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REVIEW & ANALYSIS

Exercise Intervention Research on Persons with Disabilities

What We Know and Where We Need to Go

ABSTRACT

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The purpose of this article was to provide a comprehensive review of the exercise intervention literature on persons with physical and cognitive disabilities. Electronic searches were conducted to identify research articles published from 1986 to 2006. Of the 80 physical activity/exercise interventions identified in the literature, only 32 were randomized controlled trials. The remaining studies were nonrandomized controlled trials with ($n = 16$) and without ($n = 32$) a control group. There was a mixture of exercise training modalities that involved aerobic (26%), strength (25%), and combined aerobic and strength (23%) exercises, but there were no overlapping studies using the same dose of exercise for any of the 11 disability groups. Almost half the studies targeted stroke (20%), multiple sclerosis (15%), and intellectual disability (13%), with significantly fewer studies targeting other disability groups. The current literature on exercise and disability is extremely broad in scope and has limited generalizability to any specific disability group. A new body of evidence is needed with stronger research designs that adhere to precise dosing characteristics for key health outcomes (e.g., pain/fatigue reduction, improved cardiorespiratory health). Multicenter trials will be needed for low-prevalence populations to strengthen research designs and increase generalizability of study findings.

Key Words: Disabled Persons, Exercise, Physical Activity, Randomized Controlled Trials

On October 7, 2008, the U.S. Department of Health and Human Services issued the first-ever federal report, Physical Activity Guidelines for Americans[1] (http://www.hhs.gov/news/press/2008pres/10/20081007a.html). The report provides strong scientific evidence that regular physical activity reduces the risk of a number of preventable health conditions, improves psychological well-being, and helps prevent weight gain and obesity.[2–4] The report also recommends that people with disabilities engage in regular physical activity but notes that there is limited to no evidence for certain health outcomes and disability groups.

Although most experts would agree that physical activity is an important goal for maintaining good health among adults with disabilities,[5–7] the breadth and scope of physical activity/exercise interventions targeting people with physical and cognitive disabilities have received relatively less attention in the research literature.[8,9] There is an urgent need to identify effective physical activity/exercise interventions for people with disabilities. According to the Physical Activity Guidelines for Americans report, physical activity is defined as any bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above a basal level. Commonly used categories include occupational, leisure time or recreational, household, self-care, and transportation or commuting activities. Exercise is a subcategory of physical activity that is planned, structured, repetitive, and purposive in the sense that the improvement or maintenance of one or more components of physical fitness is the objective. Data from a recent Centers for Disease Control and Prevention report[10] indicate that approximately twice as many adults with a disability (respondents were classified as having a disability if they reported having activity limitations because of physical, mental, or emotional problems, or if they required the assistance of special equipment, such as a cane, wheelchair, special bed, or special telephone) (25.6%) were physically inactive during the preceding week compared with adults without a disability (12.8%). This finding was consistent with previous studies that also reported significantly lower rates of physical activity among people with disabilities compared with the general population.[11,12] Patterns of low physical activity observed among people with disabilities raise serious concerns regarding their health and well-being, particularly as they enter their later years when the effects of the natural aging process are compounded by years of sedentary living and resultant severe deconditioning.[13]

There is a growing movement in the medical rehabilitation field to move toward evidence-based practice, i.e., integrating current research, clinical experiences, and stakeholder perspectives.[14] Evidence-based decision making is the purposeful and ongoing use of "current best evidence" or the "weight of evidence" in making decisions about how a program should be operated or what policy should be adopted.[15,16] Although there is a good body of literature on exercise interventions for people with disabilities, there has never been a quantitative review of these studies from the perspective of the type of disability, research design, exercise modality, setting where the intervention was conducted (i.e., clinic *vs.* community), and key health outcomes. Without a comprehensive understanding of these parameters, it is difficult for researchers to build from the existing literature in an effort to advance the science and to establish a stronger evidence base. Therefore, the primary focus of this article was to provide a rapid evidence review on the qualitative aspects of published physical activity/exercise interventions that have been conducted on people with disabilities. Existing gaps in research are noted with recommendations for future research.

METHODS

The studies for the current review were selected from the Disability and Health Promotion Scoping Review Matrix (the Matrix), which is a database of systematically identified articles on the topic of health promotion interventions for people with disabilities. The Matrix provides a tool for completing rapid evidence reviews summarizing the literature on specific topics related to disability and health promotion.

Unlike general literature reviews, scoping reviews and systematic reviews use the same principles and rigor that are used in primary research,[17] including the use of specific protocols to increase impartiality in study identification, appraisal, and synthesis, thereby reducing bias.[18] General literature reviews include select studies that the researcher is interested in describing related to a certain topic area, and the studies that are discussed or reviewed do not adhere to a formal set of review criteria. Systematic reviews are more appropriate for understanding narrowly drawn research questions within an established field. Scoping reviews are valuable to understand the broader "research landscape" in a field of inquiry and to provide a preliminary assessment of the research as reported in a rapid evidence review.[18] Scoping reviews are particularly important as a "stand-alone" project when a research area (such as disability and physical activity) does not have uniformity in study design and measurement[19] or to determine the feasibility or value of conducting a full systematic review or both.[20,21]

English-language peer-reviewed primary literature and review articles that examined health promotion (i.e., physical activity/exercise interventions) among adults (18–65 yrs) with disabilities were included in the review. Disability was defined as someone with a mobility, sensory, or cognitive impairment. Mental health disabilities, although important, were not included in this review.

Subject heading searches identified citations from MEDLINE, PsycInfo, and CINAHL databases from 1986 through July 2006. Subject headings used to identify the population (e.g., disabled person, central nervous system diseases, developmental disabilities) were combined with two sets of subject headings used to identify health promotion interventions (e.g., health education, nutrition, exercise) with general health-related subject headings related to health (e.g., health behavior, risk reduction behavior, quality of life). The full list of subject headings used with the searches in each database is included in the Appendix.

Article citations were excluded at the abstract level if they met the following exclusion criteria:

not disability related, not health promotion related, medically oriented treatment studies, descriptive studies, discussion articles, or program descriptions, non-English language, published before 1986, all study participants younger than 18 yrs or older than 65 yrs, and non-peer-reviewed publications (i.e., dissertations, chapters, non-peer-reviewed articles, and conference presentations). The reason for excluding studies involving participants aged 65 yrs and older was to control for aging-related factors that may attenuate the potential impact of the exercise interventions on younger individuals with disabilities. The literature that was not excluded at the abstract level was used to create a database referred to as the Disability and Health Promotion Scoping Review Matrix. The final Matrix contained 330 cited articles. All articles were coded at the abstract level according to three criteria, including disabling condition, functional disability, and health promotion topic.

Selection Criteria

The abstracts were assigned as many codes as relevant for each of the two variables. For the current review, we included studies that were assigned the physical activity health promotion topic code and the functional disability codes physical/mobility, physical/other than mobility, cognitive/intellectual disability/developmental disabilities, or cognitive/acquired. This physical activity code was assigned to studies that focused on increasing physical activity, exercise, weight loss, or fitness. Functional disability was translated, according to a rubric developed for this study, from the disabling condition or term (e.g., spinal cord injury and wheelchair user) described in the abstract unless it was explicitly specified in the text (e.g., "mobility impairment").

There were 135 citations in the Matrix database. To determine the effect of physical activity/exercise interventions on key health outcomes, only studies that met the following criteria were included: (1) interventions; (2) health outcomes as dependent variables; and, most importantly, (3) physical activity/exercise program could be implemented in a community-based exercise setting (e.g., health club and fitness facility). For this last reason, studies involving therapeutic exercise modalities such as body weight-supported treadmill training, functional electrical stimulation, and constraint-induced movement therapy were excluded. Eighty studies were included in the final analysis.

Data Extraction and Synthesis

For studies that met the inclusion criteria, one reviewer extracted the data from the abstract for each individual trial by type of disability, research design, mode of physical activity, and targeted health outcome(s). The research design was classified into one of the following categories: (1) randomized controlled trial (RCT); (2) non-RCT (i.e., subjects were not randomly assigned to an intervention or control group); (3) pre- and posttrial with no control group; (4) single-subject design; (5) case study; and (6) qualitative in-depth interview. Type of exercise was listed under the following headings: (1) aerobic training, including walking; (2) strength training; (3) flexibility training; (4) balance training; (5) aquatic physical activity; (6) Tai-Chi, Qigong, or Yoga; (7) education courses; and (8) combined exercise training program that applied more than one type of exercise such as aerobic and strength training.

Targeted health outcomes were categorized according to the 2008 Physical Activity Guidelines for Americans report,[1] which include the following domains: (1) functional health (e.g., functional ability to perform certain tasks such as walking or completing activities of daily living); (2) cardiorespiratory health (e.g., cardiorespiratory fitness and cholesterol reduction); (3) musculoskeletal health (e.g., muscle strength, endurance, flexibility, and bone mineral density); (4) metabolic health including healthy weight (e.g., insulin resistance, insulin sensitivity, body fat, and body weight); and (5) mental health (e.g., depression, cognition, and fatigue).

RESULTS

Search Results

Table 1 provides a breakdown of the review process. After the literature search was completed using the keyword search, 3987 articles were identified. The first-level review involved the development of the Matrix; there were 135 articles related to exercise. A second-level review was conducted to identify studies that were strictly physical activity/exercise interventions. Among the 135 citations in the Matrix, 19 additional studies were excluded because they were clinical rehabilitation interventions (e.g., gait training, functional electrical stimulation, constraint-induced movement training, and robot-assisted training), and 28 studies were excluded because they were noninterventions, including correlational studies, literature reviews, and commentaries. Two studies were excluded because study participants were persons with fibromyalgia ($n = 1$) and hyperkyphosis ($n = 1$), which are not specific disability types. Another six studies were excluded because they did not measure the targeted health outcomes. A total of 80 studies met the inclusion criteria and were included in the final analysis.

Characteristics of Physical Activity/Exercise Interventions

Table 2 provides the characteristics of the 80 interventions by disability, research design, exercise

TABLE 1 Classification of articles

	No. Citations	No. Excluded	No. Included	Totals
Results of electronic keyword search	3987	—	—	—
Round 1—for Matrix	—	—	—	—
Excluded at abstract level (exclusion criteria: not English language, not disability related, not peer reviewed, not health promotion, outside targeted age range [18–65 yrs], motivational intervention, outside targeted publication year [1986 to July 2006])	—	−3657	330	—
Round 2—for current review	—	—	—	—
Exercise studies	135	—	—	—
Excluded at abstract level (exclusion criteria: primary intervention involved a rehabilitation modality or technique)	—	−19	—	—
Excluded at abstract level (Exclusion criteria: nonintervention studies)	—	−28	—	—
Excluded at abstract level (Exclusion criteria: nonspecific disability type)	—	−2	—	—
Excluded at abstract level (Exclusion criteria: nonhealth-related outcomes)	—	−6	—	—
Articles included in review	—	—	—	80

type, and targeted health outcomes. Stroke[22–37] (n = 16, 20.0%), multiple sclerosis[38–49] (n = 12, 15%), intellectual disability including Down syndrome[50–59] (n = 10, 12.5%), and cross-disability[60–66] (n = 7, 8.8%) had the highest number of published physical activity/exercise trials, whereas Alzheimer disease[67–69] (n = 3, 3.8%) and amyotrophic lateral sclerosis[70,71] had the least number of trials (n = 2, 2.5%). The remaining studies (37%) were spread across traumatic brain injury, spinal cord injury, cerebral palsy, polio, muscular dystrophy, and Parkinson disease. Because one of the exclusion criteria was an age cutoff of 65 yrs, studies on Parkinson and Alzheimer diseases were reported only for subjects <65 yrs.

Research Design

Thirty-two of the 80 physical activity/exercise interventions (40.0%) were RCTs; approximately one-third of the studies (n = 22, 27.5%) were pre- and postinterventions with no control group; and the remaining studies were non-RCTs (n = 16, 20.0%), case studies (n = 4, 5%), qualitative interviews (n = 3, 3.8%), and single-subject designs (n = 2, 2.5%). One study[72] did not report its methodology.

Exercise Type

Aerobic (n = 21, 26.3%) and strength exercises (n = 20, 25.0%) were the most common forms of exercise used across the 80 physical activity/exercise interventions. For wheelchair users, upper-body ergometry was the most common exercise modality, whereas for subjects who were able to walk with or without an assistive aid, walking on level ground or on a treadmill was the most common form of exercise. Strength training included three common modalities: elastic bands, free weights, and weight machines. Approximately 23% (n = 18) of the studies reported multiple exercise types that included a combination of aerobic, strength, flexibility, or balance training. There were only a few exercise training studies that used group exercise that included aquatics (n = 8, 10%), Tai-Chi (n = 2, 2.5%), Yoga (n = 1, 1.3%), and Qigong (n = 1, 1.3%).

Health Outcomes

Functional health (n = 50, 62.5%) was the most commonly targeted health outcome, which included walking capacity, functional independence, balance, quality of life, motor function, and pain reduction. This was followed by musculoskeletal health (n = 34, 42.5%), which included muscle strength, muscular endurance, flexibility, bone mineral density, and cardiorespiratory health (n = 22, 27.5%), which included cardiorespiratory fitness, lipids and fibrinolysis. Only 12.5% of the studies (n = 10) examined the effects of an exercise intervention on improving metabolic health, which included weight reduction and weight management. Nearly 26% (n = 21) of the studies targeted one or more mental health outcomes, including reduction in depression or fatigue or improvements in social interaction and cognition.

Characteristics of Physical Activity/Exercise Interventions by Disability Group

Table 3 provides the characteristics of each intervention by disability group and whether the study outcomes were significant or nonsignificant.

Research Design

There were a greater number of RCTs reported for stroke ($n = 10$), multiple sclerosis ($n = 7$), and traumatic brain injury ($n = 3$) compared with the other disability groups. Pre- and postresearch designs were more common in studies involving intellectual disability, spinal cord injury, cerebral palsy, and muscular dystrophy. Other types of research designs used with cerebral palsy, polio, stroke, multiple sclerosis, cross-disability, and traumatic brain injury included non-RCTs, single-subject designs, case studies, and qualitative interviews.

The mean sample size (experimental and control groups combined) for the 32 RCTs ranged from 12 to 210. Thirty-eight percent ($n = 12$) had a sample size <30; 25% ($n = 8$) had a sample size between 31 and 60; and only 37.5% ($n = 12$) had sample sizes >60. Specifically, the mean sample size for RCTs involving subjects with traumatic brain injury, cerebral palsy, polio, and amyotrophic lateral sclerosis was <30.

TABLE 2 Percent and number of exercise/physical activity interventions by disability, research design, exercise type, and health outcome ($n = 80$)

Characteristic	Percentage	*n*
Disability		
Stroke	20.0	16
Multiple sclerosis	15.0	12
Cross-disability[a]	8.8	7
Intellectual disability including Down syndrome	12.5	10
Traumatic brain injury	7.5	6
Spinal cord injury	6.3	5
Cerebral palsy	7.5	6
Polio	7.5	6
Muscular dystrophy	5	4
Parkinson disease	3.8	3
Alzheimer disease	3.8	3
Amyotrophic lateral sclerosis	2.5	2
Research design		
Randomized controlled trial	40.0	32
Pre- and posttrial (without control group)	27.5	22
Nonrandomized controlled trial	20.0	16
Case study	5	4
Qualitative interview	3.8	3
Single subject design	2.5	2
Unavailable	1.3	1
Exercise type		
Aerobic	26.3	21
Strengthening	25.0	20
Combined (i.e., more than one type)	22.5	18
Education (i.e., workshop on exercise knowledge)	6.3	5
Aquatic	10	8
Tai-Chi	2.5	2
Qigong	1.3	1
Yoga	1.3	1
Flexibility	1.3	1
Balance	1.3	1
Unavailable	2.5	2
Health outcome[b]		
Functional health	62.5	50
Musculoskeletal health	42.5	34
Cardiorespiratory health	27.5	22
Mental health	26.3	21
Metabolic health including healthy weight	12.5	10

[a]Study included more than one disability group.
[b]Adds up to >100% because several studies targeted more than one health outcome.

Exercise Type

Aerobic exercise was the most common type of exercise used with individuals with stroke ($n = 6$), muscular dystrophy ($n = 2$), and Parkinson disease ($n = 2$). Strength training was more often used with individuals with multiple sclerosis ($n = 4$), cerebral palsy ($n = 3$), polio ($n = 3$), and amyotrophic lateral sclerosis ($n = 2$). In addition to the two primary exercise types (aerobic and strength), combined exercise, which was composed of more than one type of exercise modality, was used more often with individuals with spinal cord injury ($n = 4$), intellectual disability ($n = 4$), and cross-disability ($n = 3$). Aquatic exercise interventions ($n = 8$) were used with individuals with traumatic brain injury ($n = 3$), polio ($n = 2$), multiple sclerosis ($n = 2$), and stroke ($n = 1$). Alternative modes of exercise, including Tai-Chi, Yoga, and Qigong, were used only in a few studies with individuals with multiple sclerosis (Tai-Chi, $n = 1$ and Yoga, $n = 1$), muscular dystrophy (Qigong, $n = 1$), and Parkinson disease (Tai-Chi, $n = 1$). Other physical activity/exercise modes for individuals with intellectual disabilities ($n = 3$) involved an educational program that introduced ways to increase physical activity.

Health Outcomes

Functional health was the most examined health outcome in the interventions involving stroke ($n = 14$), multiple sclerosis ($n = 11$), cross-disability ($n = 4$), and Parkinson disease ($n = 3$). Musculoskeletal health was the most targeted health outcome for individuals with cerebral palsy ($n = 5$), traumatic brain injury ($n = 4$), and polio ($n = 3$). Musculoskeletal health and metabolic health were the two primary health outcome categories ($n = 5$) for individuals with intellectual disability, whereas mental health was the most commonly targeted health outcome for individuals with Alzheimer disease ($n = 3$). There were a few areas where studies reported nonsignificant findings on specific health outcomes, with the greatest number under functional health for stroke ($n = 5$), multiple sclerosis ($n = 4$), and cross-disability ($n = 1$). However, in each of these cases, there were

TABLE 3 No. studies by disability group and characteristics of intervention

Disability (No. Study)	Research Design (Mean Sample Size; Range)	Exercise Type	Health Outcomes (Significant *vs.* Nonsignificant Findings)[a]
Stroke (n = 16)[22–37]	RCT: 10[22,25,27,28,30,31,33–36] (n = 46; 12–92)	Aerobic: 6[23,24,26–28,32]	FH: 13[22,24,25,28–37] *vs.* 5[22,27,28,30,31]
	Non-RCT: 2[23,37] (n = 24; 18–30)	Strengthening: 4[25,34–36]	CRH: 5[23,26,30,31,37] *vs.* 0
	Pre- and posttrial: 3[24,26,29] (n = 16; 5–25)	Combined: 4[22,29,31,33]	MSH: 6[24,25,30,31,34,37] *vs.* 0
	Case study: 1[32] (n = 1; 1)	Aquatic: 1[30]	MBH: 1[37] *vs.* 0
	—	Education: 1[37]	MH: 1[37] *vs.* 0
Multiple sclerosis (n = 12)[38–49]	RCT: 7[38,41,42,45–47,49] (n = 70; 26–113)	Aerobic: 2[41,49]	FH: 9[39–41,43–48] *vs.* 4[38,45,46,49]
	Non-RCT: 1[40] (n = 8; 8)	Strengthening: 4[38,39,45,48]	CRH: 2[41,49] *vs.* 1[46]
	Pre- and posttrial: 3[39,44,48] (n = 16; 7–31)	Combined: 1[46]	MSH: 5[38,43,46,48,49] *vs.* 0
	Case study: 1[43] (n = 1; 1)	Aquatic: 2[43,44]	MBH: 0 *vs.* 0
	—	Tai-Chi: 1[40]	MH: 5[39,41,42,44,49] *vs.* 3[42,45,48]
	—	Yoga: 1[42]	—
	—	Education: 1[47]	—
Cross-disability (n = 7)[60–66]	RCT: 3[60,64,66] (n = 112; 33–210)	Aerobic: 1[63]	FH: 3[61,62,66] *vs.* 1[65]
	Non-RCT: 1[61] (n = 89; 89)	Strengthening: 2[61,64]	CRH: 1[63] *vs.* 0
	Pre- and posttrial: 2[62,63] (n = 15; 3–27)	Flexibility: 1[60]	MSH: 2[61,66] *vs.* 0
	Interview: 1[65] (n = 19; 19)	Combined: 3[62,65,66]	MBH: 0 *vs.* 1[60]
	—	—	MH: 0 *vs.* 2[64,65]
Intellectual disability including Down syndrome (n = 10)[50–59]	RCT: 2[57,58] (n = 34; 14–53)	Aerobic: 2[52,56]	FH: 3[50,57,58] *vs.* 0
	Non-RCT: 4[50,53,54,59] (n = 70; 17–189)	Strengthening: 1[57]	CRH: 2[56,59] *vs.* 1[51]
	Pre- and posttrial: 4[51,52,55,56] (n = 56; 6–192)	Combined: 4[50,51,58,59]	MSH: 4[50,56,57,59] *vs.* 1[51]
	—	Education: 3[53–55]	MBH: 2[55,59] *vs.* 3[53,54,56]
	—	—	MH: 2[52,58] *vs.* 0
Traumatic brain injury (n = 6)[74–79]	RCT: 3[75–77] (n = 17; 16–18)	Aerobic: 2[74,78]	FH: 3[74,75,79] *vs.* 0
	Non-RCT: 2[74,79] (n = 18; 8–27)	Balance: 1[79]	CRH: 2[76,78] *vs.* 0
	Case study: 1[78] (n = 1; 1)	Aquatic: 3[75–77]	MSH: 4[75–78] *vs.* 0
	—	—	MBH: 2[75,76] *vs.* 0
	—	—	MH: 1[77] *vs.* 0
Spinal cord injury (n = 5)[80–84]	RCT: 1[81] (n = 42; 42)	Aerobic: 1[82]	FH: 2[81,83] *vs.* 0
	Non-RCT: 1[84] (n = 38; 38)	Combined: 4[80,81,83,84]	CRH: 0 *vs.* 0
	Pre- and posttrial: 3[80,82,83] (n = 14; 7–19)	—	MSH:1[78] *vs.* 0
	—	—	MBH: 1[80] *vs.* 0
	—	—	MH: 2[82,84] *vs.* 0
Cerebral palsy (n = 6)[72,85–89]	Pre- and posttrial: 2[87,89] (n = 16; 10–22)	Aerobic: 1[88]	FH: 4[85,87–89] *vs.* 0
	Single-subject design: 2[86,88] (n = 4; 3–4)	Strengthening: 3[85,86,89]	CRH: 2[73,88] *vs.* 0
	Qualitative interview: 1[85] (n = 10; 10)	Combined: 1[87]	MSH: 4[85,86,88,89] *vs.* 1[87]
	Unavailable: 1[72] (n = 7; 7)	Unavailable: 1[72]	MBH: 0 *vs.* 0
	—	—	MH: 2[85,88] *vs.* 1[85]

TABLE 3 Continued

Disability (No. Study)	Research Design (Mean Sample Size; Range)	Exercise Type	Health Outcomes (Significant *vs.* Nonsignificant Findings)[a]
Polio (*n* = 6)[90–95]	RCT: 1[93] (*n* = 23; 23)	Aerobic: 1[90]	FH: 1[93] *vs.* 1[94]
	Non-RCT: 2[90,94] (*n* = 16; 3–28)	Strengthening: 3[91–93]	CRH: 1[90] *vs.* 1[94]
	Pre- and posttrial: 1[91] (*n* = 41; 41)	Aquatic: 2[94,95]	MSH: 3[91,92,95] *vs.* 1[94]
	Case study: 1[92] (*n* = 1; 1)	—	MBH: 0 *vs.* 0
	Qualitative interview: 1[95] (*n* = 15; 15)	—	MH: 0 *vs.* 0
Muscular dystrophy (*n* = 4)[96–99]	RCT: 1[99] (*n* = 36; 36)	Aerobic: 2[96,97]	FH: 1[99] *vs.* 0
	Non-RCT: 1[96] (*n* = 8; 8)	Strengthening: 1[98]	CRH: 2[96,97] *vs.* 0
	Pre- and posttrial: 2[97,98] (*n* = 11; 9–12)	Qigong: 1[99]	MSH: 2[97,98] *vs.* 0
	—	—	MBH: 0 *vs.* 0
	—	—	MH: 0 *vs.* 0
Parkinson disease (*n* = 3)[100–102]	Non-RCT: 2[101,102] (*n* = 19; 15–23)	Aerobic: 2[100,102]	FH: 3[100–102] *vs.* 0
	Pre- and posttrial: 1[100] (*n* = 8; 8)	Tai-Chi: 1[101]	CRH: 1[100] *vs.* 0
	—	—	MSH: 0 *vs.* 0
	—	—	MBH: 0 *vs.* 0
	—	—	MH: 1[101] *vs.* 0
Alzheimer disease (*n* = 3)[67–69]	RCT: 2[68,69] (*n* = 95; 36–153)	Aerobic: 1[68]	FH: 2[67,69] *vs.* 0
	Pre- and posttrial: 1[67] (*n* = 24; 24)	Combined: 1[67]	CRH: 1[67] *vs.* 0
	—	Unavailable: 1[69]	MSH: 0 *vs.* 0
	—	—	MBH: 0 *vs.* 0
	—	—	MH: 3[67–69] *vs.* 0
Amyotrophic lateral sclerosis (*n* = 2)[70,71]	RCT: 2[70,71] (*n* = 18; 10–25)	Strengthening: 2[70,71]	FH: 1[71] *vs.* 0
	—	—	CRH: 0 *vs.* 0
	—	—	MSH: 1[70] *vs.* 0
	—	—	MBH: 0 *vs.* 0
	—	—	MH: 0 *vs.* 0

[a]Some studies reported significant and nonsignificant results on specific health outcomes. Therefore, the total number of studies with significant and nonsignificant findings is higher than the number of studies reported for a specific disability group.

FH, functional health; CRH, cardiorespiratory health; MSH, musculoskeletal health; MBH, metabolic health including healthy weight; MH, mental health.

more exercise trials that reported significant findings for each disability group.

Table 4 summarizes the number of physical activity/exercise interventions by disability group and subcategories of health outcomes. The most frequently targeted subdomain health outcomes were muscle strength (*n* = 27), cardiorespiratory fitness (*n* = 21), and improved walking capacity (*n* = 18). The least studied outcomes were pain reduction, flexibility, and social interaction (*n* = 5); improved cognition and reduction in body weight (*n* = 3); improved lipid profile (*n* = 2); and increased bone mineral density (*n* = 2).

DISCUSSION

Although there is strong scientific evidence confirming the benefits of regular physical activity/exercise as a powerful mediator for improving various aspects of physical and psychological health in the general population,[1] there is substantially less research on the associated benefits of exercise in people with physical and cognitive disabilities. The 80 exercise trials identified in this review were spread across 11 different disability groups (including one category that combined two or more types of disabilities) and targeted several different health outcomes. Only 32 of the 80 studies (40.0%) were RCTs. The remaining studies used quasi-experimental designs (e.g., non-RCTs, pre- and posttrials, and case studies), which are notably less rigorous and limit their potential use in being translated into clinical practice. Although this is a major limitation of the existing physical activity/exercise research literature, non-RCTs reporting positive

TABLE 4 No. studies by disability group and subcategories of health outcomes

	Functional Health							CR Health		Musculoskeletal Health				Metabolic Health		Mental Health				
Disability	Walking Capacity	Functional Independence	Quality of Life	Balance	Motor Function	Pain	Other	CR Fitness	Lipids/ Fibrinolysis	Muscle Strength	Muscular Endurance	Flexibility	Bone Mineral Density	Body Weight /BMI	Body Fat	Depression	Social Interaction	Cognition	Fatigue	Other
Stroke (n = 16)	8	7	2	5	3	—	—	4	2	5	1	1	1	1	—	—	1	—	—	—
MS (n = 12)	6	2	3	3	1	1	—	3	—	4	1	—	—	—	—	2	2	1	6	—
Cross (n = 7)	1	—	2	—	1	—	—	1	—	2	—	—	—	1	—	1	—	1	—	—
ID (n = 10)	1	—	2	1	—	—	1[a]	3	—	4	1	1	—	4	1	1	—	—	—	1[b]
TBI (n = 6)	—	—	—	2	1	—	—	2	—	3	1	2	—	—	2	—	—	—	1	1[c]
SCI (n = 5)	—	—	1	—	—	2	—	—	—	—	—	—	1	1	—	1	—	—	—	—
CP (n = 6)	—	2	—	—	2	—	—	2	—	3	—	1	—	—	—	—	1	—	1	1[d]
Polio (n = 6)	—	—	—	—	—	2	—	2	—	3	—	—	—	—	—	—	—	—	—	—
MD (n = 4)	—	—	—	1	—	—	—	2	—	2[e]	—	—	—	—	—	—	—	—	—	—
PD (n = 3)	1	—	1	2	1	—	—	1	—	—	—	—	—	—	—	—	1	—	—	—
AD (n = 3)	1	—	—	—	1	—	—	1	—	—	—	—	—	—	—	2	—	1	—	1[f]
ALS (n = 2)	—	1	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Total no. interventions (n = 80)[g]	18	12	11	14	10	5	1	21	2	27	4	5	2	7	3	7	5	3	8	4

[a]Vocational capacity.[57]
[b]Maladaptive behavior.[52]
[c]Self-esteem.[77]
[d]Self-perception.[88]
[e]Muscle fiber diameter (n = 1).[97]
[f]Quality of sleep.[68]
[g]Number across outcome categories adds up to >80 studies because most studies targeted more than one outcome.
MS, multiple sclerosis; Cross, cross-disability; ID, intellectual disability including Down syndrome; TBI, traumatic brain injury; SCI, spinal cord injury; CP, cerebral palsy; MD, muscular dystrophy; PD, Parkinson disease; AD, Alzheimer disease; ALS, amyotrophic lateral sclerosis.

outcomes can serve as a framework for conducting more rigorously designed studies in the future.

Although the RCT is regarded as the gold standard for determining the efficacy and effectiveness of an exercise trial, there are several challenges in implementing such interventions in individuals with disabilities. First, it is often very difficult to obtain an adequate sample size for conducting a RCT, especially for low-incidence disability groups such as spina bifida, spinal cord injury, muscular dystrophy, cerebral palsy, and others. Second, randomization might raise some ethical concerns because there is a potential benefit associated with exercise, and "withholding treatment" could be an issue with some institutional review boards. Third, RCTs can be very expensive, especially when conducted in clinical settings that require transportation, extensive staff time, and laboratory resources.

The most exercise training studies were reported on adults with stroke (20.0%). This is not surprising, given the high incidence of this condition compared with other disability groups such as amyotrophic lateral sclerosis and polio. Although there are significant gaps in the exercise intervention literature for most groups with physical and cognitive disabilities, the least studied groups should receive the highest priority. These include individuals with spinal cord injury, cerebral palsy, traumatic brain injury, and muscular dystrophy.

Studies that reported positive outcomes were rarely, if ever, replicated. For example, one study[30] used aquatic training to improve cardiorespiratory fitness in a stroke cohort and had the largest recorded gain in peak oxygen uptake (22%). However, this study was never replicated, and in general, aquatic training has seldom been used with stroke patients and other disability groups. Similarly, exercise programs that have been effective with seniors such as Tai-Chi and Yoga also have been rarely used with populations with disabilities. Although it may be difficult to recruit large enough samples to conduct a group exercise class using these exercise modalities, aquatic exercise could be done on an individual basis in settings that have a swimming pool or therapeutic pool, and exercise programs such as Tai-Chi and Yoga could be conducted in the home setting using an exercise video developed specifically for the target population.

The majority of studies targeted functional health as the primary outcome domain (62.5%). This is not surprising, given the impairments associated with various types of physical disabilities, which often require improvements in walking capacity, functional independence, quality of life, balance, and motor function. The least targeted health outcomes were lipid reduction, increases in bone mineral density, reduced body weight/body fat reduction, and improved mental health (i.e., cognition).

A few studies included individuals with a wide range of function and age, which may have attenuated the potential effects of the training regimen on certain subgroups within the larger sample (e.g., underdosing of exercise prescription for younger *vs.* older subjects or subjects with less impairment). Although heterogeneous populations make it easier to recruit subjects (e.g., including individuals with paraplegia and tetraplegia in the same study) and obtain higher levels of statistical power, subjects with better levels of health and function may be able to participate in higher doses of exercise resulting in better health gains. Whenever possible, studies should be designed with more homogeneous samples in terms of age, health status, and functional level, or in cases when this is not possible, the exercise exposure may be able to be adjusted higher (i.e., intensity and duration) to accommodate and challenge individuals with greater levels of health and function.

Study Limitations

Interventions that included other aspects of health promotion (e.g., nutrition and health behavior counseling) were not included in this review because it was not possible to isolate the specific benefit of the exercise component from the other intervention components. Certain search terms may not have captured all of the studies on a specific disability group. Studies involving adults older than 65 yrs were not reported, which limits the findings associated with the age-related conditions of Parkinson disease and Alzheimer disease. Studies were not evaluated for their methodologic quality. Given that the data were coded at the abstract level for each individual study, ~45% of the studies did not report information related to where the study was conducted (e.g., home, clinic, and community). In the future, it would be helpful to qualify the 32 RCTs identified in this review based on certain selection criteria such as adequate sample size (i.e., computing effect sizes to determine whether each study had adequate power), equal groups (control and experimental) at baseline, blinding of study staff (i.e., different assessors for pre- and posttesting), recording of participant completion and dropout, identification of adverse events, and statistical rigor (i.e., intention-to-treat analysis and effect size).

Future Research

There is a need for researchers to develop exercise interventions that address specific disability groups and use variations in dose (i.e., intensity, frequency, duration, and type) to prevent or reduce the onset or occurrence of certain secondary conditions (e.g., weight gain, depression, pain, and fatigue) prominent in many individuals with physical and cognitive disabilities. The lack of specificity or replication of physical activity/exercise trials pertaining to the frequency, intensity, duration, and modality components of an exercise prescription for individuals with a specific disability has limited their potential use in clinical and community practice.

It is difficult to make comparisons between studies when instruments are not the same or not explained well enough to make critical comparisons between them. Given the small sample of many disabled subgroups, it would be helpful to have a recommended set of instruments for each targeted outcome with good psychometric properties so that data from various studies can be compared with each other. Moreover, the majority of outcome measures in the included studies were muscle strength, cardiorespiratory fitness, and walking capacity. There is a need to advance this research by examining the effects of exercise on more global measures such as functional health, reduction of secondary conditions (e.g., pain, fatigue, obesity, and depression), and participation in community activities (e.g., work and leisure).

The heterogeneity between and within disability groups and the low incidence of many disabilities make it extremely difficult to obtain adequate sample sizes when recruiting subjects from one setting. Multicenter clinical exercise trials are necessary for achieving adequate statistical power and for generalizing findings to certain disability groups and, ideally, to certain subgroups within a specific disability (i.e., subjects with greater or lesser health and function). Intervention fidelity is an extremely important part of conducting multicenter exercise trials so that data can be aggregated across settings. With the use of video technology, the host site could oversee an intervention at another location to ensure that the study protocol is being adhered to and to allow researchers to respond to questions in real time.

Innovative strategies for recruiting individuals who generally do not volunteer for research studies must become a high priority. Because most experimental research is conducted with volunteers, it is difficult to generalize the findings of the study to the entire subgroup. People who volunteer for exercise-related research may generally be younger or have a higher functional level or both. This is a common problem in experimental research but may be an even greater issue among people with disabilities because sample selection is limited to a small subset of the population, and certain barriers (e.g., transportation) may limit opportunities for participating in clinical research.

Given the complexity in identifying and recruiting individuals with disabilities for exercise intervention research, classifying subjects by function rather than disability may be an alternative approach to increase recruitment size and identify key health outcomes that generalize across disability groups. The use of the International Classification of Functioning, Disability and Health model[73] would allow researchers to identify specific eligibility criteria by impairment (e.g., lower-limb paralysis) and/or activity limitation (e.g., inability to walk).

Researchers must move toward establishing a stronger evidence base that supports the use of certain physical activity/exercise protocols for specific subgroups of individuals with physical and cognitive disabilities. What may be effective for improving certain health outcomes in adults with multiple sclerosis may not necessarily be as effective for individuals with spastic cerebral palsy or paraplegia. To advance physical activity/exercise research in adults with physical and cognitive disabilities, researchers should become familiar with the new Department of Health and Human Services Physical Activity Guidelines for Americans report[1] and consider using this document as a roadmap for addressing specific gaps in the physical activity/exercise literature on various subpopulations of adults with physical and cognitive disabilities.

CONCLUSION

There is a critical need to establish a stronger evidence base that can support the use of physical activity/exercise in clinical and community practice for various subgroups of adults with physical and cognitive disabilities. More rigorously designed studies (i.e., RCTs) are needed to examine the effects of various doses of exercise on key health outcomes (e.g., functional health, mental health). Researchers must conduct more structured exercise trials that build on previous research and maintain a higher level of fidelity regarding the target disability group (i.e., type and severity of disability and associated impairments and activity limitations), exercise testing instruments, and exercise exposure (i.e., dose, type, and setting). This will provide a stronger evidence base that will help support the translation of these findings into practice.

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APPENDIX: Complete list of subject headings

	Heading List 1	Heading List 2	Heading List 3
MEDLINE	Sensation disorders Central nervous system diseases Developmental disabilities Cognition disorders Abnormalities Demyelinating autoimmune diseases, central nervous system Mental retardation Fetal alcohol syndrome Neurodegenerative diseases Muscular dystrophies Disabled persons Communication disorders Chromosome aberrations	Counseling Health education Health promotion Nutrition Exercise Exercise movement techniques Primary prevention	Quality of life Activities of daily living Health behavior Health status Comorbidity Outcome and process assessment (health care) Attitude to health Risk Risk-reduction behavior Pilot projects Disability evaluation Cohort studies Program evaluation Intervention studies
PsycInfo	Somatosensory disorders Central nervous system disorders Central nervous system Developmental disabilities Cognitive impairment Cognitive ability Autism Neuropathology Brain damage Fetal alcohol syndrome Multiple sclerosis Nervous system disorders Muscular dystrophy Neurodegenerative diseases Communication disorders Down syndrome Chromosome disorders Fragile X syndrome Sensory system disorders Neuromuscular disorders Mental retardation Physical disorders Disabilities	Counseling Health education Health promotion Nutrition Exercise Motor performance Primary prevention Prevention Risk management	Quality of life Activities of daily living Health behavior Health Well-being Health status Self-perception Comorbidity Healthcare utilization Healthcare delivery Healthcare services Primary health care Attitude to health Risk perception At-risk populations Risk factors Behavior change Risk management Risk reduction behavior Risk assessment Disability evaluation Cohort analysis Program evaluation Intervention Treatment outcomes Treatment effectiveness evaluation Attitudes Outcome and process assessment (as title, abstract, heading word, table of contents, and key concepts search) Pilot project or plan program (as title, abstract, heading word, table of contents, and key concepts search)
CINAHL	Sensation disorders Central nervous system diseases Developmental disabilities Cognition disorders Abnormalities Demyelinating diseases Mental retardation Fetal alcohol syndrome Neurodegenerative diseases Muscular dystrophies Disabled Communication disorders Chromosome abnormalities	Counseling Health education Health promotion Nutrition Exercise Preventive health care	Quality of life Activities of daily living Health behavior Health status Comorbidity Outcomes Attitude to health Patient attitudes Risk factors Attitude to risk Pilot studies Disability evaluation Cohort studies Program evaluation Intervention studies