A Systematic Review of the Outcomes of Cardiovascular Exercise Programs for People With Down Syndrome

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A Systematic Review of the Outcomes of Cardiovascular Exercise Programs for People With Down Syndrome

Karen J. Dodd, PhD, Nora Shields, PhD


Objective: To determine if cardiovascular exercise programs are beneficial and safe for people with Down syndrome.

Data Sources: Electronic databases were searched from the earliest time available through to October 2004 using the following key words: Down syndrome or trisomy 21 in combination with physical fitness, exercise, physical activity, exercise therapy, exercise training, physical training, and aerobic. Additional articles were identified by manual searching and citation tracking.

Study Selection: Two reviewers independently assessed the articles identified in the initial search for the following inclusion criteria: (1) participants with Down syndrome, (2) an exercise program that conformed with the American College of Sports Medicine guidelines for increasing cardiovascular fitness, (3) assessed changes in body structure or function, activity limitation, or societal participation, and (4) used a prospective clinical controlled research design with or without random allocation to groups. Trials of low methodologic quality were excluded (PEDro score, <4). Of the 156 articles initially identified, only 4 met the inclusion criteria and underwent detailed review.

Data Extraction: Data relating to changes in body structure and function, activity limitation, participation restriction, and contextual factors from the included studies were independently extracted by the reviewers on a standardized form. Study quality was assessed using the PEDro scale.

Data Synthesis: Meta-analyses found that cardiovascular exercise programs were effective in increasing peak oxygen consumption (d = .75; 95% confidence interval [CI], 0.34–1.15), peak minute ventilation (d = .71; 95% CI, 0.15–1.28), the maximum workload achieved (d = .96; 95% CI, 0.45–1.45), and the time to exhaustion (d = .72; 95% CI, 0.29–1.15) in people with Down syndrome. No changes were found for body weight (d = .09; 95% CI, −.39 to .57). No adverse effects were reported in any of the studies.

Conclusions: The result of our review support the use of programs designed to improve cardiovascular fitness among people with Down syndrome. However, because only 4 studies were included, the findings need to be interpreted cautiously. High-quality randomized controlled trials should be completed in the future to determine the effect of these programs on activity and social participation.

Key Words: Down syndrome; Physical fitness; Physical therapy (specialty); Rehabilitation.

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PEOPLE WITH DOWN SYNDROME have lower levels of cardiovascular fitness than the rest of the community, including people with intellectual disability but without Down syndrome.1-3 Sedentary behavior as well as the physical impairments commonly associated with the condition, such as muscle weakness and hypotonia, and a higher prevalence of heart defects and circulatory abnormalities, low maximal heart rates, and pulmonary abnormalities have been suggested as reasons for their poor levels of physical fitness.4-6

Physical fitness is an umbrella term incorporating the characteristics of cardiovascular fitness, body composition, flexibility, and muscular strength and endurance, and refers to the ability to perform moderate levels of physical activity without undue fatigue.7 Like the rest of the community, it is thought that poor cardiovascular fitness puts people with Down syndrome at a greater risk of health problems such as type 2 diabetes, cardiovascular diseases, osteoporosis, and obesity.8 It can also affect their ability to work, perform activities of daily living, or participate in sporting and recreational activities.7 For these reasons, there has been an increased interest in developing and implementing programs that improve the cardiovascular fitness and ultimately the health and physical activity of people with Down syndrome.9

In people without Down syndrome, cardiovascular exercise has been shown to have a range of benefits. For example, in groups as diverse as adults with human immunodeficiency virus (HIV) or acquired immune deficiency syndrome (AIDS),9 people with rheumatoid arthritis,10 and those with mild to moderate heart failure,11 cardiovascular exercise programs have been found to improve cardiovascular fitness as measured with outcomes such as maximal oxygen consumption (Vo2max) (the maximal volume of oxygen the body can consume during exercise) and peak minute ventilation (the volume of air taken into or exhaled from the body in 1min). In people with coronary heart disease, cardiovascular exercise has been reported to significantly reduce mortality.12 Cardiovascular exercise programs also appear to be effective in increasing exercise endurance, work capacity, and distance walked in 6 minutes in people with heart failure.11 In persons with rheumatoid arthritis, improvements have been found in muscle strength, joint flexibility, and distance walked.10 Studies also suggest that cardiovascular exercise programs in combination with dietary advice are effective in improving weight loss in people with obesity13 and that, once a more normative weight has been gained, cardiovascular exercise has been found to assist these persons in maintaining their weight loss.14,15 Other benefits include psychologic well-being found in people with HIV or AIDS16 and in people diagnosed with clinical depression,16 as

From the Musculoskeletal Research Centre, School of Physiotherapy, La Trobe University, Victoria, Australia.

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Correspondence to Karen Dodd, PhD, Musculoskeletal Research Centre, School of Physiotherapy, La Trobe University, Victoria, 3086, Australia, e-mail: K.Dodd@latrobe.edu.au. Reprints are not available from the author.

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well as perceived quality of life in older men and women, and people with heart failure.

The American College of Sports Medicine (ACSM) guidelines recommend that cardiovascular exercise programs for people with Down syndrome should comprise sessions of 20 to 60 minutes of aerobic activity, performed 3 to 7 times each week, at an intensity of 55% to 90% of peak heart rate or 40% to 85% of maximum oxygen uptake reserve. These recommendations were developed from expert clinical opinion and a review of the literature on the effects of cardiovascular exercise for people with intellectual disability. However, the review appeared to include few studies that focused specifically on people with Down syndrome. Therefore, it remains uncertain whether these exercise guidelines are beneficial and safe for people with Down syndrome. Some authors have suggested that the physiologic impairments associated with Down syndrome (including lower peak oxygen consumption [VO2peak], peak heart rate and respiratory exchange ratio) might limit the ability to improve cardiovascular fitness levels, whereas others have suggested that adherence to these programs can lead to significant improvements in physiologic variables and, therefore, improve cardiovascular fitness.

The purpose of this review was to provide clinicians with evidence about the benefits and risks of cardiovascular exercise programs for people with Down syndrome by conducting a systematic review and meta-analysis of the available literature.

METHODS

Search Strategy and Selection Criteria

We searched electronic databases (MEDLINE, 1966 to October 2004; EMBASE, 1988 to October 2004; AMED, 1985 to September 2004; PsychInfo, 1967 to October 2004; Sportsdiscus, 1830 to October 2004; AusSport Med, 1989 to October 2004; ERIC, 1966 to October 2004; CINHAL, 1982 to October 2004; Cochrane library; ProQuest Digital Dissertations index, 1861 to October 2004) to identify relevant articles using the following key words: Down syndrome or trisomy 21 in combination with physical fitness, exercise, physical activity, exercise therapy, exercise training, physical training, and aerobic. Additional articles were located by manually searching the reference lists of identified articles, directly contacting researchers actively publishing in the area, and by searching the CENTRAL register of controlled clinical trials. We also tracked references of included studies and authors names through the Science Citation Index.

Two reviewers (KJD, NS) independently assessed the title and abstract of the articles identified by the search strategy against the following inclusion criteria: (1) participants with a diagnosis of Down syndrome, (2) assessed the effects of an aerobic exercise program that conformed with the ACSM guidelines for increasing cardiovascular fitness, (3) assessed changes in participants body structure or function, activity limitation or societal participation, and (4) used a prospective clinical controlled research design with or without random allocation to groups, or was a literature review that included a meta-analysis. Articles were excluded if the study was of low methodologic quality (scored <3 on the PEDro scale, see below) or if data were repeated in another included report. In cases where the latter occurred, the report that was published in a peer-reviewed journal was retained. No language restrictions were imposed. If the title and abstract did not clearly indicate whether the article should be included, the complete article was obtained to determine whether it met all 4 inclusion criteria. Disagreements were resolved by consensus.

Quality Assessment

The methodologic quality of included empirical studies was assessed using the PEDro scale. This scale scores studies between 0 and 10 depending on whether the following items of methodologic rigor are present or absent: random allocation of participants, concealed group allocation, prognostic similarity of participants at baseline, blinding of participants, blinding of therapists, blinding of assessors, greater than 85% follow-up of participants for at least 1 key outcome, intention-to-treat analysis, between-group statistical analysis for at least 1 key outcome, and provision of point estimates of variability for at least 1 key outcome. For each item, 1 point is awarded when that criterion is met. An 11th item (specified eligibility criteria) is included in the scale but is not scored. To be included in the review, trials were required to achieve a PEDro score of 4 or more.

The quality of the included articles was independently assessed by the 2 reviewers. Interobserver agreement was calculated using a weighted k statistic that rated the degree of disagreement between the final quality assessment scores of the reviewers using quadratic weights. To further improve reliability of the scale, any differences in an article’s assigned score between the reviewers were resolved by consensus.

Data Extraction

The International Classification of Functioning, Disability and Health framework considers health-related outcomes according to body structure (eg, changes in body weight) and body function (eg, changes in respiratory function such as changes in measures of VO2peak), functional activity (eg, changes in walking or running endurance), and social participation (eg, changes in the ability to gain employment). Consistent with this classification system, the study data relating to the advantages and disadvantages of programs designed to improve cardiovascular fitness were examined, as was the influence that personal and environmental contextual factors might have on program outcomes.

Data from the included studies were independently extracted by the (nonblinded) reviewers on a standardized form developed for this review. The following data were extracted: study design, sample size, subjects’ demographic data, program content and intensity, outcome measures, results, adverse effects, and contextual factors. The contextual factors of interest were the age, sex, and cognitive functioning of participants, and whether the exercise programs were completed individually or in groups and whether the programs were conducted in a clinical, laboratory, or a community setting.

Data Analysis

To enable comparison among the outcomes reported in each of the primary trials, effect sizes with 95% confidence intervals (CIs) were obtained. Effect sizes were calculated by subtracting the mean of the control group postintervention from the mean of the experimental group postintervention, divided by the standard deviation of the control group. In accordance with Cohen’s convention, effect sizes of d less than 0.20 were considered small, effect sizes between d equal to 0.20 and d equal to 0.50 were considered medium, and effect sizes greater than d equal to 0.50 were considered large.

A meta-analysis (ie, a statistically combined estimate of effect size and associated 95% CI across the primary trials) was conducted to provide an estimate of the overall effect of cardiovascular training programs on outcomes that were considered similar enough to pool. Clinical and statistical heterogeneity were examined before statistical analysis was conducted.
Clinical heterogeneity refers to differences in clinically relevant items such as participant demographics, program content, and training intensity, and the outcome measures used. Statistical heterogeneity refers to the variability in treatment outcomes investigated in the different primary trials. Either a fixed- or random-effects model can be used when analyzing pooled data. A fixed-effects model assumes that any variability among the different effect sizes is due to random variation, and so this model is most appropriate if data are statistically homogeneous. In contrast, a random-effects model assumes that variability is due to a combination of random sampling error and systematic sources of variation. A random-effects model is recommended when data are heterogeneous. To decide which model should be used, the statistical heterogeneity of effect sizes was examined using the Q statistic. For this review, we used a conservatively high significance threshold (P < .1) to reduce the possibility of statistical heterogeneity having an impact on the results. All calculations were done using MetaView, version 5.3.5 Sensitivity analysis (specified a priori) was conducted to investigate if removing the largest trial or a trial that included a combination program (eg, cardiovascular and strength training) had an impact on the findings.

RESULTS

The initial search strategy identified 156 articles. After screening the titles and abstracts of these articles, 18 potentially relevant articles remained. All were empirical studies. Of these, 5 articles were excluded because they did not use a clinical controlled research design.6,10,26-30 1 article was excluded because it did not have Down syndrome, and 2 were excluded because of poor methodologic quality. This left a total of 3 randomized controlled trials (RCTs), and 1 non-RCT for detailed review. Table 1 summarizes the findings of the included trials.

As table 1 shows, study quality measured with the PEDro scale ranged from 5 to 6 out of 10, with a median score of 6. For this review, we did not expect that participants or clinicians implementing the program would be blind to the intervention; therefore, a maximum score of 8 was predicted. None of the trials reported that outcome measurements were taken by an assessor blind to group allocation, and no study used adequate concealed allocation of participants to groups. All control data were collected from participants who had not participated in any regular physical training. The interobserver reliability of assessing the methodologic quality of the articles was κ equal to .75, with a disagreement of only 1 point in 1 of the articles.

The exercise programs were fairly similar. As the table shows, all programs comprised low-impact exercises such as brisk walking, rowing, cycling, or jogging. The exercise sessions were typically conducted in 30-minute sessions held 3 times a week, and the duration of programs were short, ranging from 10 to 16 weeks. Short warm-up and cool-down periods were included as part of each program. One of the programs included a 15-minute progressive resistance exercise program in addition to the aerobic exercises.

Motivational strategies were an integral part of all of the programs. Strategies included use of physical reinforcement (eg, pat on the back), visual reinforcement (eg, a smile), edible reinforcement (eg, a healthy food), or verbal reinforcement (eg, an approving comment like “good job”), as well as the ability to choose the equipment they would use at each session.

Effect on Body Function

All of the studies reported sufficient data to calculate effect sizes for changes in the body function of people with Down syndrome after participation in a cardiovascular exercise program (see fig 1). As the figure illustrates, a positive outcome was found for cardiovascular fitness as measured by relative VO2peak. Although 2 of the individual trials had CIs that crossed 0 (the line of no effect), when the results of the 4 studies were aggregated into a fixed-effects model, the total sample of 107 subjects showed there was a significant effect for exercise training (d = .75, z = 3.60, P < .001). The largest individual effect size was found for a group of 15 men with a mean age of 24.6 ± 3.3 years who completed a 12-week jogging and walking training program held 3 times a week. 3 of the included studies measured VO2peak instead of VO2max. VO2max is usually measured during a maximal (graded) exercise test and is taken as the point when oxygen consumption ceases to increase with a corresponding increase in workload. A “true” VO2max is often difficult to determine precisely because people, such as those with an intellectual disability, may stop the exercise test before oxygen consumption plateaus. In this case they are considered to have reached their VO2peak. The percentage mean change from baseline in VO2peak ranged between 1% and 20%, with the 2 larger studies reporting changes on the order of 15% and 20%, respectively.

Three studies reported sufficient data to calculate the effect size of training on peak minute ventilation (see fig 1). An increase in peak minute ventilation suggests improvement in ventilatory capability. Meta-analysis using a fixed-effects model suggested that cardiovascular fitness programs significantly increased ventilation values after training (d = .71, z = 2.46, P = .007). An increase in workload results in a linear increase in VO2peak and a corresponding curvilinear increase in peak minute ventilation. Therefore, this result is consistent with the findings for VO2peak.

Two trials reported sufficient data to calculate the effect size of training on maximum workload capacity (see fig 1). Meta-analysis showed there was an increase in maximum workload (d = .96, z = 3.69, P < .001). An additional study also reported a significant increase on workload after participating in a treadmill walking program, but insufficient data were reported and so an effect size for this outcome could not be calculated.

Three studies reported the effects of training on outcome measures related to physical endurance, ie, the ability of the body to perform a moderately strenuous activity over a period of time (see fig 1). A meta-analysis of these 3 trials found that the length of time participants with Down syndrome could exercise before they reached exhaustion was increased (d = .72, z = 3.30, P < .001). The percentage mean change from baseline to time to exhaustion ranged between 23% and 27%.

Effect on Body Structure

The effect that cardiovascular training has on body weight was reported in 2 trials. Meta-analysis revealed that the training programs had no effect on body weight (d = .09, z = .34, P = .368). Similarly, the individual effect sizes did not show changes in percentage body fat (d = .30; 95% CI, -0.69 to 1.29) or body mass index (d = .04; 95% CI, -0.51 to 0.59).

Effect on Activity and Participation

No empirical evidence was found about the effects that cardiovascular exercise programs might have on the psychologic functioning, functional activities, or on societal partici-
Table 1: A Summary of the Findings of the 4 Articles Included in This Review

<table>
<thead>
<tr>
<th>Author</th>
<th>PEDro Score</th>
<th>Sample Size</th>
<th>Mean Age (SD y)</th>
<th>Sex</th>
<th>Severity of Intellectual Disability</th>
<th>Previous Exercise Participation</th>
<th>Program Details</th>
<th>Training Intensity</th>
<th>Body Structure/Function Outcomes</th>
<th>Activity and Participation Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rimmer et al⁷*</td>
<td>6</td>
<td>52</td>
<td>39.4±6.4</td>
<td>29 W, 23 M</td>
<td>Mild to moderate</td>
<td>Sedentary for at least 1y prior to the program</td>
<td>30min aerobic machine-based (eg, treadmill, stationary bicycle) exercise program, 15min PRE; 3/wk for 12wk</td>
<td>50%–70% V\textsubscript{O}\text{\textsubscript{2}} peak</td>
<td>V\textsubscript{O}\text{\textsubscript{2}} peak; time to exhaustion; bench press and leg press 1-RM; grip strength; body weight and BMI</td>
<td>ND</td>
</tr>
<tr>
<td>Tsimaras et al⁸²</td>
<td>5</td>
<td>25</td>
<td>24.6±3.3</td>
<td>25 M</td>
<td>IQ 45–60</td>
<td>Not reported</td>
<td>10-min warm-up, 30min jog/walking program; 3/wk for 12wk</td>
<td>65%–75% max HR assessed at start of program</td>
<td>V\textsubscript{O}\text{\textsubscript{2}} peak, VSpeak, time to exhaustion</td>
<td>ND</td>
</tr>
<tr>
<td>Varela et al¹¹*</td>
<td>6</td>
<td>16</td>
<td>21.4±3.0</td>
<td>16 M</td>
<td>Mean IQ 38.8</td>
<td>Not reported</td>
<td>10-min warm-up, 25-min rowing program, 10-min cool down; 3/wk for 16wk</td>
<td>55%–70% V\textsubscript{O}\text{\textsubscript{2}} peak</td>
<td>V\textsubscript{O}\text{\textsubscript{2}} peak, VSpeak, time to exhaustion, distance traveled, work level reached; body weight, body fat percentage</td>
<td>ND</td>
</tr>
<tr>
<td>Millar et al⁹⁰*</td>
<td>6</td>
<td>14</td>
<td>17.7±2.9</td>
<td>3 W, 11 M</td>
<td>IQ 30–70</td>
<td>Not reported</td>
<td>10-min warm-up, 30-min brisk walking/jogging, 10-min cool down program; 3/wk for 10wk</td>
<td>65%–75% max HR</td>
<td>V\textsubscript{O}\text{\textsubscript{2}} peak, VSpeak, time to exhaustion</td>
<td>ND</td>
</tr>
</tbody>
</table>

Abbreviations: 1-RM, 1 repetition maximum; BMI, body mass index; HR, heart rate; IQ, intelligence quotient; max, maximum; M, men; ND, no data; PRE, progressive resistance exercise; SD, standard deviation; VSpeak, peak ventilation; W, women.

*Signifies the RCTs.
pation or self-perceived quality of life in people with Down syndrome.

Negative Effects

No unexplained withdrawals or negative effects such as injuries were reported in any of the studies. This suggests that cardiovascular exercise programs are safe for people with Down syndrome. However, only 1 study specifically addressed this issue, stating there were no unusual electrocardiographic (heart) symptoms exhibited during exercise testing. Therefore, it is possible that, although relatively minor adverse events such as muscle soreness or fatigue did occur, they were not systematically recorded or reported. A number of studies did report use of strategies to decrease the risk of injuries. For example, in 1 study, assistants maintained close supervision to "ensure safety," and in another, a modified exercise regime and testing procedures were used to reduce the risk of injuries.

Sensitivity Analysis

Sensitivity analyses were conducted to explore whether the removal of the largest and also the combined cardiovascular and progressive resistance exercise program would affect the findings of this review. Excluding this trial did not change the significance of the time taken to reach exhaustion ($d = 1.19$; 95% CI, 0.52–1.86), the maximum workload achieved ($d = 1.64$; 95% CI, 0.51–2.77), or body weight ($d = 0.20$; 95% CI, −0.78 to 1.18). However, excluding the trial decreased the estimated effect of training on VO$_2$peak (relative) ($d = 0.52$; 95% CI, −0.40 to 1.43).

Contextual Factors

Environmental factors. Programs were typically conducted for groups of 5 to 7 participants with the assistance of 1 exercise supervisor to 2 to 4 participants with Down syndrome. The professional background of people employed to lead and support participants during the program was often not reported, but at least 2 programs employed people with knowledge of exercise prescription, such as an exercise physiologist and physical education teachers. Two programs were conducted in a laboratory setting, and the other 2 were held in community settings. These community settings were a municipal gymnasium and a community rowing club. Use of exercise equipment varied across the programs. However, 3 programs used moderately expensive exercise equipment, including motorized treadmills, stationary bicycles, and rowing machines.

Personal Factors

As shown in Table 1, the effects of cardiovascular exercise have been studied more extensively in men with Down syndrome. Although 2 studies included both men and women, 1 of these samples comprised a higher proportion of men. The remaining 2 studies investigated only men. As table 1 shows, the intellectual ability of the participants as measured with tools such as the Stanford-Binet Intelligence Scale did not seem to adversely affect the findings. Participants with a range of scores suggesting mild to quite severe intellectual impairment experienced benefits from the programs.

The impact that a participant’s age might have on the effects of a cardiovascular program remain largely unknown. This is because, apart from 1 trial that included older adults aged between 28 and 55 years, all other trials were conducted on adolescents and young adults with Down syndrome. It is not known if young children or older people with Down syndrome can benefit from cardiovascular training programs.
The effects of concurrent health problems on the ability to participate in cardiorespiratory exercise programs remain unclear because all of the studies excluded subjects with a history of cardiac problems, metabolic disease, or orthopedic problems. Health conditions such as these are known to be more prevalent in people with Down syndrome. Therefore, the effects that these concurrent problems might have on the ability to participate in exercise programs are an important issue to consider because they affect the generalizability of findings.

The efficacy of an exercise program is dependent on both the effectiveness of the program and program adherence. Adherence rates can also provide clinicians with indirect evidence about the clinical feasibility and acceptability of the training program to the participants. None of the studies reported on adherence to the training program, but none reported withdrawals from the program. It also remains unknown if people with Down syndrome can retain the benefits of training over time, because none of the trials included a follow-up measurement session after completion of the program.

**DISCUSSION**

The sedentary lifestyle of people with Down syndrome is believed to be among the main factors contributing to their decreased levels of physical fitness. This in turn can increase their risk of health problems and can reduce their employment, social, and recreational opportunities. The results of this review indicate that cardiovascular exercise programs that conform to the ACSM guidelines for people with Down syndrome can be an effective means of improving the physical fitness of these people.

Meta-analyses found programs were effective in increasing the maximum workload achieved ($d = 96; 95\% CI, 0.44–1.47$), the time to exhaustion ($d = 72; 95\% CI, 0.29–1.15$), VO$_{2\text{peak}}$ ($d = 75; 95\% CI, 0.34–1.15$), and peak minute ventilation ($d = 71; 95\% CI, 0.15–1.28$) in people with Down syndrome. The findings of this review suggest that exercise sessions should be around 30 minutes in duration at an intensity of 50% to 75% of VO$_{2\text{peak}}$ and that sessions should be held 3 times a week for between 12 and 16 weeks. Positive changes in fitness were achieved using relatively simple activities such as jogging, cycling or rowing.

No unexplained withdrawals or negative effects were reported in any of the studies, suggesting that cardiovascular exercise programs are safe for people with Down syndrome. A common limitation of the included studies, however, was the lack of a blinded assessor. It has been suggested that effect sizes can be overestimated by as much as 35% when assessments are not blinded. Therefore, the findings of this review may overestimate the true effects of cardiovascular exercise training programs for people with Down syndrome.

Relative VO$_{2\text{peak}}$ is commonly used as a key indicator of cardiovascular fitness. VO$_{2\text{peak}}$ is determined by cardiac output, ie, the product of heart rate and stroke volume. Of these 2 variables, stroke volume is the primary determinant of VO$_{2\text{peak}}$. An increase in stroke volume will produce an increase in VO$_{2\text{peak}}$ and because stroke volume is known to be increased by training, an increase in VO$_{2\text{peak}}$ is also expected. The mechanism by which stroke volume increases includes changes to the heart’s structure through ventricular wall remodeling, producing hypertrophy of the myocardium, and an increase in chamber size, and changes in the peripheral circulation including increased blood volume and increased blood vessels in skeletal muscle, providing an increased blood flow and venous return.

A meta-analysis of the 4 included studies found an overall improvement in relative VO$_{2\text{peak}}$ values. However, sensitivity analysis revealed this to be influenced by the results reported by Rimmer et al who incorporated progressive resistance exercises into their program. One explanation for this finding might be that, although the focus of progressive resistance exercise is not to improve VO$_{2\text{peak}}$, it has been found that this type of exercise can produce changes in this parameter. In addition, a strong correlation has been found between VO$_{2\text{peak}}$ and leg strength in people with Down syndrome. Therefore, these results might suggest that a combined program of progressive resistance and aerobic exercise may have a larger impact on cardiovascular fitness than aerobic exercise alone in people with Down syndrome.

An alternative explanation might be that some people with Down syndrome may only have the capacity for a small change in VO$_{2\text{peak}}$ because of the physiologic anomalies associated with their condition, such as heart abnormalities, pulmonary hypoplasia, and hypotonia. The lower peak heart rates at high exercise intensities associated with Down syndrome may also reduce the ability to improve VO$_{2\text{peak}}$, which is dependent on cardiac output. Therefore, the larger sample size included in the study of Rimmer et al may have been needed to detect a change. The expected percentage change in VO$_{2\text{peak}}$ from a cardiovascular training program based on the ACSM exercise guidelines in people without disabilities is 10% to 15%. The observed percentage change in VO$_{2\text{peak}}$ found in our review of people with Down syndrome was 1% to 20%. Therefore, although it appears that some people with Down syndrome are capable of achieving only a small increase in their VO$_{2\text{peak}}$ through cardiovascular training, others appear to be capable of a degree of change in VO$_{2\text{peak}}$ through cardiovascular training similar to that of people without disabilities.

Large effect sizes were reported for both endurance-related outcomes (maximum workload achieved and time to exhaustion). In the case of time to exhaustion, the percentage mean change from baseline was over 20%, corresponding to participants continuing with a maximal exercise test for an additional 1.5 to 3.4 minutes. This is likely related to the participants changing from a sedentary lifestyle to participating in an exercise program that included an endurance element. Although the implications of these changes for people with Down syndrome are unknown, it is possible that this increased level of endurance could significantly affect their ability to perform skills such as activities of daily living, community integration, and employment. The latter is of particular importance because the employment of people with Down syndrome often depends on their ability to perform light to moderate levels of physical labor.

The inability of cardiovascular programs to significantly reduce body weight is in agreement with previous research in healthy populations. Previous trials of people without impairments have shown that use of exercise alone has only a modest effect on body mass. Dieting is a more effective means of altering body mass, and a combination of dieting and exercise is even more effective.

High staff-participant ratios were 1 characteristic of the programs implemented. Because the participants with Down syndrome were easily distracted and they required close supervision to ensure that they exercised at the required intensities, programs were run in small groups (5–7 participants) with a ratio of 1 staff for 2 to 4 participants.

Motivational strategies were also fundamental to all of the programs. For example, Millar et al found that constant positive reinforcement was necessary—otherwise participants stopped exercising immediately. This strategy was particularly important in the early stages when participants were adapting to an exercise program, but another study found that the benefits of exercise could be sustained by the time to exhaustion (d = 0.11; 95% CI, 0.04–0.18), which is likely related to the participants changing from a sedentary lifestyle to participating in an exercise program that included an endurance element. Although the implications of these changes for people with Down syndrome are unknown, it is possible that this increased level of endurance could significantly affect their ability to perform skills such as activities of daily living, community integration, and employment. The latter is of particular importance because the employment of people with Down syndrome often depends on their ability to perform light to moderate levels of physical labor. The inability of cardiovascular programs to significantly reduce body weight is in agreement with previous research in healthy populations. Previous trials of people without impairments have shown that use of exercise alone has only a modest effect on body mass. Dieting is a more effective means of altering body mass, and a combination of dieting and exercise is even more effective.

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amount of input could be gradually reduced as the program progressed.

Three of the programs used moderately expensive exercise equipment. However, this equipment would be readily available in community gymnasiums and in many clinics. It may also be possible to substitute the tasks described in these programs for others that do not require sophisticated equipment, for example, track running instead of treadmill running. The choice of what type of equipment to use may also depend on the age range of the participants. For example, Rimmer commented that stationary bicycling was useful for older people with Down syndrome in terms of comfort and safety because many participants had poor balance and coordination skills and refused to walk on a treadmill.

Although the outcome of this review suggests that programs designed to improve cardiovascular fitness can be beneficial for people with Down syndrome, it is unknown whether changes brought about by cardiovascular training can be retained by this population over time because no study included a follow-up phase. The effect that a participant’s age, sex, or concurrent health problem might have on program outcomes or on a person’s ability to participate in these programs also remains largely unknown. It is also unknown what the effect of an exercise program has on the ability of people with Down syndrome to undertake daily functional tasks, on their ability to participate in work or social-related activities, and on their psychologic well-being and quality of life. There is also a need to determine the implications of longer term exercise training regimens. These issues need to be addressed in future studies.

CONCLUSIONS

The results of this review support the use of cardiovascular programs for people with Down syndrome. However, only 4 studies meet the inclusion criteria of the review and, therefore, further research needs to be completed before it can be confidently concluded that these types of programs are beneficial for these people. It is possible that adverse effects from training may occur in the Down syndrome population and, because previous studies have not reported on this issue, clinicians should remain cautious when instigating a treatment regimen. High-quality RCTs should be completed in the future to determine the effect of these programs on activity and social participation.

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References


Supplier
a. National Collegiate Clearinghouse, Box 8101, NCSU, Raleigh, NC 27695.