Dual-Energy X-Ray Absorptiometry to Measure the Influence of a 16-Week Community-Based Swim Training Program on Body Fat in Children and Adolescents With Intellectual Disabilities

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Objective: To use dual-energy x-ray absorptiometry (DXA) to measure the effects of a 16-week community-based swim training program on percent body fat in children and adolescents with intellectual disability (ID).

Design: Convenience sample.

Setting: University sport complex and exercise science laboratory.

Participants: Children and adolescents (n=8; mean age ± SD, 13.1 ± 3.4y), 2 girls and 6 boys with ID, of varying fat levels (11%–35%).

Intervention: A swim training program lasting for the duration of 16 weeks with three 1-hour sessions held at a 25-m pool each week.

Main Outcome Measure: Assessing percent body fat at pretest and posttest through the use of DXA.

Results: After the 16-week exercise training program, we observed a 1.2% median increase in body fat percentage with a range from –0.3% to 4.5%. Wilcoxon matched-pairs signed-ranks tests suggest that these results are statistically significant (P = 0.039; exact).

Conclusions: Exercise training alone proved ineffectual in reducing percent body fat in 8 children and adolescents with ID. Further research should consider implementing a combined diet and exercise program. To gauge the effectiveness of intervention programs, valid methods and complex measurement tools such as DXA should be used to assess changes in percent body fat in such a heterogeneous population.

Key Words: Absorptiometry, photon; Body composition; Rehabilitation; Swimming.

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PEOPLE WITH INTELLECTUAL disabilities may be 30% more obese and 7% more extremely obese than people without ID.1 A lack of participation in physical activity remains a serious concern,2,3 and there exists an urgent need to find effective interventions to address and prevent elevated levels of obesity among people with ID.4 Research has associated obesity with a number of health concerns such as coronary heart disease, type 2 diabetes, and osteoarthritis.5 Heyward and Stolarczyk6 recommended researchers assess percent body fat levels because people may be classified as obese if they possess excessive body fat even if they are not necessarily defined as overweight according to body mass index. However, an extensive literature review6 on nutrition and people with ID emphasized the limited number of validated anthropometric methods and acceptable guidelines for classifying adiposity based on health risk for people with ID. Researchers found that the discrepancy in measurement methods made it virtually impossible to undertake a meta-analysis of weight-related nutritional risk research in this population.

Certain studies have already demonstrated that participation in exercise training programs by people with ID may contribute to a decrease in percent body fat.7,8 However, additional preventative research has shown percent body fat might not necessarily change after exercise-alone programs.9-10 More specifically, children or adolescents have not decreased in percent body fat after involvement in various exercise training programs.9,11 The variation in the type of measurement used to estimate percent body fat might explain the fairly inconsistent results produced in the limited number of studies conducted to date. In order to calculate percent body fat accurately, researchers have thus far used anthropometric methods such as bioelectric impedance analysis10 and skin fold measurements,7,9,11 which rely on different regression equation calculations. These prediction equations should, in theory, take into account the specific physical and body composition characteristics of the participants measured because sex, age, residency, and even primary disability diagnosis have all been shown to affect results when using such equations.11 However, past studies exploring change in percent body fat in this population have not implemented equations specifically designed for people with ID, which calls into question the accuracy of research findings to date.7-11 The importance of finding an accurate measure for people with ID is exacerbated by the challenges of often having small sample sizes and the great variability that

List of Abbreviations

ACSM American College of Sports Medicine
DXA dual-energy x-ray absorptiometry
ID intellectual disability

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exists within separate subtypes of ID. In the absence of population specific equations, it may be necessary to use more complex measurement tools that account for this variability such as DXA, hydrostatic weighing, or air displacement plethysmography. However, Pitetti and Tan, measuring participants with varying degrees of fat levels (21% body fat on average at baseline pretest), declined to use hydrostatic weighing in their study because of difficulty obtaining reliable spirometry measurements and participants’ fear of water.

Research has yet to use DXA to examine changes in percent body fat in participants with ID involved in an aerobic exercise training program. Other studies have used DXA on people without ID and have shown the method to exhibit minimal bias based on factors such as age, sex, physical activity level, race, or proportion of body fat. Researchers have also relied on the DXA because of its precise measurements in different populations. The DXA possesses a quick scan time and also does not require active participant involvement, all of which are important factors when working with participants who have an ID. Furthermore, the method has proved effective as a criterion measure for a number of other instruments and has also been validated against underwater weighing and the 4-compartment model.

In addition to using valid and reliable testing measurements, it is also important to follow specific exercise training guidelines when assessing changes in percent body fat in participants with ID. The ACSM guidelines advises people with ID to undertake an aerobic exercise program at an intensity reaching up to 60% to 80% of their maximum heart rate for the duration of 20 to 60 minutes, 3 or more times a week. It has been suggested that the length of time required to reduce percent body fat may range from anywhere between 4 and 6 months. Despite inactivity and the prevalence of obesity among people with ID, the meta-analysis by Dodd and Shields examined 156 articles and found that, by excluding trials of low methodologic quality (PEDro score <4), only 4 cardiovascular programs for participants with ID as a result of Down syndrome met recommended training procedure guidelines for exercise.

Aquatic exercise training has been shown to offer benefits for people with ID in terms of cardiorespiratory endurance, muscular endurance, speed, static balance, and agility. Moreover, although it used skin fold measurements based on nonpopulation-specific prediction equations, a 12-week combined water and land exercise program demonstrated change in percent body fat for men with Down syndrome of varying degrees of fat level (1/4 defined as obese according to body mass index). However, a purely water-based, sports-specific swim training program combined with a more complex measurement method has not yet been used to instigate change in percent of body fat among people with ID as a whole. Indeed, studies implementing aerobic exercise programs to assess percent body fat thus far have tended to use laboratory-based exercise programs. A sports-specific competitive swim training program provides a necessary model for service delivery, which may in turn facilitate widespread accessibility to children and their families.

In view of the inconsistent methods used for measuring body fat in previous studies and also the limited research that follows specific exercise training guidelines, the purpose of this study was to use DXA to measure the effects of a 16-week swim training program following ACSM guidelines on percent body fat in adolescents with ID. The hypothesis was that the swim training program would lead to a decrease in the participants’ overall body fat percentage as measured by DXA.

### METHODS

#### Participants

Eight children and adolescents with IDs (2 girls and 6 boys; mean age ± SD, 13.1 ± 3.4y) were referred for participation in the study by service providers for ID at local schools. The study recruited a community sample in order to duplicate a real-world scenario in which various subtypes of ID as well as percent body fat ranges are often present (table 1). Verification that the sample represented participants with ID was based on parental knowledge, strong adherence to school placement, and service provider confirmation of an ID. In addition, because this study was aimed at future obesity prevention, child and adolescent participant body fat ranged from 11.4% to 35.2% at pretest baseline. Based on the standards by Lohman, for percent body fat levels in children, 4 boys maintained optimal fat levels, 2 more had very high levels, and the 2 girl participants had moderately high and high body fat levels, respectively.

Prior to commencement of the intervention, participants had already reached a swimming level that satisfied the Royal Lifesaving Society’s Swim to Survive Standard. Participants were excluded from the study if they were unable to attend the exercise training program without parental support, if they had any underlying health condition that would prevent them from participation, or if they were taking part in any other training programs. Given the participants’ respective IDs, it was necessary to outline the testing procedures, potential benefits, associated risks, and the time required for the study in an information letter and discussion session prepared for partici-

<table>
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<tr>
<th>Participant</th>
<th>Sex</th>
<th>Age (y)</th>
<th>Disability</th>
<th>BMI (kg/m²)</th>
<th>Pretest</th>
<th>Posttest</th>
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</thead>
<tbody>
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<td>Boy</td>
<td>9</td>
<td>NS; Moderate ID</td>
<td>17.7</td>
<td>−1.15</td>
<td>17.2</td>
</tr>
<tr>
<td>2</td>
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<td>17.3</td>
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<tr>
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</tr>
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<td>32.7</td>
</tr>
<tr>
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<tr>
<td>8</td>
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<td>17</td>
<td>DS; Mild ID</td>
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<td>16.3</td>
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</tbody>
</table>

Abbreviations: BF%, percent body fat; BMI, body mass index; DS, Down syndrome; NA, not applicable; NS, no known syndrome.

[Table 1: Demographic Information and Levels of Percent Body Fat at Pretest and Posttest]
panting and their parents and/or guardians. In addition, the participants’ guardians all provided written informed consent and the participants themselves gave assent prior to the commencement of the study. The study protocol was approved by the institutional research ethics board.

Procedures

Protocol. For assessment of percent body fat, pretest occurred immediately prior to the commencement of the swim training intervention program, and posttest took place immediately after the end of the 16-week training intervention. Participants were required to follow specific guidelines on testing days: (1) they were asked to have no water or food 2 hours prior to testing, and (2) they were asked to wear a standardized light cotton shirt and shorts that contained no metal to minimize clothing absorption.15

Height and weight. Using a stadiometer (Tanita HR-200),8 the participants’ height, without footwear, was measured to the nearest 0.1 cm. Participants stood erect with head straight forward and eyes fixed in the Frankfort plane. Each participant’s back and shoulders were directly against the wall with feet together flat on the floor. Weight was measured to the nearest 0.1 kg using a calibrated digital scale. Body mass index was calculated by dividing weight (kg) by height (m) squared.

Dual-energy x-ray absorptiometry. DXA Hologic QDR-1000W Whole Body Bone Densitometer (Version 6.10) performed all scans to assess percent body fat in the participants. Using an anthropometric phantom (Hologic X-CALIBER Model DPA/QDR-140) of known densities, technicians calibrated the DXA scanner on each day of testing following the procedures recommended by the manufacturer to ensure reliability between scans. We used Software Version 6.10 to analyze the scans. The same DXA technician performed every scan throughout each test following the guidelines instructed by the manufacturer. Each scan lasted approximately 20 minutes with the participant lying down to complete the scan.

Swim training intervention. The swim training sessions took place in an indoor 25-m competitive-size swimming pool (78°F) in swim lanes alongside members of the local competitive swim team in order to provide the real-world environment of a competitive, sports-specific program. Participants focused on performing the front crawl stroke and also carrying out lines on percent body fat in 8 children and adolescents with intellectual disability (n = 8) after a 16-week exercise training program following ACSM guidelines for assessment of percent body fat in 8 children and adolescents with ID. The Wilcoxon matched-pairs signed-ranks test is a nonparametric alternative to the paired-sample t test, which does not require that the data follow a normal distribution. Therefore, we used a 2-tailed Wilcoxon matched-pairs signed-ranks test to determine the impact of swim training on body fat percentage in individuals with ID. The Wilcoxon matched-pairs signed-ranks test is a nonparametric alternative to the paired-sample t test, which does not require that the data follow a normal distribution and has been used recently in repeated-measures designs with small sample size.26 We set statistical significance at P less than .05 and applied the software package GraphPad Prism 3.0, which provides an exact P value calculation for the Wilcoxon matched-pairs signed-ranks test.

RESULTS

After the 16-week exercise training program, we observed a 1.2% median increase body fat percentage with a range from –0.3% to 4.5%. The results of the Wilcoxon matched-pairs signed-ranks test indicate that this increase was statistically significant, P equal to .039 (exact), as shown in figure 1.

DISCUSSION

This study sought to use the DXA to measure the effects of a 16-week exercise training program following ACSM guidelines on percent body fat in 8 children and adolescents with ID of various body fat levels. The swim training program, taking

![](https://example.com/image.png)

Fig 1. Change in percent body fat (%) for all children and adolescent participants with intellectual disability (n=8) after a 16-week swim training intervention according to DXA.
place for 1 hour, 3 times a week for 16 weeks, proved ineffective with participants significantly gaining percent body fat after the intervention. The hypothesis was not supported. In addition, neither body mass index nor weight decreased after the swim training program.

This study was the first to use DXA, a more complex measurement tool, to assess changes in percent body fat after an exercise intervention based in a community setting. The findings, although only preliminary given the small sample size and nonrandom method of recruitment, are consistent with those of Pitetti and Tan,9 who used skinfold measurement to assess 12 participants of different fat levels and failed to witness an overall significant loss of percent body fat. Similarly, although using different testing measurements, Pommering et al10 and Ozmen et al11 reported no significant changes in percent body fat after aerobic exercise programs. Interestingly, Pommering et al10 also found certain participants to increase in percent body fat after a 10-week program according to bioelectrical impedance analysis. As of yet, no exercise intervention has produced a reduction in percent body fat among children and adolescents with ID. These results agree with data collected for children without ID as a meta-analysis by Resnicow and Robinson27 underlined that only 7 of 77 cardiovascular prevention programs significantly improved adiposity. Ordoñez et al,9 admittedly focusing only on men with Down syndrome, did find a decrease in body fat after a 12-week exercise program, but this study remains an exception and may be a result of the fact that body fat distribution in this population may be more truncal, indicating increased levels of abdominal and visceral fat stores.13 The results of our study, when aligned with other studies using different measurement techniques, indicate that there may be a need for a change of direction with regard to future prevention programs for people with ID. At the very least, the lack of effect exercise interventions alone are having on reducing percent body fat in people with ID warrants closer scrutiny, because past research has yet to document clearly the pattern emerging in studies to date.

This study became the first to apply aquatic exercise alone as a means to decrease percent body fat in people with various IDs and simultaneously meet specific health guidelines in terms of frequency, intensity, and duration of exercise.18 However, the swim training intervention did not reduce body fat in participants, and this finding may be a consequence of several noteworthy factors. All 8 participants lived in family settings, and this finding may be a consequence of several notable changes in percent body fat after aerobic exercise programs. Interestingly, Pommering et al10 also found certain participants to increase in percent body fat after a 10-week program according to bioelectrical impedance analysis. As of yet, no exercise intervention has produced a reduction in percent body fat among children and adolescents with ID. These results agree with data collected for children without ID as a meta-analysis by Resnicow and Robinson27 underlined that only 7 of 77 cardiovascular prevention programs significantly improved adiposity. Ordoñez et al,9 admittedly focusing only on men with Down syndrome, did find a decrease in body fat after a 12-week exercise program, but this study remains an exception and may be a result of the fact that body fat distribution in this population may be more truncal, indicating increased levels of abdominal and visceral fat stores.13 The results of our study, when aligned with other studies using different measurement techniques, indicate that there may be a need for a change of direction with regard to future prevention programs for people with ID. At the very least, the lack of effect exercise interventions alone are having on reducing percent body fat in people with ID warrants closer scrutiny, because past research has yet to document clearly the pattern emerging in studies to date.

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In terms of comprehension, this quandary may be even more troublesome for certain children and adolescents with ID, especially in light of the abrupt lifestyle changes made after the introduction of an exercise training intervention held 3 times a week. The study by Croce,7 despite examining only 3 obese young adult participants (age range, 24–30y) and using nonpopulation-specific prediction equations for measurement, demonstrated the underlying potential and feasibility of combining exercise and diet to produce body fat loss in participants with ID. The study’s diet intervention required a weekly reduction of 3500kcal from the participants’ diet below what was required to maintain body weight in addition to five 1-hour sessions of aerobic exercise a week using treadmills and cycle ergometers. At a reduction rate of 3500kcal a week, it has been suggested that participants may experience a weight loss of approximately .45kg each week.7 Using DXA, future studies may consider analyzing the effects on a larger sample of a joint exercise and food monitoring intervention. Closer collaboration between researchers in nutrition and other health science related fields may offer great potential to examine changes in percent body fat in this population.

**Study Limitations**

The authors acknowledge that the study’s hypothesis may not have been supported in part because of errors in the estimation of percent body fat by DXA itself. However, researchers have been hard pressed to find an accurate method to measure percent body fat in people with ID. As a result of the questionable validity and reliability of the methods used to date, it has been difficult to draw conclusions with regard to measuring changes in percent body fat in this population. In comparison with previous studies, we used a measurement tool that has proved useful as a criterion measure for different instruments14 and has already been validated against both underwater weighing15 and the 4-compartment model.16 DXA has previously provided accurate measurements in diverse populations17,18 and has demonstrated minimal bias with regard to age, sex, physical activity level, race, or proportion of body fat.13

Ideally, the study should have been conducted in the form of a randomized controlled trial, which is regarded as the most efficient way of determining the effectiveness of an exercise intervention. However, this limitation is consistent with most exercise interventions conducted on different populations with disabilities. A recent exhaustive literature review by Rimmer et al19 documented the difficulties associated with implementing exercise interventions on people with various disabilities. The review underlined the unique challenges involved in conducting randomized controlled trials in particular and offered explanations for why so few have been adopted on people with ID. The researchers highlighted the ethical concerns raised by withholding treatment for people with disabilities who may benefit from such an intervention, especially in light of the lack of community-based opportunities available to engage in different forms of exercise.18 Moreover, controlled trials often require transportation, an extensive support staff, and access to numerous laboratory resources needed specifically for working with people with different disabilities.
Participants consisted of a small, heterogeneous group, which makes it troublesome to generalize findings to a larger population. This study took place in a small community, and it proved extremely difficult to obtain participants who had reached an adequate level of swimming based on the Royal Lifesaving Society’s Swim to Survive Standard to the commencement of the research. Even without consideration of swimming ability level, the lack of homogeneity within ID and the low incidence of this type of disability within the community made it extremely challenging to obtain a large sample size for a study occurring 3 times a week for 16 weeks. Similar to Croce, new research may want to examine participants who are more obese in order to assess the effectiveness of interventions in producing changes in percent body fat. It is plausible that percentage body fat change may occur to a lesser degree among participants with lower baseline percentage body fat values. However, in the only other study to concentrate on obese participants, Pomerening et al. found no change in percent body fat after an exercise intervention. Moreover, 2 systematic reviews addressing obesity in children without ID suggest that there exists insufficient evidence to determine the nature of the relationship between degree of obesity at treatment initiation and outcome.

Nevertheless, it is probable clinicians or researchers in school, institution, or group home settings would likely encounter similar variation within sample population when working with people with ID. This factor again emphasizes the need to find appropriate testing methods that account for such a heterogeneous population and the likelihood of encountering a variety of disabilities in communities to comprehend fully the effectiveness of health promotion initiatives. Our study’s diverse population sample replicated the real-world nature of applying methods to measure the effectiveness of a percent body fat intervention on people with ID. Results should be read cautiously because of the small sample size and lack of control group, but this research nonetheless offers an important framework for more rigorously designed future studies that use DXA, use a control group, and follow specific exercise guidelines in terms of frequency, intensity, and duration.

CONCLUSIONS

In conclusion, this study’s results suggest that percent body fat did not decrease in 8 adolescents with ID after a 16-week community-based swim training program. This study, when considered with findings from similar studies for people with and without ID, promotes the need to implement a dietary intervention alongside an exercise intervention when assessing methods of reducing percent body fat in people with ID. In addition, this study shows that DXA, as a more complex measurement tool, may be used successfully to assess changes in percent body fat among adolescents with ID during an intervention program.

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