

Physical activity interventions for children with Down syndrome:

A synthesis of the research literature

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*Abstract*

This synthesis highlights the available physical activity interventions/programs for children with Down syndrome. More specifically, the literature review examined evidence-based research in the areas of dance and movement, balance and stability, two-wheel bicycle, strength and agility and barriers and facilitators. The literature review used peer-reviewed and scholarly articles in order to examine the most effective physical activity intervention/programs for children with Down syndrome. Results showed that all physical activity interventions/programs can be effective for children with Down syndrome, especially when developmentally appropriate modifications and adaptations are incorporated. Dance and movement programs, balance and stability exercises using virtual reality games, learning to ride a two-wheel bicycle and strength and agility interventions can enhance the whole child's quality of life through participation and exposure.

*Keywords: Down syndrome, children, physical therapy, intervention, training, barrier, dance therapy, movement therapy, participation, benefits, balance, adolescents, bicycle, strength therapy and therapy*

## Chapter 1 - Introduction

The most recognizable genetic condition associated with intellectual disabilities is Down syndrome (Winnick, 2017). Down syndrome is the most common chromosomal condition diagnosed in the United States according to the Centers for Disease Control and Prevention (2017). According to the National Down Syndrome Society (2014), one in 691 people are born in the United States with Down syndrome every year.

A person born with Down syndrome experiences one of three chromosomal abnormalities. These abnormalities are characterized as trisomy 21 (nondisjunction), translocation or mosaicism. Trisomy 21 accounts for 95% of all cases according to the National Down Syndrome Society (2014). All cases however, demonstrate mental and physical changes to the body with adjoining affects regarding growth and physical development, medical problems and intellectual ability (Winick, 2017).

Children with Down syndrome often demonstrate deficits in muscular endurance, strength and motor skill development (Sugimoto, Bowen, Meehan and Stracciolini, 2016). Effects of developmental delays for children with Down syndrome are associated with “muscle hypotonia, poor balance, inadequate control of posture and underdeveloped posture control” (Albin, 2016). Life spans due to medical conditions for persons with Down syndrome are approximately 10 years less than the general population of people with intellectual disabilities (Winnick, 2017). Associated medical conditions include congenital heart defects, respiratory and hearing problems, Alzheimer’s disease, childhood leukemia, thyroid conditions (Winnick, 2017) and can lead to more complications such as obesity, cardiovascular diseases and diabetes (Sugimoto et al., 2016).

Children with Down syndrome also experience a delay in motor milestones and physical patterning, which can require physical therapy to obtain gross motor skills and live a physically active life (Shields, Dodd and Abblitt, 2009) “The goal of physical therapy is to minimize the development of the compensatory movement patterns that children with Down syndrome are prone to develop” (Winders, 2001, p.1). Physical therapy sessions however, are not always seen as enjoyable by children and therefore require other types of quality, enjoyable training programs/interventions that provide the same benefits as physical therapy. The goal is to enhance and improve the child’s physical abilities, increase functionality and potential transition into the workplace or community (Shields, Taylor and Fernhall, 2010).

Looking closely at the barriers and facilitators of program development and interventions involving strength training, dance/movement, balance and cycling training programs will serve as predictive tools to help enhance functional movement opportunities for children with Down syndrome. Children with Down syndrome are at risk of other health concerns; therefore, regular physical activity is essential (Shields et al., 2009). These alternative interventions/programs have the potential to improve physical skills, promote socialization, exhibit health benefits and provide a pathway that leads towards a better quality of life for people with Down syndrome.

This paper will focus on describing research on various movement programs/interventions for children with Down syndrome and comparing their effectiveness and feasibility for implementation. This review will explore whether each program/intervention has effective attributes in promoting an inclusive environment that accommodates the developmental differences of children with Down syndrome and

supports early exposure to physical activity. Exploring various training programs/interventions that are effective for children with Down syndrome, alternative to traditional physical therapy, will provide recommendations for physical activity specialists, parents and educators in a school and/or community setting. The purpose of this review is to evaluate different research-based physical activity interventions/programs for children with Down syndrome and understand the unique characteristics of each.

### **Statement of the Problem**

There are several different intervention/programs that can specifically target children with Down syndrome to enhance their physical activity level or help achieve motor skill patterns for functionality. Research-based intervention/programs include cycling, movement and dance, strength and agility and balance training. Barriers and facilitators of intervention/programs are also reviewed with attention to feasibility, replication and perspectives of child and parent. An overview of different physical activity programs will be examined in this synthesis to determine the most effective interventions for children with Down syndrome.

### **Purpose of the Study**

The purpose of this synthesis is to examine the literature on available physical activity interventions/programs for children with Down syndrome and determine the most effective evidence-based interventions. The following research questions were used to focus this study:

1. What physical activity interventions/programs are available for children with Down syndrome?

2. What impact do various interventions/programs have on the physical, cognitive, emotional and social health of children with Down syndrome?
3. What is the suggested implementation age for various interventions/programs for children with Down syndrome?
4. What are the parental perspectives of intervention/training programs?
5. What are the barriers and facilitators for intervention/programs for children with Down syndrome?
6. What are some recommendations for physical activity specialists when working with children with Down syndrome? In community programs? In a physical education setting?

### **Operational Definitions**

*Agility*- the ability to move and change direction and position of the body quickly and effectively (Lin and Wuang, 2012).

*Balance*- key element in the performance of most movement activities and utilizes visual, auditory, kinesthetic and tactile information (Winnick, 2017).

*Dance therapy*- psychological treatment that uses movement focused on the emotional and physical integration of participants (Winnick, 2017).

*Down syndrome*- the most recognizable genetic condition associated with intellectual disabilities where the person has an extra chromosome causing mental and physical changes to the body (Center for Disease Control, 2017).

*Movement therapy*- “physiotherapeutic use of movement to further the emotional, cognitive, physical and social integration of the individual” (Albin, 2016, p.59)

*Physical therapy*- the use of traditional physical activities for rehabilitation prescribed by a physician (Winnick, 2017).

*Physical activity specialist* (also known as an adapted physical education teacher)- someone who provides direct teaching responsibilities, program coordination and leadership (Winnick, 2017).

*Virtual reality*- using a computer interface that provides real-time environmental simulation and interacts with the user via multiple senses (Wuang, Chiang, Su and Wang, 2011).

### **Assumptions**

For the purpose of this study, the following assumptions were made:

1. Literature was exhaustive and comprehensive including backward searches.
2. Although limited, the effect of the size of the number of the participants in each study is large enough to be helpful.
3. Researchers used valid and reliable instruments honestly and truthfully to the best of their ability.
4. All participants in the studies completed instruments honestly, truthfully, and to the best of their ability.
5. All data coding and analysis of studies were transcribed by more than 1 researcher to establish validity.

### **Delimitations**

For the purpose of this study, the following delimitations were applied:

1. All children in this study were between the ages of 5-21 +/- 2 years.

2. All studies must be referenced, published after 2005 in a scholarly journal and available in English.
3. Students received only the intervention or program for the duration of the study with no traditional physical therapy in addition.
4. Studies including participants over the age of 22 or referred to as *adults* were not included.
5. There was no limit to location of study. Studies from around the world were included except those that were not translated into English.
6. All participants in the study had Down syndrome and no other medical or health conditions except a developmental cognitive delay.

**Limitations**

For the purpose of this study, the following limitations were applied:

1. Small sample sizes.
2. Limited research on movement therapies involving dance.
3. Limited research on children with Down syndrome only.
4. Limited research on children under the age of 21 only.

## Chapter 2 – Methods

The purpose of this chapter is to review the process used to investigate what movement interventions or training programs are effective and available for children with Down syndrome. The State University of New York College at Brockport Drake Memorial Library database was used for the primary search. The studies selected for this synthesis were located using the EBSCO Host database and backward searches from the references of articles. Within EBSCO Host, the following databases were searched: SPORTDiscus, Academic Search Complete and Education Source. Thirteen articles were found using these databases to support the purpose of the study.

The initial search for critical mass articles and research studies included being peer-reviewed, scholarly, 2005- current and published with references in an academic journal. Articles and research studies were found using keywords and phrases relevant to the research questions. The keywords identified were: *Down syndrome, children, physical therapy, intervention, training, barrier, dance therapy, movement therapy, participation, benefits, balance, adolescents, bicycle, strength therapy and therapy*. The phrases identified per individualized searches were searched in different combinations, including two, three or four keywords used simultaneously in attempt to generate as many articles as possible. Combinations included: (1) *Down syndrome AND children AND physical activity AND intervention*, (2) *Down syndrome AND physical activity AND training*, (3) *Down syndrome AND children and physical activity AND barrier*, (4) *Down syndrome AND children AND dance therapy OR movement therapy*, (5) *Down syndrome AND dance therapy OR movement therapy AND participation*, (6) *Down syndrome AND dance AND benefits*, (7) *Down syndrome AND balance*, (8) *Down syndrome AND*

*balance AND adolescents, (9) Down syndrome AND children AND bicycle, (10) Down syndrome AND strength AND therapy and (11) Down syndrome AND therapy AND children AND balance.* This process was repeated until the literature was exhausted and good quality articles were found. In various cases the same articles repetitively appeared in multiple searches.

For an article to be included in the literature review additional criteria also had to be met. This criterion included a full-text English transcript with references and the article must involve children with Down syndrome aged 5-21. Articles were not excluded if published outside of the United States. These delimitations helped focus the review of literature and article search.

An initial search of the keyword *Down syndrome AND children* within the SPORTDiscus database, resulted in identification of 150 articles. To refine results search, the addition of keywords *physical activity AND intervention* were added resulting in 46 results. In addition, the search was expanded to include three more databases; Academic Search Complete and Education Source. Of the 46 results, 22 were reviewed from Academic Search Complete, 12 were reviewed from SPORTDiscus, 12 were reviewed from Education Source and 0 were reviewed from Humanities Source. From there, four articles were selected and one article's references were used to select an additional article. A total of three articles were selected at this point to be a part of the review of literature.

Utilizing a combination of the three databases; SPORTDiscus, Academic Search Complete and Education Source, ten more separate searches were completed to refine results and observe reoccurring articles. Keywords *Down syndrome AND children AND*

*physical activity AND training* developed 30 results. Of those 30 reviewed, two were used for the review of literature. Keywords *Down syndrome AND children AND physical activity AND barrier* developed 12 results. Of those 12 reviewed, one article from Education Source was used for the review of literature. Keywords *Down syndrome AND children AND dance therapy OR movement therapy* established 52 results. Adding the keyword of *AND balance* refined the search to eight. One article was used from SPORTDiscus database for the review of literature.

Keywords *Down syndrome AND dance therapy OR movement therapy* established 110 results. To refine these results further the keyword *AND participation* limited the search to four. Of these four, one article was used from Academic Search Complete database for the critical mass. Keywords *Down syndrome AND dance AND benefits* established three results. Of these three, one article was used from the Education Source database for the review of literature. Keywords *Down syndrome AND balance* generated 332 results. Of those 332, SPORTDiscus database included 39 results. Those 39 articles were reviewed and two met the criteria for the critical mass.

The final four searches included articles from SPORTDiscus, Academic Search Complete and Education Source databases. The keywords *Down syndrome AND balance AND adolescents* generated 22 results. One article from SPORTDiscus was used in the critical mass. The keywords *Down syndrome AND children AND bicycle AND therapy* generated seven results. Two articles from Education Source were used for the critical mass. The keywords *Down syndrome AND strength AND therapy* generated 74 results. Of those 74, the Education Source database generated nine articles. One article was chosen to be included in the review of literature. Finally, the keywords *Down syndrome*

*AND therapy AND children AND balance* generated 38 results. One article from Academic Search Complete database was chosen to be included in the critical mass.

A total of 13 articles were chosen to be a part of the review of literature after an exhaustive and comprehensive search of the available literature. Articles came from journals such as, *Adapted Physical Activity Quarterly*, *Pediatric Physical Therapy*, *Research in Developmental Disabilities*, *Journal of Intellectual Disability Research*, *Focus on Autism and Other Developmental Disabilities*, *Research in Dance Education*, *Physiotherapy Theory and Practice*, *European Journal of Human Movement*, *Physical Therapy*, *Clinical Rehabilitation* and *Sport and Society*.

The articles included in this synthesis were a mix of qualitative and quantitative methods. The literature review included three qualitative, eight quantitative and two mixed methods. The means by which data was collected were questionnaires and interviews for qualitative studies. SPSS software and standardized testing was used to analyze data for quantitative studies.

The smallest sample size was one participant for three studies; a phenomenological case study, case report and eight-week intervention program. The largest study had a sample size of 110 participants in a virtual reality quantitative study. The critical masses for this synthesis consisted of 404 total subjects.

### **Chapter 3 – Review of Literature**

The purpose of this chapter is to review the literature that examines the different training programs and interventions available for children with Down syndrome. Specifically, this chapter will explain the components of programs influencing a child with Down syndrome's functional movement ability, balance and coordination, strength and agility and the barriers and facilitators of program implementation. This review will categorize programming into five categories; dance and movement, balance and stability, two-wheel bicycle, strength and agility and barriers and facilitators.

It should be noted that all of the following articles characterized children with Down syndrome as having potential limiting factors related to daily independence including; musculoskeletal and neuromuscular effects (hypotonia, ligament laxity, lack of muscle strength), delayed motor development resulting in decreased movement velocity, balance and delayed reaction times. Children with Down syndrome studied in the articles mentioned vary on cognitive ability, but did not have any other medical concerns. In some specific cases, children were excluded from the study if they had mobility problems, difficulty maintain bipedal stance, received additional drug therapy, had a neuromuscular or vestibular disease, had the inability to understand a game program, complete a questionnaire or any other health impairment that would be a health risk.

#### **Dance and Movement**

Dancing is a physical activity which involves expressionistic quality, mind-body awareness and can be done in a physical education setting or in the community. Dancing is a form of physical activity that can be performed by children with Down syndrome. To support this, a study by Reinders, Bryden & Fletcher's (2015) aimed to investigate

whether a child with Down syndrome would benefit from participating in a recreational dance program. The lived experience of a 21-year-old male (Luke) with Down syndrome with a similar functional capability of a seven or eight-year-old, was explored through a qualitative approach. This included the child's lived experience from the perspective of the child himself, his parents and the dance instructor. Luke participated in a six-week community dance class which met once a week with other students with disabilities aged 8-24. All peers in the dance class were female except for Luke. There was a 2:1 volunteer to student ratio.

Data was collected through one on one interviews, pre-and post-intervention. All interviews were audiotaped, transcribed verbatim and stripped of identifiers. Field notes and observations of the first and last class were also included. Several researchers plus the principal investigator analyzed transcripts independently then discussed their findings together to insure validity. The researchers established four themes: *Luke at Dance*, *Luke at Home*, *Dance! Dance! Dance!* and *Becoming a Dancer*. Only *Luke at Dance* and adjacent subthemes (psychological benefits, physical benefits, social benefits and the impact of music on the benefits of class) were discussed.

This study found that Luke's self-confidence, body awareness, self-esteem and encouragement to dance were enhanced post intervention. This is noted to be in direct correlation with the dance class framework which consisted of a ballet warm-up (one body part at time) to classical music, isolation exercises, simple traveling steps, dance routine, choreography, and free dance to pop music.

When combining the parent's opinion and the researcher's findings, the participant's experience in the dance class may have been even more enhanced if there

were more male students and peers his age. It was suggested that future studies should look at the psychological and physical benefits of a mixed gender dance class for children with Down syndrome.

A similar structured study was conducted by Gutierrez-Vilahu, Masso-Ortigosa, Costa-Tustusaus, Guerra-Balic & Rey-Abella's (2016). Gutierrez-Vilahu et al. (2016) compared postural control in static standing in young adults with and without Down syndrome, with eyes open and closed post 18-week intervention program of physical training based on classical, modern and creative dance movement. The dance program structure was organized by warm up activity, core strength and ballet barre, proprioception exercise with balance open-eyed and closed-eye, dance choreography, improv exercise/image recognition and finally a relaxation time.

The participants in this study were required to be between 17-22 years old and have a low-moderate intellectual disability. A total of 22 participants were included- eleven (five males and six females) had Down syndrome with a mean age of 20.55 and eleven (four males and seven females) typically developing participants had a slightly older mean age of 20.77. Participants with and without Down syndrome were included in this study to demonstrate validity and comparisons between groups.

To measure differences between open-eyed and closed-eyed static balance after dance movement intervention for children with Down syndrome and typically developing peers, two likewise groups were generated and assessed. The tool used to evaluate the center of pressure (COP) of the participants was a piezoelectric platform with a recording frequency 1,000 Hz. Statistics revealed that the children with Down syndrome's COP oscillated more compared to their typically developing counterparts, resulting in greater

improvement after participation in the dance program. Findings also indicated that “motor organization in children and adolescents with Down syndrome followed the same principles as in the general population but with some variations to adapt movement difficulty in decision making associated with Down syndrome” (Gutierrez-Vilahu et al., 2016, p.234) Gutierrez-Vilahu et al. (2016) recommended that dance or sensorimotor movement can be directed toward improving postural control and balance in children with Down syndrome because it is an enjoyable leisure and social activity that can be practiced over extended periods of time.

Integration into a community dance program is also an option for children with Down syndrome as a way of enhancing their abilities in the psychomotor, cognitive and affective domains. To support this, Becker and Dusing’s (2010) qualitative research study aimed to report the feasibility of integrating a child with Down syndrome into a community performing arts program with modifications to enhance participation. The participant for this study was an 11-year-old girl with Down syndrome. During a fourteen-week performing arts session (dance class), the participant worked one on one with a physical therapy student assistant with a background in dance, in a class of typically developing peers. The intervention was 90-minutes in duration, every Saturday morning in preparation for a culminating final public performance. The authors utilized The Pediatric Quality of Life Inventory Parent Report Questionnaire (PedsQL Version 4) to assess the participant before and after the intervention.

Prior to participation in the study, the parent report scores on a range of 31-70, totaled 51. Post intervention, the parents PedsQL score was increased to 57 due to the participants increased ability to run with improved coordination, increased speed,

decreased loss of balance and a narrower base of support. The participant's mother also noted that her child's ability to retain information improved and her socialization skills were enhanced. Becker and Dusing (2010) distinguished this finding as a prominent transitional skill to help the participant gain more independence. They concluded that with appropriate modifications and the right program for a child with Down syndrome, a child can be successfully included in a community program with other typically developing peers.

To support dance and movement interventions in a physical education setting, a study by Moraru, Hodorca and Vasilescu's (2014) researched the design and implementation of exercises that could be used in an adapted program for children with Down syndrome. Moraru et al. (2014) utilized gymnastics movements to improve the physical and psychological features of children with Down syndrome, given their motivation for physical activity. Participants included three children with Down syndrome between the ages of 10-14. The methods included an eight-month FUN fitness testing protocol with the goal of assessing joint flexibility, muscle elasticity, force and balance. The program included locomotion exercises, specific exercises related to dance and gymnastics which could be easily translated into a physical education setting.

The findings of this study relate to the findings of the previously mentioned study by showing that children with Down syndrome have the ability to improve and develop new motor skills throughout their lives with developmentally appropriate modification (Becker & Dusing, 2010; Moraru et al. 2014). Specific to the Moraru et al. (2014) study, spine mobility was increased by one to three centimeters and a decreased time was noted for 10 uplifts in a chair post programming for all three children. Two children increased

their maximum sit-ups by four to five repetitions compared to initial values, while the third child increased by one repetition. Finally, all three children had significant balance improvement while in a unipodal stance. Moraru et al. (2014) suggest that parental involvement and participation greatly assists a child's comfort level when learning new exercises and skills and applying them in different environments.

To summarize these studies, all support a relationship between dance/movement interventions and an increase in psychomotor, cognitive and affective domains for children with Down syndrome. All studies required modifications such as more explanations and demonstrations (Gutierrez-Vilahu et al., 2016) one-on-one assistance and physical guidance (Becker and Dusing, 2010) involving parents as support and encouragement (Moraru et al., 2014) and the dance instructor having knowledge of Down syndrome and individualized characteristics (Reinders et al., 2015) in order for the participants to be successful.

### **Balance and Stability**

Enhancing the balance ability of a child with Down syndrome is important because better balance will decrease their fear of falling or getting hurt and thereby increasing their desire to participate in physical activity (Jankowicz-Szymanska, Mikolajczyk and Wojtanowski, 2012). Utilizing virtual reality technology to motivate a child's interest in physical activity can be used as a physical therapy resource to help improve functional mobility, quality of movement and to improve cortical reorganization for children with Down syndrome (Reis, Neiva, Filho, Ciolac, Verardi, Siqueira, Goncalves, Silva, Hiraga and Tonello, 2017).

A recent study by Reis et al. (2017) alludes to the fact that there is a relationship between motor coordination, balance and body mass index for children with Down syndrome. Reis et al. (2017) proposes that virtual reality training is relatively new, as opposed to other more traditional therapeutic strategies, but suggests it as a way to promote health for children with Down syndrome.

In this study, twelve children with Down syndrome were organized into two groups; a group receiving virtual reality intervention and a control group. The virtual reality group consisted of seven children with a mean age of nine, while the control group consisted of five children with a mean age of eight. To measure balance, Reis et al. utilized the Korperkoodinationstest Fur Kinder (KTK) body assessment and the Pediatric Balance Scale (PBS).

After a two-week introduction to Xbox 360 Kinect TM device's games and controls, participants played a Kinect adventures game for 16 sessions. It should be noted that this game was used because it involved balance movements using skills such as balance, coordination, visual-manual and gross motor coordination to find success with games. Data from pre- and post-testing was statistically analyzed by SPSS software. Through analysis of this data, it was determined that virtual reality training showed significant differences in all of the tasks proposed after the intervention. These tasks included reaching forward with an outstretched arm, standing with one foot forward and standing on one foot. According to the KTK and PBS assessments, Reis et al. (2017) concluded that virtual reality training can be recommended as a therapy treatment for children with DS because it favors the development of motor coordination and balance.

Reis et al. (2017) suggested that “virtual reality training should be associated with everyday activities and can be included as treatment for children with Down syndrome because it contributes to improving overall coordination in a short period of time” (p.64).

Berg, Becker, Martian, Primrose and Wingen’s (2012) study provided a family-supported virtual reality training intervention that included similar conclusions. The study examined the motor outcomes of a child with Down syndrome following an eight-week intervention period of Nintendo Wii use.

The participant was a 12-year-old boy with Down syndrome who completed 547 minutes of Wii playing time. With informed consent of the participant’s parents, The Bruininks-Oseretsky Test of Motor Proficiency 2<sup>nd</sup> edition (BOT-2) found improvements in manual dexterity, upper limb coordination, balance and running speed. The self-perception profile questionnaire found an enhanced self-efficacy of program success by giving the participant the choice of what game to play to maintain interest and improve compliance with participation. Overall, this study shows that because of the Wii intervention, the participant’s stability index improved and the participant showed gains in the motor control areas he practiced the most. “Virtual gaming may offer children incentives for participation and skill acquisition that cannot be fully experienced in real world activities. Children are offered perceptual, sensorimotor and cognitive feedback regarding their success in negotiating these landscapes and can respond to feedback to improve performance” (Berg et al., 2012, p. 79).

Wii gaming device technology is supported in another study by Wuang, Chaiang, Su and Wang (2011) who sought to help children with Down syndrome enhance their balance skills and coordination. Wuang et al. (2011) examined the relationship of virtual

reality training, using Wii gaming technology, and standard sensorimotor function training. The participants for this study included 110 children with Down syndrome between the ages of 7-12. Similar to the previous study mentioned, children were evaluated using the BOT-2 test. Children were randomly assigned to two groups; one received virtual reality Wii training and the other received standard occupational therapy and a variation of therapeutic activities. After statistical analysis using SPSS software, the findings of the study found that out of all groups who received virtual reality training, the group who used the Wii significantly outperformed the traditional occupational therapy group. Virtual reality intervention could provide massive intensive sensorimotor simulation to activate mirror neuron systems needed to induce brain activation (Wuang et al., 2011).

To summarize, using virtual reality gaming to increase balance and stability for children with Down syndrome allows children to interact with a computer simulated environment and receive real time feedback on performance thus, allowing the child to rely more on internal feedback and self-evaluation in a safe environment (Wuang et al., 2011; Berg et al., 2012). The use of video games, such as the Wii or Kinect, may also allow children with Down syndrome to be more socially interactive with peers because these games are so popular. A limitation of the aforementioned studies includes an increased knowledge of the technology virtual reality interventions require to improve the application of the video game for a child with Down syndrome (Reis et al., 2017).

### **Two-Wheel Bicycle**

Two-wheeled bicycle riding skills is considered a societal norm in many countries, including the US. Children usually learn around the age of six or seven

(MacDonald, Esposito, Hauck, Jeong, Hornyak, Argento and Ulrich, 2012). Less than 10% of children with Down syndrome who are under the age of 15 can ride a Two-wheel bicycle (Ulrich, Burghardt, Lloyd, Tiernan and Hornyak, 2011). Two-wheel bicycle riding can help promote socialization and increase physical activity for children with Down syndrome (MacDonald et al., 2012). According to Ringenbach, Holzapfel, Mulvey, Jimenez, Benson and Richter (2016), assisted cycling therapy (ACT) has the “potential to further independence and autonomy in persons with Down syndrome” (p.1080) leading to a better quality of life. Ulrich et al. (2011), Ringenbach et al. (2016) and Benson and Ritcher (2016) all agree the cognitive disabilities that children with Down syndrome have limit their opportunities to participate in physical activities and it requires more time to practice and receive instruction with a two-wheel bicycle compared to typically developing peers (Ulrich et al, 2011; Ringenbach et al. 2016 and Benson and Ritcher, 2016).

Ulrich et al. (2011) investigated patterns of physical activity in children with Down syndrome and its association with health and functioning using a two-wheel bicycle intervention. The participants in this study included 72 children who had Down syndrome, were between the ages of 8-15 years old (average age 12) and could not ride a two-wheel bike pre-intervention. Measurements used to evaluate the participants included leg strength (manual muscle tester MMT), standing balance (one foot, hands on hips, 60 sec) and physical activity (seven consecutive days with accelerometers). Statistical analysis revealed that 56% of the total group learned to ride a two-wheel bicycle with 75 minutes of individualized training over five consecutive days.

Ulrich et al. (2011) utilized an intervention called Lose The Training Wheels. This programming used adapted bikes, had trained staff with experience working with children with Down syndrome and its main goal was to progress every child to ride a standard two-wheel bicycle. This study demonstrated the potential to decrease sedentary time and increase time in moderate-to-vigorous physical activity, which is essential for children with Down syndrome who are already at higher risk for health impairments (Ulrich et al. 2011). It should be noted that parents of children in this study perceived that due to the bike intervention, their children were more willing to try other physical activities because their fears diminished after learning how to ride bike. Fears included falling down and getting hurt, which relates back to research about balance and stability for children with Down syndrome.

A similar study which also used the Lose The Training Wheels intervention was conducted by MacDonald et al. (2012). The participants in this study included 30 children with Down syndrome between the ages of 9-18 years old. Similar to the aforementioned study, leg strength, standing balance and the Peabody Picture Vocabulary Test (PPVT-4) was used to collect data. Children with Down syndrome were categorized into riders and nonriders. The two groups were statistically different in all leg strength tasks: right and left leg extension, and right and left leg flexion, finding that the children receiving the intervention can successfully demonstrate the ability to ride a two-wheel bicycle. The most successful riders had higher scores on the PPVT-4, a lower percentage of body fat and were significantly older in the group, heavier and stronger (MacDonald et al., 2012). Results indicate learning to ride a bicycle later in life when physically stronger and heavier may be easier than teaching a young child with Down syndrome.

One of the important reasons for teaching a child with Down Syndrome how to ride a bicycle is to impact their opportunities to participate in physical activity and enhance their quality of life (Ringenbach et al., 2016). Children with Down syndrome who know how to ride a two-wheel bicycle are exposed to more socialization opportunities. The skill of riding a bicycle can be done with family, peers and in the community (MacDonald et al., 2012). Ringenbach et al. (2016) found that assisted cycling therapy may be a promising exercise modality for persons with Down syndrome, which in turn could translate to a better quality of life and other related outcomes (Ringenbach et al., 2016).

This quantitative study involved 17 (10 male and seven female) participants with Down syndrome. During eight-weeks of an assisted cycling therapy intervention, participants were measured using the Peabody Picture Vocabulary test, the Lafayette Instrument Visual Choice Reaction Time Apparatus and the NEPSY Knock-Tap Task. Results of the study indicated that eight-weeks of assisted therapy sessions can improve reaction time inhibition and language fluency in adolescents with Down syndrome.

It is important for persons with Down syndrome to be provided with motor skills that can be done with peers, family and individually (Ulrich et al. 2011; Ringenbach et al. 2016). This study alludes to the fact that improved sport performance (bicycle riding) through faster reaction time may result in greater sports participation that would be especially important for persons with Down syndrome who often have low rates of sports participation to begin with (Ringenbach et al., 2016).

**Strength and Agility**

Characteristics of Down syndrome include skeletal muscle hypotonia and ligamentous laxity which can lead to a greater increase of injury (Gupta, Rao and Kumaran 2011). According to the National Down Syndrome Society (2014) atlantoaxial instability is common in at least 10-30% of children with Down syndrome and is commonly asymptomatic. This is an important fact to reduce the risk of a spinal cord injury when attempting to use strength training as an intervention to enhance physical ability of children with Down syndrome.

Gupta et al. (2011) and Hussein (2017) support that strength training for children is a safe and effective intervention to promote strength and balance for children with Down syndrome. To support this notion, Gupta et al. (2011) studied 23 children between the ages of seven and 15 with Down syndrome. Following six-weeks of exercise programming, three test trials between two groups (experimental group -12, control group -11) were measured using the BOT-MP assessment. It is important to note that the findings of this study may have been greater if training started at greater than 50% of the participants 1RM. Statistical analysis revealed that there was a statistical significance between groups regarding muscular strength of lower limb muscles and overall balance when compared to the control group who did not receive exercises. These improvements are documented to be from an enhanced neural recruitment rather than muscle fiber changes due to the fact that the length of the programming was only six weeks in duration. An intervention of this duration is feasible for children with Down syndrome because compliance was adhered to and proper modifications and explicit demonstrations were provided (Gupta et al., 2011).

Another study that aimed to investigate strength and agility exercises through a training program for adolescents with Down syndrome was conducted by Lin and Wuang (2012). This study involved 92 participants between the ages of 12-18. Two groups of 46 participants each were formed, an experimental group and a control group. A questionnaire, the Wechsler Intelligence Scale for Children 3<sup>rd</sup> edition, a hand-held dynamometer and the BOT-2 was used in this study. Post six-week exercise training program, which included treadmill exercises and virtual reality gaming, the researchers concluded that the lower extremity muscle strength and agility performance of the experimental group improved significantly compared to the control group. Lin and Wuang (2012) also found that the average heart rate after the intervention was 125 beats per minute and 60% maximum heart rate was reached. BMI was positively correlated to average muscle strength, but not agility performance. Agility is defined in this study as “the ability to move and change direction and position of the body quickly and effectively while under control, and requires the integration of isolated movement skills using a combination of balance, coordination, speed, reflexes, strength, endurance and stamina” (Lin and Wuang, 2012, p. 2237).

To summarize, the aforementioned study and this study both showed significant gains in muscle strength and performance noteworthy enough to recommend that a feasible strength program for children with Down syndrome should be approximately six weeks in duration (Lin and Wuang 2012; Gupta et al. 2011).

### **Barriers and Facilitators**

A big problem with programming for children with Down syndrome is accessibility and modification. Fifty eight percent of children with Down syndrome do

not meet the daily physical activity time recommendations (Barr and Shields, 2011). The qualitative study by Barr and Shields (2011) studied the barriers and facilitators of physical activity specifically for children with Down syndrome. The researchers interviewed 20 parents of children with Down syndrome less than the age of 17, to get a first-hand perspective of what they perceived to be the barriers and facilitators of physical activity for their children.

A variety of themes related to facilitators and barriers emerged. The facilitators included: the positive role of family, opportunities for social interaction with peers, structured accessible programs that make adaptations available and the child's determination to succeed with the physical skill, cognitive ability and coordination to participate. The barriers included: characteristics that are associated with Down syndrome, competing family responsibilities, reduced physical, behavioral and cognitive skills and lack of accessible programming. Overall, the researchers concluded that programs for children with Down syndrome would benefit the child's "long-term health and well-being, increase participation and maximize the social benefits associated with physical activity" (Barr and Shields, 2011, p. 1021). The authors suggested that children with Down syndrome were more likely to be engaged in physical activity when encouragement was provided by family and the child actively found him/herself involved in peer interaction during activity.

## Chapter 4 – Discussion

The purpose of this chapter is to synthesize the results of the articles in chapter 3 and answer the original research questions proposed in chapter 1. Interventions as part of the literature review were divided into the five categories: dance and movement, balance and stability, two-wheel bicycle, strength and agility and barriers and facilitators. This section will discuss specific findings in relation to the research questions that guided the research for the literature review.

### **Research Question #1 What physical activity interventions/programs are available for children with Down syndrome?**

The literature resulted in 12 articles that provided information on what interventions/programs are available for children with Down syndrome. The physical activity interventions/programs available for children with Down syndrome included dance and movement, balance and stability, two-wheel bicycle and strength and agility.

The category of dance and movement encompassed research by Gutierrez-Vilahu et al. (2016), Becker and Dusing (2010), Moraru et al., (2014) and Reinders et al., (2015). Overall, results indicated that “motor organization in children and adolescents with Down syndrome follow the same principles as the general population but with some variations to adapt movement” (Gutierrez-Vilahu et al., 2016, p.234). Dance and movement is a recommended and appropriate physical activity intervention or program for children with Down syndrome to participate in because of the socialization benefits (Becker and Dusing, 2010, Reinders et al, 2015), individualized instruction (Becker and Dusing, 2010), increased postural and body control (Gutierrez-Vilahu et al., 2016, Moraru et al., 2014) and motor skill enhancement (Reinders et al, 2015). Becker and Dusing (2010) and

Reinders et al., (2015) utilized pre-existing community dance programs focused on qualitative discussion ultimately alluding to the fact that a child with Down syndrome's overall quality of life can be enhanced by dance intervention (Becker and Dusing, 2010, Reinders et al., 2015). Gutierrez-Vilahu et al., (2016) and Moraru et al., (2014) based their research on standardized testing protocols to assess quantitative results demonstrating that implementing exercises related to dance and movement increase motor skills to enhance body functionality for children with Down syndrome (Gutierrez-Vilahu et al., 2016 and Moraru et al., 2014).

The category of balance and stability encompassed research by Berg et al., (2012), Reis et al., (2017) and Wuang et al., (2011). All three studies utilized virtual reality gaming to improve balance, stability and coordination in children with Down syndrome. Balance and stability intervention/programs using virtual reality games can be used to increase physical activity time, as an incentive for participation and skill acquisition (Berg et al., 2012) and as an option to promote functional mobility (Reis et al., 2017) for children with Down syndrome. Wuang et al., (2011) noted that virtual reality could provide massive intensive sensorimotor simulation to activate mirror neuron systems needed to induce long term effects of brain function in children with Down syndrome.

Balance and stability are often a problem for children with Down syndrome due to the typical characteristics associated with the disability such as poor muscle tone, poor balance, perceptual difficulties and poor vision and hearing loss (Winnick, 2017). Therefore, the balance and stability interventions/programs reviewed in the literature

provide an important direction for improving this needed physical function to lead a physically active life.

The category of two-wheel bicycle riding encompassed research by Macdonald et al. (2012), Ringenbach et al. (2016) and Ulrich et al., (2011). MacDonald et al. (2012) and Ulrich et al. (2012) both utilized Lose The Training Wheels Program that concluded future bicycle training interventions can be easily implemented in a school-setting (MacDonald et al., 2012), appropriate modifications allow a child with Down syndrome to independently ride a bicycle (MacDonald et al., 2012; Ulrich et al., 2011) and riding a bicycle has the potential to decrease sedentary time which is essential for children with Down syndrome who are already at a higher risk for health impairments (Ulrich et al., 2011). Ringenbach et al. (2016) agreed with Ulrich et al. (2011) that “a single bout of moderate intensity aerobic exercise has been shown to improve inhibition in young adults with Down syndrome (Ringenbach et al., 2016, p.1074).

Finally, the category of strength and agility encompassed research by Gupta et al. (2011) and Lin an Wuang (2012). Both studies concluded that muscular strength is an essential skill for functional daily activities (Gupta et al., 2011; Lin and Wuang, 2012). Lin and Wuang (2012) and Gupta et al. (2011) both agreed that traditional physical therapy exercises improve physical activity, however, repetitive training is often too uninteresting for children with Down syndrome and it is most effective to be innovative and creative with exercises.

To summarize, there are various physical activity interventions/programs for children with Down syndrome that are available in an individualized, group, school or community setting. The most important factors involved in physical activity

intervention/programs stated by the research are feasibility (Gupta et al., 2011), creativity (Lin and Wuang, 2011) and knowledge of instructor to adapt and modify programming (Reis et al., 2017).

**Research Question #2 What impact do various interventions/programs have on the physical, cognitive, emotional and social health of children with Down syndrome?**

People with Down syndrome often have limited physical activity experiences because of functional and structural impairments. The benefits of physical activity are well established for people with Down syndrome, but it should be noted that physical activity interventions/programs will not only enhance the physicality of an individual but they also have physiological benefits. Exertion and skill acquisition increase as well as the psychological benefits of exercise and participation for children with Down syndrome (Berg et al., 2012). Positive interactions with peers in a social setting and physical traits such as balance and posture increase in functionality for children with Down syndrome as a result of intervention/programs (Gutierrez-Vilahu et al., 2016, Moraru et al., 2014).

According to the literature, dance and movement interventions, balance and stability, two-wheel bicycle and strength and agility programs have shown to have a positive impact on all domains of learning. Children with Down syndrome demonstrated a boost of self-confidence, enhanced self-assurance and increases in their cognitive capacity (Reinders et al., 2015). “Participation in community recreation programs supported the development of peer relationships, enhanced self-esteem and improved general health” for children with Down syndrome (Becker and Dusing, 2010, p.275).

**Research Question #3 What is the suggested implementation age for various interventions/programs for children with Down syndrome?**

According to the research, “skill programs aimed at developing running, jumping, climbing, balance and ball skills from a young age in children with Down syndrome might have a long-term influence of the amount of physical activity they undertake in the future and should be considered part of family activities, structured therapy, early intervention programs and school curriculum” (Barr and Shields, 2011, p.1030).

Children with Down syndrome lag behind typically developing peers and acquire various health-related comorbidities that may be affected by a lack of active participation in physical activity (Macdonald, 2012). Shaping neural connections at a young age through exposure to various interventions/programs can lead to neuroplasticity for the child with Down syndrome (Wuang et al., 2011). An exact age of implementation per physical activity intervention/program for children with Down syndrome was not solidified to an ideal age through the literature review of research. However, the authors of the literature recommended that interventions/programs would be most effective for the child with Down syndrome if implemented as early as possible. As a child grows older, the gap of physical skill and cognitive ability increases and makes it harder for the child to participate in physical activity. Children who participated in “early intervention programs or one-on-one therapy to promote the development of their motor skills are less likely to experience a decline in function with age” (Barr and Shields, 2011, p.1030).

**Research Question #4 What are the parental perspectives of intervention/training programs?**

Parental perspectives of physical activity programs for children with Down syndrome allude to the fact that their children were more willing to try other physical activity options after a positive experience. Their child's fears diminished after learning how to ride a two-wheel bicycle, which in turn promoted more physical activity (Ulrich et al., 2011). Parents who are involved, educate themselves and act as a positive role model see positive responses from their children (Barr and Shields, 2011).

**Research Question #5 What are the barriers and facilitators for intervention/programs for children with Down syndrome?**

Understanding the barriers and facilitators children with Down syndrome experience with physical activity is essential for health care professionals, sports and recreation industry personnel, adapted physical activity specialists and physical education teachers/coaches. The goal is to design effective intervention strategies, programs and opportunities to promote life-long physical activity for people with Down syndrome (Barr and Shields, 2011).

The use of physical activity interventions/programs for children with Down syndrome have the potential to benefit the whole child with appropriate modifications and adaptations (Becker and Dusing, 2010; Wuang et al., 2011; MacDonald et al., 2012; Barr and Shields, 2011). It is important to note that "individuals developing physical activity programs for children with Down syndrome can draw on successful strategies used to promote physical activity among children with typical development" (Barr and Shields, 2011, p. 1030).

The most common facilitators for children with Down syndrome are: the use of one on one instruction and encouragement from peers (Becker and Dusing, 2010; Reinders et al., 2015), parental involvement (Moraru et al., 2014; Barr and Shields, 2011), transferability of skills to authentic situations and functional activities (Reis et al., 2017; Wuang et al., 2011; Lin and Wuang, 2012) and ever-changing exercises and creativity of programming as opposed to traditional repetitive physical therapy exercises (Wuang et al., 2011; Lin and Wuang, 2012).

Barriers are different than typically developing peers for children with Down syndrome because of cognitive delays and lack of social/behavioral skills, as well as physical skill differences (Barr and Shields, 2011). The most common barriers for children with Down syndrome are: the physical, cognitive and emotional limitations children with Down syndrome may have creating difficulty in participating in community programming without developmental adaptations or modifications (Becker and Dusing, 2010; Berg et al., 2012; Macdonald et al., 2012; Ulrich et al., 2011), funding of interventions/programs (Becker and Dusing, 2010; Rienders et al., 2015), negative labeling of a child with Down syndrome's ability (Moraru et al., 2014) accessibility and length of program/intervention (Rienders et al., 2015; Gupta et al., 2011; Lin and Wuang, 2012) and knowledge of the instructor (Becker and Dusing, 2010; Ries et al., 2017). Non-traditional interventions/programs are often overlooked, seen as inaccessible, a financial burden or unknown to the implementer or the family of the child with Down syndrome (Becker and Dusing, 2010; Barr and Shields, 2011; Reis et al., 2017). Such barriers need to be eliminated by ensuring that physical activity is enjoyable, early-intervention is

encouraged and equal appropriate opportunities are provided for the child with Down syndrome (Barr and Shields, 2011).

**Research Question #6 What are Some Recommendations for Physical Activity Specialists When Working with Children with Down Syndrome? In Community Programs? In a Physical Education Setting?**

Physical activity specialists “face the task of providing successful, enjoyable and challenging learning experiences for all students” (Winnick, 2017). It is essential that children with Down syndrome are integrated into programs in the community and the physical education setting. As result of the literature review, recommendations for physical activity specialists are established: provide one-on-one instruction to further break down and demonstrate skills to be successful (Becker and Dusing, 2010), modify and adapt equipment (Wuang et al., 2011; MacDonald et al., 2012), integrate the child with Down syndrome into pre-existing programs (Becker and Dusing, 2010) use peer helpers (Becker and Dusing, 2010), do not label a child before assessing his/her present level of performance (Moraru et al., 2014) involve parents (Moraru et al., 2014; MacDonald et al., 2012), make the program feasible and accessible (Gupta et al., 2011; Lin and Wuang, 2012) and increase knowledge of intervention area and characteristics of Down syndrome (Ries et al., 2017; Barr and Shields, 2011).

## **Chapter 5 – Conclusion and Future Research Needs**

The purpose of this chapter is to present conclusions for the most effective research based physical activity interventions/programs for children with Down syndrome and make recommendations for future research.

### **Conclusion**

The physical activity interventions/programs discussed within the categories of the literature reviewed indicated the available options children with Down syndrome have in contrast to traditional physical therapy to promote health and motor skill. Specifically, the literature review pointed out that children with Down syndrome have a positive benefit from participating in an intervention or physical activity program.

Expectations of programs/interventions created for children with Down syndrome are specifically dependent on the unique characteristics of the child. It is clear that with modification and adaptation, dance and movement, balance and stability virtual reality gaming, learning to ride a two-wheel bicycle and strength and agility exercises can help a child overcome physical limitations and characteristics associated with Down syndrome by increasing physical functions of the body leading to a better quality of life.

### **Future Research Needs**

In the future, more research needs to be done on physical activity interventions/programs for children with Down syndrome, especially involving dance and movement. Authors noted that dance was the most common physical activity program regarding participation for children with Down syndrome (Barr and Shields, 2011). However, the research available for this review of literature was very limited, and the sample sizes were very small. English versions of articles from all topics were also

difficult to encounter and required Interlibrary Loan from the Drake Memorial Library Database.

Another possible recommendation for the future is to study the implementation of the same program/intervention across multiple environmental contexts and ages to establish effectiveness and explore the known barriers and facilitators for children with Down syndrome. It would also be interesting to research the same program/intervention taught by different physical activity specialists (i.e. adapted physical education teacher vs occupational therapist vs dance teacher) to see if the teaching style and/or the environment impacts success for children with Down syndrome. More research should also come directly from the perspective of the children with Down syndrome as well as their peers and family.

Final recommendations for future research include having more participants included in the studies, more studies investigated in the same geographical location, in depth descriptions of program exercises and organization, collecting data on the socio-economic status of participants, allowing choice of physical activity or exercise for the child and following up results of interventions/programs.

## References

- Albin, C. (2016). The benefit of movement: Dance/movement therapy and down syndrome. *Journal of dance Education, 16*(2), 58-61. doi: 10.1080/15290824.2015.1061196
- \*Barr, M., Shields, N. (2011). Identifying the barriers and facilitators to participation in physical activity for children with down syndrome. *Journal of Intellectual Disability Research, 55*(2), 1020-1033. Doi:10.1111/j.1365-2788.2011.01425.x
- \*Becker, E. and Dusing, S. (2010). Participation is possible: A case report of integration into a community performing arts program. *Physiotherapy Theory and Practice, 26*(4), 275-280. doi: 10.3109/09593980903423137
- \*Berg, P., Becker, T., Martian, A., Primrose, K. & Wingen, J. (2012). Motor control outcomes following nintendo wii use by a child with down syndrome. *Pediatric Physical Therapy, 78-84*. doi: 10.1097/PEP.0b013e31823e05e6
- Centers for Disease Control and Prevention. (2017, September 28). *Facts about down syndrome*. Retrieved from: <https://www.cdc.gov/ncbddd/birthdefects/DownSyndrome.html>
- \*Gupta, S., Rao, B. & Kumararn, S.D. (2011). Effect of strength and balance training in children with downs syndrome: A randomized controlled trial. *Clinical Rehabilitation, 25*, 425-432. Doi:10.1177/0269215510382929
- \*Gutierrez-Vilahu, L., Masso-Ortigosa, N., Costa-Tustusaus, L., Guerra-Balic, M. & Rey-Abella, F. (2016). Effects of dance program on static balance on a platform in young adults with down syndrome. *Adapted Physical Activity Quarterly, 33*, 233-252. Doi: 10.1123/APAQ.2015-0048

- Jankowicz-Szymanska, A., Mikolajczyk, E. & Wojtanowski, W. (2011). The effect of physical training on static balance in young people with intellectual disability. *Research in Developmental Disabilities, 33*, 675-681. doi: 10.1016/j.ridd.2011.11.015
- \*Lin, H. and Wuang, Y. (2012). Strength and agility training in adolescents with down syndrome: A randomized controlled trial. *Research in Developmental Disabilities, 33*, 2236-2244. Doi: 10.1016/j.ridd.2012.06.017
- \*MacDonald, M., Esposito, P., Hauck, J., Jeong, I., Hornyak, J., Argento, A. and Ulrich, D. (2012). Bicycle training for youth with down syndrome and autism spectrum disorders. *Focus on Autism and Other Developmental Disabilities, 27*(1), 12-21. Doi: 10.177/1088357611428333
- \*Moraru, C., Hodorca, M. & Vasilescu, D. (2014). The role of gymnastics and dance in rehabilitating motor capacities in children with down syndrome. *Sport and Society, 14*, 102-106. Retrieved from: <https://search.ebscohost.com/>
- National Down Syndrome Society. (2017, September 28). *Down syndrome facts*. Retrieved from: <http://www.ndss.org/Down-Syndrome/Down-Syndrome-Facts/>
- \*Reinders, N., Bryden, P. & Fletcher, P. (2015). Dancing with down syndrome: a phenomenological case study. *Research in Dance Education, 16*(3), 291-307. Doi: 10.1080/14647893.2015.1036018
- \*Reis, J., Neiva, C., Filho, D., Ciolac, E., Verardi, C., Siqueira, L., ... Tonello, M. (2017). Virtual reality therapy: Motor coordination and balance analysis in children and teenagers with down syndrome. *European Journal of Human Movement, 38*, 53-67. Retrieved from: <http://www.eurjhm.com/>

- \*Ringenbach, S., Holzapfel, S., Mulvey, G., Jimenez, A., Benson, A. & Richter, M. (2016). The effects of assisted cycling therapy (act) and voluntary cycling on reaction time and measures of executive function in adolescents with down syndrome. *Journal of Intellectual Disability Research*, 60(2), 1073-1085. doi: 10.1111/jir.12275
- Shields, N., Dodd, K. and Abblitt, C. (2009). Do children with down syndrome perform sufficient physical activity to maintain good health? A pilot study. *Adapted Physical Activity Quarterly*, 26, 307-320. Retrieved from: <http://journals.humankinetics.com/journal/apaq>
- Shields, N., Taylor, N. & Fernhall, B. (2010). A study protocol of a randomized controlled trial to investigate if a community based strength training programme improves work task performance in young adults with down syndrome. *BMC Pediatrics*, 10(17) doi: 10.1186/1471-2431-10-17
- Sugimoto, D., Bowen, S., Meehan, W. & Stracciolini, A. (2016). Effects of neuromuscular training on children and young adults with down syndrome: Systematic review and meta-analysis. *Research in Developmental Disabilities*, 55, 197-206. Doi: 10.1016/j.ridd.2016.04.003
- \*Ulrich, D., Burghardt, A., Lloyd, M., Tiernan, C. & Hornyak, J. (2011). Physical activity benefits of learning to ride a two-wheel bicycle for children with down syndrome: A randomized trial. *Physical Therapy*, 91(10), 1463-1477. Retrieved from: <https://academic.oup.com/ptj>

Winnick, J. and Porretta, D. (2017). *Adapted physical education and sport* (6<sup>th</sup> ed.).  
Champaign, IL: Human Kinetics.

Winders, P. (2001). The goal and opportunity of physical therapy for children with down syndrome. *Down Syndrome Quarterly*. 6(2). 1-5. Retrieved from:  
<http://www.denison.edu/dsq>

\*Wuang, Y., Chaiang, C., Su., C. & Wang, C. (2011). Effectiveness of virtual reality using wii gaming technology in children with down syndrome. *Research in Developmental Disabilities*, 32, 312-321. Doi: 10.1016/j.ridd.2010.10.002

\* = Critical Mass Articles

Appendix A

Article Grid

Theme	APA Citation	Purpose	Methods & Procedures	Analysis	Findings	Discussion /Key Points /Comments
Dance	<p>Gutierrez-Vilahu, L., Masso-Ortigosa, N., Costa-Tustusaus, L., Guerra-Balic, M. &amp; Rey-Abella, F. (2016). Effects of dance program on static balance on a platform in young adults with down syndrome. <i>Adapted Physical Activity Quarterly</i>, 33, 233-252. Doi: 10.1123/APAQ.2015-0048</p>	<p>The aim of this study was to compare postural control in static standing in young adults with and without DS, with eyes closed and open.</p>	<p>Participants: 11 with DS (mean age 20.55, 5 males, 6 female) 11 TD (mean age 20.77, 4 males, 7 female) Inclusion criteria: between 17-22yr, level of ID low-moderate Excluded if: mobility problem, difficulty maintaining bipedal stance, vestibular or neuromuscular disease, or drug therapy -informed consent – Barcelona, Spain -recruited from education center Methods: Quantitative 18-week program of physical training based on classical, modern, and creative dance -tested by 2 PT's with special expertise in dance and body language -setting in a classroom for dance -2 weeks prior/ descriptive data recorded,</p>	<p>-evaluated using piezoelectric platform (recording frequency 1,000 Hz) -COP computed by: sway area, ROM-AP, ROM-ML, max displacement in time-domain -normality test (Shapiro-Wilks) -time and frequency data (Mann-Whitney U test) -All calculated by IBM-SPSS version 20</p>	<p>Time-domain: preTR- differences between DS/TD in sway area, ROM-AP, ROM-ML and max displacement excursion preTR- no significant difference between TD/DS groups in anteroposterior and max displacement differences in ROM-ML and sway area  Frequency domain: preaTR- OE lowered in participants with DS postTR- no difference DS/TD  CE condition: preTR: differences in time-domain/sway area, ROM-AP postTR: differed in all time-domain parameters</p>	<p>-dance program: warm up activity (5-10min), core strength and ballet barre (15min), proprioception exercise with balance OE/CE (20min), choreography (20min), improv exercise/image recognition (15min), relaxation(5-10min) &gt;DS group received more explanations and demo's -individuals with DS characteristics: musculoskeletal and neuromuscular effects (hypotonia, ligament laxity, lack of muscle strength), delayed motor development resulting in decreased movement velocity and delayed reaction times "Motor organization in children and adolescents with DS followed the same principles as in the general population but with some variations to adapt movement difficulty in decision making associated with DS" (p.234). -DS children center of gravity oscillates more compared to TD peers- showing greater improvement after training -"Dance can be a good physical activity, promoting sensory integration and postural control and as an enjoyable leisure and</p>

			<p>-2 trials, 30 secs, barefoot COP static stand test</p> <p>-dependent variables: ROM-AP, ROM-ML, sway area, max displacement, median frequency in anteroposterior axis, median frequency in mediolateral axis</p> <p>-independent variables: conditions (visual –OE or CE), pre-and post, group</p>		<p>frequency domain: no difference TD/DS in pre or postTR</p>	<p>social activity, it can be practiced and extended time periods the potential to achieve more long-term effects” (p.235)</p> <p>-before TR participants had significantly worse postural control, it is possible that TR helped participants with DS improved their postural control in OE</p> <p>-Although no differences were observed in pre and posttest training for participants with DS, the study shows the potential of dance (sensorimotor) enhancing postural and balance control for people with DS.</p> <p>-young people with DS have a different balance pattern on the platform than TD.</p> <p>-Program benefit: using visual input to improve balance and coordination, which suggest that postural control in people with DS could benefit from improved sensory integration.</p> <p>“Young people with DS differ from TD participants in terms of control of center of gravity during static standing, specifically in extent of displacement rather than the oscillation frequency of their center of gravity” (p.248)</p> <p>-dance can be directed toward improving postural control in children with DS</p>
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Dance	<p>Becker, E. and Dusing, S. (2010). Participation is possible: A case report of integration into a community performing arts program. <i>Physiotherapy Theory and Practice</i>, 26(4), 275-280. doi: 10.3109/09593980903423137</p>	<p>The aim of this study was to report the feasibility of integrating a child with DS into a community performing arts program with modification to enhance participation.</p>	<p>Participant – 11 yr old girl, with DS and mild cognitive impairment, no other health/medical impairment No other PT or OT in conjunction of study</p> <p>Methods 14 week performing arts session with 1:1 PT student assistant Intervention: every Saturday for 90 minutes preparing for public performance</p>	<p>Pediatric Quality of Life Inventory Parent Report Questionnaire Version 4</p>	<p>Completed every session and participated in public performance with assistance of peers PedsQL score increased from 51-57 Child able to run with improved coordination, increased speed, decreased loss of balance, and a narrower base of support following completion of program Improved the ability to retain information, get along with peers, increased ability to keep up with her school work Participation improved her endurance, strength, and ability to run and jump She enjoyed participating</p>	<p>With appropriate modifications and the right program for a child with DS, a child can be successfully included in a community program with other TD peers. “Participation in community recreation programs supports the development of peer relationships, enhances self-esteem and improves general health” (p.275). Because of physical, cognitive and emotional limitations children with DS may have it can sometimes be difficult to participate in community programs without developmental adaptations or modifications. “Integrated community programs may support the development of social relationships between children with and without disabilities that will enhance participation throughout adulthood” (p.276). Barrier: staffing financial, knowledge to adapt Adaptations for DS: 1:1 assistant to help child with peers surroundings and skills: breaking down complex skills in parts until the whole task was accomplished, and hands on guidance to help child move across the state at appropriate time rate and correct placement Suggestion: peer helpers same age help support at interpersonal level</p>
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						With modification participation is possible!
Dance	<p>Moraru, C., Hodorca, M. &amp; Vasilescu, D. (2014). The role of gymnastics and dance in rehabilitating motor capacities in children with down syndrome. <i>Sport and Society, 14</i>, 102-106. Retrieved from: <a href="https://search.ebscohost.com/">https://search.ebscohost.com/</a></p>	<p>The aim of this study was to design and implement a system of exercises and use them as a program adapted to the physical and psychological features of children, given their motivation for physical activity.</p>	<p>Participants: 3 children with DS age 10-14</p> <p>-Romania</p> <p>Methods: 8 months FUN fitness testing protocol</p>	<p>Force of leg test: 10 uplifts from chair, use stopwatch</p> <p>Mobility spine test in anterior plane: flexion of body front trying to touch toes</p> <p>Abdominal force of body flexion- 60 seconds of sit ups</p> <p>Unipodal balance: standing one leg with eyes closed, measure time before losing balance (max 30sec)</p>	<p>-decreased time for 10 uplifts in chair post test</p> <p>-increase of spine mobility by 1-3 cm</p> <p>-2 subjects increased 4-5 repetitions, 1 subject increased by 1 rep</p> <p>- improvements made on each leg for all except 1 subject on 1 leg</p>	<p>-all children have the ability to improve and develop new motor skills throughout their lives</p> <p>-goal of study to assess joint flexibility and muscle elasticity, force and balance</p> <p>-must not label, exclude or offend child with DS</p> <p>-program – walking and running, specific dance and gymnastics exercises, force and resistance exercises, standing, finishing with standing and breathing exercises to recover from effort during program</p> <p>Children with DS have lack of development of qualitative elements of physical activities such as the aspect of body control, balance rotation and extension</p> <p>-Children with DS compensate their stabilization problems using static and symmetrical movement strategies</p> <p>-This program over 8 months “emphasizes the importance of implementing exercises specific to dance and gymnastics in the daily schedule of these children” (p.106).</p> <p>-It is noted that parental involvement and participation must be seen as means of encouragement of the child in order to apply the newly acquired</p>

						<p>motion skills in different environments.</p> <p>-This study doesn't go into very much detail about specific dance program (activity) however, shows motor improvements/ efficiency for children with DS.</p>
Dance	<p>Reinders, N., Bryden, P. &amp; Fletcher, P. (2015). Dancing with down syndrome: a phenomenological case study. <i>Research in Dance Education</i>, 16(3), 291-307. Doi: 10.1080/14647893.2015.1036018</p>	<p>The aim of this study was to investigate if a child with DS would benefit from participating in a recreational dance program. The study explored the lived experience of the child by looking at influential factors and by gathering information from the perspective of the child's</p>	<p>Participant: 21 yr old male (Luke) with DS          Functional capability similar to 7-8 yr old, Kindergarten level cognitive ability- unable to communicate 95% of time          Dance instructor (Sue).          Certified OT, dance instructor certification          -Southwestern Ontario          Methods: Qualitative method – one child's lived experience from the perspective of self, parents and dance instructor.          Procedure:          6- week community dance class (students aged 8-24, all disabilities. All female class except Luke).          2:1 student: volunteer ratio          Participants emailed background questionnaire to gain context          One-on-one semi structured interviews week 1 (pre) and week 6 (post)</p>	<p>Data Collection:          ethics approval obtained          All interviews audiotaped, transcribed verbatim, stripped of identifiers + field notes + observation of 1<sup>st</sup> and last class          Several researchers + principal investigator analyzed transcripts independently then discussed together</p>	<p>4 themes established:          Luke at Dance, Luke at Home, Dance!          Dance! Dance!          Becoming a Dancer          ONLY Luke at Dance + subthemes (psychological benefits, physical benefits, social benefits and the impact of music on the benefits of class)          -Luke's self-confidence, body awareness, self-esteem and encouragement to dance were enhanced</p>	<p>-dance class outline: ballet warm-up (one body part at time) to classical music, isolation exercises, simple traveling steps, dance routine, choreography, free dance (pop music).          -data credibility: triangulation of data collection and analyzed transcripts  <i>Research Question #2</i>          -dance boosted Luke's self-confidence and self-assurance, increased cognitive capacity (stop and listen to music, observe teacher)          -became excited when encouraged and complemented by peers          -showed increase in physical activity but NOT dance skill development- however, coordination improved with respect to specified movements          -dance provided social experiences that he would not have otherwise          -dance provides him with the opportunity to meet with other people in a social setting          -class would not be beneficial without music component / familiarity of music may influence</p>

		parents and dance instructor.				child's movement and participation in class -participating in a dance program may provide children with DS the opportunity to develop motor skills - #4 barriers of program include: expenses (renting studio, hiring dance instructor, training helpers, advertising classes). Funding to increase availability, accessibility, and public knowledge of recreational dance programs
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Balance	<p>Berg, P., Becker, T., Martian, A., Primrose, K. &amp; Wingen, J. (2012). Motor control outcomes following nintendo wii use by a child with down syndrome. <i>Pediatric Physical Therapy</i>, 78-84. doi: 10.1097/PEP.0b013e31823e05e6</p>	<p>The aim of this study was to examine the motor outcomes of a child with DS following an 8-week intervention period of family supported Nintendo Wii use.</p>	<p>Participant: 12yr old, attends public school</p> <p>Inclusion: diagnosed with DS, age 7-12, minimal exposure to Wii games, English communication, access to TV</p> <p>Exclusion: inability to understand game program, inability to complete a questionnaire, health impairments for exercise</p> <p>Methods: questionnaire and standardized tests, Biodex BioSway Balance system, The BodyStat Quadscan 4000</p> <p>8-week intervention program, 20 minutes 4 timers a week</p> <p>Procedures: Informed consent 3 PT students trained to administer BOT-2 pre and post (week 0 and week 8)</p>	<p>Questionnaire: self-perception profile for children, athletic competence subscale, physical appearance subscale</p> <p>Standardized test: 1Bruininks-Oseretsky Test of Motor Proficiency 2<sup>nd</sup> ed, manual coordination, body coordination, strength and agility subscales</p> <p>-Test of visual perceptual skills 3<sup>rd</sup> ed, visual spatial relationships, visual form constancy, visual figure ground subscales</p>	<p>Total 547 minutes over 8 weeks</p> <p>-improvements in BOT-2 manual dexterity, upper-limb coordination, balance and running speed and agility scaled scores</p> <p>-strength score did not change</p> <p>-bilateral coordination scaled score decreased</p> <p>-postural stability tests and limits of stability tests indicate improvements in postural control</p> <p>-overall stability index showed improvement</p> <p>-Child showed gains in motor control areas he practiced the most</p>	<p>-characteristics: low muscle tone, ligamentous laxity, hypermobility</p> <p>-enhance self-efficacy of program by giving child choice/what game he wants to play to maintain interest and improve compliance - an early commitment to movement and physical activity may mean a more independent life for those with DS</p> <p>#2- people with DS often have limited physical activity experiences because of functional and structural impairments. The benefits of physical activity are well established and for people with DS, motor control programs will not only enhance the physicality of an individual but also has physiological benefits of “exertion and skill acquisition but also the psychological benefits of exercise and participation” (p.78). This includes socialization and enhanced game-related competencies-participation in virtual gaming may offer same advantage in a safe setting for children with DS, “Virtual gaming may offer children incentives for participation and skill acquisition that cannot be fully experienced in “real world” activities. Children are offered perceptual, sensorimotor and cognitive feedback regarding their success in negotiating these landscapes</p>
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						and can respond to feedback to improve performance” (p.79). - Wii games provided visual, auditory, haptic biofeedback possibly promoting enhancement of motor and postural control skills needed to successfully play games.
Balance	Reis, J., Neiva, C., Filho, D., Ciolac, E., Verardi, C., Siqueira, L., ... Tonello, M. (2017). Virtual reality therapy: Motor coordination and balance	The aim of this study was to study the relationship between motor coordination and balance	Participants- 12 children with DS- 2 groups VRG- 7 mean age of 9, CG-5 mean age of 8 Brazil Inclusion: children with DS who have ability to understand simple instructions and are physically able to perform	Xbox 360 Kinect TM device Korperkoodi nationstest Fur Kinder (KTK) body assessment test (includes subtests of coordination,	3.3 – 20 min and max playing time average 12.2 min The VRT showed significant differences in all the task proposed after the VRT program Statistically significant differences were	Characteristic: presence of extra chromosome, physical and mental characteristics causing a delay in the development of skills such as motor deficits, and changes in motor coordination that could limit independence in daily activities of children and teenagers with DS “The literature has shown that interventions with exercise and conventional rehabilitation help in

<p>analysis in children and teenagers with down syndrome. <i>European Journal of Human Movement</i>, 38, 53-67. Retrieved from: <a href="http://www.eurjhm.com/">http://www.eurjhm.com/</a></p>	<p>and body mass index.</p>	<p>exercise as authorized by a physician's medical certificate Methods – analytical, prospective, quasi-experimental and randomized study with control group CG, and quantitative approach Random sampling to choose 2 groups, Pre-and post testing to see results of intervention training program 4 weekly sessions of 20 min max performed every 48 hours during 4 weeks = 16 training sessions introduction to games for 2 weeks before to understand the controls required by the games</p>	<p>rhythm, balance, strength, laterality, speed, agility) In study used: balance beam, monopedal jump, side jump, transfer on platform  Balance evaluated with Pediatric Balance Scale (PBS)- higher the score better the balance  SPSS- non-parametric Wilcoxon test and Mann-Whitney were applied p&lt;.05</p>	<p>found among task values: reaching forward with an outstretched arm in the pre-treatment situation; standing with one foot forward; standing on one foot; reaching forward with an outstretched arm in the pre and post treatment situations; and in the final score in the post-treatment situation; the highest values were obtained by the VRT in all situations Not a change in the overall motor performance according to KTK criteria although this change occurred only when the tasks were analyzed individually. Balance variable found statistically significant</p>	<p>the development of motor skills of children and adults with DS, even for showing improved quality of motor responses of these children after intervention” (p.55). Virtual Reality Therapy can be used as a PT resource to help improve functional mobility, quality of movement and improving cortical reorganization. VRT is relatively new as opposed to other more traditional therapeutic strategies to help promote health. -Kinetic adventures game used because involves balance movements using skills such as balance, coordination, visual-manual and gross motor coordination -Potential BMI decrease = increase health of individual with DS Recommendation: to establish the effects of VRT in physiotherapy : use the Xbox 360 as an effective tool to show significant improvement in motor coordination and balance of children and adolescents participating in VRT programs in all tests) balance, lateral jumping, monopedal jumping and lateral transposition) Concluded that BMI had influence on the results of the equilibrium test. That means that higher the BMI value the lower the result in the PBS test.</p>
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						<p>VRT can be recommended as therapy treatment for children with DS because it favors the development of motor coordination and balance.</p> <p>Need to increase the knowledge in this intervention area to improve the application of the video game as a therapeutic treatment for children with DS.</p> <p>“Execution of sort sessions weekly of VRT associated with normal activities of a the institution may be included as treatment for children with DS, contributing to improve overall coordination already in a short period of time” (p.64).</p> <p>This is a real life activity that can serve as an effective program as well as something that can be done socially.</p>
Balance	<p>Wuang, Y., Chaiang, C., Su., C. &amp; Wang, C. (2011). Effectiveness of virtual reality using wii gaming technology in children with down syndrome. <i>Research in Developmental</i></p>	<p>The aim of this study was to examine if virtual reality using Wii gaming technology is effective in enhancing sensorimo</p>	<p>Participants 110 total</p> <p>Inclusion: age 7-12 with DS</p> <p>Excluded, preexisting neurological disorder, autism, deaf or blind</p> <p>Pediatric occupational therapy</p> <p>5 elementary schools- metropolitan city</p> <p>Methods</p> <p>The Bruinks-Oserestsky Test of Motor Proficiency (BOT-2 Test)- motor</p>	<p>SPSS 15 MANOVA has applied with pre-intervention test scores as dependent measures</p> <p>MANOVA conducted to investigate post intervention differences in test</p>	<p>No significant difference between pre-intervention scores for all groups</p> <p>VRWii group significantly outperformed the SOT group on three BOT-2 subsets (fine motor, upper limb coordination, running speed and agility), all TSIF subsets with the exception of sensory discrimination subset</p>	<p>DS is one of the leading causes of intellectual disabilities. Characterized by delays in motor milestone attainment, sensorimotor performance deficit, perceptual dysfunctions, significant limitations in intellectual and behaviors.</p> <p>&gt;perceptual-motor slowness, decreased motor proficiency</p> <p>“Effective therapy to enhance sensorimotor function is thus of paramount importance in facilitating integration in daily</p>

	<p><i>Disabilities</i>, 32, 312-321. Doi: 10.1016/j.ridd.2010.10.002</p>	<p>tor functions compared to standard sensorimotor training among children with DS.</p>	<p>behavior in relation to fluency and flexibility of movement Developmental Test of Visual Motor Integration The Test of Visual Motor Integration (VMI)- tap graphomotor function that involves the use of fingers an hands The Test of Sensory Integration Function (TSIF)- difficulties in the sensory integrative process</p> <p>Intervention: Group 1(52) - VRWii, Wii sports,  Group 2 (52) - Standard OT, tactile perception activities, swings, bilateral integration through dance and gymnastics, equilibrium reactions with therapeutic ball or tilting board  Group 3 - CG 20 videotaped therapy sessions from 2 therapists, 4 pt scale  Each group 1 hour session 2 days per week for 24 weeks  Procedure: Randomization of groups</p>	<p>performance among groups</p>	<p>Both VRWii and SOT group scored significantly higher the CG on all test measures POST VRWii therapy produced largest effect sizes in all of assessments in exception to manual dexterity, sensory discrimination and sensory modulation</p>	<p>life and reducing the immediate burden and future expense on the society” (p.312) VR could provide massive intensive sensorimotor simulation to activate mirror neuron systems needed to induce brain provide for massive and intensive sensorimotor stimulation</p> <p>Barrier to traditional therapy: very repetitive and offer little to keep young mind occupied.... VR can help solve this problem</p> <p>VR= “a user-computer interface that consists of real-time environmental simulation that is the users could interact with the scenario or environment via multiple sensory channels” (p.313). 2 therapists received TR and had minimum 10 yrs experience before administering therapies to groups Results indicate that VRWii improved motor proficiency, visual-integrative abilities and sensory integrative functions for children with DS VRWii allows children to interact with a computer simulated environment and receive real time feedback on performance – encourages child to rely more on internal feedback and self-evaluation</p>
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						<p>“The nature of VRWii therapy promotes an optimal sensory intake by allowing the child to actively explore and organize diverse sensory inputs” (p.319). Results of this study demonstrate that VR therapy can benefit children with DS because it optimized the integrated processing of sensory cues and motor responses. – Provides constant opportunities for children with DS to integrate visual, vestibular and proprioceptive inputs.</p> <p>Recommendation:          -specific verbal-motor difficulties have implications for motor instruction          Shaping neural connections at a young age, so early intervention is essential. – can lead to neuroplasticity.          Modify needs to meet child’s needs          Wii chose over VR because expenses, practicality and availability          -feasible, and can facilitate brain plasticity of children that engage connection and can have long term effects.</p>
2-Wheel Bicycle	MacDonald, M., Esposito, P., Hauck, J., Jeong, I., Hornyak, J., Argento, A.	The aim of this study was to investigate the	Participant: 30 youth with DS Inclusion: 9-18, DS Recruited from parent support groups, organizations and local	Descriptive study, SPSS 16, Divided into groups based on disability	“Youth with DS, riders and nonriders were statistically different in all leg strength task: right and left leg extension,	This paper dealt with autism and DS. Focus on DS portion. Two-wheeled bicycle riding skills considered a societal norm in many countries, including the US.

<p>and Ulrich, D. (2012). Bicycle training for youth with down syndrome and autism spectrum disorders. <i>Focus on Autism and Other Developmental Disabilities</i>, 27(1), 12-21. Doi: 10.177/1088357611428333</p>	<p>effectiveness of an individualized adapted bicycle intervention implemented over five consecutive days to promote the ability of youth with DS and ASD to ride a two wheel bicycle.</p>	<p>schools, inability to ride a 2-wheel bike</p> <p>Michigan</p> <p>Excluded: severe behavior problems, obesity, health problems</p> <p>Methods PRE-intervention measurements collected from all prior to intervention: Peabody Picture Vocabulary Test (PPVT-4), Leg strength (3 trials), Standing balance (timed one leg test up to 60 sec), <i>SRS- 65 item questionnaire only for ASD group</i></p> <p>2 groups: riders and nonriders (dependent variable + assessments) Lose the Training Wheels LTTW intervention: 5 consecutive days 75 minutes each day, 1:1 with instructor -use adapted bikes, verbal encouragement, decreased wheels/rollers as child became more confident and more proficient</p>	<p>DS or ASD, further categorized into riders or nonriders-based on 100ft independent riding skill Use independent sample t tests examined differences between riders and nonriders</p>	<p>and right and left leg flexion. The individuals with DS who learned to ride were significantly older, heavier and stronger” (p.17). Results suggest learning to ride a bike later in life when stronger and heavier may be easier than teaching a young child with DS.</p> <p>30 total 22 or 73.3% riders 100ft 19 or 63.3% braking skill 5 or 16.7% self start skill</p>	<p>Children usually learn around the age of 6 or 7. Big socialization aspect of riding a bike – skill that can be done with friends, family and in community Health-related comorbidities in individuals with DS are common and may be affected by a lack of active participation in PA. Children with DS lag behind TD peers: milestones delayed = barrier to PA -successful independent riding was determined if a child could ride a 2 wheeled bike a minimum of 100 feet</p> <p>Recommendation -use adapted equipment and person centered instructional approach, appropriate behavior modification -parents enroll child in bicycle training program should encourage PE teacher to work on leg strength during winter and spring -practice balance skills Children with DS “acquired the age-appropriate ability to ride a two-wheel bicycle when appropriate adaptations and instructional techniques were implemented. Future bicycle-training interventions should occur within a school-based program” (p.19).</p>
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						<p>Lose the training wheels LTTW: non for profit organization dedicated to teaching individuals with disabilities to ride 2 wheel bike: uses adapted bikes to teach required skills to be successful With appropriate adaptations instructional techniques were implemented, a majority of youth with DS in study successfully demonstrated the ability to ride a 2-wheel bike (p.17). Successful riders had higher scores on the PPVT and lower percentage of body fat. -increases likelihood of PA</p>
2-Wheel Bicycle	<p>Ringenbach, S., Holzapfel, S., Mulvey, G., Jimenez, A., Benson, A. &amp; Richter, M. (2016). The effects of assisted cycling therapy (act) and voluntary cycling on reaction time and measures of executive function in adolescents with down syndrome. <i>Journal of Intellectual</i></p>	<p>The aim of this study was to examine the effects of 8 weeks of ACT on measure of Reaction time, set-shifting inhibition and LF in persons with DS.</p>	<p>Participants: 17 (10 male, 7 female)</p> <p>Methods 8 weeks of ACT Pre test Peabody Picture Vocabulary Test, Lafayette Instrument Visual Choice Reaction Time Apparatus (at least 5 trials pre, 20 trials for intervention) NEPSY Knock-Tap Task (response inhibition test, 6 trials pre, 15 test trials)</p> <p>Procedure: Use Theracycle 3 cycling sessions per week for 8 weeks totally 24 sessions</p>	<p>Quantitative No statistical difference in dependent variables existed between groups ANOVA</p>	<p>No group differences in descriptive characteristics ACT improved RT significantly more than VC or NC group Information processing as assessed by simple RT improved following ACT but did not show any improvements after VC or NC</p> <p>8 weeks of ACT can improve RT inhibition and LF in adolescents with DS.</p>	<p>ACT = assisted cycling therapy Persons with DS have deficits in cognitive control compared to TD persons. – these limit opportunities to participate in PA “A single bout of moderate intensity aerobic exercise has also been shown to improve inhibition in young adults with DS” (p.1074).</p> <p>Intervention: 5 min warm up followed by 30 minute cycling session (individual sessions not group cycling)</p> <p>Important for persons with DS to maintain RTs as they age because of increased prevalence of Alzheimer’s disease</p>

	<p><i>Disability Research, 60(2), 1073-1085. doi: 10.1111/jir.12275</i></p>					<p>Improved sports performance through faster RTs may result in greater sports participation that would be especially important for person with DS who have low sports participation. (p.1078)</p> <p>“Light intensity cycling may be used to improve set-shifting and associated pathopsychological symptoms in adolescents with DS” (p.1078).</p> <p>ACT has the potential to further independence and autonomy in persons with DS.</p> <p>ACT may be a promising exercise modality for persons with DS, which could translate to a better quality of life and other related outcomes. (p.1080).</p> <p>Recommendation: -light aerobic activity to benefits set-shifting ability *need to investigate everyday behaviors and how impacted by ACT or other interventions for children with DS</p>
2-Wheel Bicycle	<p>Ulrich, D., Burghardt, A., Lloyd, M., Tiernan, C. &amp; Hornyak, J. (2011). Physical activity benefits of</p>	<p>The aim of this study was to investigate if increasing PA and motor</p>	<p>Participants: 72 children who had DS and between 8-15 years (average age 12), none could ride a 2 wheel bike initially</p> <p>Michigan, Ohio, Indiana</p> <p>Methods</p>	<p>Mixed-model analysis SPSS 18 P&lt;.05 *partial funding</p>	<p>No significant group differences were found in any of the variables measured at pre-intervention. No significant groups X time interactions were observed.</p>	<p>Experience significant delays in the onset of early motor milestones, have higher rates of overweight and obesity</p> <p>Children with DS eventually learn motor skills and related to that is the skill of bicycle riding- this can provide many opportunities to</p>

	<p>learning to ride a two-wheel bicycle for children with down syndrome: A randomized trial. <i>Physical Therapy</i>, 91(10), 1463-1477. Retrieved from: <a href="https://academic.oup.com/ptj">https://academic.oup.com/ptj</a></p>	<p>skill repertoire of children with DS would have a positive impact on patterns of PA associated with health and functioning.</p>	<p>Group 1 : 36 experimental with bike intervention Analyzed: 19 (9 boys, 10 girls)</p> <p>Group 2: 36 control group no bike Analyzed: 27 (11 boys, 16 girls)</p> <p>Procedure: Measurements obtained (leg strength, standing on one leg for balance, height, weight, skinfolds and PA) pre: 1 month before, post-1 (7 weeks after), post -2 (1 year after)</p> <p>LLTW 5 consecutive days for 75 minutes per day</p> <p>Assessments: Leg strength (manual muscle tester MMT) Standing balance (one foot, hands on hips, 60 sec) PA (7 consecutive days with accelerometers)</p>		<p>Significant group X time interactions were found for SED, MVPA and AVGMIN NO significant difference in total activity monitor wear time between the groups. (12.8-13.6 hours per day average)</p> <p>Results demonstrate that 56% of the total participants in the experimental group learned to ride 2 wheel bike with 75 minutes of individualized training over 5 consecutive days. 44% of the total participants in the EXP group did not learn to ride a 2-wheel bike independently within 5-day intervention.</p>	<p>engage in PA, social interactions with family peers and in community.</p> <p>Teaching children with DS how to ride a 2 wheel bike may result in a decrease of sedentary activity and increase MVPA benefiting the child multiple ways.</p> <p>Intervention: Lose the training wheels LTTW, used adapted bikes, trained staff with experience, goal to progress to standard 2 wheel bike From a survey of 298 families of children with DS, 9.7% of children could ride a 2 wheel bike with average age being 12.5 (p.1468). “Bicycle riding can be done for exercise and recreation in many locations, including parks, bicycle paths, large parking lots, local neighborhood sidewalks and school playgrounds” (p.1469). Recommend: -parents to encourage continued practice of riding -intervention longer than 5 days -look into acquiring skills in other PA to improve participation and health related outcomes. -organize bike riding groups to encourage riders to train and enter the bike riding events in Special Olympics Barrier: fear of falling</p>
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						<p>Key point: group who received bike intervention significantly increased the time spent in MVPA one year post compared to control group</p> <p>Key point: Parents perceived that because of the bike intervention their children were more willing to try other PA because their fears diminished after learning how to ride bike.</p> <p>This study demonstrates the potential to decrease sedentary time and increase time in MVPA which is essential for children with DS who are already at higher risk for health impairments.</p>
Strength	<p>Gupta, S., Rao, B. &amp; Kumaram, S.D. (2011). Effect of strength and balance training in children with downs syndrome: A randomized controlled trial. <i>Clinical Rehabilitation</i>, 25, 425-432. Doi:10.1177/02692155110382929</p>	<p>The aim of this study was to determine the effect of a strength and balance training program for children with down syndrome</p>	<p>Participants: 23, age 7-15 Inclusion, DS, ability to stand and walk independently, follow simple instructions Excluded: preexisting cardiovascular condition vision or hearing problems</p> <p>Methods Stratified random sampling Experimental group 12 Control group 11</p> <p>Procedure was explained and demonstrated to the children – 3 test trials Balance measured by BOTMP</p>	<p>SPSS 11.5 Mann-Whitney U test was used to analyze between group variables Non parametric tests were used</p>	<p>Statistical significance between groups regarding strength in all muscle groups Scores on BOTMP test increased from 10.5- 19.5 in experimental group Statistically different except in walking on a line, standing on a balance beam with eyes closed and stepping over a response stick of balance beam</p>	<p>DS characterized by: clinical symptoms- orthopedic, cardiovascular, neuromuscular, cognitive, visual, perceptual Most common genetic cause of developmental disability and affects gross and fine motor skills Muscle strength is essential for functional daily activities Intervention group- specific exercise training program with progressive resistance exercises for the lower limbs and balance training over 6 weeks, 3 times a week, strength training start at 50% of 1RM, 2 sets of 10 reps for each exercise, positive reinforcement Control group- no special intervention, lived daily life</p>

						<p>Key finding: post intervention children with DS were able to improve the strength of lower limb muscles and overall balance when compared to control group</p> <p>Strength of all muscle groups improved.</p> <p>Important to note that results may have been greater if training was started at greater than 50% 1RM</p> <p>Training program was given for 6 weeks as compared to the 10/12 week programs in other studies.</p> <p>Feasible because no drop outs and compliance.</p>
Strength	<p>Lin, H. and Wang, Y. (2012). Strength and agility training in adolescents with down syndrome: A randomized controlled trial. <i>Research in Developmental Disabilities</i>, 33, 2236-2244. Doi: 10.1016/j.ridd.2012.06.017.</p>	<p>The aim of this study was to investigate the effects of a proposed strength and agility training program of adolescents with DS.</p>	<p>Participants: 92 Inclusion: 13-18yr, in high school. DS, able to follow simple directions Excluded: other medical conditions, PT or OT in the year -recruited from 17 schools and 4 institutions</p> <p>Methods 46 experimental 46 control</p> <p>Questionnaire, Wechsler Intelligence Scale for Children-Third Edition, Hand-Held dynamometer, BOT-2</p> <p>Procedures: 20 min warm up to familiarize with equipment, 6-week intervention program (35</p>	<p>SPSS 15 ANOVAs performed to compare the pre and post intervention differences in muscle strength and agility performance between the control and the exercise group</p> <p>Pearson correlation was used to investigate the relations between pre-intervention and muscle</p>	<p>Average heart rate after intervention was 125 beats per minute and 60 % max heart rate was reached</p> <p>Body weight in exercise group decreased after intervention compared to control.</p> <p>BMI was positive correlated to averaged muscle strength but not agility performance</p> <p>Significant group difference in terms of strength in all muscle groups following the 6-week intervention: hip extensors, hip flexors, knee flexors,</p>	<p>70-75% of individuals with DS attaining an IQ between 25-50</p> <p>Characterized by several clinical symptoms including: orthopedic, cardiovascular, musculoskeletal and perceptual impairments</p> <p>-muscle strength is an essential ability o achieve effective and functional movements</p> <p>-lower extremity muscle strength is important to enhance physical health, ability to perform daily activities for children with DS</p> <p>Agility is “the ability to move and change direction and position of the body quickly and effectively while under control, and requires the integration of isolated movement skills using a combination of balance, coordination, speed, reflexes, strength, endurance and stamina” (p.2237).</p>

			<p>minute sessions per week)- 5 min treadmill ex (2 speed 0 degrees, increased to 3 speed at 5 degrees) and 20 min VR based exercise program (Nintendo Wii gaming tech to represent 50- 50% of max heart rate)</p>	<p>strength and agility</p>	<p>knee extensors, ankle plantar flexors Pre-agility score 11 for both, Post exercise group score improved to 16 and post control group decreased to 10</p>	<p>Main finding is that the lower- extremity muscle strength and agility performance in adolescents with DS improved significantly after 6-week exercise training program comparing to the controls. Recommend: simple program for a shorter duration around 6 weeks! – this is efficient Individualize sessions Suggestion for program development: It is important to develop a strength program that enhances functionality for daily living and transition into the work place. Creating a program that is feasible, and this can be accomplished by giving the opportunity for a therapist to supervise at a low-cost high frequency program. Traditional therapies to improve PA in individuals with disabilities are repetitive and offer very little to keep a young mind occupied so it is more effective and motivating for training programs to be innovative and creative. Muscle strength and BMI are correlated but agility performance is not associated with BMI. Usually strength programs are 12 weeks or more however, the findings of this study showed significant gains in muscle strength and agility performance</p>
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						are noteworthy given the relatively short-period of the intervention.
Barriers and Facilitators	<p>Barr, M., Shields, N. (2011). Identifying the barriers and facilitators to participation in physical activity for children with Down syndrome. <i>Journal of Intellectual Disability Research</i>, 55(2), 1020-1033. Doi:10.1111/j.1365-2788.2011.01425.x</p>	<p>The aim of this study was to explore the barriers and facilitators of physical activity for children with Down syndrome.</p>	<p>Participants: 20 parents (16 mothers / 4 fathers) of 16 children (age 2-17, 10 girls, 6 boys, mean age of 9.9 +/- 4.8) with DS. Recruited through community (Victoria, AUS) disability support program Purposeful sampling- to increase likelihood of relevant themes Inclusion criteria- child of parent &lt;17 and interview conducted in English 13 lived metropolitan area / 7 lived regional area</p> <p>Method: exploitative qualitative study 18 in-depth interviews (20-50min) by 1 researcher (BARR) 4 conducted by phone, 14 face-to-face</p> <p>Flyer used to advertise study</p> <p>Procedure: written informed consent obtained Interviews recorded by MP3 voice recorder (2 general questions followed by a series of focused open-ended questions)</p>	<p>Data collection &amp; analysis completed concurrently so that initial coding (broken down into categories) was used as foundation for future data collection Data recorded &amp; transcribed verbatim by 2 researchers (BARR &amp; SHIELDS) using thematic analysis Data categories were organized and grouped into themes Used NVivo Software (Version 8)</p>	<p>Facilitators:</p> <ol style="list-style-type: none"> <li>The positive role of family <ul style="list-style-type: none"> <li>-parental influence</li> <li>&gt;put their own time in</li> <li>&gt;educate instructor of program</li> <li>-siblings</li> <li>&gt;assist with engaging in PA</li> <li>-positive role model</li> </ul> </li> <li>Opportunity for social interaction with peers <ul style="list-style-type: none"> <li>-good verbal communicators thrive</li> <li>-gives purpose</li> <li>-gives meaning</li> <li>-makes enjoyable</li> <li>-socialization</li> </ul> </li> <li>Structured accessible programs that make adaptations for children with DS. <ul style="list-style-type: none"> <li>-specificity (receive direct attention/guidance)</li> <li>-mainstream program with appropriate adaptations (breaking own skills, manageable components)</li> </ul> </li> </ol>	<p>-58% of children with DS do not meet PA recommendations</p> <ul style="list-style-type: none"> <li>-no exclusion criteria mentioned</li> <li>-formal activities children participated in: dance, swimming, basketball, football, karate, tennis, gymnastics</li> <li>-informal activities children participated in (younger children): walking, jumping on trampoline, bicycling, running with siblings</li> <li>-validation form used to clarify points/add info by participants</li> <li>-credibility enhanced by using more than 1 researcher to code data (coded independently then compared results and discussed themes)</li> <li>-DS characteristics include: hypertonia, obesity, congenital heart defects, communication impairments</li> <li>-social, environment and familial are also factors that influence PA</li> <li>-a mainstream program allows the child with DS to interact with other typically developing children, however understanding rules/interpreting instructions is limited</li> </ul> <p>Key Points:</p> <ul style="list-style-type: none"> <li>-eliminate barriers (different than typically developing peers because of the cognitive and lack of social/behavioral skills) + physical skill differences</li> </ul>

			<p>Prompts were used to generate/elaborate more data</p>		<p>4.Determined to succeed and has physical skill          -cognitive ability/coordination/          physical skills helped child understand rules and made more likely to participate          -feel sense of normalization          Barriers:          1.DS characteristics          2.competing family responsibilities          -1:1 supervisions, overprotective parents          3.reduced physical or behavioral skills          -gap in cognitive skills          -increased frustration if not appropriate instruction/activity          4.lack of accessible programs</p>	<p>-ensure social interaction is part of activity  <i>Research Question #5</i>          -Understanding the barriers and facilitators children with DS experience with physical activity is essential for health care professionals, sports and recreation industry personnel, adapted physical activity specialists and physical education teachers/coaches.. -The goal is to design effective intervention strategies, programs and opportunities to promote life-long fitness for people with DS.          -Programs for children with DS benefit the child's "long-term health and well-being, increase participation and maximize the social benefits associated with PA" (p.1021).          -Children with DS respond positively to instructors that provide equal opportunity and make activity enjoyable/appropriate.          -Barr and Shields (2011) found that dancing was the most common physical activity program of participation for children with DS.          -Children with DS more likely to participate in PA if family/peers involved, activity is enjoyable and social interaction is involved.  <i>Research Question: #4</i></p>
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						<p>As a child with DS grows older, the gap of physical skill/cognitive ability increases and makes it harder for the child to participate in PA. Children whom participated in “early intervention programs or one-on-one therapy to promote the development of their motor skills” are “less likely to experience a decline in function with age” (Barr and Shields, 2011, p.1030). - According to research, “skill programs aimed at developing running, jumping, climbing, balance and ball skills from a young age in children with DS might have a long-term influence on th4e amount of physical activity they undertake and should be considered part of family activities, structured therapy, early intervention programs and school curriculum” (Barr and Shields, 2011, p.1030). -“Individuals developing physical activity programs for children with DS can draw on successful strategies used to promote physical activity among children with typical development” (Barr and Shields, 2011, p.1030).</p>
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