

Integrative Review of Physical Activity Intervention Research with Aging Adults

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This paper reviews randomized, controlled trials (RCTs) that have attempted to increase physical activity behavior by aging adults. A systematic review was necessary because numerous studies target older adults, and previous reviews have addressed a limited range of primary studies. Computerized database, ancestry, and extensive search strategies by authors of research reported in English between 1960 and 2000 located diverse intervention trials. RCTs reporting endurance physical activity or exercise behavioral outcomes for at least five subjects were included. Integrative review methods were used to summarize extant research. Forty-two studies were retrieved. Seventeen RCTs with 6,391 subjects were reviewed. A wide variety of intervention strategies were reported. The most common interventions were self-monitoring, general health education, goal setting, supervised center-based exercise, problem solving, feedback, reinforcement, and relapse prevention education. Few studies individually adapted motivational interventions, used mediated intervention delivery, or integrated multiple theoretical frameworks into the intervention. Links between individual intervention components and effectiveness were not clear. Common methodological weaknesses included small samples, untested outcome measures, and time-limited longitudinal designs. Significant numbers of aging adults increased their physical activity in response to experimental interventions. The amount of increased activity rarely equaled accepted behavior standards to achieve positive health outcomes. Further work is essential to identify successful strategies to increase activity by larger numbers of elders and to accelerate the increase in activity by those who change activity behaviors. Sex and ethnic differences need further investigation. There is a vital need for rigorously designed studies to contribute to this science. *J Am Geriatr Soc* 51:1159–1168, 2003.

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Physical and psychological benefits of increased physical activity have been widely documented in healthy and chronically ill older adults.^{1–3} Despite this information, older adults remain largely sedentary.^{3,4} Only 12% of adults aged 75 and older engage in 30 minutes of moderate physical activity 5 or more days per week, and 65% report no leisure physical activity.³ These alarming statistics have contributed to Healthy People objectives focused on increasing physical activity by vulnerable groups such as aging adults.³ Unfortunately, progress toward Healthy People goals has not been documented.

Considerable research has tested interventions to increase activity by younger adults and by patient populations of all ages. Currently, intervention research with older adults is being reported more frequently. Previous reviews of physical activity interventions have included heterogeneous samples and diverse settings and outcomes. Typically they contain few studies with older adults and often focus on health outcomes rather than activity behavior.^{4–10} To address these limitations in the review literature, a broad integrative review was conducted on studies that tested interventions attempting to increase general physical activity or aerobic exercise by aging adults.

METHODS

Inclusion Criteria

Explicit inclusion criteria were used to ensure review of all relevant studies. Studies were included if they met the following criteria.

Mean subject age of 65 and older.

Minimum of five participants.

Reported during the years 1960 through 2000.

Directly measured overall physical activity or episodic endurance exercise outcome variables.

Used a randomized, controlled trial (RCT) design with statistical analysis comparing treatment and control groups. Research report in English.

Published and unpublished studies were included in this review. Studies focused on episodic exercise (repetitive movement of large muscles) or overall physical activity (total amount of energy expenditure associated with bodily movements) were included in this review.

Literature Search Strategies

Multiple search strategies were employed to enlarge the scope of studies retrieved and thus limit the bias introduced by narrow searches. An experienced reference librarian conducted computerized searches of diverse databases (AgeLine, SportDiscus, PsychoINFO, MEDLINE, CINAHL, DAI). Ancestry searches were conducted on previous review articles of physical activity interventions for aged or other populations and on all potential primary studies. Computerized searches were conducted on all authors of retrieved studies meeting the inclusion criteria. These extensive search strategies yielded 42 potential studies (38,408 subjects) that were then reviewed for eligibility.

RESULTS

Seventeen studies (6,391 subjects) that fully met the inclusion criteria were identified. Four of the eligible studies were reported in multiple publications. These multiple reports described results at different intervals after the intervention or reported on subsamples. The report using the longest duration of follow-up with the largest number of subjects was selected.

Only one study found greater physical activity in control subjects than treatment subjects.¹¹ Ten of the 17 studies reported greater physical activity or exercise by treatment subjects than control subjects.¹²⁻²¹ Descriptions of the studies that focused on walking as a form of physical activity are presented in Table 1. Four of the six walking-focused studies reported more walking in the treatment than in the control subjects. Table 2 provides information about studies focused on overall physical activity or forms of exercise other than walking. Six of these 10 studies reported greater physical activity or exercise scores in experimental subjects than control subjects.

METHODOLOGICAL ATTRIBUTES OF RCT STUDIES

Sampling Issues

Sample sizes ranged from 20 to 3,097 subjects. The median sample size was 92 participants. Four of the five studies with sample sizes less than 60 subjects reported no difference in physical activity scores between experimental and control subjects. Nine studies targeted aging adults with particular health problems or visiting physicians. Six of the nine studies targeting patient populations reported greater physical activity by the treatment groups. In contrast, equal numbers of studies not targeting patient populations reported more activity by treatment subjects and no differences between treatment and control groups (four of eight studies). Women were well represented in most

studies (35% to 100% female samples). Only six of the 17 studies report minority enrollment.

Design and Measurement Issues

Nine of the studies examined exercise adoption because they assessed behavior change within 6 months of completion of the intervention. Only four of these studies reported significantly greater exercise adoption by treatment than control groups. Seven studies examined exercise maintenance by measuring behavior 6 months or more after the intervention. Five of the seven maintenance studies reported greater activity in the experimental groups.¹²⁻¹⁷ Nine studies reported validity or reliability of their physical activity measure or used a previously developed measure. Instruments measured diverse components of activity behavior, but few measures addressed all three dimensions of physical activity (intensity, duration, frequency).

INTERVENTIONS TESTED AND ASSOCIATED RESULTS IN RCT STUDIES

Theoretical Frameworks for Interventions

Ten of the 17 studies specified theoretical frameworks for the interventions. Seven of the 10 studies with a theory-based intervention reported positive findings, whereas only three of the seven without theoretical frameworks reported positive findings. The most common theoretical framework was social cognitive theory, which seven projects used.^{12,13,17-19,22,23} Social cognitive theory posits that self-efficacy expectancy (perceived confidence that one can perform a specific behavior) and outcome expectancy (anticipated consequences of behavior) strongly influence behavior. Self-efficacy has been consistently and strongly associated with exercise in older adults, and social cognitive theory is commonly used in health behavior change trials.²⁴ Five of the seven social-cognitive-theory-based intervention studies reported positive results. The transtheoretical model was the only other framework reported by more than one study.^{18,20,25} The transtheoretical framework considers the temporal perspective of health behavior change by specifying the stages people go through to change exercise behavior (precontemplation, contemplation, preparation, action, and maintenance). The transtheoretical model also identifies specific behavior change processes (e.g., consciousness raising, stimulus management, reinforcement, supportive relations) that are differentially effective at each stage of change. Transtheoretical model approaches have been used extensively in smoking cessation research and are now being applied more frequently to other health behaviors, such as exercise. Two of the three interventions studies based on the transtheoretical model reported positive outcomes.^{18,20} Some studies used multiple theoretical frameworks to develop interventions. Four of the five studies reporting combined theoretical frameworks for their interventions found significant treatment effects.^{12,13,18,21}

Supervised Exercise as an Intervention

The presence or absence of supervised exercise is the most notable difference between interventions. Three of the five studies with supervised, center-based exercise reported positive treatment effects.^{12,14,18} Often, studies with super-

Table 1. Characteristics of Randomized Controlled Trials Focused on Walking Activity

Author*	Sample†	Motivational Content, Individualized, Theoretical Basis, and Supervised Exercise‡	Intervention Delivery§	Intensity/Treatment Dose	Outcome Measures¶	Results¶
Atkins ²¹	N = 53 Subjects: patients with moderate to severe chronic pulmonary obstructive disease Sex: 63% women Minority: unstated Age: 64.79	Behavior modification: contingency management, behavioral contract, modeling, progressive muscle relaxation. Cognitive modification: thought restructuring, modeling. Cognitive-behavioral modification: condensed version of all content. Individualized: no Theory: behavior modification, cognitive-behavior modification, cognitive modification Supervised exercise: no	Setting: homes Context: individual Intervenor: psychology graduate students Format: instruction Mediated: no	Seven 1-hour sessions Frequency: weekly then every other week Duration: 3 months	Instrument: walking logs, validated with physiological measures Follow-up: 3 months	Significantly greater walking time by the combined cognitive-behavior modification group than for all other groups
Friedman ²⁰	N = 87 Subjects: older adults from internal medicine practices Sex: 66% women Minority: 30% minority Age: 67 (≥60)	Feedback, health-risk appraisal, health education, goal setting, relapse prevention training, self-monitoring. Individualized: yes, computer-individualized responses Theory: transtheoretical model Supervised exercise: no	Setting: home Context: individual Intervenor: computer-generated messages Format: instruction Mediated: telephone delivery	Twelve 3- to 10-minute sessions. Frequency: weekly Duration: 3 months	Instrument: investigator developed self-report of walking minutes Follow-up: at end of intervention	Experimental group walked significantly more than control subjects
Graham ¹¹	N = 57 Subjects: older adults Sex: 47% female Minority: unstated Age: 68 (50 – 90)	Experimental group 1: Self-monitoring, health education Individualized: exercise plan (group 1) Experimental group 2: self-monitoring, health education. Individualized: no (group 2) Theory: unstated Supervised exercise: no	Setting: home Context: individual Intervenor: graduate student Format: written instruction Mediated: partial mail delivery	One in-person contact and three sets of mailed materials. Frequency: every 3 weeks Duration: 9 weeks	Instrument: investigator developed self-report of walking time Follow-up: immediately after the intervention	Control group subjects walked significantly more than either experimental group
Hamdorf ¹⁴	N = 66 Subjects: aging women Sex: 100% female Minority: unstated Age: 65 (60–70)	No motivational content. Individualized: no Theory: unstated Supervised exercise: progressive walking program	Setting: unstated Context: unstated Intervenor: experienced fitness instructor Format: unstated Mediated: no	Unstated Frequency: two times per week Duration: 6 months	Instrument: investigator developed measure of walking frequency Follow-up: 6 months	Treatment group subjects walked significantly more than control subjects.

(Continued)

Table 1. Characteristics of Randomized Controlled Trials Focused on Walking Activity

Author*	Sample†	Motivational Content, Individualized, Theoretical Basis, and Supervised Exercise‡	Intervention Delivery§	Intensity/Treatment Dose	Outcome Measures¶	Results
Kerse ¹⁵	N = 233 Subjects: elderly patients in general practice clinics Sex: 54% female Minority: unstated Age: 73 (≥65)	Health education. Individualized: no Theory: unstated Supervised exercise: no	Setting: ambulatory care settings Context: individual Intervenor: primary physician Format: instruction Mediated: no	Unstated. Frequency: unstated Duration: unstated	Instrument: National Heart Foundation measures of overall physical activity Follow-up: 1 year	Experimental group walked significantly more than control group
Sullivan ²²	N = 92 Subjects: adults with knee osteoarthritis Sex: 92% female Minority: 12% minority Age: 69 (40-89)	Health education, social support, self-monitoring, modeling, feedback, reinforcement, social support, thought restructuring, shaping, stimulus control, contracting, goal setting, relapse prevention Individualized: no Theory: PRECEDE and self-efficacy Supervised exercise: yes	Setting: hospital Context: researcher formed group Intervenor: unstated Format: instruction Mediated: no	Twenty-four 90-minute sessions Frequency: three times per week Duration: 2 months	Instrument: investigator developed instrument to measure habitual walking Follow-up: 1 year	No significant difference in walking distance/week between experimental and control subjects

* First citation presented outcome data furthest from the intervention.

† Ages are mean (range).

‡ Individualized interventions are adapted for each subject.

§ Mediated included any delivery medium other than face-to-face encounters (e.g., telephone, mail).

¶ Follow-up time reflects the interval between completion of the intervention and measurement of the outcome variable.

|| Results comparing treatment group with control group.

PRECEDE = predisposing, reinforcing, and enabling causes in educational diagnosis and evaluation (model).

vised exercise also included motivational components. Seven of the 12 studies without supervised exercise reported greater exercise in the treatment group than in the control group.

Motivational Intervention Content

Individual studies used multiple motivational strategies and tested diverse arrays of motivational content. For example, one study used social support, stimulus control, self-regulation, health education, self-monitoring, goal setting, barrier management, commitment activities, reinforcement, problem solving, and relapse prevention.¹² Another study used a more limited intervention consisting of health education and self-monitoring.²⁶ Self-monitoring and health education (content about the health benefits of exercise and general information about how to exercise) were the most commonly used interventions. Other common interventions were goal setting ($n = 6$), problem solving ($n = 5$), feedback ($n = 5$), reinforcement/contingencies ($n = 5$), relapse prevention education ($n = 4$), and modeling ($n = 4$). Contracting, social support, health-risk appraisal, thought restructuring, stimulus control, and self-regulation were less common. No intervention reported by four or more studies was consistently associated with positive or negative findings. For example, self-monitoring was associated with positive findings in four studies and negative findings in four others.

Four of the six studies with individualized interventions reported greater exercise in the treatment groups than the control groups. These interventions were individualized for each subject. For example, one study used computer-generated individualized communication based on information previously provided by participants.²⁰ Other studies individualized recommended exercise. For example, a study used a “personalized” exercise program for treatment subjects.¹¹

Intervention Delivery Attributes

Three of the five studies that delivered interventions in subjects’ homes reported positive results. Each of the four studies that delivered interventions in aggregate community sites, such as senior centers or churches, reported more exercise by experimental subjects than control participants.^{13,16–18} Interventions delivered to individuals were about equally likely to result in positive (6/11 studies) and negative findings (5/11). Four of the six studies that delivered interventions to researcher-formed groups reported positive findings. Delivery of intervention to existing groups was rare. Only one study included multiple family members within larger researcher-formed groups.¹⁷ Seven studies used mediated delivery (e.g., mail-delivered materials) of at least part of their interventions. For example, one study included phone-delivered motivational sessions as one component of the intervention.¹⁶ Four of the five studies using phone intervention delivery reported more exercise by experimental than control subjects.^{13,16,18,20} Interventionists varied widely and included peer/lay leaders, graduate students, certified exercise trainers, nurses, and physicians. Instruction was the most common format for conveying information to subjects.

Supervised exercise sessions were usually delivered two or three times per week over a period of 2 to 6

months. Motivational sessions were most commonly scheduled weekly over a period of 1 to 12 weeks, unless they were combined with supervised exercise sessions that continued for longer time periods.

DISCUSSION

The studies that reported significant increases in physical activity ($n = 10$) confirm that some older adults are able to increase their activity levels.^{12–21} The sizable number of studies without significant findings ($n = 7$) suggests that new interventions are needed to assist more older adults to increase their activity to adequate levels in reasonable lengths of time.^{11,22,23,25–28} No single intervention component or attribute reported by large numbers of studies dramatically or consistently produced successful outcomes. This may reflect lack of effective interventions, lack of treatment integrity, poor standardization of intervention delivery, or inappropriate choice of instruments. Additional RCTs with well-defined intervention components are needed to determine effective interventions.

Interventions with elements consistent with learning theories (e.g., reinforcement, cues) were well represented. Several studies noted social cognitive theory as the basis for the interventions, and their findings support the use of social cognitive theory for intervention development. Information from studies basing interventions on the trans-theoretical model will increase as more studies currently in progress begin to report results. Meta-analysis to examine support for particular theoretical frameworks for intervention development would be useful. This sort of quantitative synthesis could only be conducted on studies with diverse age groups, because too few gerontology studies exist. Researchers are beginning to combine theoretical frameworks to design interventions. This review suggests that this may be a useful strategy and essential to move toward interventions that are effective in changing a multifaceted behavior such as physical activity.²⁹ The link between the theoretical constructs and specific attributes of interventions was often unclear in studies using frameworks. Explicit articulation of the theoretical foundation of interventions would strengthen the contribution of individual studies to conceptual understandings of health behavior change.

Study designs are variably effective in documenting causal relationships in this literature. The proportion of RCTs, considerably fewer than half of the retrieved studies, limits confidence in findings from this domain of literature. Nonrandom assignment of subjects and single-group pre/post test designs, even in “healthy” older adults, are common limitations in this research. There is an encouraging trend for more-recent studies, those published since 1990, to be RCT designs. Another methodological challenge is the proliferation of investigator-developed instruments, when even developed instruments have well-documented limitations.³⁰ A third methodological limitation is the common practice of examining physical activity adoption but not following subjects long enough to determine maintenance. A related concern is the interpretation of outcome values. The activity behavior criteria for “success” are not clear. Although the American College of Sports Medicine guidelines define success as exercise for 30 minutes at least 5 days per week that persists for at least 6 months, these

Table 2. Characteristics of Randomized Controlled Trials Focused on Activity other than Walking

Author*	Sample†	Motivational Content, Individualized, Theoretical Basis, and Supervised Exercise‡	Intervention Delivery§	Intensity/Treatment Dose	Outcome Measures	Results¶
Brawley ¹²	N = 60 Subjects: healthy sedentary older adults Sex: 63% female Minority: unstated Ages: (65–80)	Social support, self-regulation, health education, self-monitoring, goal setting, barrier management, commitment, reinforcement, stimulus control, problem solving, relapse prevention. Individualized: no Theory: social cognitive theory and group dynamics Supervised exercise: yes	Setting: unstated Context: researcher-formed group Intervenor: certified exercise leaders Format: lecture, discussion Mediated: no	Supervised exercise: Fifteen 1.5-hour sessions; 30-minute motivational sessions Frequency: two times per week for 3 weeks then weekly Duration: 6 months	Instrument: previously developed 7-Day Physical Activity Recall Follow-up: 3 months	Group-mediated cognitive behavioral subjects performed more moderate physical activity than other subjects
Burton ²⁸	N = 3,097 Subjects: Medicare beneficiaries Sex: 64% female Minority: 14.3% Ages: (≥65) N = 798 Subjects: Medicare beneficiaries enrolled in health maintenance organization Sex: 52% female Minority: unstated Ages: (≥65)	Health-risk appraisal, counseling Individualized: no Theory: unstated Supervised exercise: no Health-risk appraisal, goal setting, feedback, problem-solving, contracting, self-monitoring, reinforcement Individualized: no Theory: social learning theory, self-control, and self-change Supervised exercise: no	Setting: physician office Context: individual Intervenor: primary physician Format: counseling Mediated: no Setting: community centers Context: individual + researcher formed groups Intervenor: unstated Format: presentation, discussion, skill practice Mediated: partial telephone (individual counseling)	Two to four brief sessions Frequency: 6–12 months Duration: 2 years Eight 2-hour sessions + phone counseling Frequency: weekly (workshop), unstated phone Duration: 8 weeks (workshops): 24 months (phone)	Instrument: investigator developed instrument to categorize subjects as sedentary Follow-up: 2 years Instrument: investigator developed measure of exercise frequency, duration, and intensity Follow-up: 48 months	No difference between groups in sedentary rates Experimental groups maintained significantly more exercise than control group
King ¹⁸	N = 103 Subjects: sedentary older adults Sex: 64% female Minority: 5% minority Ages: 70 (≥65)	Self-monitoring, problem solving, skills practice Individualized: no Theory: social cognitive theory and transtheoretical model Supervised exercise: yes	Setting: community recreation center Context: researcher formed group Intervenor: unstated Format: instruction and demonstration Mediated: telephone (partial)	Sixty minutes exercise, 12- to 15-minute phone calls Frequency: exercise two times per week; phone: weekly for 1 month, every other week for 2 months, monthly for 9 months Duration: 1 year	Instrument: previously developed CHAMPS measure for elders with documented validity and reliability Follow-up: at completion of intervention	Experimental group expended significantly more cal/kg than control subjects

(Continued)

Table 2. (Continued)

Author*	Sample†	Motivational Content, Individualized, Theoretical Basis, and Supervised Exercise‡	Intervention Delivery§	Intensity/Treatment Dose	Outcome Measures¶	Results
Leveille ¹⁶	N = 201 Subjects: chronically ill elders recruited from primary care settings Sex: 56% female Minority: unstated Ages: 77 (≥70)	Content not described Individualized: based on chronic illnesses Theory: unstated Supervised exercise: no	Setting: senior center Context: individual Intervenor: geriatric nurse practitioner, peer supporters Format: instruction Mediated: telephone (partial)	Mean of three visits and nine phone calls; <20% attended 7-week (2-hour) class Frequency: unstated Duration: 1 year	Instrument: Physical Activity Scale for the Elderly measure of overall activity Follow-up: 12 months	Treatment group had significantly higher physical activity scores than control group
Lorig ¹⁷	N = 952 Subjects: patients with heart or lung disease, arthritis, or stroke Sex: 65% female Minority: 10% minority Ages: 66 (40–90)	Thought restructuring, problem solving, feedback, modeling, goal setting. Individualized: modify own plans Theory: social cognitive theory Supervised exercise: no	Setting: churches, senior centers, libraries, clinics Context: researcher formed groups, sometimes family members Intervenor: lay leaders Format: group Mediated: no	Seven 2.5-hour sessions Frequency: weekly Duration: 7 weeks	Instrument: investigator developed measure of time in exercise, reported validity, and reliability testing Follow-up: 6 months	Intervention group exercised significantly more than control group
Montgomery ¹⁹	N = 290 Subjects: patients with Parkinson's disease Sex: unstated Minority: unstated Ages: 69	Health education, feedback. Individualized: computer-generated personalized letters Theory: social cognitive theory Supervised exercise: no	Setting: home Context: individual Intervenor: unstated Format: instruction Mediated: mail	Three mailings Frequency: every 2 months Duration: 6 months	Instrument: investigator developed measure of exercise frequency Follow-up: unstated	Significantly more experimental subjects than control subjects exercised
Sims ²⁵	N = 20 Subjects: elderly patients Sex: 35% female Minority: unstated Ages: 72	Motivational interviewing. Individualized: personalized exercise plan Theory: transtheoretical model Supervised exercise: no	Setting: home Context: individual Intervenor: nurse Format: instruction Mediated: telephone	Three sessions Frequency: every 2 to 4 weeks Duration: 6 weeks	Instrument: previously developed leisure activity measure and heart rate monitors Follow-up: 2 weeks	No significant differences between groups in leisure physical activity
Trujillo ²⁶	N = 46 Subjects: older adults Sex: 84% female Minority: 37 African-American Ages: 68 (≥55)	Health education, self-monitoring. Individualized: no Theory: unstated Supervised exercise: no	Setting: unstated Context: individual Intervenor: doctoral student Format: instruction Mediated: no	One session Frequency: n/a Duration: n/a	Instrument: investigator developed self-report of physical activity with test-retest reliability reported Follow-up: 1 month	No significant difference in physical activity scores between treatment and control groups

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Table 2. Characteristics of Randomized Controlled Trials Focused on Activity other than Walking (Continued)

Author*	Sample†	Motivational Content, Individualized, Theoretical Basis, and Supervised Exercise‡	Intervention Delivery§	Intensity/Treatment Dose	Outcome Measures¶	Results¶¶
Van Baar ²⁷	N = 201 Subjects: Dutch adults with hip or knee osteoarthritis Sex: 79% female Minority: unstated Ages: 68 (40–85)	Health education. Individualized: no Theory: unstated Supervised exercise: no	Setting: unstated Context: individual Intervenor: physiotherapist (supervised exercise) and physician (instruction) Format: instruction Mediated: no	Unstated Frequency: one to three times per week for supervised exercise (depending on pain) Duration: 3 months	Instrument: previously developed self-report measure of physical activity Follow-up: at completion of intervention	No significant difference in activity scores between treatment and control groups
Yaffe ²³	N = 35 Subjects: community-dwelling elders Sex: 66% female Minority: unstated Ages: 65 (55–82)	Modeling, commitment, self-monitoring, relapse prevention education, reinforcement, goal setting, problem solving, barrier management Individualized: personalized exercise program Theory: social learning theory Supervised exercise: no	Setting: university Context: researcher formed group Intervenor: unstated Format: instruction Mediated: no	One session Frequency: n/a Duration: n/a	Instrument: investigator developed exercise log Follow-up: 1.5 months	No group differences in exercise behavior

* First citation presented outcome data furthest from the intervention; other citations presented preliminary or related findings.

†Ages are mean (range).

‡Individualized interventions are adopted for each subject.

§Mediated included any delivery medium other than face-to-face encounters (e.g., telephone, mail).

¶Follow-up time reflects the interval between completion of the intervention and measurement of the outcome variable.

¶¶Results comparing treatment group with control group.

n/a = not available; CHAMPS = Community Health Activities Model Program for Seniors.

studies did not define criteria of success or compare their results with any external success criteria. Studies examined differences in scores, without attention to any external criteria of success.

In the reviewed studies, individuals were randomized to treatment groups. In future studies, random assignment of existing social units, such as families or volunteer or religious organizations, might more fully reflect older adults' existing powerful social relationships. Randomizing by groups would require significantly more individual subjects, but a small number of initial studies might determine whether this is a fruitful area of research. Multilevel interventions, those aimed at the personal, social network, and community level, have yet to be examined in older adults.

Sampling plans have inadequately addressed the heterogeneity of old age despite clear evidence that subject attributes can have a profound effect on responsiveness to interventions.⁴ For example, few studies included significant numbers of old-old subjects (≥ 85), and none were focused on this vulnerable subgroup. Overly broad categories of subjects can obscure important differences.⁹ Fewer than half of the studies noted their minority enrollment, and Hispanic elders were rarely included. Results are seldom reported by sex, despite some evidence that this may be important.⁹ It remains unclear whether the presence of particular chronic illnesses, such as arthritis, influences intervention effectiveness. Aging adults who are least likely to participate in physical activity studies constitute a major challenge because they may be those most in need of increased activity.⁸ Future investigations need to explore treatment effectiveness in terms of the diversity of older adults.

The form of exercise or physical activity recommended to aging adults needs to be further examined. Lifestyle activity recommendations encourage older adults to accumulate minutes of physical activity spread over the entire day. Some recent evidence suggests potential beneficial effects of lifestyle activity and the probability that some aging adults may be more receptive to lifestyles activity changes than episodic exercise. Only one of the RCT studies focused on lifestyle physical activity,¹² although others measured overall physical activity and thus may have encouraged lifestyle activity. Frequently, research reports provided limited information about the nature of physical activity suggested to subjects. Only six studies focused on walking behavior, despite walking being the predominant form of physical activity by older adults. Walking is an easily accessible activity that older adults may perceive as "natural." In contrast, older adults may perceive that other forms of exercise are more "work" and require more structure. This important dimension of recommended physical activity needs additional research.

The importance of intervention delivery setting has not been fully explored in this area of research. For example, seven of the nine studies targeting specific patient populations reported positive results. Yet only two studies used primary healthcare settings for intervention delivery. Most older adults visit their providers at least yearly, and these interventions may reach elders most likely to benefit from activity but least likely to volunteer for exercise interventions in other settings. Setting also may be important if it represents a valuable component of older adults' lives. Al-

though several studies delivered interventions in senior, retirement, or community centers likely to be familiar to aged subjects, only one study delivered interventions in a religious organization setting.¹⁷ Evidence that religious organization-based programs may be effective suggests that this location should be tested.

Alternative modes of intervention delivery have not been extensively explored with older adults. For example, none of the motivational interventions were delivered via the Internet. Aging adults are rapidly acquiring access to the Internet, and future cohorts will be computer literate and accustomed to receiving information in this format. Instruction remains the dominant mode of motivation information delivery. Alternative delivery modes that are more respondent participatory, and thus draw on aging adults' extensive life experiences, might be particularly useful in this population.

This review was limited to studies attempting to increase endurance (aerobic or cardiovascular) exercise or overall physical activity. Evidence of the benefits of resistance and flexibility exercise is accumulating.² Future reviews will likely find sufficient numbers of studies designed to increase other forms of exercise. Several studies document the potential to increase activity among aging adults, but several studies, often with similar interventions, do not report success in changing activity behavior. These mixed findings suggest that additional primary research is necessary. Further development of this science requires suitably large RCTs with psychometrically sound measures of activity behavior at least 6 months after the intervention. In addition, research reports must provide sufficient details about methods and interventions to allow meaningful interpretation of findings.

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