

## Effect of an intensive physical conditioning program on body composition and isometric strength in children with Down syndrome

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### Abstract:

**Purpose:** Was to determine the effect of a physical fitness program on body composition and isometric strength in children with Down syndrome. **Methods:** Twenty-two children with DS, 13 in the experimental group (EG) and 9 in the control group (CG). Isometric handgrip strength, body height, weight, triceps and the medial calf skinfolds were measured. The body mass index (BMI) was computed from body height and weight. The physical fitness program was performed for 16-weeks, 5 times per week, on 55-min sessions. **Results:** Significant pre- to post-intervention reductions in BMI were observed in both EG ( $22.2 \pm 2.5$  vs.  $20.7 \pm 2.5$  kg/m<sup>2</sup>;  $P \leq 0.0001$ ), and CG ( $23.3 \pm 4.9$  vs.  $21.9 \pm 4.6$  kg/m<sup>2</sup>;  $P \leq 0.001$ ). Significant pre- to post-intervention reductions were observed in medial calf skinfold and isometric strength in the EG ( $14.9 \pm 5.5$  vs.  $14.6 \pm 3.2$  mm;  $P = 0.008$ ) and ( $2.4 \pm 4.0$  vs.  $9.2 \pm 2.0$  kg;  $P \leq 0.0001$ ), respectively. **Conclusion:** A physical fitness program improved isometric strength and body composition in Down syndrome participants. Children with Down syndrome can improve their quality of life by performing structured physical fitness training.

**Key Words:** Down syndrome, isometric strength, body composition, training.

### Introduction

It is estimated that there are approximately 250,000 people with Down syndrome in Mexico (Romero et al., 2014), a similar estimation to the 250,000 to 400,000 diagnosed in the United States (Ptomey, Szabo, Willis, Gorczyca, et al., 2018). The life expectancy for this group is approximately of 55 years, given to physical and congenital heart problems. One newborn will have Down syndrome out of 3000 pregnancies in women under the age of 29 years, out of 2000 pregnancies in women aged 30 to 34, out of 280 pregnancies in women aged 35 to 39, out of 70 pregnancies in women aged 40 to 44, and out of 40 pregnancies in women between 45 to 49 years of age (Romero et al., 2014). Thus, older pregnant women are more likely to have a pregnancy with Down syndrome (Gaulden, 1992).

The Down syndrome results from the trisomy of the human chromosome 21, which will determine, among other characteristics, intellectual disability and growth retardation (Gaulden, 1992). The growth of children with Down syndrome differs substantially compared with children without disabilities; with approximately 2 to 3 cm less in body height than their peers. The slower growth is not generally attributable to a growth hormone (GH) deficiency (Kaminker & Armando, 2008). Reduced muscular strength, cardiovascular capacity, sleep problems, and impaired walking performance are also observed in Down syndrome participants (Chen & Ringenbach, 2018; Mendonca, Borges, Wee, & Fernhall, 2018).

In Mexico, children who are born with Down syndrome lack of an all-inclusive attention to address their intellectual and motor disabilities. There are not enough centers devoted to these children; therefore, children are left unattended. However, in several countries, children with Down syndrome engage in specific programs tailored to their needs, including physical assessments. For instance, in Granada, Spain, Zurita Ortega et al. (2010), studied the prevalence of hyperlaxity in the school population ( $n = 2956$ , 49.9% male and 50.1% female) and to determine the age where the condition was more frequent using the Beighton test (Grahame, Bird, & Child, 2000). The 25.4% of the participants, including a high proportion of females, showed a positive Beighton.

In Brazil, Rodrigues-Nunes and Dupas (2001), developed a theoretical model about the family experience of having a child with Down syndrome. Participants were 10 Down syndrome families who were trained in promoting children's independence and autonomy through constant stimulation and continuous development. Using semi-structured interviews, it was found that families reported frustration, reaching the

conclusion that having a Down syndrome son exerts a strong impact on the family, especially on parents, who report high stress and adaptation difficulties.

Melville, Cooper, McGrother, Thorp, and Collacott (2005), studied overweight and obesity rates on 247 adult couples (47.4% women and 52.6% men) with Down syndrome or intellectual disability (controls) of similar age, sex, and residence zone. The mean age of Down syndrome participants was 37.2 yr. (range 20 to 69 yr.) and the control group was 37.2 yr. (range 20 to 65 yr.). The data showed that women with Down syndrome had higher body mass index (BMI = body weight (kg)/body height (m<sup>2</sup>)) scores than controls. Adiposity increased in participants with Down syndrome to 77.7% when combining overweight, obesity and morbid obesity values. Men with Down syndrome showed higher prevalence of overweight and lower morbid obesity rates compared to controls. In summary, there is a significant increase of adiposity in the Down syndrome population and those with intellectual disability when compared with the general population. Women with Down syndrome have the highest rates of overweight, consistent to previous findings (Basil et al., 2016; Bell & Bhate, 1992; Bertapelli, Pitetti, Agiovlasis, & Guerra-Junior, 2016; Prasher, 1995).

Mosso et al. (2011), reported on the nutritional status, aerobic capacity and muscular performance in children with Down syndrome before and after a physical activity intervention. The intention was to include 18 children aged between 5 and 10 yr.; however, children were excluded from the study because of low muscle tone (hypotonia), motor skills, and congenital heart disease. The physical activity program implemented showed increased muscle strength and decreased hypotonia in Down syndrome participants.

Madrigal Bolaños and Solano Trejos (2008), conducted an investigation to determine the association between aerobic capacity and body composition. Aerobic power was estimated from the 1-mile walking test and the BMI and body fat percentage measured body composition. Participants were 54 volunteers, 40 with mental retardation (12 women and 28 men) and 14 with Down syndrome (5 women and 9 men) between 14 and 40 yr. old. No significant correlations were found between aerobic power and body composition in participants with Down syndrome.

In spite of international research on Down syndrome population, there is scarce evidence on physical training program in Mexican children with Down syndrome. Therefore, the purpose of the study was to determine the effects of a physical fitness program on body composition and isometric strength in children with Down syndrome aged 8-16 yr.

## **Material & methods**

### *Participants*

We recruited 8 to 16 yr. old children with Down syndrome (n = 22), who were randomly assigned to an experimental group (EG, n = 13) and a control group (CG, n = 9). Volunteers were excluded from the study if they were currently participating in organized sports, had a diagnosed congenital heart disease and other serious cardiovascular disease, and if they had been subjected to any physical activity program before.

### *Measurement instruments*

Body height (cm) was measured with a Seca<sup>®</sup> stadiometer (model 213, Hamburg, Germany). The participant stood still on the platform, with the heels close to the edge of the stadiometer, and the head in the Frankfurt horizontal plane and with arms to the sides next to the body. Participants were asked to perform maximum inspiration and the measurement was recorded.

Body weight (kg) was measured with a Tanita<sup>®</sup> InnerScan Body Composition Monitor scale (model, BC-533, Tanita Corporation of America, Inc., Illinois, USA). Participants stood up still in the center of the scale, back and hips straight, and after a few seconds, the reading was recorded.

Measurements were taken from subcutaneous triceps and calf sites using a Slim Guide<sup>®</sup> caliper (Creative Health, Ann Arbor, MI, USA). We followed the procedures outlined by the International Society for the Advancement of Kinanthropometry (International Society for the Advancement of Kinanthropometry, 2001). The participant remained relaxed in standing position, with the arm relaxed, and then was asked to perform a slight external rotation with the arm and elbow extended to the side of the body. The skinfold measurement was recorded holding it with the thumb and index finger, taking into account half the length of the elbow towards the shoulder. In the case of the calf fold, the participant was placed standing in a relaxing position with arms at the side of the body and the dominant foot (right or left) placed on a box. The correct position of the knee and leg was at 90° and with the hamstring relaxed. The fold was recorded parallel to the long axis of the leg.

Isometric force was measured with a MSD hand-held hydraulic dynamometer (model SH5001, Düsseldorf, Germany). The participant stood up and held the dynamometer with his dominant hand, taking a grip as firmly as possible. The arm was flexed at 90° and next to the thorax, and at the signal; the subject pressed the dynamometer as hard as possible.

### *Procedures*

Parents and/or legal guardians were contacted through elementary schools and were invited to participate in the study. They were informed about the purpose of the study and asked to read and complete the informed consent form if they were interested in having their child participating in the study. The study protocol

followed the Helsinki Protocol for studies on human subjects. In a second stage, initial body composition and isometric strength tests were applied.

The EG performed a physical activity program lasting 16-weeks. The program included progressive resistance exercises aimed at increase strength, muscle tone, and weight control. The program frequency was 5 days per week, and each session consisted of three phases: a) initial warm-up phase and familiarization with materials, b) main exercise phase, and c) cool-down or recovery phase. During the warm-up phase (5- to 10-min), the purpose was to have participants perform wide movements to increase range of motion and body temperature by playing cooperative and individual games. The main exercise phase (30- to 35-min) consisted of circuit and “tabata” exercises. Different materials were used, such as weight discs, tension ropes, dumbbells, medicine balls and handgrips. The exercises were focused on the upper-body segments (i.e., forearm, biceps, triceps, shoulders and pectorals) and included biceps curl, triceps extension, chest press, and handgrip with different degrees of tension. The exercises using the participant’s own body weight focused on releasing muscle tension following the use of the workout material and were mainly different types of push-ups. Finally, the cool-down phase (approximately 10-min) was aimed at return participant to the resting state. Flexibility exercises of different muscle groups were performed, as well as relaxation through breathing exercises.

The children in the CG continued with their regular activities offered by the institution. These included Spanish language, natural sciences, personal independence skills and health protection, mathematics and art (e.g., painting, coloring storybooks). At the end of the program, the EG and CG were measured again on body composition and isometric strength variables.

#### Statistical analysis

The data was analyzed with the IBM-SPSS program, version 20 for Windows. Descriptive statistics are presented as mean and standard deviation (M ± SD). Mixed analysis of variance (ANOVA) tests (2 groups x 2 genders x 2 measurements) were computed for height, weight, BMI, strength and calf and triceps skinfolds. Statistical significance was set *a priori* at P ≤ 0.05.

#### Results

The EG had 46% males and 54% females, and the CG 55% and 45%, accordingly. The mean age in the EG was 12.3 ± 2.06 yr. and 11.4 ± 1.94 yr. in the CG. The 76% of the EG participants only had Down syndrome, 16% had Down syndrome and Autistic Disorder, and 8% had Down syndrome, Autistic Disorder and Attention Deficit Hyperactivity Disorder. In the CG, 77% only had Down syndrome, and 23% had Down syndrome, Autistic Disorder and Attention Deficit Hyperactivity Disorder. The anthropometric and physical characteristics of the participants is presented in table 1.

**Table 1**

*Anthropometric and physical characteristics of the participants (n = 22).*

Variables	Experimental (n = 13)				Control (n = 9)			
	Males (n = 6)		Females (n = 7)		Males (n = 6)		Females (n = 3)	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Age (yr.)	12.2 ± 1.9	-	12.4 ± 2.3	-	12.0 ± 2.0	-	10.7 ± 1.5	-
Height (cm)	133.2 ± 8.2	135.6 ± 8.5	131.8 ± 5.8	133.8 ± 4.7	130.4 ± 4.4	132.5 ± 4.7	132.1 ± 6.2	133.3 ± 6.4
Weight (kg)	37.7 ± 6.7	36.5 ± 7.0	40.1 ± 4.1	38.5 ± 5.4	39.3 ± 9.7	38.0 ± 9.5	40.6 ± 2.6	39.5 ± 2.8
BMI (kg/m <sup>2</sup> )	21.1 ± 1.8	19.7 ± 1.8	23.2 ± 2.9	21.5 ± 3.0	23.3 ± 6.3	21.8 ± 5.9	23.3 ± 1.0	22.2 ± 0.9
C-SKF (mm)	11.2 ± 4.3	10.0 ± 4.2	18.1 ± 4.5	15.3 ± 4.7	15.0 ± 2.7	14.8 ± 3.2	14.7 ± 4.5	14.0 ± 4.0
T-SKF (mm)	11.0 ± 2.8	12.7 ± 3.8	16.0 ± 5.4	15.9 ± 5.0	18.0 ± 5.5	17.7 ± 4.4	12.7 ± 3.5	12.3 ± 3.1
Strength (kg)	5.3 ± 3.3	10.8 ± 4.1	5.9 ± 3.2	9.9 ± 0.9	2.3 ± 1.2	3.5 ± 0.8	2.3 ± 2.1	3.0 ± 1.0

Note: C-SKF: calf skinfold; T-SKF: triceps skinfold; BMI: Body mass index.

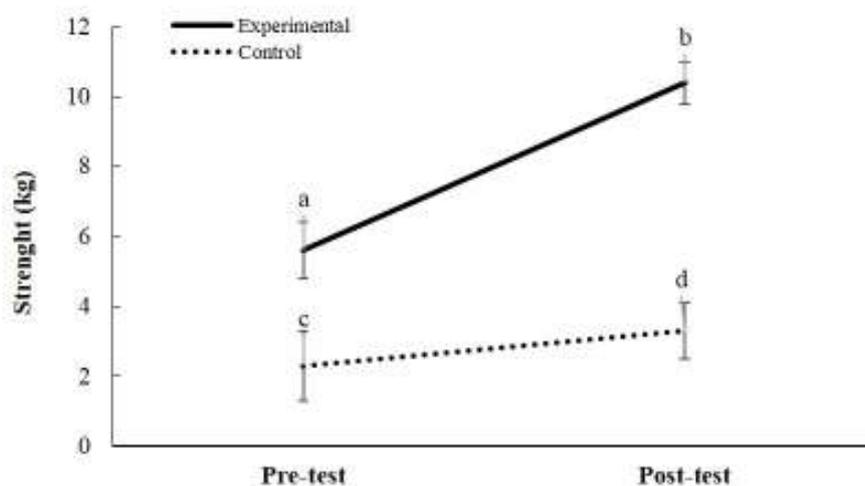
ANOVA did not show significant triple interactions for body height (P = 0.621), weight (P = 0.686), BMI (P = 0.461), calf skinfold (P = 0.508), triceps skinfold (P = 0.477) and isometric strength (P = 0.651). No significant double interactions (group x measurements) were found for body height (P = 0.260), weight (P = 0.796), BMI (P = 0.563), calf skinfold (P = 0.087), and triceps skinfold (P = 0.391). A significant double interaction was found in isometric strength (P = 0.002, Figure 1). This finding was explained by a change in strength in the EG from pre- to post-test (P ≤ 0.0001), as opposed to the CG (P = 0.221).

No significant double interaction (gender x measurements) were found on body height ( $P = 0.210$ ), weight ( $P = 0.853$ ), BMI ( $P = 0.857$ ), calf skinfold ( $P = 0.230$ ), triceps skinfold ( $P = 0.477$ ), and isometric strength ( $P = 0.370$ ).

Significant measurement main effects were found for body height, weight, BMI, calf skinfold and isometric strength. Regardless of gender or group, participants had a higher stature at the end of the study (Pre-test =  $131.9 \pm 1.4$  vs. Post-test =  $133.8 \pm 1.4$  cm;  $P \leq 0.0001$ ), a lower body weight (Pre-test =  $39.4 \pm 1.5$  vs. Post-test =  $38.1 \pm 1.6$  kg;  $P = 0.001$ ), a lower BMI (Pre-test =  $22.7 \pm 0.9$  vs. Post-test =  $21.3 \pm 0.8$  kg/m<sup>2</sup>;  $P \leq 0.0001$ ), a small calf skinfold (Pre-test =  $14.7 \pm 0.9$  vs. Post-test =  $13.5 \pm 0.9$  mm;  $P = 0.013$ ), and a higher isometric muscle strength (Pre-test =  $4.0 \pm 0.6$  vs. Post-test =  $6.8 \pm 0.5$  kg;  $P \leq 0.0001$ ). No statistically significant main effect was found in the triceps skinfold ( $P = 0.735$ ).

**Figure 1**

Changes in isometric muscle strength in Down syndrome participants. Significant changes are depicted by  $p < 0.001$  <sup>a</sup> vs. <sup>b</sup>; and non-significant changes by  $p > 0.05$  <sup>c</sup> vs. <sup>d</sup>.



## Discussion

We studied the effect of a physical fitness program on the body composition and isometric strength in children with Down syndrome. In the present study, participants in the EG had an attendance equal to or greater than 80% of the classes in the program. Other studies have shown attendance rates of 70% (González-Agüero et al., 2011) and 92% (Shields et al., 2013).

In this study, body weight was reduced in the EG and CG at the end of the program. This result is consistent with the study by Ordoñez, Rosety, and Rosety-Rodríguez (2006), where moderate-intensity aerobic training reduced adiposity in male adolescents with Down syndrome. This is a positive finding given the high prevalence of obesity in children with Down (Bertapelli et al., 2016); for instance, in the United States, obesity rates are almost four times higher in children with down syndrome than children from the general population (Basil et al., 2016).

However, body composition variables have provided equivocal findings. For instance, the study by Víquez Ulate and Mora Campos (2011), did not report significant changes in pectoral, axillary and suprailiac skinfolds, although there was a trend to increase; while for the abdominal skinfold there was significant increase. No significant changes were reported following the detraining phase, and a significant reduction in calf skinfold was observed in the EG, while in the CG there was an increase. This result is consistent to the findings by Guerra Balic (2000), where a CG increased skinfold adiposity following training compared to the EG. This finding is partially explained by the lack of physical activity in the CG that prevented reductions in body adiposity. González-Agüero et al. (2011), reported changes in body composition variables assessed by dual-energy X-ray absorptiometry (DXA) following 21 weeks of physical conditioning in Down syndrome participants. Compared to a CG, participants in the EG showed higher total and lower-limbs lean mass with no concurrent changes in overall adiposity. This finding has to be interpreted with caution since having a higher proportion of lean mass is relevant since it regulates several physiological processes (e.g., blood glucose), however, reducing the relative body fat content is also a desired goal of any conditioning program in Down syndrome participants inconsistently observed in training studies (González-Agüero et al., 2011; Li, Chen, Meng How, & Zhang, 2013).

Exercises programs aimed at increasing muscular strength and endurance are needed in children with Down syndrome given their low muscle tone and exertion capacity (Horvat, Croce, Pitetti, & Fernhall, 1999; Li

et al., 2013; Viquez Ulate & Mora Campos, 2011). A previous review showed significant improvements in cardiovascular fitness in Down syndrome population (Dodd & Shields, 2005). Two meta-analysis report consistent findings on muscle strength (Li et al., 2013; Sugimoto, Bowen, Meehan, & Stracciolini, 2016). The meta-analysis by (Li et al., 2013), identified five high-quality studies showing moderate to high improvements in muscular strength and balance, and equivocal findings on cardiovascular fitness and body composition. A recent meta-analysis by (Sugimoto et al., 2016), also reports large to moderate effects on general strength and moderate to small effects on maximal strength.

In the present study, a significant increase in isometric strength was observed in the EG compared to the CG, a finding consistent with previous reports (Lin & Wuang, 2012; Shields et al., 2013; Viquez Ulate & Mora Campos, 2011). Viquez Ulate and Mora Campos (2011), found significant strength changes in pectoral, dorsal, biceps femoris, quadriceps and triceps muscles following 6 weeks of resistance training in swimmers with Down syndrome. These findings were maintained two weeks following detraining. Interestingly, there were no significant adaptations in biceps strength following training; however, a significant reduction was observed following the two weeks of detraining. In a study by Shields et al. (2013), Down syndrome participants performed a resistance training protocol twice a week for 10 weeks, and compared to a CG, the EG increased their upper and lower limb strength. Lin and Wuang (2012), reported on Down syndrome participants who performed a fitness training program three times a week for 6 weeks and showed increases in hip extensor, hip flexor, knee extensor, knee flexors, hip abductors, and ankle plantar flexor muscles compared to a CG. Interestingly, knee muscle groups showed the greatest gains among all the muscles measured (Lin & Wuang, 2012).

In the present study, participants trained 16 weeks, 5 days per week, for a total of 80 exercise sessions. Compared to other studies with a smaller number of total sessions (e.g., 18 to 42) (González-Agüero et al., 2011; Lin & Wuang, 2012; Shields et al., 2013; Viquez Ulate & Mora Campos, 2011), we believe that we provided enough stimuli to participants to improve isometric strength and body composition. Since general aerobic and resistance training programs appear to benefit strength and cardiovascular health, other variables need to be studied when designing exercise interventions (e.g., nutrition, exergames, concurrent training, etc.), as well as other outcomes. For instance, recent evidence suggests that video conferencing might improve moderate- to vigorous physical activity (Ptomey, Szabo, Willis, Greene, et al., 2018) and cognitive variables (Ptomey, Szabo, Willis, Gorczyca, et al., 2018).

## Conclusions

This is the first physical training study conducted on Down syndrome population in Tijuana, Mexico. The participants of the experimental group showed an increased isometric strength and a reduction in the calf skinfold. In both groups (EG and CG) a significant reduction in BMI was observed. The Down syndrome children studied showed a high rate of overweight according to their age and height.

## Conflicts of interest

The authors declare no conflict of interest.

## References

- Basil, J. S., Santoro, S. L., Martin, L. J., Healy, K. W., Chini, B. A., & Saal, H. M. (2016). Retrospective Study of Obesity in Children with Down Syndrome. *The Journal of Pediatrics*, 173, 143-148. doi: <https://doi.org/10.1016/j.jpeds.2016.02.046>
- Bell, A. J., & Bhate, M. S. (1992). Prevalence of overweight and obesity in Down's syndrome and other mentally handicapped adults living in the community. *J Intellect Disabil Res*, 36 (Pt 4), 359-364.
- Bertapelli, F., Pitetti, K., Agiovlasitis, S., & Guerra-Junior, G. (2016). Overweight and obesity in children and adolescents with Down syndrome-prevalence, determinants, consequences, and interventions: A literature review. *Res Dev Disabil*, 57, 181-192. doi: 10.1016/j.ridd.2016.06.018
- Chen, C. J. J., & Ringenbach, S. D. R. (2018). Walking performance in adolescents and young adults with Down syndrome: the role of obesity and sleep problems. *J Intellect Disabil Res*, 62(4), 339-348. doi: 10.1111/jir.12474
- Dodd, K. J., & Shields, N. (2005). A systematic review of the outcomes of cardiovascular exercise programs for people with Down syndrome. *Arch Phys Med Rehabil*, 86(10), 2051-2058. doi: 10.1016/j.apmr.2005.06.003
- Gaulden, M. E. (1992). Maternal age effect: The enigma of Down syndrome and other trisomic conditions. *Mutation Research/Reviews in Genetic Toxicology*, 296(1), 69-88. doi: [https://doi.org/10.1016/0165-1110\(92\)90033-6](https://doi.org/10.1016/0165-1110(92)90033-6)
- González-Agüero, A., Vicente-Rodríguez, G., Gómez-Cabello, A., Ara, I., Moreno, L. A., & Casajús, J. A. (2011). A combined training intervention programme increases lean mass in youths with Down syndrome. *Res Dev Disabil*, 32(6), 2383-2388. doi: <https://doi.org/10.1016/j.ridd.2011.07.024>

- Grahame, R., Bird, H. A., & Child, A. (2000). The revised (Brighton 1998) criteria for the diagnosis of benign joint hypermobility syndrome (BJHS). *J Rheumatol*, 27(7), 1777-1779.
- Guerra Balic, M. (2000). *Down syndrome and response to physical exertion*. Ph.D., Universitat de Barcelona, Barcelona, España. Retrieved from <http://diposit.ub.edu/dspace/bitstream/2445/36649/2/TESIS.pdf>
- Horvat, M., Croce, R., Pitetti, K. H., & Fernhall, B. (1999). Comparison of isokinetic peak force and work parameters in youth with and without mental retardation. *Med Sci Sports Exerc*, 31(8), 1190-1195.
- International Society for the Advancement of Kinanthropometry. (2001). *International Standards for Anthropometric Assessment*. International Society for the Advancement of Kinanthropometry. Underdale, Australia. Retrieved from <http://www.ceap.br/material/MAT17032011184632.pdf>
- Kaminker, P., & Armando, R. (2008). Down Syndrome: First part: clinical-genetic approach. *Archivos argentinos de pediatría*, 106(3), 249-259.
- Li, C., Chen, S., Meng How, Y., & Zhang, A. L. (2013). Benefits of physical exercise intervention on fitness of individuals with Down syndrome: a systematic review of randomized-controlled trials. *Int J Rehabil Res*, 36(3), 187-195. doi: 10.1097/MRR.0b013e3283634e9c
- Lin, H.-C., & Wang, Y.-P. (2012). Strength and agility training in adolescents with Down syndrome: A randomized controlled trial. *Res Dev Disabil*, 33(6), 2236-2244. doi: <https://doi.org/10.1016/j.ridd.2012.06.017>
- Madrigal Bolaños, L., & Solano Trejos, H. (2008). *Aerobic capacity and body composition in subjects with mental retardation and Down syndrome*. Lic., Universidad Nacional, Heredia, Costa Rica. Retrieved from <http://www.repositorio.una.ac.cr/bitstream/handle/11056/13206/Tesis%206506?sequence=1&isAllowed=y>
- Melville, C. A., Cooper, S. A., McGrother, C. W., Thorp, C. F., & Collacott, R. (2005). Obesity in adults with Down syndrome: a case-control study. *J Intellect Disabil Res*, 49(Pt 2), 125-133. doi: 10.1111/j.1365-2788.2004.00616.x
- Mendonca, G. V., Borges, A., Wee, S. O., & Fernhall, B. (2018). Oxygen uptake efficiency slope during exercise in adults with Down syndrome. *J Appl Res Intellect Disabil*, 31(5), 897-904. doi: 10.1111/jar.12449
- Mosso, C., Santander, P., Pettinelli, P., Valdés, M., Celis, M., Espejo, F., . . . Sepúlveda, F. (2011). Evaluation of an intervention in physical activity in children with Down syndrome. *Revista chilena de Pediatría*, 82(4), 311-318.
- Ordoñez, F. J., Rosety, M., & Rosety-Rodríguez, M. (2006). Influence of 12-week exercise training on fat mass percentage in adolescents with Down syndrome. *Medical science monitor*, 12(10), CR416-CR419.
- Prasher, V. P. (1995). Overweight and obesity amongst Down's syndrome adults. *J Intellect Disabil Res*, 39 ( Pt 5), 437-441.
- Ptomey, L. T., Szabo, A. N., Willis, E. A., Gorczyca, A. M., Greene, J. L., Danon, J. C., & Donnelly, J. E. (2018). Changes in cognitive function after a 12-week exercise intervention in adults with Down syndrome. *Disabil Health J*, 11(3), 486-490. doi: 10.1016/j.dhjo.2018.02.003
- Ptomey, L. T., Szabo, A. N., Willis, E. A., Greene, J. L., Danon, J. C., Washburn, R. A., . . . Donnelly, J. E. (2018). Remote Exercise for Adults with Down Syndrome. *Transl J Am Coll Sports Med*, 3(8), 60-65.
- Rodrigues-Nunes, M. D., & Dupas, G. (2001). Independence of children with Down syndrome: the experiences of families. *Revista Latino-Americana de Enfermagem*, 19(4), 985-993.
- Romero, S., del Carmen, M., Navarrete Hernández, E., Canún Serrano, S., Reyes Pablo, A. E., & Valdés Hernández, J. (2014). Prevalence of Down syndrome in Mexico using the certificates of live birth and stillbirth during the period 2008-2011. *Boletín Médico del Hospital Infantil de México*, 71(5), 292-297.
- Shields, N., Taylor, N. F., Wee, E., Wollersheim, D., O'Shea, S. D., & Fernhall, B. (2013). A community-based strength training programme increases muscle strength and physical activity in young people with Down syndrome: A randomised controlled trial. *Res Dev Disabil*, 34(12), 4385-4394. doi: <https://doi.org/10.1016/j.ridd.2013.09.022>
- Sugimoto, D., Bowen, S. L., Meehan, W. P., & Straccolini, A. (2016). Effects of Neuromuscular Training on Children and Young Adults with Down Syndrome: Systematic Review and Meta-Analysis. *Res Dev Disabil*, 55, 197-206. doi: <https://doi.org/10.1016/j.ridd.2016.04.003>
- Viquez Ulate, F., & Mora Campos, A. (2011). Effects of Weight Resistance Training on Swimmers with Down Syndrome. *Retos*, 19, 10-14.
- Zurita Ortega, F., Ruiz Rodríguez, L., Martínez Martínez, A., Fernández Sánchez, M., Rodríguez Paiz, C., & López Liriaa, R. (2010). Hiperlaxity ligamentous (Beighton test) in the 8 to 12 years of age school population in the province of Granada. *Reumatología Clínica (English Edition)*, 6(1), 5-