Strength versus aerobic program: effects on body composition and health-related physical fitness levels of youths with Down syndrome

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Aims: To determine the effect of a 16-week fitness program (strength vs. aerobic) on different indicators of body composition and components of health-related physical fitness in youths with Down syndrome.
Methods and procedures outcomes: Fifty adolescents (19 girls and 31 boys; average age, 18.33 ± 1.42 years) with Down syndrome were recruited and randomized to two groups (strength group vs. aerobic group). Adolescents allocated in the aerobic group carried out a physical activity program three times a week for 16 weeks meanwhile adolescents allocated in the strength group performed a fitness program three times a week for 16 weeks.
Results: The exercise group had significant improvements in all health-related physical fitness variables ($p < .05$) but not on body composition.
Conclusions and implications: A sixteen week fitness program consisting of three sessions of 60 min is able to increase levels of health-related physical fitness but not on body composition in youths with Down syndrome. The aerobic program does not seem to show significant differences.

Keywords: Cardiorespiratory fitness; fatness; strength; Down syndrome; youths

Introduction

Down syndrome (DS) is the most common chromosomal disorder produced by a partial or full extra copy of chromosome 21 (Roizen 2002). It is also the most common single intellectual disability (ID) (Presson *et al.* 2013). Individuals with DS could show several clinical symptoms including diabetes, cardiovascular or musculoskeletal problems, and obesity (Bull 2011, Roizen *et al.* 2014). Childhood obesity is a complex health issue. It occurs when a child is well above the normal or healthy body mass (Sahoo *et al.* 2015). Childhood obesity has increased substantially worldwide (NCD Risk Factor Collaboration 2017), and health problems derived from obesity (i.e. breathing problems, fatty liver disease, or high blood pressure) have been observed both in the population with and without DS (Bertapelli *et al.* 2016, Lobstein *et al.* 2015).

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Reviewing the latest studies carried out with young population with DS, it is observed that their levels of overweightness or obesity are higher compared to the youth population with and without ID (O'Shea *et al.* 2018). In general, young people with DS obtain higher values in variables such as body mass index (BMI), waist circumference or waist to height ratio (WtHR), and lower values in health-related physical fitness (Mendonca *et al.* 2010, Palomba *et al.* 2020, Soler Marín *et al.* 2011). These results lead to greater health problems in this population (Bertapelli *et al.* 2016). Focusing on intervention studies in population with DS, changes in some indicators of body composition were evaluated after completing the program (González-Agüero, Ara, *et al.* 2011a, González-Agüero *et al.* 2013, Seron *et al.* 2014). In general, there are few studies that show a decrease in body fat levels after the intervention (Ordonez *et al.* 2006, Ulrich *et al.* 2011).

Health-related physical fitness is considered an important marker of health in youth (Zhu *et al.* 2011).

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There is evidence demonstrating that low levels of health-related physical fitness during adolescence has a negative influence on health status later in life (Zaqout *et al.* 2016). Regarding studies carried out in general population, it is observed that 60–80% of young people have healthy levels of cardiorespiratory fitness or motor fitness (Ortega *et al.* 2011). However, in populations with DS the data seems to be concerning since it has been observed that in general this population presents lower levels of health-related physical fitness than their counterparts without ID (González-Agüero *et al.* 2010, Izquierdo-Gomez *et al.* 2013). A possible explanation for these results could be the motor deficiencies and physical ability (Malak *et al.* 2015), postural control (Giustino *et al.* 2021), and gait impairments (Schott *et al.* 2015) observed in this population. Despite these data, youths with DS are able to improve their levels of health-related physical fitness after following a training program (González-Agüero *et al.* 2010, Li *et al.* 2013). Findings showed that this group was able to reduce their body fat percentage levels but reported no cardiovascular effects.

Regarding gender difference, two large retrospective population-based studies offer information regarding gender differences in overweight and obesity among youth with DS (Myrelid *et al.* 2002, Van Gameren-Oosterom *et al.* 2012). These two studies suggested a higher prevalence of overweight in females. Cross-sectional studies reporting BMI in boys and girls with DS (Abdallah *et al.* 2013, González-Agüero, Ara, *et al.* 2011a, Loveday *et al.* 2012). Findings are suggestive of higher body mass status in girls than boys with DS. Differences in lean mass levels were studied in this population showing significant differences. González-Agüero, Ara, *et al.* (2011a), found that children with DS had lower levels of fat but higher levels of lean mass.

To our knowledge, there is a need to develop a greater number of programs focused on evaluating the effect of a fitness program on a group of youths with DS. Due to the negative effect of overweight or obesity and low levels of physical fitness on the health of the population with Down syndrome (Bertapelli *et al.* 2016, Lobstein *et al.* 2015), it is necessary to investigate how to mitigate their negative impact on this population. Therefore, the aim of this study is to determine the effect of a 16-week fitness program on different indicators of body composition (BMI, waist circumference, hip circumference, and WtHR) and components of health-related physical fitness (handgrip strength, standing long jump, motor fitness, and cardiorespiratory fitness) in youths with DS and observe if there are differences between sex.

Methods and materials

Participants

In total, 50 students (19 girls and 31 boys; average age, 18.33 ± 1.42 years) with DS between 17- and 20-year old and enrolled in a special education school from Spain were recruited in this study. The exclusion criteria were as follows: students with hearing or visual impairment, orthopedic impairment, congenital or traumatic brain injury, cardiopulmonary diseases, or other multiple disabilities. This study, did not consider individuals who had been active in physical efficiency programs during the last 3 months previous to the research, people not diagnosed with DS and who presented a severe or profound ID (DSM-V, 2013), had been active in some other similar study, did not have authorization from their parents-managers, or had not completed the questionnaire of preparation for physical activity.

The Special School described the IQ assessment of its students as mild or moderate (IQ 35 to 49) or as identified by their parents or legal guardians (American Association on Intellectual and Developmental Disability 2010, Shields *et al.* 2010). Of the 67 candidates, 50 were eligible and evaluated 17 of these candidates were considered ineligible due to: (a) not meeting the inclusion criteria ($n = 11$) and (b) refusing to participate ($n = 6$). Finally, 25 adolescents (11 female and 14 male) were assigned to the strength group and 25 adolescents to the aerobic group (8 female and 17 male).

After signing the consent form, the measurements of the different indicators of body composition and physical fitness were obtained. The study was conducted between September 2019 and December 2019. The study's protocol was performed in accordance with the Helsinki Declaration and approved by the Bioethics Committee of the National Research Council (Madrid, Spain) (Declaration of Helsinki 2000).

Randomization

Participants were randomly allocated to either the strength or aerobic group using a concealed allocation, block randomization method that ensured approximately equal numbers in each group (Altman *et al.* 1999). Participants in subgroups of four, with six different ways or permutations in which to get two strength and two aerobic participants in each subgroups (2:2:1) were considered. The order of the subgroups was made from a random number of table and assignments sealed in sequentially numbered dark envelopes. Participants were assigned to their allocation by a physiotherapist not involved in the study (Shields *et al.* 2008).

Measurements

Assessment of body composition

The procedures followed in this process have been validated to be used in youths with DS in multiple studies (Ruiz *et al.* 2011, Tejero-Gonzalez *et al.* 2013). Two different *time* measurements of body composition were performed and the average of each one was obtained (Ruiz *et al.* 2011).

Body mass index (BMI)

Participants were measured barefoot and wearing light clothing. An electronic scale (model SECA 701, Hamburg, Germany) to the nearest 0.1 kg was used to measure body mass. A telescopic height-measuring instrument (model SECA 220) to the nearest 1 mm was used to assess the height. BMI was calculated dividing body mass by squared height (km/m^2). To obtain b*ody mass* the youth had to stand on the platform of the scale without support. The youth stood still over the center of the platform with the body mass distributed between both feet. For b*ody height*, hair ornaments had to be removed and braids had to be undone. The youth stood on the stadiometer with bare feet placed slightly apart and the back of the head, shoulder blades, buttocks, calves, and heels touching the vertical board. Legs had to be kept straight and the feet flat. The tester had to position the youth's head so that a horizontal line drawn from the ear canal to the lower edge of the eye socket runs parallel to the baseboard. The headpiece of the stadiometer had to be pulled down to rest firmly on top of the head and compress hair. The measurement (cm) was done when the participant was in maximal breathing inspiration (Ruiz *et al.* 2011).

Waist circumference

To estimate central body fat of each participant abdomen, we used a non-elastic tape in a horizontal plane around the abdomen at the level of the iliac crest (SECA 200; SECA) (Savva *et al.* 2000). The youth stood with the abdomen relaxed, the arms at the sides, and feet together. In some obese youth, it may be difficult to identify a waist narrowing. In such cases, the smallest horizontal circumference should be measured in the area between the iliac spine superior and the costal edge in the midaxillary line (Ruiz *et al.* 2011). The measurement was obtained in cm.

Hip circumference

It was measured at the level of the greatest protrusion of the buttocks when the youth was standing straight with feet together. The youth stood sideways to the observer with feet together and arms folded. The observer passed the tape around the body at the level of the most prominent protrusion of the buttocks, so that, it lightly touched but did not compress the skin (Cameron 2012). The measurement was obtained in cm.

Waist to height ratio

It is a simple measurement for assessment of overweightness. Compared to just measuring waist circumference. WtHR is equally fair for short and tall persons. WtHR is evaluated by dividing the waist circumference or waist size of a person by the height of the person, and it is used to assess the body fat distribution of the participants (Alves Junior *et al.* 2017). The measurement was obtained in percentage.

Assessment of physical fitness

The assessment of the levels of physical fitness were carried out following the parameters established for this special population (Cabeza-Ruiz *et al.* 2019). Handgrip strength and standing long jump tests were performed twice and the mean of the scores was obtained while cardiorespiratory fitness and six-minute walk tests were carried out once. To avoid possible problems with the execution of physical tests, there was a familiarization period of the tests for 3 days (not included in the 16 weeks of study). Finally, participants in both groups had to attend a total of 75% of the sessions to be part of the study (González-Agüero, Ara, *et al.* 2011a). All young people were included in the analysis.

Handgrip strength

Upper-body muscular strength was assessed by the handgrip strength test with a hand dynamometer with an adjustable grip (TKK 5101 Grip D; Takey, Tokyo, Japan). Adolescents with DS performed the test in a sitting position to focus their attention on tightening the handgrip. This adaptation in the DS population did not show significant differences ($p > .2$) between positions (seated vs. standing) in the handgrip strength scores in adolescents without DS in the pilot study (Tejero-Gonzalez *et al.* 2013).

Standing long jump test

Lower-body muscular strength was measured by using the standing long jump test. Participants had to jump as far as possible, pushing off vigorously and landing with their feet together. The distance was equivalent from the take-off line to the back of the foot on landing (Tejero-Gonzalez *et al.* 2013).

Motor fitness (4 × 10 m)

Motor fitness was measured by the 4 × 10 m shuttle-run test to assess speed of movement, agility, and coordination. The present test also included four sponges that were carried one by one to the different lines. The subjects ran back and forth four times along a 10-m track at the highest speed possible. At the end of each track section, the subjects deposited or picked up a sponge from a line on the floor (Ruiz *et al.* 2006). The test has been used in other studies on health-related physical fitness in youth with DS (Izquierdo-Gomez *et al.* 2015). Data were measured in seconds.

Cardiorespiratory fitness

Cardiorespiratory fitness was assessed by the 20-m shuttle-run test. Participants were required to run between two lines 20 m apart, while keeping pace with a pre-recorded audio CD. The initial speed was 8.5

kmh^{-1}, which was increased by 0.5 kmh^{-1} each minute (1 min = one stage). Participants were instructed to run in a straight line, to pivot on completing a shuttle (20 m), and to pace themselves in accordance with the audio signals. The test was finished when the participants failed to reach the end lines concurrent with the audio signals on two consecutive occasions (Tejero-Gonzalez *et al.* 2013). All adolescents were assessed based on the level of cardiorespiratory fitness recorded in laps (Castro-Piñero *et al.* 2014). The 20-m shuttle run has been shown to be a valid and reliable field measurement of cardiorespiratory fitness of youths with DS (Tejero-Gonzalez *et al.* 2013).

Six-minute walk test

The 6MWT is an automatic rhythm test which requires a person to walk as far as possible in 6 min on a slope-free floor without running. The test was carried out on an athletics track. Each youth was instructed to cover as much distance as he/she could walk in 6 min. They were told to keep going continuously, if possible, but to not be concerned if they had to slow down or stop to rest. They should feel that they could not have covered more ground in the allotted time. An instructor accompanied the youths, acting as timekeeper and giving encouragement as necessary (Butland *et al.* 1982, Cabeza-Ruiz *et al.* 2019).

Intervention

The intervention was performed over a period of 16 weeks and each session (3 times a week) consisted of a 10 min warm-up, 45 min of training and a 5 min cool-down (60 min). The development of motor behavior is the main objective in the youth population with DS and for this reason, tasks of motor exploration and basic motor skills have been worked. The aerobic group carried out a physical activity programmed focused on aerobic capacity and motor development while the strength group carried out a programmed focused on the development of the components of physical fitness (strength). (Please see Appendix for overview).

The training adjustments in individual's terms of intensity, volume, types of loads and recovery time were based on objective parameters (heart rate) and assessment parameters (behavioral sample of fatigue, alteration of running mechanics, verbal manifestation, and self-reported participant). Instructors carried out a heart rate check during each exercise in order to adjust it to the parameters set up at the beginning of the session. A heart rate sensor (Garmin) was used to assess the heart rate levels of the participants. In addition, during the execution of the exercise, they observed possible alterations in the way that participants did the activity. Finally, when the exercise was over, coaches had a small conversation with all participants to analyze the state of fatigue. If the participant was unable to carry on a fluid conversation without symptoms of fatigue, the rest time between exercises was increased.

Statistical analysis

SPSS statistical software version 20.0 (IBM Inc., USA) was used for statistical analysis. Mean values and standard deviations or percentages were used to describe the pretest and pos-test data. Kolmogorov–Smirnov tests indicated normal distribution of the studied variable. The paired *t*-test was executed to examine whether differences existed between the pretest and pos-test results for both the strength and aerobic group. Outcomes were analyzed using analysis of covariance on the change scores with the baseline measure of that variable used as the covariate (Tong 2012). Where baseline variables were significantly different, they too were entered as covariates. The mean difference within each group and the mean difference between the groups, and the 95% CIs of the mean differences were also calculated. Effect sizes and 95% was also calculated for the change scores. All statistical tests were performed to show the differences segmented by sex group. The significance level was $p < .05$. This methodology was used in different studies (Shields *et al.* 2008, Wu *et al.* 2017).

Results

Figure 1 shows the progress through trial. All participants belonging to the study completed the intervention protocol successfully. No health problems were noted in participants of both groups over the 16-week period. Descriptive characteristics of the study's sample on pre-intervention and post-intervention of body composition and physical fitness variables are summarized in Table 1. Both groups showed similar values of age, body mass, height ($p > .05$) or ID at baseline and post-intervention.

Table 2 shows differences between the pretest and pos-test results regarding body composition and physical fitness for the aerobic and strength groups. Regarding body composition variables only significant differences were observed in hip circumference between both groups after the intervention ($p = .038$; 95% CI = –1.288 to −0.617). The aerobic group showed an increase in BMI and hip circumference. The strength group did not show significant differences in body composition variables. Concerning physical fitness components, significant differences were observed in all variables between groups after 16 weeks of intervention [Handgrip strength ($p = .005$; 95% CI = 2.963 to 4.626); standing long jump ($p = .001$; 95% CI = 11.067 to 20.456); motor fitness ($p = .038$; 95% CI = –5.920 to −3.927); cardiorespiratory fitness ($p = .019$; 95% CI = 2.792 to 5.517); 6-min walk test ($p = .034$; 95% CI =33.109 to 68.739)]. The strength group showed an increase in all physical fitness variables while the

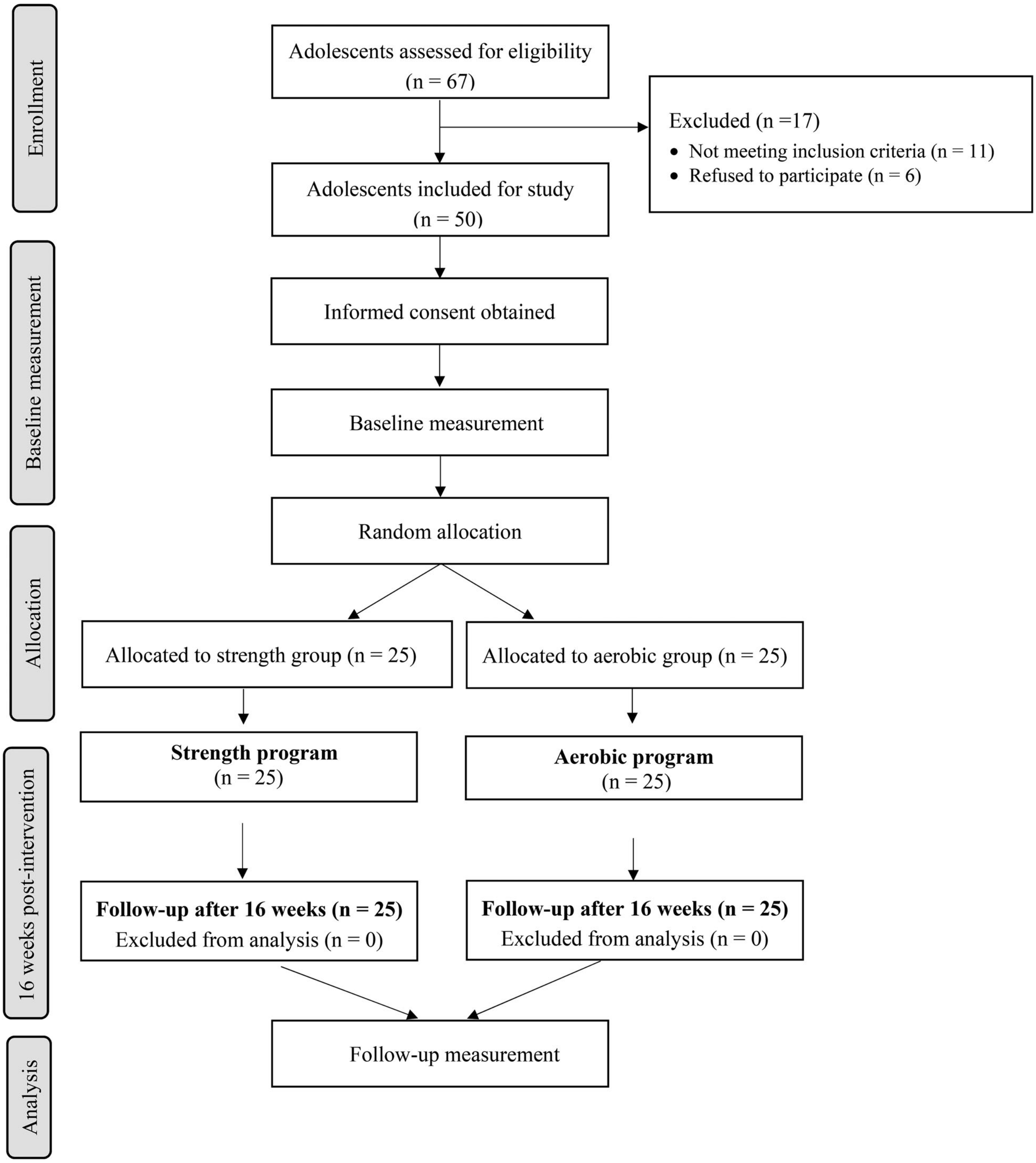

Figure 1. Flowchart of the results of the sample recruitment.

aerobic group showed a decrease in standing long jump and motor fitness.

Table 3 shows differences between baseline and follow-up results regarding body composition and physical fitness in female groups. Regarding body composition, the aerobic group showed an increase in hip circumference after 16 weeks while the strength group obtained increases in waist circumference and WtHR. Only hip circumference showed significant difference between groups at 16 weeks ($p = .024$; 95% CI = –0.938 to −0.232). Regarding physical fitness variables, the aerobic group obtained worse results in standing long jump and motor fitness. The strength group showed improvement in all physical fitness variables after the intervention. Finally, the analysis showed significant differences between female groups in all physical fitness variables [Handgrip strength ($p = .029$; 95% CI = 1.845 to 4.336); standing long jump ($p = .032$; 95% CI = 12.032 to 21.136); motor fitness ($p = .041$; 95% CI = –7.611 to −3.826); cardiorespiratory fitness ($p = .018$; 95% CI = 2.194 to 5.890); 6-min walk test ($p = .012$; 95% CI = 23.552 to 85.080)].

Table 1. Descriptive characteristics of study sample at baseline and post-intervention.

	Groups mean (*SD*)					
Outcome	Aerobic group ($n=25$)		Strength group ($n=25$)		Aerobic group vs. Strength group	
Physical characteristics	Pretest	Post-test	Pretest	Post-test	*p* value*	*p* value **
Age (years)	18.37 (1.51)	18.82 (1.51)	18.30 (1.33)	18.75 (1.33)	0872	.872
Body mass (kg)	58.77 (10.37)	60.28 (1.91)	55.44 (6.36)	55.69 (6.35)	0177	.179
Height (cm)	152.02 (8.90)	152.39 (9.14)	150.06 (8.16)	150.09 (8.17)	0075	.076
Level of perceived ID, *n* (%)[a]						
Mild	21 (84)		22 (88)			
Moderate	4 (16)		3 (12)			
Severe	0 (0)		0 (0)			
Gender *n*, (%)[a]						
Male	17 (68)		14 (56)			
Female	8 (32)		11 (44)			

Abbreviations *SD*: standard deviation; ID: intellectual disability.
[a]Or *n* and percentage when indicated.
*Significant differences between pretest aerobic and pretest strength group.
**Significant differences between post-test aerobic and post-test strength group.

Table 4 indicates differences between baseline and follow-up results regarding body composition and physical fitness in male groups. Regarding to body composition variables, only hip circumference seems to show differences between male groups ($p=.029$; 95% CI = –1.675 to −0.761). Only the aerobic group showed an increase in hip circumference ($p=.001$). Regarding physical fitness variables, the aerobic group obtained an increase in motor fitness while the strength group showed an increase in all variables except for motor fitness. Finally, the study showed significant differences between male groups in all physical fitness variables at the 16th week follow-up [Handgrip strength ($p=.009$; 95% CI = 3.151 to 5.465); standing long jump ($p=.041$; 95% CI = 8.829 to 23.488); motor fitness ($p=.038$; 95% CI = –5.784 to −3.272); cardiorespiratory fitness ($p=.014$; 95% CI = 2.342 to 6.416); 6-min walk test ($p=.025$; 95% CI = 28.744 to 76.033)].

Discussion

This study analyzed the effect of a 16 week fitness program in different indicators of body composition and health-related physical fitness variables in a sample of youths with DS. Findings showed that youths with DS, who were part of the strength group, increased their levels in all variables of physical fitness following the 16-week fitness program, whereas no effect in body composition variables were observed. Also, the study showed that the aerobic group obtained worse results in most of the variables analyzed after the intervention. Attending differences between sexes, the female and male strength groups improved in all physical fitness variables. However, physical fitness values observed in the aerobic group (women and male) were lower than those shown by the strength group at the 16 week follow-up. These findings reinforce the idea that training programs with high levels of intensity are able to improve some variables of physical fitness in youth population with DS.

Results obtained in this study showed that those youth with DS (intervention group) who presented high levels of overweightness in different indicators of body composition (i.e. BMI, waist circumference or waist-height ratio) were not able to reduce these levels significantly after 16 weeks of a fitness program (Paul *et al.* 2019). These same results were obtained for the aerobic group where they were not able to reduce their body composition levels after performing the basic motor skills program. These results are consistent with findings observed in different studies on the population with DS (Hardee *et al.* 2017).

For example, the work carried out by González-Agüero, Vicente-Rodríguez, et al. (2011b) in a sample of 31 children and adolescents with DS (14 female/17 male) between the age of 10 and 19 obtained data similar to those shown in our study. This program aimed to determine whether young people with DS were able to decrease fat mass and increase lean mass after 21 weeks of conditioning combined with a plyometric jump training program. Findings suggested that 21 weeks of conditioning combined with plyometric jump training was an effective method for increasing lean mass in young people with DS; however, no changes in body composition (BMI, % body fat) were observed. In this same line is the work done by González-Agüero *et al.* (2013) where a whole-body vibration program was performed. Results showed that a 20-week workout was not enough to improve body composition in adolescents with DS.

However, the results obtained in this study contrast with the findings observed in the work of Aguiar *et al.* (2008), Shields et al. (2015), and Silva *et al.* (2017). For example, the work of Aguiar *et al.* (2008) was held with a sample of 21 young adults (23.3- × 2.1-year old) where a judo program was used. The duration of the program was 16 weeks with three sessions per week of 60 min. In this study, the results showed that participants were able to significantly reduce their body fat levels. Shields et al. (2015) aimed to investigate whether a physical activity program, designed

Table 2. Differences between the pretest and post-test results regarding body composition and physical fitness for the aerobic and strength groups.

Outcome	Groups mean (*SD*)				Difference within groups, mean difference (*SD*)		Difference between groups, mean difference (95%CI)		
	Aerobic group ($n = 25$)		Strength group ($n = 25$)		Difference within groups week 16 minus-week 0*		Difference between groups week 16 minus-week 0		
Body composition	**Pretest**	**Post-test**	**Pretest**	**Post-test**	**AG**	**SG**	**SG vs. AG**	***p* value**	**Effect size**
BMI (kg/m^2)	25.35 (3.33)	25.86 (3.58)	24.84 (3.89)	24.95 (3.93)	0.51 (1.08)	0.10 (0.34)	–0.404 (–0.867 to 0.058)	.154	0.16
Waist circumference (cm)	77.99 (10.18)	77.77 (8.18)	76.77 (4.42)	76.97 (4.49)	–0.22 (5.68)	0.20 (0.70)	0.356 (–1.962 to 2.674)	.692	0.10
Hip circumference (cm)	88.65 (6.63)	89.45 (6.64)	88.33 (6.71)	88.18 (7.05)	0.80 (0.14)	–0.14 (0.81)	–0.952 (–1.288 to –0.617)	**.038**	**0.55**
WtHR (%)	51.29 (5.75)	51.02 (5.20)	51.33 (4.38)	51.45 (4.33)	–0.27 (3.59)	0.12 (0.48)	–0.335 (–1.127 to 1.797)	.702	0.21
Physical fitness									
Handgrip strength (kg)	13.06 (8.66)	12.56 (7.90)	13.77 (6.75)	17.05 (7.78)	–0.50 (1.26)	3.27 (1.60)	3.795 (2.963 to 4.626)	**.005**	**0.73**
Standing long jump (cm)	69.36 (33.90)	62.70 (30.50)	70.91 (26.18)	79.68 (27.31)	–6.66 (11.12)	8.77 (4.48)	15.762 (11.067 to 20.456)	**<.001**	**0.85**
Motor fitness (sec)	28.18 (3.73)	29.39 (3.60)	26.17 (3.02)	22.48 (3.28)	1.21 (1.67)	–3.68 (1.80)	–4.923 (–5.920 to –3.927)	**.038**	**0.42**
Cardiorespiratory fitness (laps)	8.96 (5.65)	8.40 (5.76)	8.12 (2.78)	11.72 (3.15)	–0.56 (2.93)	3.60 (1.60)	4.155 (2.792 to 5.517)	**.019**	**0.58**
6-min walk test (m)	540.00 (35.43)	530.60 (51.65)	538.96 (36.79)	579.60 (36.60)	–9.40 (34.75)	40.64 (27.98)	50.924 (33.109 to 68.739)	**.034**	**0.38**

Statistically significant differences are in bold ($p < .05$).
SD: standard deviation; CI: confidence interval; AG: aerobic group; SG: strength group; BMI: body mass index; WtHR: waist to height ratio.
*Derived from analysis of covariance with dependent variable as covariates (baseline weight).

Table 3. Differences between baseline and post-intervention results regarding body composition and physical fitness in female groups.

	Groups mean (*SD*)				Difference within groups, mean difference (*SD*)		Difference between groups, mean difference (95%CI)		
Female	**Aerobic group ($n = 8$)**		**Strength group ($n = 11$)**		**Difference within groups week 16 minus-week 0***		**Difference between groups week 16 minus-week 0**		
Body composition	**Pretest**	**Post-test**	**Pretest**	**Post-test**	**AG**	**SG**	**SG vs. AG**	***p* value**	**Effect size**
BMI (kg/m^2)	25.53 (2.12)	25.91 (1.88)	25.77 (4.35)	25.83 (4.50)	0.38 (1.04)	0.60 (0.47)	–0.320 (–1.084 to 0.443)	.473	0.18
Waist circumference (cm)	71.20 (4.97)	72.43 (4.87)	77.60 (4.91)	78.09 (5.01)	1.23 (1.64)	0.48 (0.36)	–0.747 (–1.860 to 0.365)	.219	0.23
Hip circumference (cm)	87.36 (6.58)	88.19 (6.52)	91.10 (8.71)	91.33 (8.85)	0.82 (0.08)	0.22 (0.53)	–1.585 (–0.938 to −0.232)	**.024**	0.51
WtHR (%)	50.18 (4.29)	50.72 (4.32)	52.02 (4.50)	52.32 (4.51)	0.53 (1.17)	0.30 (0.25)	–0.229 (–1.016 to 0.557)	.605	0.17
Physical fitness									
Handgrip strength (kg)	11.90 (7.51)	13.50 (7.38)	9.44 (1.98)	12.15 (2.41)	–0.40 (1.16)	2.70 (1.31)	3.091 (1.845 to 4.336)	**.029**	0.68
Standing long jump (cm)	69.37 (30.37)	60.06 (27.85)	49.14 (15.37)	57.45 (14.76)	–8.31 (4.25)	8.31 (4.69)	16.584 (12.032 to 21.136)	**.032**	0.35
Motor fitness (sec)	27.30 (4.12)	29.15 (4.59)	27.90 (1.92)	24.03 (2.96)	1.85 (1.40)	–3.87 (2.13)	–5.718 (–7.611 to −3.826)	**.041**	0.42
Cardiorespiratory fitness (laps)	6.75 (3.33)	6.00 (3.42)	5.63 (1.50)	8.09 (2.11)	–0.75 (1.58)	3.27 (2.00)	4.042 (2.194 to 5.890)	**.018**	0.88
6-min walk test (m)	537.55 (31.35)	518.72 (35.34)	511.72 (21.12)	547.45 (21.63)	–18.82 (46.74)	35.72 (7.07)	54.316 (23.552 to 85.080)	**.012**	0.74

Statistically significant differences are in bold ($p < .05$).
SD: standard deviation; CI: confidence interval; AG: aerobic group; SG: strength group; BMI: body mass index; WtHR: waist to height ratio.
*Derived from analysis of covariance with dependent variable as covariates (baseline weight).

Table 4. Differences between baseline and post-intervention results regarding body composition and physical fitness in male groups.

Male	Groups mean (*SD*)				Difference within groups, mean difference (*SD*)		Difference between groups, mean difference (95%CI)		
	Aerobic group ($n = 17$)		Strength group ($n = 14$)		Difference within groups week 16 minus-week 0*		Difference between groups week 16 minus-week 0		
Body composition	**Pretest**	**Post-test**	**Pretest**	**Post-test**	**AG**	**SG**	**SG vs. AG**	***p* value**	**Effect size**
BMI (kg/m^2)	25.26 (3.83)	25.84 (4.21)	24.11 (3.47)	24.25 (3.43)	0.57 (1.13)	0.13 (2.55)	–0.405 (–1.050 to 0.240)	.186	0.29
Waist circumference (cm)	81.19 (10.53)	80.28 (8.31)	76.10 (4.06)	76.09 (3.99)	–0.90 (6.76)	–0.01 (0.82)	0.617 (–3.178 to 4.412)	.809	0.08
Hip circumference (cm)	89.25 (6.77)	90.04 (6.82)	86.16 (3.65)	85.71 (4.08)	0.79 (0.16)	–0.44 (0.88)	–1.218 (–1.675 to –0.761)	**.029**	0.46
WtHR (%)	51.81 (6.39)	51.17 (5.69)	50.78 (4.37)	50.76 (4.12)	–0.64 (4.27)	–0.02 (0.57)	0.434 (–1.961 to 2.829)	.693	0.23
Physical fitness									
Handgrip strength (kg)	13.61 (9.31)	13.05 (8.31)	17.17 (7.23)	20.89 (8.43)	3.72 (1.72)	–0.50 (1.26)	4.308 (3.151 to 5.465)	**.09**	0.81
Standing long jump (cm)	69.82 (36.32)	63.94 (32.42)	88.00 (19.19)	97.14 (21.52)	9.13 (4.44)	–6.66 (11.12)	16.159 (8.829 to 23.488)	**.041**	0.44
Motor fitness (sec)	28.60 (3.60)	29.51 (3.20)	24.80 (3.08)	21.27 (3.08)	–3.52 (1.58)	1.21 (1.67)	–4.528 (–5.784 to –3.272)	**.038**	0.35
Cardiorespiratory fitness (laps)	10.00 (6.28)	9.54 (6.36)	10.07 (1.81)	13.92 (1.73)	3.85 (1.23)	–0.56 (2.93)	4.379 (2.342 to 6.416)	**.014**	0.59
6-min walk test (m)	541.15 (38.06)	536.18 (57.89)	560.36 (32.17)	604.86 (23.50)	44.50 (37.02)	–9.40 (34.75)	52.388 (28.744 to 76.033)	**.025**	0.38

Statistically significant differences are in bold ($p < .05$).
SD: standard deviation; CI: confidence interval; AG: aerobic group; SG: strength group; BMI: body mass index; WtHR: waist to height ratio.
*Derived from analysis of covariance with dependent variable as covariates (baseline weight).

according to the framework of Rimmer *et al.* (2008), was feasible. Furthermore, it investigated whether it led to improvements in walking ability, risk factors associated with chronic diseases, and changes in physical activity after implementation of the intervention between eight young youth with DS (23-year old). Results from this study showed, that participants were able to reduce their body fat levels (body mass, waist circumference) after an 8 week interventions with two weekly 45-minute sessions. In this same line, the work carried out by Silva *et al.* (2017) aimed to assess the effect of a Wii program on different fitness and body composition variables (BMI, % body mass, visceral fat, waist circumference) in a sample of 27 adults with DS (18- to 60-year old). As a result of this study, it was observed that after 8 weeks of intervention, participants were able to significantly reduce their body composition levels.

One of the possible explanations for the different results shown between our study and the scientific literature may be the methodology used. Our study used a doubly indirect methodology to obtain the values of body composition while in other cases an indirect methodology was used with the use of more effective and accurate systems (dual energy X-ray absorptiometry) for the evaluation of body composition (González-Agüero, Vicente-Rodríguez, et al. 2011b). Another explanation could be the number of weeks in duration of the various physical activity programs. An increase in intervention weeks may be necessary for more reliable results.

Focusing on the importance of the training programs, the literature reviewed about the effects of intervention programs on different variables of physical fitness in adolescent DS population showed that greater effects were observed in studies with a minimum duration of 8 weeks. In fact, the studies carried out for 6 months increased the positive effect on physical fitness variables (Bertapelli *et al.* 2016, Hardee *et al.* 2017, Paul *et al.* 2019). Our data showed that a fitness program was effective in significantly increasing levels of different variables of physical fitness (handgrip strength; standing long jump; motor fitness; cardiorespiratory fitness; 6-min walk test) in adolescents with DS after 16 weeks. In addition, improvements in fitness levels after intervention were observed in both sexes. However, the aerobic group experiences no improvement after a special program for 16 weeks, 3 times/weeks, 60 min/sessions, training the aerobic capacity and motor skills. These findings suggest that the use of progressive resistance training program with a minimum duration of 8 weeks may be more effective at improving the physical fitness of young people with DS.

For example, Shields *et al.* (2010) aimed to determine the effects of a student-led community-based progressive resistance training program for adolescents with DS. This program was developed in a sample of 23 adolescents with DS (17 boys, 6 girls; mean age 15.6 × 1.6 years). The intervention was a student-led progressive resistance training program, comprising six exercises using weight machines performed twice a week for 10 weeks. The experimental group attended 90% of their scheduled sessions. They demonstrated improvement in lower limb muscle strength compared to the control group. However, there were no significant differences between the groups for upper limb muscle strength or physical function measures.

In this same line are the data obtained by Cowley *et al.* (2011). The purpose of this study was to examine the effect of progressive resistance training on leg strength, aerobic capacity and physical function in persons with DS. This study was conducted on a sample of 30 participants with DS (age 28 *SD* 8 years) assigned to an intervention or control group. The intervention group performed resistance training 2 days per week for 10 weeks. Participants performed tests to measure leg strength, peak aerobic capacity and timed performance on chair rise, walking and stair ascent and descent. Participants receiving the intervention significantly increased their leg strength. These changes were significantly greater than in the control group. The findings observed in our study are consistent with those observed in the study of Cowley *et al.* (2011) as the intervention group, both male and female, managed to significantly increase their results in the standing long jump test. Years later, Shields *et al.* (2013) made an intervention with the intention of investigating effects of a student-led progressive resistance training program in adolescents and young adults with DS. Participants (30 female, 38 males; mean age 17.9) allocated to the intervention group completed a 10-week, twice a week student-led progressive resistance training program at their local community gym. Results showed that the intervention group was able to significantly increase upper and lower limb strength at week 11.

Results obtained in this study coincide with results found in the literature, as it is observed that youth with DS who have participated in a physical activity program are able to increase their speed levels regardless of sex. For example, the study conducted by Lin *et al.* (2012) aimed to investigate the effects of a proposed strength and agility training program on 92 youths with DS (13–18 years). The exercise training program consisted of a 5-min treadmill exercise and one 20-min virtual-reality based activity administered three times a week for 6 weeks. Conclusions of this work showed that the intervention group had significant improvements in agility and muscle strength in all muscle groups assessed in comparison to the control group.

In this study, the effect of training on the handgrip strength variable was also analyzed, since its importance for health has been demonstrated in DS population, even in older people without disabilities (Coelho-Junior *et al.* 2019, Rijk *et al.* 2016). For example, Chen *et al.* (2014) assessed the relation between handgrip strength and the impact of an aerobic exercise on grip strength in young men with DS. Twenty males with DS were assigned to an exercise group, who walked using an incremental protocol on a treadmill for 20 min at aerobic levels. Participants assigned to the intervention group improved on the grip test after the intervention. However, our study does not seem to show significant differences in the aerobic group.

Finally, other variables analyzed in this study was the cardiorespiratory capacity of the participants. Regarding evidence shown in the literature (Seron *et al.* 2017, Shields *et al.* 2015, Silva *et al.* 2017), we can understand that a fitness program with a minimum duration of 8 weeks can significantly improve the cardiorespiratory capacity of young people with DS. For example, Silva *et al.* (2017) developed a randomized controlled study. During the intervention period, the experimental group completed a 2-month Wii-based exercise program encompassing up to 22 sessions. Participants completed three 1-h sessions per week, either individually or together with another participant. The study demonstrated that regular aerobic exercise increased the aerobic capacity of youths with DS and thus justified the use of fitness programs on this population. Moreover, Seron *et al.* (2017) investigated the effects of 12 weeks of aerobic and resistance training on the maximal and submaximal cardiorespiratory fitness of 41 young people with DS. The training program lasted 12 weeks, with frequency of 3 days a week for aerobic training group and two resistance training group and duration of 50 min per session. Both training programs led to an improvement in cardiac efficiency during submaximal activities and increased maximum ventilation, which demonstrates a cardiorespiratory improvement. Our findings suggest that the only program that showed improvements in the participants' cardiorespiratory fitness was the strength program. Possibly the difference in methodology used in each study may have a significant effect on the results. It would be necessary to generate studies with a similar training methodology to more reliably understand the results obtained.

There are three main limitations to the study. First, the sample of convenience prevents generalization in the overall population with DS. Second, in this study, measurements of puberty were not performed. Third, the diet of the participants was not controlled although the special education school regulates the food intake of the students. One of the great limitations of the present study is the comparison between different methodologies used. The different studies exhibited show different methodologies and this causes the difficulty to be able to compare the results. Otherwise, strengths of our study are the inclusion of validated physical fitness test batteries to assess fitness levels in the population with DS (Cabeza-Ruiz *et al.* 2019, Shields *et al.* 2015). The objective that was pursued with the use of these fitness batteries is to follow a methodology that allows future studies to be compared.

Conclusions

Results of this study suggested that a 16-week strength program consisting of three sessions of 60 min each were able to increase levels of health-related physical fitness in a sample of adolescents with DS. However, none of the body composition markers suffered any kind of effect after carrying out the intervention in the strength group. The aerobic program does not seem to show significant differences. Although these findings agree with those shown in the scientific literature, they should be taken with caution. The absence of control for variables such as sedentary lifestyle, caloric dietary intake or the basal energy expenditure of participants could have important effects in this special population. Therefore, conducting studies with a larger sample of participants and controlling for possible confounding variables could offer valuable information on the effect of training in the young population with DS. This would help health professionals to design interventions aimed at the needs of this special population.

Practical applications

This study demonstrates that people with DS experience significantly improved health benefits from fitness training. It has been shown that a fitness training program can favorably alter the levels of physical fitness in adolescents with DS when exercising at a moderate to high intensity level 3 times per week. However, this type of training and intensity seems to have no effect on body composition variables in this population. A longer training program may be necessary to see a positive effect on body fat levels.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix

Intervention

Aerobic group

Three weekly sessions of 60 min each. The development of motor learning and in the ability to perform activities continuously (aerobic activities) for as long as possible were the main object of the program. The work was oriented to the following associated content:

Participants walked on a treadmill (NordicTrack summit 4500; NordicTrack Inc., Chaska, Minnesota).

Adapted or modified collective games and sports: football and basketball games with ball to develop the throw, games to develop the races, games to develop the ability to walk, games to develop the ability to hit, games to develop the skills of lifting, carrying and transporting.

Coordinating qualities: general dynamic coordination and dynamic balance.

Basic skills: displacement, jumping, throwing, receptions, games and sports (dance).

Balance coordination exercises: Simple balance on one leg, balance on hands and knees, torsion jumps, obstacle course, balance on benches.

Basic skills: Turns in contact with the ground, turns in suspension, turns with constant grip of hands (fixed bar), turns with supports and multiple and successive suspension.

Strength group

Three weekly sessions of 60 min each. The sessions had been structured considering the Curriculum proposal in individual motor actions in stable environments, which were based on physical preparation individually with the aim of improving and increasing physical fitness levels (Strength). The sessions had the same content structure that marks the Physical Education Curriculum. The work was oriented to the following associated content:

Physical fitness: strength, speed, endurance, and agility.

Type of exercise:

- Horizontal rowing with dumbbell
- Chest press with dumbbells
- Split squat with dumbbells (one forward leg)
- Step ups
- TRX
- Dumbbell squat (Legs apart)
- Propellant with elastic band
- Squat band (elastic band)
- Drag exercises 5–8 kg
- Multiple exercises with resistance bands
- Scrolling exercises with ball.