Microsoft Excel 2007 [29]. All codebooks were created by the first author with contributions from the second and third authors. Every codebook was then reviewed and tested by all authors. Codebooks were then modified by the first author and reviewed and tested by all authors until final codebooks for data abstraction were available after three iterations. The main categories of variables coded were (1) study characteristics (journal, risk of bias assessment, etc.), (2) group characteristics (age, bodyweight, etc.) and (3) outcome characteristics (changes in FN and LS BMD, secondary outcomes, etc.). All codebooks could retain up to 324 items from each study.

The a priori primary outcomes for this study were changes in FN and LS BMD. Secondary a priori outcomes included changes in other BMD sites (whole body, Ward's triangle, intertrochanter, trochanter, total hip, radius, ulna, calcaneus, os calcis), body weight, body mass index (BMI), lean body mass (LBM), percent body fat, fat mass, muscular strength (upper and/or lower), muscular power, cardiorespiratory fitness, balance (static and dynamic), calcium intake, vitamin D intake and fractures. The exercise load rating for each exercise group from each study was calculated using the product of vertical ground reaction force and rate of force application as described by Weeks and Beck [30].

All data were abstracted by the first two authors, independent of each other. They then met and reviewed every selection for correctness. Differences were resolved by discussion. If agreement could not be reached, the third author served as a conciliator. Missing data from one study that met all inclusion criteria was requested and successfully obtained [25].

Risk of bias assessment

Risk of bias was assessed using the Cochrane risk of bias assessment tool [31]. Briefly, risk of bias is assessed as either low risk, high risk, or unclear risk in five primary areas: (1) sequence generation, (2) allocation concealment, (3) blinding of participants, personnel and outcome assessors, (4) incomplete outcome data, and (5) selective outcome reporting. Given the objective nature of BMD assessment, all studies were considered to be at a low risk of bias with respect to blinding. Risk of bias for selective outcome reporting was coded as "low risk" only if the study reported a study protocol identification number [32]. All risk of bias assessments were conducted by the first two authors, independent of each other. They then met and reviewed every item for agreement. Disagreements were resolved by consensus.

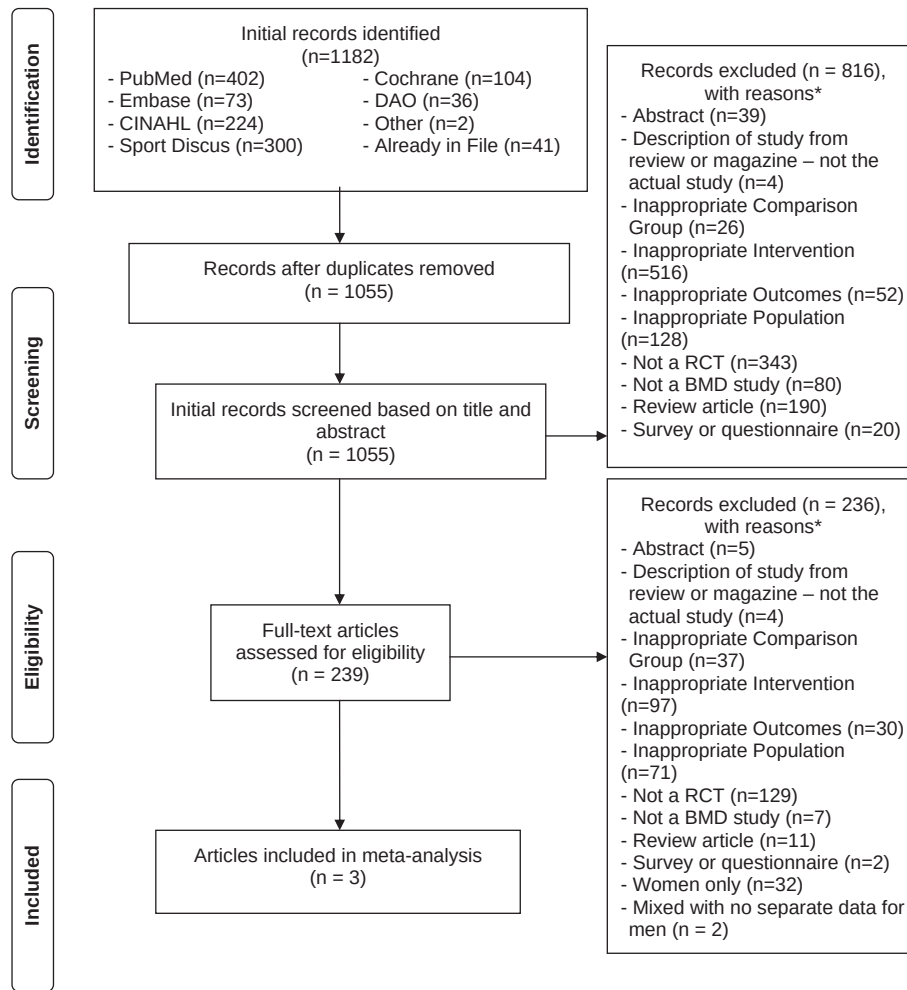


Fig. 1. Flow diagram for the selection of studies. *, number of reasons exceeds the number of studies because some studies were excluded for more than one reason.

Statistical analysis

Calculation of effect sizes from each study

The a priori primary outcomes for this meta-analysis were changes in FN and LS BMD. These were calculated using the standardized effect size (ES) g [33]. The g was chosen over the original metric because of the different methods used to report data, specifically, absolute versus relative changes in BMD as well as the variability in assessing BMD across different studies. The g for each group from each study was calculated as the change score difference (absolute or relative) in the exercise group minus the change score difference in the control group, divided by the pooled standard deviation of the exercise and control groups. The variance for each g was calculated from final sample sizes using traditional procedures [33]. All g 's were corrected for small sample bias [33].

The a priori secondary outcomes included changes in BMD at any site other than the FN and LS as well as changes in body weight in kilograms, BMI in kg/m^2 , LBM, percent body fat, muscular strength (lower and upper), muscular power, cardiorespiratory fitness, balance (static and dynamic), calcium, vitamin D intake and fracture risk. However, because of a lack of data (<2 studies and/or <3 total g 's per outcome), meta-analysis of secondary outcomes was limited to changes in total hip BMD, body weight and BMI. For total hip BMD, g was calculated using the same procedures as for our primary outcomes, FN and LS BMD. For body weight and BMI the original metric ES for each group from each study was calculated by subtracting the change score difference in the exercise group from the change

score difference in the control group. Variances were calculated from the pooled standard deviations of change scores in the intervention and control groups.

Effect size pooling

All ESs were pooled using a random-effect, method of moments model [34]. This approach weights studies by the inverse of the variance and incorporates heterogeneity into the model [34]. For both primary and secondary outcomes, pooling was limited to those outcomes with a minimum of 3 ESs from at least 2 studies. Multiple groups from the same study were analyzed both independently and with multiple groups collapsed so that only one ES represented each outcome from each study. For g , the magnitude may be considered as trivial (<0.20), small (≥ 0.20 to <0.50), medium (≥ 0.50 to <0.80), or large (≥ 0.80) [35]. A two-tailed z -score alpha value of ≤ 0.05 was considered statistically significant while alpha values >0.05 but ≤ 0.10 were considered as a trend. Precision was determined using two-tailed 95% confidence intervals (CIs). For outcomes with statistically significant results or a trend for statistically significant results, estimation of treatment effects in a new trial was calculated using 95% prediction intervals (PI) [36–38]. Analysis of secondary outcomes was considered exploratory because they were not part of the inclusion criteria, and thus, may represent a biased sample. After initial pooling, any outcomes with statistically significant residuals, i.e., outliers ($p \leq 0.05$) were deleted from all further analysis.

Heterogeneity of pooled results based on fixed-effect models were examined using the Q statistic and I^2 , an extension of Q that more accurately reflects heterogeneity [39]. The alpha value for statistical significance for Q was set at $p \leq 0.10$. For I^2 , values of 25% to <50% may be considered small, 50% to <75% medium, and $\geq 75\%$ large [39]. Potential bias due to small-study effects was examined using the approach of Duval and Tweedie [40,41]. For FN and LS BMD, influence analysis was conducted in order to examine the effects of each ES on the overall results.

Moderator and meta-regression analyses

Given the small number of ES's for each outcome, no moderator or meta-regression analyses were performed.

Software used for statistical analysis

All data were analyzed using Comprehensive Meta-Analysis (version 2.2) [42], Microsoft Excel 2007 [29] and SSC-Stat (version 2.18) [43].

Results

Study characteristics

Of the 1055 citations reviewed, three studies representing nine groups (five exercise and four control) and up to 275 participants (152 exercise, 123 control) met all eligibility criteria [25,44,45]. The number of groups exceeded the number of studies because two studies included more than one intervention group [25,44]. A flow diagram that describes the selection of studies is shown in Fig. 1 while a general description of the included studies is shown in Table 1. A list of excluded studies, including the primary reason(s) for exclusion, is available upon request from the corresponding author.

Two of the included studies were dissertations [44,45] while the other was published in a peer-reviewed journal [25]. All three were published in the English-language starting with the year 2004 and ending in 2011 [25,44,45]. One study was conducted in the United States [45], one in Australia [25] and one in China [44]. Prior to randomization, one study matched participants by age and calcium intake [25] while another matched according to gender [44]. However, since the focus of this meta-analysis was on men, data for women were not included. The maximum number of men in which final BMD assessment was available in each group from each study ranged from 6 to 44 in the exercise groups (mean $\pm$ SD, 30 ± 15 , Mdn, 30) and 9 to 43 in the controls (mean $\pm$ SD, 31 ± 16 , Mdn, 36). None of the studies used a crossover design. All three studies provided sample size estimates [25,44,45].

Participant characteristics

A description of the baseline characteristics of participants is shown in Tables 1 and 2.

Within-study ages ranged from 41 to 79 years in the exercise groups and 50 to 79 years in controls. Dropouts ranged from 0% to 12.5% in the exercise intervention groups (mean $\pm$ SD, $4.9\% \pm 4.6\%$, Mdn, 4.3%) and 3.3% to 10.0% in the controls (mean $\pm$ SD, $5.6\% \pm 3.0\%$, Mdn, 4.5%). The primary reason for dropping out was time constraints. Other reasons included moving as well as dissatisfaction with participation in the study. No serious adverse events were reported. For those studies in which race/ethnicity information was available, one was limited to Asian participants [44] while another was limited to Whites [25]. Two of the studies reported that none of the participants were taking any type of drugs that could affect bone metabolism [25,45]. None of the studies appeared to include participants who had osteoporosis [25,44,45]. However, one study did include some participants with osteopenia [25]. For cigarette smoking, one study reported that some participants smoked cigarettes [44] while another reported that none did [25]. With respect to alcohol consumption, one study reported that none of the participants in the control and one exercise group consumed alcohol while some reportedly consumed alcohol in another exercise group [44]. No change in exercise habits beyond the actual exercise intervention was reported by one study [25]. For calcium and vitamin D intake, two groups from two studies received supplemental calcium and vitamin D [25,45] while one group from one study did not receive any type of calcium and vitamin D supplementation [25]. One study reported that none of the participants had a history of fractures prior to study entry [25].

Exercise intervention characteristics

A general description of the exercise interventions is provided in Table 1. As can be seen, the exercise modalities varied both within and between studies. Length of exercise training took place 3 times per week for 32 to 72 weeks (mean $\pm$ SD, 56 ± 17 weeks, Mdn, 52 weeks). Compliance ranged from 63% to 96% (mean $\pm$ SD, $72.4\% \pm 14.5\%$, Mdn, 63%). Three groups participated in supervised exercise while one group each participated in combined supervised and unsupervised exercise or unsupervised exercise only. For location, three groups participated in facility-based exercise while one group each participated in either home and facility-based exercise or home-based exercise only. Load ratings for the exercise interventions ranged from 10 to 1375 (mean $\pm$ SD, 556.0 ± 747.6 , Mdn, 10).

Table 1
General characteristics of included studies.

Study	Country	Participants	Exercise intervention	BMD assessment
Hong [44]	China	82 healthy men 65 to 74 yrs of age assigned to a Tai Chi (n = 26), resistance training (n = 27, or control (n = 29) group	3 days/wk: Tai Chi: Yang style, 24 forms, 45 min; Resistance Training: 1 set, 30 reps, 7 exercises, Therabands used for resistance; for 12 months	DEXA (Hologic QDR 4500 Elite) at the FN & LS
Kukuljan et al. [25]	Australia	176 healthy men 50 to 79 yrs of age assigned to an exercise (n = 46), exercise + milk (n = 43), control (n = 44) or milk (n = 43) group	3 days/wk, 60–75 min/session, Resistance Training: 2–3 sets, 8–20 reps, 50–85% 1RM, 6–8 exercises plus 3 moderate-impact weight-bearing exercises (jumping & stepping) in between resistance exercises 3 sets of 10–20 reps, for 18 months	DEXA (GE Lunar Prodigy) at the FN & LS
Zeilman [45]	United States	16 sedentary men with irritable bowel syndrome 41 to 75 yrs of age assigned to either an exercise (n = 7) or control (n = 9) group	3 days/wk, 50 min/session, stretching, flexibility calisthenics & walking with weighted vests and a pedometer, for 32 wks	DEXA (Lunar Prodigy) at the FN & LS

Notes: BMD, bone mineral density; DEXA, dual-energy X-ray absorptiometry; FN, femoral neck; LS, lumbar spine; yrs, years; min, minute(s); wks, weeks; wk, week; RM, repetition maximum; reps, repetitions; description of groups limited to those that met the inclusion criteria for the current meta-analysis; description of BMD assessment limited to the primary outcomes of the current meta-analysis (FN and LS). Number of subjects limited to those in which final BMD assessments were available.

Table 2
Initial physical characteristics of participants.

Variable	Exercise					Control				
	Groups (#)	Participants (#)	Mean $\pm$ SD	Mdn	Range	Groups (#)	Participants (#)	Mean $\pm$ SD	Mdn	Range
Age (yrs)	5	152	62.0 $\pm$ 7.4	62	51–69	4	123	62.3 $\pm$ 4.0	61	59–68
Body weight (kg)	–	–	–	–	–	–	–	–	–	–
BMI (kg/m ²)	3	65	26.4 $\pm$ 4.4	24	23.6–31.4	–	–	–	–	–
BMD (g/cm ²)										
Femoral neck	3	93	0.907 $\pm$ 0.040	0.922	0.862–0.938	3	94	0.926 $\pm$ 0.007	0.927	0.919–1.933
Lumbar spine	5	152	1.105 $\pm$ 0.135	1.106	0.950–1.247	4	123	1.158 $\pm$ 0.133	1.218	0.960–1.238
Total hip	5	146	0.914 $\pm$ 0.109	0.890	0.774–1.026	4	123	0.982 $\pm$ 0.092	1.007	0.850–1.062

Notes: Groups (#), number of groups in which data were available; participants (#), number of participants nested within groups; SD, standard deviation; Mdn, median; BMD, bone mineral density, BMI, body mass index; –, insufficient data (<3).

BMD assessment characteristics

All three studies used dual-energy X-ray absorptiometry (DEXA) for assessing LS and FN BMD [25,44,45]. Two studies used the Lunar Prodigy instrument [25,45] while the other used the Hologic QDR 4500 [44]. With respect to the site of LS BMD assessment, two studies assessed BMD at the L2–L4 sites [44,45] and the other at the L1–L4 sites [25]. Insufficient data were reported on the site-specific reliability of the instruments for assessing FN and LS BMD.

Risk of bias assessment

All three studies were considered to be at a low risk of bias with respect to randomized sequence generation, blinding and incomplete outcome data (attrition bias) [25,44,45]. In contrast, all three studies were considered to be at an unclear risk for bias in relation to allocation concealment and incomplete outcome reporting [25,44,45].

Changes in primary outcomes

Changes in FN BMD

Changes in FN BMD are shown in Table 3 and Fig. 2. Overall, a moderate and statistically significant benefit of exercise on FN BMD was observed as well as a trend for a statistically significant and moderate amount of heterogeneity. No outliers were detected and no adjustment for small-study effects was necessary. The 95% PI was –0.542 to 6.590. With each group deleted from the model once, the study by Zeilman [45] had the most significant influence, resulting in a large and statistically significant benefit when excluded and non-significant results when pooled with each of the other groups (Fig. 3). When results were collapsed so that only one *g* represented each study, results were small, non-significant, and with a large and statistically significant amount of heterogeneity ($g = 0.284$, 95% CI = –0.946, 1.514, $p = 0.65$, $Q = 5.2$, $p = 0.02$, $I^2 = 80.8\%$).

Changes in LS BMD

Changes in LS BMD are shown in Table 3 and Fig. 4. As can be seen, a trend for a small and statistically significant benefit of exercise on LS BMD was observed. This was equivalent to a relative benefit of approximately 1%. No heterogeneity was found. In addition, no outliers were detected and no adjustment for small-study effects was necessary. The 95% PI was –0.176 to 0.556. With each group deleted from the model once, the exercise and milk group in the study by Kukuljan et al. [25,45] had the most significant influence, resulting in a statistically significant benefit of exercise on LS BMD when excluded from the model (Fig. 5). When results were collapsed so that only one *g* represented each study, results remained small with a trend for statistical significance and no heterogeneity ($g = 0.190$, 95% CI = –0.036, 0.416, $p = 0.10$, $Q = 0.04$, $p = 0.98$, $I^2 = 0\%$).

Changes in secondary outcomes

Changes in secondary outcomes are shown in Table 3. As can be seen, no statistically significant benefit of exercise was observed at the total hip. In addition, no significant heterogeneity was observed and no outliers were detected. With each group deleted from the model once, results remained non-significant. When findings were collapsed so that only one *g* represented each study, results remained non-significant with a small amount of non-significant heterogeneity ($g = -0.024$, 95% CI = –0.341, 0.294, $p = 0.88$, $Q = 3.13$, $p = 0.21$, $I^2 = 36.2\%$). For body weight, a small non-significant reduction was observed as well as no statistically significant heterogeneity. In addition, no outliers were found. When each group was deleted from the model once, results remained non-significant with no statistically significant heterogeneity. When findings were collapsed so that only one ES represented each study, results remained non-significant with a small amount of non-significant heterogeneity (–0.06 kg, 95% CI = –0.24, 0.11 kg, $p = 0.48$, $Q = 0.58$, $p = 0.45$, $I^2 = 0\%$). For BMI, there was a trend for a small, statistically significant reduction along with

Table 3
Changes in primary and secondary outcomes.

Variable ^a	ES (#)	Participants (#)	Mean (95% CI)	Z (p)	Q (p)	I ² (%)
<i>Primary</i>						
Femoral neck	3	187	0.583 (0.031, 1.135)	2.07 (0.04)*	5.6 (0.06)**	64.0
Lumbar spine	5	275	0.190 (–0.036, 0.416)	1.65 (0.10)**	3.0 (0.55)	0
<i>Secondary</i>						
Total hip	5	269	–0.035 (–0.270, 0.199)	–0.30 (0.77)	4.3 (0.37)	6.0
Body weight (kg)	3	103	–0.06 (–0.24, 0.11)	–0.71 (0.48)	0.9 (0.64)	0
BMI (kg/m ²)	3	103	–0.19 (–0.41, 0.02)	–1.75 (0.08)**	0.7 (0.71)	0

^a Unless noted otherwise, all outcomes are reported as standardized effect size (*g*); ES, effect size; #, number; participants (#), number of exercise and control participants nested within ES's and studies; Z(*p*), z-score and alpha value; Q(*p*), Cochran's Q statistic and alpha value; I² (%), I-squared.

* Statistically significant ($p \leq 0.05$).

** Trend for statistical significance ($p > 0.05$ to ≤ 0.10).

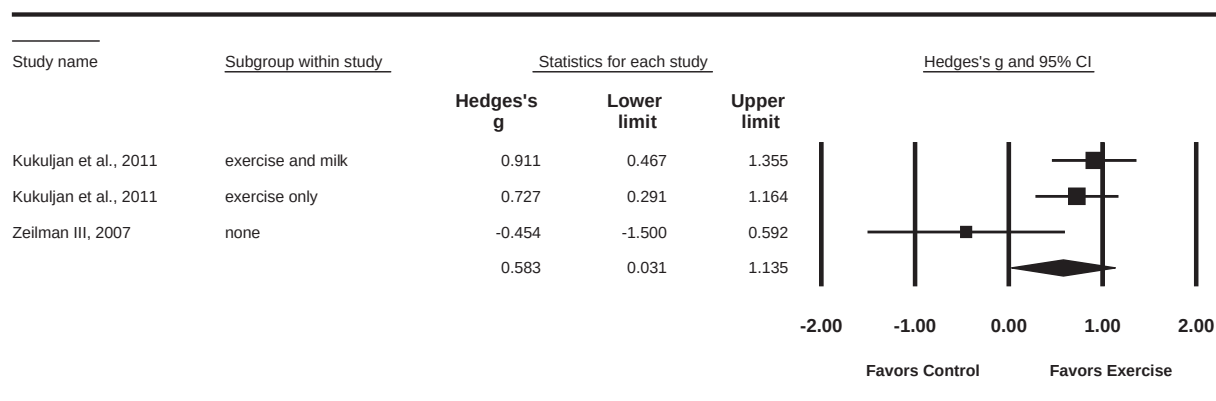


Fig. 2. Forest plot for changes in FN BMD. Forest plot for point estimate standardized effect size changes (g) in FN BMD. The black squares represent the standardized mean difference (g) while the left and right extremes of the squares represent the corresponding 95% confidence intervals. The middle of the black diamond represents the overall standardized mean difference (g) while the left and right extremes of the diamond represent the corresponding 95% confidence intervals.

no statistically significant heterogeneity. This was equivalent to a relative reduction of approximately 2%. No outliers were observed. The 95% PI was -1.60 to 1.22 kg/m². With each group deleted from the model once, this trend no longer existed across any of the deletions. When findings were collapsed so that only one ES represented each study, there was a trend for a small, statistically significant reduction along with no statistically significant heterogeneity (-0.19 kg/m², 95% CI = -0.41 , 0.02 kg/m², $p = 0.08$, $Q = 0.63$, $p = 0.43$, $I^2 = 0\%$).

Discussion

To the best of the authors' knowledge, this is the first meta-analysis that specifically addresses the randomized controlled trial literature with respect to the effects of ground and/or joint reaction force exercise on FN and LS BMD in men. Overall, a moderate and statistically significant benefit was observed at the FN while a trend for a small and statistically significant benefit was observed at the LS. However, the findings for both FN and LS BMD were sensitive to influence analysis and/or collapsing multiple groups from the same study so that only one g represented each study. For FN BMD, the study by Zeilman [45] appeared to be highly influential. Specifically, when deleted from the model, the overall benefits in FN BMD were considered to be large and statistically significant. However, when included with either of the other two studies deleted [25,44], the overall findings were no longer statistically significant. Furthermore, and not surprisingly, FN results also became non-significant when

only one g represented each study. This was most likely the result of a greater influence of the Zeilman study on the overall results [45]. Finally, the PI for estimating the expected results of a new trial crossed zero for FN BMD. While PI should not be confused with CI since the former are based on a random mean effect while CI are not [36], PI may be beneficial for future researchers interested in conducting randomized controlled intervention trials addressing the effects of ground and/or joint reaction force exercise on FN BMD in men.

While the overall results for LS BMD were not statistically significant, there was a trend for a small, statistically significant benefit ($p = 0.10$) with no apparent heterogeneity when analyzed at both the group and study level. However, results were statistically significant when the exercise and milk group in the study by Kukuljan et al. [25] was deleted from the model. The influence of this group on the overall results may have been the result of the g for this study being calculated based on the difference between an exercise and milk versus milk only group as opposed to an exercise only versus non-intervention control group. In contrast, changes in LS BMD were no longer statistically significant when the other groups were deleted from the analysis. Finally, the PI for estimating the expected results of a new trial included zero.

Given the small number of g's included and the instability of results, it is believed that there is currently insufficient evidence to recommend exercise as a singular intervention for improving and/or maintaining FN and LS BMD in men. However, similar to recent clinical practice

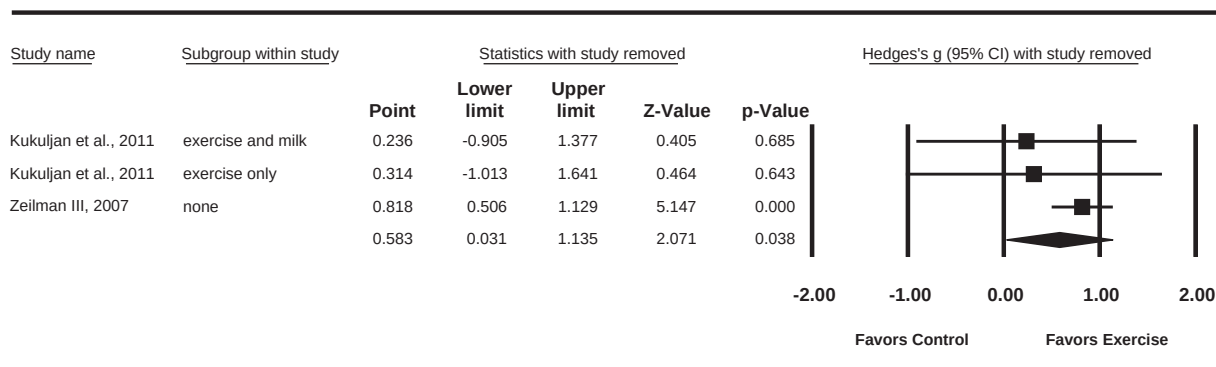


Fig. 3. Influence analysis for changes in FN BMD. Influence analysis for point estimate standardized effect size changes (g) in FN BMD with each corresponding study deleted from the model once. The black squares represent the standardized mean difference (g) while the left and right extremes of the squares represent the corresponding 95% confidence intervals. The middle of the black diamond represents the overall standardized mean difference (g) while the left and right extremes of the diamond represent the corresponding 95% confidence intervals. Results are ordered from smallest to largest values of g.

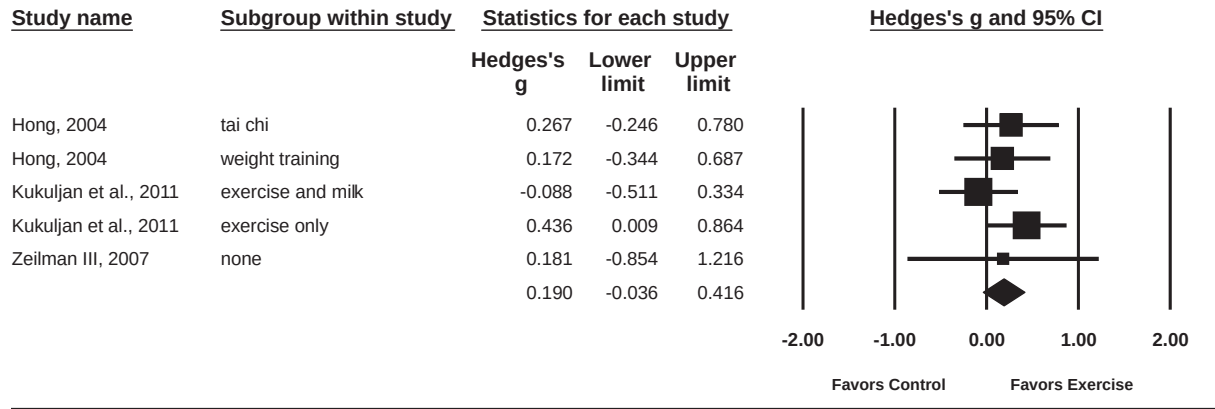


Fig. 4. Forest plot for changes in LS BMD. Forest plot for point estimate standardized effect size changes (g) in LS BMD. The black squares represent the standardized mean difference (g) while the left and right extremes of the squares represent the corresponding 95% confidence intervals. The middle of the black diamond represents the overall standardized mean difference (g) while the left and right extremes of the diamond represent the corresponding 95% confidence intervals.

guidelines by the Endocrine Society on osteoporosis in men [46] it is suggested that men, especially those at risk for osteoporosis, participate in regular exercise. While the Endocrine Society guidelines suggest that men participate in weight bearing, i.e., ground reaction force exercise, three to four times per week for 30 to 40 min per session, the American College of Sports Medicine Position Statement suggests that adults participate in ground reaction force exercise, i.e., weight bearing endurance exercise, 3 to 5 times per week for 30 to 60 min per session as well as joint reaction force exercise, i.e., weight training, 2 to 3 times per week [47]. Despite the current lack of convincing evidence to support the use of exercise for improving and/or maintaining FN and LS BMD in men, it would seem plausible that adherence to the latter would be more appropriate, especially given the other benefits and minimal risk derived from participation in both [47,48].

For secondary outcomes, the overall results indicated no statistically significant changes for total hip BMD or body weight. However, there was a trend for a statistically significant reduction in BMI. While these results are interesting, secondary outcomes in any meta-analysis should be viewed with caution since they may represent a biased sample given that they are only included if data for the primary outcomes of interest are available.

While the results of the current meta-analysis are important, they should be viewed with regard to the following. First, the number of results for both FN and LS BMD was small. While some might consider

the number of results too small for meta-analysis, it's important to realize that one of the very reasons for conducting a meta-analysis is when the number of results for a particular outcome is small. To support this contention, the Cochrane Collaboration currently recommends a minimum of two studies for inclusion in a meta-analysis [49]. The inclusion of a small number of studies in meta-analyses is common. For example, Davey et al., recently reported that the median number of studies included in a meta-analysis was three with an interquartile range of 2 to 6 [50]. Thus, the currently reported meta-analysis is consistent with contemporary practice. In addition, a minimum of 2 studies seems reasonable given that multiple participants are nested within each study. The former notwithstanding, the small number of studies in the current meta-analysis may limit one from generalizing beyond the populations included in each of the studies. Clearly, additional randomized controlled trials addressing the effects of exercise on FN and LS BMD in men are needed. This recommendation is consistent with the 2008 US Department of Health and Human Services Physical Activity Guidelines for Americans [51].

Second, two of the three studies included in the current meta-analysis were dissertations [44,45]. Some might consider the inclusion of such as inappropriate because of the perception that they are of lower quality when compared with research published in peer-reviewed journals. However, in a recent study by Moyer et al., it was concluded that unpublished dissertations should be included in comprehensive literature

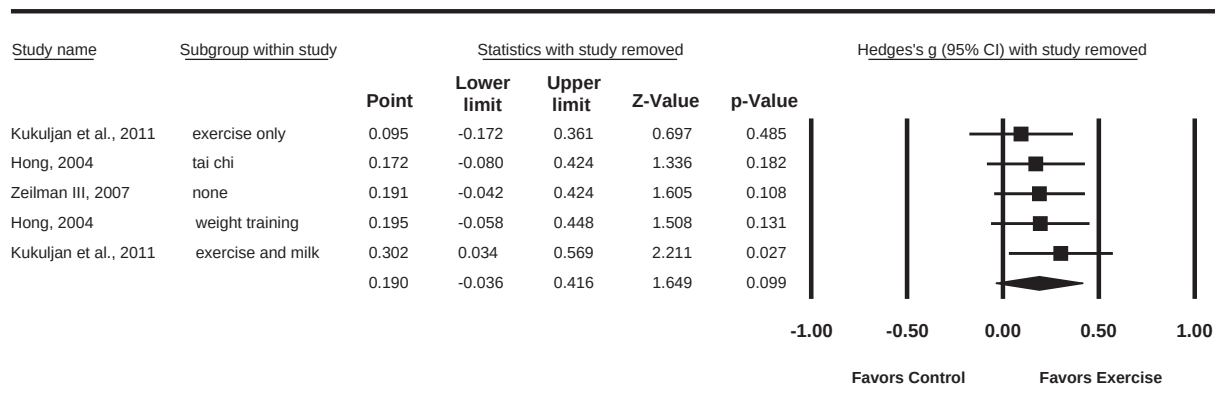


Fig. 5. Influence analysis for changes in LS BMD. Influence analysis for point estimate standardized effect size changes (g) in LS BMD with each corresponding study deleted from the model once. The black squares represent the standardized mean difference (g) while the left and right extremes of the squares represent the corresponding 95% confidence intervals. The middle of the black diamond represents the overall standardized mean difference (g) while the left and right extremes of the diamond represent the corresponding 95% confidence intervals. Results are ordered from smallest to largest values of g .

reviews, including meta-analyses [52]. Overall, they found that unpublished dissertations were not of lower quality when compared to those that were eventually published [52]. In addition, doctoral dissertations are (1) easy to access in comparison to other forms of gray literature, (2) free from some types of bias common in peer-reviewed literature, and (3) reported thoroughly [52]. To further support the inclusion of unpublished work such as dissertations, Cook et al., found that approximately 80% of meta-analysts and methodologists felt that unpublished material should definitely or probably be included in meta-analyses [53].

Third, because of the stricter study inclusion criteria for the current meta-analysis, including, lack of previous exercise, study design (randomized controlled trials only) and site assessed (FN and LS), none of the studies from the previous meta-analysis in men conducted more than a decade ago met the criteria for inclusion [19]. In addition, five randomized controlled trials published since the last meta-analysis were also excluded. The reasons for exclusion included (1) no clear indication of whether participants were physically active prior to enrollment [54], (2) participants serving as their own control [55], (3) previously exercising participants who were also allowed to exercise outside their intervention assignment [56], (4) no comparative control group (both groups exercised) [57] and (5) a lack of data specific to the FN and LS and which appeared to be strikingly similar to the included dissertation by Hong but with different authors [44]. Furthermore, two excluded studies included both men and women but separate data were not available for calculation of *gs* according to gender [58,59]. Given the former, it is the investigative team's belief that this new versus updated meta-analysis better reflects the current state of the randomized controlled trial literature with respect to exercise and FN and LS BMD in men.

Conclusions

There is insufficient evidence at this time to recommend ground and/or joint reaction force exercise for improving and/or maintaining FN and LS BMD in men. Additional well-designed randomized controlled trials in men are needed before any final recommendations can be formulated.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.bone.2012.11.031>.

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