Editorial Manager(tm) for Nursing Research
Manuscript Draft

Manuscript Number: NRES-D-08-00075

Title: Meta-analysis of quality-of-life outcomes from physical activity interventions

Article Type: Original Article

Corresponding Author: Dr. Vicki Conn, PhD, RN, FAAN

Corresponding Author's Institution: University of Missouri Columbia

First Author: Vicki Conn, PhD, RN, FAAN

Order of Authors: Vicki Conn, PhD, RN, FAAN; Adam R Hafdahl, PhD; Lori M Brown, MS

Manuscript Region of Origin: UNITED STATES

Abstract: Background: Interventions to increase physical activity among chronically ill adults are intended to improve quality of life as well as reduce disease complications or slow disease progression.
Objective: This meta-analytic review integrates quality-of-life outcomes from primary research studies testing interventions to increase physical activity among adults with chronic illness.
Methods: Extensive literature searching strategies were employed to locate published and unpublished primary research testing physical activity interventions. Results were coded for studies that had at least 5 participants with chronic illness. Fixed- and random-effects meta-analytic procedures included moderator analyses.
Results: Eighty-five samples from 66 reports with 7,291 subjects were synthesized. The mean quality-of-life effect size for two-group comparisons (treatment vs. control) was 0.11 (higher mean quality-of-life scores for treatment subjects than for control subjects). The treatment group pre-post comparison effect size was 0.27 for quality of life. Heterogeneity was modest in two-group comparisons. Most design and sample attributes were unrelated to intervention effects on quality of life. Studies that exclusively used supervised center-based exercise reported larger quality-of-life

improvements than studies that included any educational-motivational content. Effect sizes were larger among unpublished and unfunded studies. The effect size for physical activity did not predict the quality-of-life effect size.
Discussion: Subjects experience improved quality of life from exposure to interventions designed to increase physical activity, despite considerable heterogeneity in the magnitude of the effect. Future primary research should include quality-of-life outcomes so that patterns of relationships among variables can be further explored.

**Vicki S. Conn PhD RN FAAN**
**Office of Research**

April 7, 2008

Molly Dougherty PhD RN FAAN
Editor, Nursing Research
CB# 7460 Carrington Hall
University of North Carolina at Chapel Hill
Chapel Hill ND 27599-7460

Dear Mickey,

We are submitting a manuscript, 'Meta-analysis of quality-of-life outcomes from physical activity interventions' for publication consideration in *Nursing Research.* The paper reports original meta-analysis research.

The manuscript does not contain any copyrighted material. The manuscript is not under review by any other journal. Each of the authors has contributed substantially to the manuscript. The authors declare no conflicts of interest in relationship to this research or this manuscript. The authors have approved the final version of this paper. Financial support for the research is listed in the manuscript acknowledgement. The project was approved by the Institutional Review Board for the Protection of Human Subjects as not requiring informed consent.

We appreciate your review of this manuscript.

Sincerely,

*Vicki S. Conn*

Vicki S. Conn PhD RN FAAN
Editor, *Western Journal of Nursing Research*
Potter-Brinton Distinguished Professor
Associate Dean for Research
School of Nursing, University of Missouri

S317 School of Nursing MU Columbia, MO 65211 conn@missouri.edu 573 882 0231

*** Title Page & Acknowledgements**

Title: Meta-analysis of quality-of-life outcomes from physical activity interventions

Authors:

Vicki S. Conn PhD RN FAAN
Associate Dean & Potter-Brinton Distinguished Professor
School of Nursing
University of Missouri, Columbia MO

Adam R. Hafdahl PhD
Consultant
Mathematics Department
Washington University, St. Louis MO

Lori M. Brown MS
Research Specialist
School of Nursing
University of Missouri, Columbia, MO

Corresponding Author:

Vicki S. Conn PhD RN FAAN
S317 School of Nursing
University of Missouri
Columbia, MO 65211
573 882 0231 (office)
573 884 4544 (fax)
conn@missouri.edu

Acknowledgement: Financial support provided by a grant from the National Institutes of Health (R01NR07870) to Vicki Conn, principal investigator.

Keywords: quality of life, exercise, chronic disease, meta-analysis

Abstract

Background: Interventions to increase physical activity among chronically ill adults are intended to improve quality of life as well as reduce disease complications or slow disease progression.

Objective: This meta-analytic review integrates quality-of-life outcomes from primary research studies testing interventions to increase physical activity among adults with chronic illness.

Methods: Extensive literature searching strategies were employed to locate published and unpublished primary research testing physical activity interventions. Results were coded for studies that had at least 5 participants with chronic illness. Fixed- and random-effects meta-analytic procedures included moderator analyses.

Results: Eighty-five samples from 66 reports with 7,291 subjects were synthesized. The mean quality-of-life effect size for two-group comparisons (treatment vs. control) was 0.11 (higher mean quality-of-life scores for treatment subjects than for control subjects). The treatment group pre-post comparison effect size was 0.27 for quality of life. Heterogeneity was modest in two-group comparisons. Most design and sample attributes were unrelated to intervention effects on quality of life. Studies that exclusively used supervised center-based exercise reported larger quality-of-life improvements than studies that included any educational-motivational content. Effect sizes were larger among unpublished and unfunded studies. The effect size for physical activity did not predict the quality-of-life effect size.

Discussion: Subjects experience improved quality of life from exposure to interventions designed to increase physical activity, despite considerable heterogeneity in the

magnitude of the effect. Future primary research should include quality-of-life outcomes so that patterns of relationships among variables can be further explored.

Key word: exercise, chronic illness, well-being

Meta-Analysis of Quality-of-Life Outcomes from Physical Activity Interventions

Most adults with chronic illnesses remain sedentary despite evidence of potential health benefits of increased physical activity (PA). Interventions to increase PA among chronically ill adults are intended to improve quality of life (QOL) and reduce disease complications or slow disease progression. PA's potential benefits have contributed to the large body of primary research testing interventions to increase PA among adults with chronic illness. Few previous reviews have addressed QOL outcomes. This quantitative synthesis meets the need to synthesize and integrate the QOL outcome findings to inform future research and guide practice.

Researchers have summarized PA intervention research in numerous narrative reviews and a growing number of meta-analyses. Although reviewers often mention PA's consequences for QOL, few summarize findings that used QOL measures. Instead, reviews address symptoms or health outcomes that are assumed to be related to QOL (Ciccolo, Jowers, & Bartholomew, 2004; Dishman, 2003; Rietberg, Brooks, Uitdehaag, & Kwakkel, 2005). However, neither symptom changes nor health outcomes are adequate proxies for QOL outcomes (Netz, Wu, Becker, & Tenenbaum, 2005). PA may improve QOL beyond changes in symptoms and physical function (Drewnoski & Evans, 2001; Netz et al. 2005).

Few reviewers have examined QOL outcomes directly. Rejeski, Brawley, and Shumaker's (1996) narrative review of the link between increased PA and QOL concluded that findings are inconsistent. Some meta-analyses have addressed QOL-related outcomes (e.g. fatigue, depression, anxiety) but have not synthesized QOL outcomes that were measured directly (Devos-Comby, Cronan, & Roesch, 2006; Fox, 2000; Puetz, O'Connor, & Dishman, 2006). The scarce meta-analytic reviews addressing

QOL outcomes from PA interventions have been limited to specific diseases or to older adults and have reported mixed outcomes (Netz et al., 2005; Spronk, Bosch, Veen, den Hoed, & Hunink, 2005; Taylor et al., 2005). We designed this meta-analysis to address the need to quantitatively summarize the effects of PA interventions on QOL outcomes in broader participant populations.

This synthesis addressed the following research questions (1) What are the overall effects of interventions to increase PA on QOL outcomes after interventions? (2) Do PA interventions' effects on QOL outcomes vary depending on characteristics of paprticipants, methodology, or interventions? (3) Do PA behavior outcomes following interventions predict QOL outcomes? (4) For two-group comparisons, do control groups' post-test outcome measures differ significantly from pre-test values?

## Method

We used research synthesis methods widely reported in the literature to identify and secure potential primary research reports, evaluate their eligibility, extract data from research reports, meta-analyze primary study characteristics and findings, and interpret meta-analysis results. This project is part of a larger study synthesizing PA interventions among chronically ill adults. Further details about methods and results of the findings regarding PA outcomes and disease-specific health outcomes are available in other articles (Conn, Hafdahl, Brown, & Brown, 2008; Conn, Hafdahl, LeMaster et al., 2008; Conn, Hafdahl, Mehr et al. 2007; Conn, Hafdahl, Minor, & Nielsen, in press; Conn, Hafdahl, Moore, Nielsen, & Brown, in press; Conn, Hafdahl, Porock, McDaniel, & Nielsen, 2006; Nielsen, Hafdahl, Conn, LeMaster, & Brown, 2006). The project was approved by the Institutional Review Board for the Protection of Human Subjects as not requiring informed consent.

*Sample*

*Primary study search strategies*. We used diverse search strategies to limit the bias introduced by narrow searches (Conn, Isamaralai et al., 2003; Nony, Cucherat, Haugh, & Boissell, 1995). A reference librarian performed computerized searches in 11 databases using broad search terms (Conn, Isamaralai et al., 2003). The National Institutes of Health database of funded studies was searched. Ancestry searching was conducted on all eligible studies and review articles. We completed computerized searches on all authors of eligible studies. Hand searches of 42 journals with a preponderance of potential primary studies were completed for chronic illness-specific journals (e.g. *Diabetologia*) and general journals that publish PA research (e.g. *Medicine & Science in Sports & Exercise*).

*Selection criteria*. Primary research reports of studies with interventions designed to increase PA behavior were included. We included English language studies of at least 5 adults with chronic illnesses disseminated after 1970. Studies with diverse designs and sample sizes were included. Small sample studies, sometimes with inadequate statistical power to detect group differences, were included. Studies were weighted such that small-sample studies had proportionally less impact on aggregate findings. We included pre-experimental studies because (1) some investigators find it unethical to withhold treatment for any subjects, (2) randomization may not be feasible in some studies, and (3) novel interventions or difficult-to-recruit samples may be found in pre-experimental studies (Brown, Upchurch, Anding, Winter, & Ramirez 1996; Dusseldorp, van Elderen, Maes, Meulman, & Kraaij, 1999). Analyses were conducted separately for single group pre-post design studies and for two-group outcome comparisons. Because the biggest difference between published and unpublished

research is the statistical significance of the findings (Cook et al., 1993; Conn, Valentine, Cooper, & Rantz, 2003), we included both unpublished and published studies to reduce the potential overestimation of the magnitude of true population effects.

We included studies that attempted to increase PA behavior by using supervised center-based exercise interventions that measured post-intervention PA, educational-motivational interventions designed to increase PA, or both. Studies with diverse QOL measures were included if adequate data were available to calculate effect sizes (e.g. means and variability measures, exact *p* value from *t* test, *t* statistic). We did not include data from measures that did not directly assess QOL (e.g. measured depression, anxiety, mood, physical or social function). We coded the most distal QOL and PA outcome data available in the reports, since enduring outcomes are most important.

*Data Management*

*Data Abstraction*. We developed, pilot tested, and revised a coding frame to assess outcomes of primary studies and characteristics of sources, subjects, methods, and interventions. Coding elements were derived from attributes coded in previous behavior-change meta-analyses, intervention attributes reported in research literature, suggestions from experts in meta-analysis and PA, and findings from the research team's previous studies. Dissemination vehicle, year of distribution, and presence of funding were coded as source attributes. Participant characteristics included age, gender and minority distribution, and chronic illness inclusion criteria (e.g. diabetes). Attrition, random assignment, and the length of the interval between the intervention and outcome measurement were coded as methodological characteristics. We coded intervention information including presence or absence of supervised center-based exercise and of educational-motivational sessions, details about any center-based supervised exercise,

behavioral target (PA exclusively vs. PA plus other behaviors), intervention intensiveness, social setting, and recommended PA. Other details of interventions were coded but inadequately reported for moderator analyses. We coded PA behavior outcomes from studies to enable us to examine the association between PA behavior effects and QOL outcomes. For QOL, we included measures that described by primary authors as addressed life satisfaction, well-being, or QOL as outcomes. In some reports, we used a priori lists of QOL and PA behavior measures, with preference given to widely-used and validated instruments, to select among multiple measures.

Two extensively trained coders extracted the data. Discrepancies in coding were resolved by the senior author or other member of the research team as appropriate. Data coding was not masked because evidence indicates it does not decrease bias. We cross checked all author lists to locate research reports that might contain overlapping samples to ensure that only independent samples were analyzed. We contacted authors to clarify the uniqueness of samples when reports were unclear.

*Data Analysis.* Table 1 lists important features of the data analyses. We calculated a standardized mean difference effect size (ES) for QOL and PA outcomes. For comparisons between treatment and control groups after the intervention, the ES is the mean of the treatment group minus the mean of the control group, divided by their pooled standard deviation. In two-group comparisons, positive ESs reflect better scores among treatment subjects than control subjects. In single-group studies, positive ESs indicate that subjects scored better after than before the intervention. ESs were weighted such that studies with larger samples had more influence. Homogeneity between studies was assessed with *Q*. Outliers were examined graphically and statistically. Random-effects analyses were used to estimate the mean and variability of true ESs across

studies. (Fixed-effects analyses were also conducted; the report focuses on random-effects results.) The random-effects model is appropriate because we expected to find heterogeneous studies with varied methods that tested diverse interventions. A Common Language Effect Size (CLES) was calculated to aid interpretation of findings. We did not convert the ESs to an original metric because of the wide variation in QOL measures used and the variation in scoring among studies using the same measure. Moderator analyses were conducted using meta-analytic analogues of ANOVA and regression to determine whether QOL ESs were related to source attributes, methods, intervention characteristics, or PA behavior ESs. Moderator analyses should be considered exploratory given the lack of previous research to suggest hypothesis testing and given the number of studies retrieved. Further information about the analyses is available from the senior author (VC).

## Results

We ultimately included in the meta-analysis 85 samples described in 66 studies in which (approximately) 7,291 subjects participated (a list of included studies is available from the senior author). The independent group analysis included 5,159 subjects. The pre-post comparison analyses included 4,486 treatment subjects and 3,780 control subjects. The most common chronic illness target populations were cardiac ($k$ = 24), cancer ($k$ = 21), diabetes ($k$ = 19), and arthritis ($k$ = 7). ($k$ represents the number of comparisons.) Table 2 provides descriptive information about the included studies. Sample size ranged from 8 to 927 subjects with small and moderate samples being common. Attrition was modest from both treatment and control groups among the studies that reported this information. Women were well represented in the samples. The median of mean age was 61 years. Among the studies that used center-based

supervised exercise, typical exercise included 36 sessions of nearly 1-hour duration. Interventions duration varied from 1 week to 52 weeks.

*Overall Effects of Interventions on Quality-of-Life Outcomes*

Table 3 contains results from analyses that address the first and fourth research questions. We focus on random-effects results. The overall mean effect in two-group studies was .11. The treatment group's mean pre- versus post-test ES was .27 for both assumptions regarding the pre-post association. Each type of comparison demonstrated significant ES heterogeneity according to the *Q* homogeneity test, but for two-group studies this was only barely significant and relatively small as quantified by the between-studies variance component's square root (i.e., the true ESs' SD), $\hat{\sigma}_{\delta}$ = .071. These findings document that, although interventions' effects varied somewhat among studies, on average interventions to increase PA improved QOL outcomes, $p < 0.001$ in every case. In contrast, control subjects experienced little improvement, with only the comparison under the high-association assumption being statistically significant at $.05 < p < .10$.

The CLES for the two-group comparisons was .53, indicating that 53% of the time a random treatment subject would have a better QOL value than a random control subject after the intervention. The CLES for treatment group pre- and post-intervention comparisons was .58 (assuming no pre-post correlation), indicating that 58% of the time a treatment subject's QOL score would be better at outcome assessment than at baseline measurement. The CLES for control groups was .51, indicating that control subjects are slightly more likely to have a better outcome QOL score than baseline QOL value. The highly diverse measurement of QOL prevented us from converting ES

estimates to an original metric. There was no obvious evidence of publication bias in the funnel plots.

*Moderator Analysis*

Moderator analyses that address the second and third research questions are presented in Tables 4 and 5. Dichotomous moderator analyses for two-group comparisons are presented in Table 4. Unpublished studies reported considerably larger mean ESs (.39) than published studies (.09). Studies without external funding reported larger mean ESs (.31) than studies with external funding (.08). No statistically significant differences were observed between studies that randomly assigned subjects versus those that did not; studies that focused only on PA behavior versus those targeting multiple health behaviors; interventions delivered to individuals versus those given to groups; or studies with specific exercise recommendations (including intensity) versus those without such recommendations. The mean ES difference between studies with center-based supervised exercise (.17) and studies without supervised exercise (.08) did not reach statistical significance. Studies that did not use educational-motivational sessions (they used only supervised center-based exercise) reported significantly larger mean ESs (.24) than studies using only educational-motivational sessions or combined educational-motivational sessions with center-based supervised exercise (.02).

Two-group continuous moderator analyses findings are shown in Table 5. Mean QOL ESs were not predicted by participants' mean age; proportion female, minority, or attrition; extent of supervised exercise or educational-motivational contact between interventionists and subjects; or PA recommendations. In addition, the PA outcome ES was unrelated to QOL outcome ES.

We have not reported in the tables a moderator analysis we conducted to determine if QOL ES differed among the three most common types of chronic illnesses with adequate data (diabetes, cardiac disease, and cancer). The mean QOL ES was .21 for cardiac disease, .15 for cancer, and .04 for diabetes. The results revealed that these differences were not statistically significant ($Q_{between}$ = 3.0).

## Discussion

This meta-analysis documented that subjects who receive interventions designed to increase their PA experience better QOL outcomes over their baseline scores and in comparison to control subjects. The magnitude of the ES is difficult to assess because too few studies used any single QOL measure in exactly the same way to allow us to convert the ES to an original metric. The ES magnitude seems modest. It is unclear what ES would represent a clinically meaningful improvement in QOL among chronically ill adults. People with major chronic illnesses experience many reasons for declining QOL, including the disease itself and physical or psychosocial sequelae of the disease, and onerous or distressing treatments. Chronically ill study subjects often are recruited from specialty medical practice settings and may already be receiving optimal medical care. Even a small change in QOL may be important since QOL is a complex phenomenon likely affected by diverse factors. It is important to note that these findings were heterogeneous, as expected, though less so for two-group than pre-post comparisons and less so for QOL outcomes than for other health and PA outcomes reported in these primary studies (Conn, Hafdahl, Brown et al., 2008; Conn, Hafdahl, Mehr et al., 2007; Conn, Hafdhal, Minor et al., in press; Conn, Hafdahl, Moore et al. in press).

The explanation for QOL changes is unclear. These interventions were designed to change PA behavior, not to directly affect QOL. Mean differences in PA behavior were

not associated with QOL mean differences in the moderator analyses. It is possible that people achieved small increases in PA that were not detected by the PA measures but that contributed to increased QOL; however, this is inconsistent with the magnitude of ESs on PA in a related study (Conn, Hafdahl, Brown et al., 2008). Even small improvements in functional status from slight increases in PA may contribute to improved QOL. Previous meta-analyses of disease-specific outcomes (e.g. HbA1c, arthritis functional status) among common chronic illnesses documented improved health outcomes (Conn, Hafdahl, Mehr et al., 2007; Conn, Hafdahl, Minor et al., in press; Conn, Hafdahl, Moore et al., in press; Nielsen et al., 2006). These improvements may explain the improvements in QOL. It is also possible that subjects experienced enhanced perceived mastery over their chronic illnesses. Future primary PA research should include QOL measures and report the association between improvements in QOL and PA behavior changes to address this issue and avoid possible ecological fallacy in interpreting meta-analytic findings (Berlin, Santanna, Schmid, Szczech & Feldman, 2002). Research syntheses focused on correlates of and explanatory models for QOL could address the association between PA and QOL more directly.

The exploratory moderator analyses documented some intriguing suggestive findings that future research should examine. We did not expect to find the larger ES among unpublished and unfunded studies. These findings do not support the pattern of publication bias against studies with small ESs often reported in the literature (Cook et al., 1993; Conn, Valentine, Cooper, & Rantz, 2003). These unpublished and unfunded studies may include projects with extraordinary researcher effort to ensure successful projects, such as graduate student research. The finding of no association between ES

and random assignment of subjects does not support the common assumption of bias toward positive effects in studies without random assignment.

Our finding that behavior target (PA behavior only vs. multiple health behavior) was not associated with ES differences contrasts with previous meta-analyses of PA behavior and health outcomes that have documented better outcomes among studies that targeted only PA behavior (Conn, Valentine, & Cooper, 2003; Conn, Hafdahl, Mehr et al., 2007; Conn, Hafdahl, Brown et al., 2008). The meta-analyses that reported larger effects for interventions that focused exclusively on PA behavior have examined outcomes directly affected by PA behavior. The explanation for these differences may become clearer as more intervention trials include QOL outcomes as well as PA behavior and health outcomes.

The absence of moderator effects for age, gender, and minority distribution suggests that diverse samples may experience modest improvement from interventions to increase PA. People with chronic illnesses may avoid changing PA behavior because they fear further decline in their QOL. Many are dealing with demanding chronic illnesses that require continual self-management. Health care providers and health educators may use these exploratory findings to counter fears that increased PA will necessarily decrease QOL.

These findings suggest that interventions using only supervised center-based exercise may have more impact on QOL than interventions including educational-motivational content, regardless of whether it is accompanied by supervised exercise. These findings contrast with previous work documenting a lack of superiority of supervised exercise for PA behavior and health outcomes (Conn, Hafdahl, Mehr et al., 2007). Although the exploratory moderator analyses are intriguing, they should be

interpreted with caution. Relationships documented in the moderator analyses may be confounded by other sample- or study-level characteristics. Further primary studies testing differences within randomized controlled trials are needed.

We focused on QOL outcomes as measured by well-being, life satisfaction, and QOL measures. We excluded studies that used mood, energy, or fatigue measures as QOL outcomes, though some studies described these as QOL outcomes. Although findings have been mixed, some research has suggested a link between PA and mood (Conn, Hafdahl, Porock et al., 2006; Rietberg et al., 2005) and between PA and energy/fatigue (Puetz, Beasman, & O'Connor, 2006). Few studies in this meta-analysis addressed mood outcomes; after more primary studies reporting mood outcomes have been conducted, a synthesis of mood outcomes would be valuable.

In conclusion, this meta-analysis documented modest improvements in QOL outcomes among adults with chronic illnesses following interventions to increase PA. We encourage researchers and providers evaluating interventions designed to increase PA to include QOL outcome measures in their projects.

References

Berlin, J. A., Santanna, J., Schmid, C. H., Szczech, L. A., Feldman, H. I., & Anti-Lymphocyte Antibody Induction Therapy Study (2002). Individual patient- versus group-level data meta-regressions for the investigation of treatment effect modifiers: ecological bias rears its ugly head. *Statistics in Medicine, 21(3),* 371-387.

Brown, S. A., Upchurch, S., Anding, R., Winter, M., & Ramirez, G. (1996). Promoting weight loss in type II diabetes. *Diabetes Care, 19(6),* 613-624.

Ciccolo, J. T., Jowers, E. M., & Bartholomew, J. B. (2004). The benefits of exercise training for quality of life in HIV/AIDS in the post-HAART era. *Sports Medicine, 34(8),* 487-499.

Conn, V., Hafdahl, A., Brown, S., & Brown, L. (2008). Meta-analysis of patient education interventions to increase physical activity among chronically ill adults. *Patient Education and Counseling, 70,* 157-172.

Conn, V., Hafdahl, A., LeMaster, J., Ruppar, T., Cochran, J., & Nielsen, P. (2008). Interventions to improve self-management among adults with type 1 diabetes: Meta-analysis of metabolic outcomes. *American Journal of Health Behavior, 32,* 315-329.

Conn, V., Hafdahl, A., Mehr, D., LeMaster, J., Brown, S., & Nielsen, P. (2007). Meta-analysis of metabolic effects of interventions to increase exercise among adults with type 2 diabetes. *Diabetologia, 50(5),* 913-921.

Conn, V., Hafdahl, A., Minor, M., & Nielsen, P. (In press). Physical activity interventions among adults with arthritis: Meta-analysis of outcomes. *Seminars in Arthritis and Rheumatology.*

Conn, V., Hafdahl, A., Moore, S., Nielsen, P., & Brown, L. (In press). Meta-analysis of interventions to increase physical activity among adults with cardiovascular disease. *International Journal of Cardiology.*

Conn, V., Hafdahl, A., Porock, D., McDaniel, R., & Nielsen, P. (2006). A meta-analysis of exercise interventions among people treated for cancer. *Supportive Care in Cancer, 14(7),* 699-712.

Conn, V., Isamaralai, S., Rath, S., Jantarakupt, P., Wadhawan, R., & Dash, Y. (2003). Beyond MEDLINE for literature searches. *Journal of Nursing Scholarship, 35(2),* 177-182.

Conn, V., Valentine, J., & Cooper, H. (2002). Interventions to increase physical activity among aging adults: a meta-analysis. *Annals of Behavioral Medicine, 24(3),* 190-200.

Conn, V., Valentine, J., Cooper, H., & Rantz, M. (2003). Grey literature in meta-analyses. *Nursing Research, 52,* 256-261.

Cook, D. J., Guyatt, G. H., Ryan, G., Clifton, J., Buckingham, L., Willan, A., et al. (1993). Should unpublished data be included in meta-analyses? Current convictions and controversies. *JAMA, 269(21),* 2749-2753.

Devos-Comby, L., Cronan, T., & Roesch, S. C. (2006). Do exercise and self-management interventions benefit patients with osteoarthritis of the knee? A meta-analytic review. *Journal of Rheumatology, 33(4),* 744-756.

Dishman, R. K. (2003). The impact of behavior on quality of life. *Quality of Life Research, 12 Suppl 1,* 43-49.

Drewnoski, A., & Evans, W. (2001). Nutrition, physical activity, and quality of life in older adults: Summary. *Journal of Gerontology, 56A,* 89-94.

Dusseldorp, E., van Elderen, T., Maes, S., Meulman, J., & Kraaij, V. (1999). A meta-analysis of psychoeduational programs for coronary heart disease patients. *Health Psychology, 18(5),* 506-519.

Fox, K. (2000). The influence of physical activity on mental well-being. *Public Health Nutrition, 2,* 411-418.

Gleser, L. J., & Olkin, I. (1994). Stochastically dependent effect sizes. In H. Cooper & L. Hedges (Eds.), *The handbook of research synthesis* (pp. 339-355). New York, NY: Russell Sage Foundation.

Hedges, L. (1994). Fixed effects models. In H. Cooper & L. Hedges (Eds.), *The handbook of research synthesis* (pp. 285-299). New York, NY: Russell Sage Foundation.

Hedges, L., & Olkin, I. (1985). *Statistical methods for meta-analysis*. Orlando, FL: Academic Press.

Hedges, L., & Vevea, J. (1998). Fixed- and random-effects models in meta-analysis. *Psychological Methods, 3,* 486-504.

Kline, R. B. (2004). Beyond significance testing: reforming data analysis methods in behavioral research. Washington, DC: American Psychological Association.

Lipsey, M. W., & Wilson, D. B. (2001). *Practical meta-analysis.* Thousand Oaks, CA: Sage Publications.

Littell, J. H., Popa, M., & Forsythe, B. (2005). Multisystemic Therapy for social, emotional, and behavioral problems in youth aged 10-17. *Cochrane Database of Systematic Reviews(4),* CD004797.

McGraw, K. O., & Wong, S. P. (1992). A common language effect size statistic. *Psychological Bulletin, 111(2),* 361-365.

Morris, S. B. (2000). Distribution of the standardized mean change effect size for meta-analysis on repeated measures. *British Journal of Mathematical & Statistical Psychology, 53(Pt 1),* 17-29.

Morris, S. B., & DeShon, R. P. (2002). Combining effect size estimates in meta-analysis with repeated measures and independent-groups designs. *Psychological Methods, 7(1),* 105-125.

Netz, Y., Wu, M. J., Becker, B. J., & Tenenbaum, G. (2005). Physical activity and psychological well-being in advanced age: a meta-analysis of intervention studies. *Psychology & Aging, 20(2),* 272-284.

Nielsen, P. J., Hafdahl, A. R., Conn, V. S., LeMaster, J. W., & Brown, S. A. (2006). Meta-analysis of the effect of exercise interventions on fitness outcomes among adults with type 1 and type 2 diabetes. *Diabetes Research and Clinical Practice, 74(2),* 111-120.

Nony, P., Cucherat, M., Haugh, M. C., & Boissel, J. P. (1995). Critical reading of the meta-analysis of clinical trials. *Therapie, 50(4),* 339-351.

Puetz, T. W., Beasman, K. M., & O'Connor, P. J. (2006). The effect of cardiac rehabilitation exercise programs on feelings of energy and fatigue: a meta-analysis of research from 1945 to 2005. *European Journal of Cardiovascular Prevention & Rehabilitation, 13(6)*, 886-893.

Puetz, T. W., O'Connor, P. J., & Dishman, R. K. (2006). Effects of chronic exercise on feelings of energy and fatigue: a quantitative synthesis. *Psychological Bulletin, 132(6),* 866-876.

Raudenbush, S. (1994). Random effects models. In H. Cooper & L. Hedges (Eds.), *The handbook of research synthesis* (pp. 301-321). New York, NY: Russell Sage Foundation.

Rejeski, W. J., Brawley, L. R., & Shumaker, S. A. (1996). Physical activity and health-related quality of life. *Exercise & Sport Sciences Reviews, 24,* 71-108.

Rietberg, M. B., Brooks, D., Uitdehaag, B. M., & Kwakkel, G. (2005). Exercise therapy for multiple sclerosis. *Cochrane Database of Systematic Reviews(1),* CD003980.

Shadish, W., & Haddock, C. (1994). Combining estimates of effect sizes. In H. Cooper & L. Hedges (Eds.), *The handbook of research synthesis* (pp. 261-282). New York, NY: Russell Sage Foundation.

Spronk, S., Bosch, J. L., Veen, H. F., den Hoed, P. T., & Hunink, M. G. (2005). Intermittent claudication: functional capacity and quality of life after exercise training or percutaneous transluminal angioplasty--systematic review. *Radiology, 235(3),* 833-842.

Taylor, R. S., Brown, A., Ebrahim, S., Jolliffe, J., Noorani, H., Rees, K., et al. (2004). Exercise-based rehabilitation for patients with coronary heart disease: systematic review and meta-analysis of randomized controlled trials. *American Journal of Medicine, 116(10),* 682-692.

Vevea, J. L., & Hedges, L. V. (1995). A general linear model for estimating effect size in the presence of publication bias. *Psychometrika, 60(3)*, 419-435.

Table 1

*Meta-Analytic Management of Data*

| Analysis feature | Approach or Rationale |
|---|---|
| Standardized mean difference effect size (ES) (Hedges & Olkin, 1985; Morris, 2000; Morris & DeShon, 2002) | Two-group: post-intervention difference between treatment and control means divided by pooled SD.<br>One-group: difference between baseline and outcome means divided by baseline SD. Analyses conducted under assumptions of no (linear) correlation ($\rho_{12} = 0$) and high correlation ($\rho_{12} = .8$) because baseline and outcome scores are probably correlated.<br>Adjusted each ES for bias.<br>Weighted each ES by inverse of within-study sampling variance to address sample size differences.<br>Managed studies with multiple treatment groups & no control as multiple single-group pre-post studies. |
| Outlier identification (Hedges & Olkin, 1985; Lipsey & Wilson, 2001) | Examined ESs graphically.<br>Evaluated externally standardized residuals and homogeneity (*Q* statistic, variance component) as each ES was removed one at a time. |
| Dependencies in studies with multiple treatment groups compared to single control group (Gleser &Olkin, 1994) | Combined each study's dependent ESs into single independent ES by generalized least-squares, then used standard univariate random-effects analyses. |
| Random-effect model (Hedges & Olkin, 1985; Raudenbush, 1994) | Assumes observed ESs vary among studies due to both subject-level sampling error & study-level sources of error (Shadish & Haddock,1994).<br>Consistent with heterogeneous behavioral and educational interventions (Littell, Popa, & Forsyth, 2005).<br>More information about combining heterogeneous |

| | |
|---|---|
| | studies elsewhere (Conn, Hafdahl, Mehr et al., 2007).<br>Main parameters of interest:<br>▪ Mean ES (average true ES over studies).<br>▪ Between-studies variance component (heterogeneity of true ESs among studies), estimated by weighted method of moments.<br>Constructed 95% confidence intervals (CIs) for mean ES based on normal-theory standard errors. |
| Common Language Effect Size (CLES) (Kline, 2004; McGraw & Wong, 1992) | Probability that a random treatment subject would attain better a QOL score than a random control subject, or that a subject would score higher after than before treatment. |
| Homogeneity assessment (Lipsey & Wilson, 2001) | Calculated *Q* statistic as weighted sum of squares that has chi-squared distribution under homogeneity. |
| Publication bias assessment (Lipsey & Wilson, 2001; Vevea & Hedges) | Plotted ES against sampling variance.<br>Funnel-shaped plot (smaller studies scatter more broadly around mean ES, while larger studies cluster more tightly), suggesting absence of publication bias. |
| Moderator analyses (Hedges, 1994; Raudenbush, 1994) | Used mixed- and fixed-effects moderator analyses; fixed-effects results available from senior author.<br>Continuous moderators: Tested effects by *z* test of unstandardized regression slope ($\hat{\beta}$) in meta-analytic analogue of regression.<br>Dichotomous moderators: Tested effects by between-groups heterogeneity statistic ($Q_{between}$) in meta-analytic analogue of ANOVA.<br>Large variance component often increases standard error and decreases statistical power; interpret findings cautiously when significant heterogeneity exists.<br>Findings should be interpreted as exploratory. |

Table 2

*Characteristics of Primary Studies Included in Combined-Illness Quality-of-Life Meta-Analyses*

| Characteristic | *k* | Min | $Q_1$ | *Mdn* | $Q_3$ | Max |
|---|---|---|---|---|---|---|
| Sample size per study | 66 | 8 | 21 | 58 | 128 | 927 |
| Proportion of sample assigned to treatment group[a] | 35 | .45 | .50 | .53 | .64 | .76 |
| Proportion attrition from treatment group | 52 | .00 | .01 | .10 | .20 | .57 |
| Proportion attrition in comparison group[a] | 28 | .00 | .06 | .10 | .18 | .40 |
| Proportion female | 55 | .00 | .28 | .56 | .85 | 1.00 |
| Mean age (years) | 60 | 40 | 53 | 61 | 67 | 82 |
| Minutes supervised exercise per session | 14 | 17 | 33 | 53 | 60 | 75 |
| Total number super. exercise sessions | 25 | 12 | 24 | 36 | 48 | 96 |
| Number of weeks over which intervention was delivered | 55 | 1 | 8 | 12 | 21 | 52 |

*Note.* Includes all studies that contributed at least one independent-groups or pre-post effect size to primary analyses. Independent samples within studies aggregated by summing sample sizes before computing proportions and using weighted mean of other characteristics. *k* = number of studies providing data on characteristic; $Q_1$ = first quartile, $Q_3$ = third quartile. [a]Computed for independent-groups studies only.

**Table**

Table 3

*Independent-Groups Post-test and Single-Group Pre-Post Comparisons on Quality of Life: Fixed- and Random-Effects Point and Interval Estimates and Tests*

| | | Fixed-effects analysis | | | Random-effects analysis | | | |
|---|---|---|---|---|---|---|---|---|
| ES type | *k* | $\bar{d}$ | *SE*($\bar{d}$) | $\delta$ 95% CI | *Q* | $\hat{\mu}_\delta$ | *SE*($\hat{\mu}_\delta$) | $\mu_\delta$ 95% CI | $\hat{\sigma}_\delta$ |
| Independent-groups | 42 | .10*** | .029 | (.05, .16) | 55.79† | .11*** | .033 | (.05, .17) | .071 |
| Treatment pre-post $\rho_{12}$ = .80 | 71 | .22*** | .010 | (.20, .24) | 441.88*** | .27*** | .027 | (.22, .33) | .195 |
| Treatment pre-post $\rho_{12}$ = .00 | 71 | .26*** | .021 | (.22, .30) | 121.09*** | .27*** | .032 | (.21, .33) | .156 |
| Comparison pre-post $\rho_{12}$ = .80 | 25 | .05** | .017 | (.01, .08) | 56.29*** | .06* | .029 | (.00, .11) | .099 |
| Comparison pre-post ,$\rho_{12}$ = .00 | 25 | .05† | .037 | (-.02, .12) | 11.92 | — | — | — — | .000 |

*Note.* Under homogeneity, *Q* is distributed approximately as chi-square with *df* = *k* – 1, where *k* is the number of (possibly dependent) observed effect sizes; this tests both homogeneity ($H_0$: $\delta = \delta_i$) and the between-studies variance component $\sigma_\delta^2$ ($H_0$: $\sigma_\delta^2 = 0$). Weighted method of moments used to estimate $\sigma_\delta^2$. Potential outliers excluded based on random-effects standardized residuals. †*p* < .10, **p* < .05, ***p* < .01, ****p* < .001 (for $\bar{d}$, $\hat{\mu}_\delta$, and *Q*).

**Table**

Table 4

*Independent-Groups Post-test Comparisons on Quality of Life: Dichotomous Moderator Mixed-Effects Analyses*

| Moderator | $k_0$ | $k_1$ | $Q_W$ | $\hat{\mu}_{\delta_0}$ | $\hat{\mu}_{\delta_1}$ | $SE_{dif}$ | $Q_B$ | $\hat{\sigma}_{\delta}$ |
|---|---|---|---|---|---|---|---|---|
| Publication status | 5 | 37 | 46.5 | .39* | .09** | .156 | 3.7† | .073 |
| Funding | 8 | 34 | 44.6 | .31** | .08* | .101 | 5.4* | .062 |
| Random allocation | 5 | 37 | 48.5 | .22* | .09* | .103 | 1.6 | .084 |
| Days after intervention | 18 | 18 | 37.5 | .07 | .08† | .067 | 0.0 | .061 |
| Supervised exercise | 28 | 14 | 49.0 | .08* | .17** | .073 | 1.5 | .087 |
| Behavioral target | 17 | 25 | 48.6 | .17** | .08* | .076 | 1.5 | .085 |
| Intervention social context | 14 | 28 | 50.7 | .10 | .11** | .073 | 0.0 | .095 |
| Supervise exercise sessions | 28 | 8 | 36.8 | .06† | .16 | .111 | 0.9 | .052 |
| Educ./motivational sessions | 16 | 14 | 33.2 | .24*** | .02 | .083 | 7.1** | .084 |
| Recommend specific exercise | 34 | 8 | 50.3 | .10** | .13 | .094 | 0.1 | .093 |
| Recommend exercise intensity | 3 | 11 | 18.5 | .02 | .19* | .214 | 0.7 | .174 |

*Note.* $k_j$ = number of (possibly dependent) ES estimates in group coded *j*. Moderator levels: publication status (0 = unpublished, 1 = published); funding (0 = no funding, 1 = some funding), days after intervention (0 = none, 1 = at least 1); behavioral target (0 = physical activity only, 1 = multiple health behaviors); intervention social context (0 = individual, 1 = group); supervised exercise sessions (0 = no center-based supervised sessions, 1 = at least 1); educational/motivational sessions (0 = no educational or motivational sessions, 1 = at least 1); recommended specific exercise (0 = not walking, 1 = walking); recommended intensity (0 = low, 1 = moderate or high); others (0 = absent, 1 = present). Heterogeneity statistics: $Q_B$ = between groups (distributed as chi-square on *df* = 1 under $H_0$: $\delta_0 = \delta_1$ or $H_0$: $\mu_{\delta_0} = \mu_{\delta_1}$), $Q_W$ = combined within groups (distributed as chi-square on *df* = $k_0 + k_1 - 2$ under $H_0$: $\sigma^2_{\delta_0} = \sigma^2_{\delta_1} = 0$). Weighted method of moments used to estimate between-studies variance component $\sigma^2_{\delta}$. Reported if $k_0 \geq 3$ and $k_1 \geq 3$. †$p$<.10, *$p$<.05, **$p$<.01, ***$p$<.001 (for $Q_B$,$Q_W$, $\hat{\mu}_{\delta_0}$, and $\hat{\mu}_{\delta_1}$).

**Table**

Table 5

*Independent-Groups Post-test Comparisons on Quality of Life: Linear Continuous Moderator Mixed-Effects Analyses*

| Moderator | *k* | $Q_{residual}$ | $\hat{\beta}_0$ | $\hat{\beta}_1$ | $SE(\hat{\beta}_1)$ | $\hat{\sigma}_\delta$ |
|---|---|---|---|---|---|---|
| Mean age (years) | 40 | 46.7 | -0.108 | 0.004 | 0.0034 | .089 |
| Proportion female | 32 | 39.6 | 0.150 | -0.021 | 0.1354 | .116 |
| Proportion ethnic minority | 6 | 8.1† | 0.492 | -1.165 | 0.9759 | .339 |
| Attrition proportion | 33 | 33.7 | 0.132 | -0.360 | 0.5426 | .055 |
| Days after intervention | 18 | 24.1† | 0.186 | -0.042 | 0.1689 | .129 |
| Supervised exercise contact | 8 | 6.8 | -1.670 | 0.559 | 0.8179 | .114 |
| Educ./motivational contact | 14 | 15.6 | -0.147 | 0.056 | 0.2144 | .090 |
| Recommended min/wk | 11 | 8.2 | 0.357 | -0.001 | 0.0012 | .000 |
| PA two-group *d* | 29 | 33.1 | 0.125 | 0.039 | 0.1321 | .091 |
| PA pre-post treatment *d* | 16 | 18.9 | 0.169 | -0.070 | 0.1439 | .108 |
| PA pre-post comparison *d* | 14 | 14.3 | 0.138 | 0.109 | 0.2364 | .073 |

*Note.* *k* = number of (possibly dependent) ES estimates. Moderators: proportion ethnic minority (proportion Black, Hispanic, or Native American); days after intervention (common log of positive days); supervised exercise contact (common log of positive minutes of supervised contact); educational/motivational contact (common log of positive minutes of educational/motivational contact); others are relatively self-explanatory. $\hat{\beta}_0$ = unstandardized intercept estimate; $\hat{\beta}_1$ = unstandardized slope estimate. $Q_{residual}$ = residual heterogeneity statistic, beyond that due to moderator (distributed as chi-square on *df* = *k* – 2 under $H_0$: $\sigma^2_{\delta|x} = 0$, where *x* is moderator value). Weighted method of moments used to estimate between-studies variance component $\sigma^2_\delta$. Analysis reported if *k* ≥ 6.

†*p* < .10 (for $\hat{\beta}_1$ and $Q_{residual}$).

Copyright Transfer Form

Click here to download Copyright Transfer Form: ToC signed Conn manuscript.pdf

## *Nursing Research*

**Authorship Responsibility, Financial Disclosure, and Copyright Transfer**

**Manuscript Title:** Meta-analysis of quality-of-life outcomes from physical activity interventions

**Corresponding Author:** Vicki S. Conn
**Address, Telephone, and Fax Numbers:** S317 School of Nursing, MU, Columbia MO 65211
office: 573 882 0231 fax: 573 884 4544

**Each author must read and sign the following statements, and if necessary, photocopy this document and distribute to coauthors for their original ink signatures. Please compile all forms and include them with the manuscript.**

**CONDITIONS OF SUBMISSION:**

**RETAINED RIGHTS:** Other than copyright, all proprietary rights (such as patent rights) are retained by the authors.

**ORIGINALITY:** The authors warrant that this submission is an original work. Neither this work nor a similar work has been published or will be submitted for publication elsewhere while under consideration by this Journal.

**AUTHORSHIP RESPONSIBILITY:** The authors certify that they have participated sufficiently in the intellectual content, the analysis of data, if applicable, and the writing of the work, to take public responsibility for it. They have reviewed the final version of the work, believe it represents valid work, and approve it for publication. Moreover, should the editors of the Journal request the data upon which the work is based, they shall produce it.

**DISCLAIMER:** The undersigned warrant that this work contains no libelous or unlawful statements and does not infringe on the rights of others. If excerpts (text or figures) from copyrighted works are included, written permission will be secured by the authors prior to submission, and credit will be properly acknowledged.

**INSTITUTIONAL REVIEW BOARD/ANIMAL CARE COMMITTEE APPROVAL:** The undersigned authors certify that their institutions have approved the protocol for any investigation involving humans or animals and that all experimentation was conducted in conformity with ethical and humane principles of research.

**TRANSFER OF COPYRIGHT:**

**AUTHORS' OWN WORK:** The undersigned authors hereby transfer, assign, or otherwise convey all copyright ownership worldwide, in all languages, and in all forms of media now or hereafter known, including electronic media such as CD-ROM, Internet, and Intranet, to Lippincott-Raven Publishers in the event that such work is accepted for publication in the Journal. To reproduce any figure or text from this article in future works of their own, the authors must obtain written permission. Such permission will not be unreasonably withheld by the copyright holder.

**GOVERNMENT EMPLOYEES:**

☐ If this article exists in the public domain because it was written as part of the official duties of the Authors as employees of the U.S. government, check this box.

***Note to Government Employees:** If this work has been written in the course of employment by the United States Government, the above box should be checked, and a copy of the relevant departmental statement of policy attached. A work prepared by a government employee as part of his/her official duties is called a "work of the U.S. Government" and is not subject to copyright. If it is not prepared as part of the employee's official duties, it may be copyrighted.*

**FINANCIAL DISCLOSURE:** The undersigned authors certify that they have no commercial associations (e.g., consultancies, stock ownership, equity interest, patent-licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article, except as disclosed on a separate attachment. All funding sources supporting the work and all institutional or corporate affiliations of the authors are acknowledged in a footnote.

| Signature | Printed Name | Date |
|---|---|---|
| Vicki S Conn | Vicki S Conn | 4/10/2008 |
| ☒ Author's own work | ☐ Work for hire | ☐ Government |
| Adam R Hafdahl | Adam R Hafdahl | 4/10/2008 |
| ☒ Author's own work | ☐ Work for hire | ☐ Government |
| Lori M Brown | Lori M Brown | 4/10/2008 |
| ☒ Author's own work | ☐ Work for hire | ☐ Government |
| | | |
| ☐ Author's own work | ☐ Work for hire | ☐ Government |