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Physical Activity in Individuals with Down Syndrome: An Overview, and Suggestions for Appropriate Activities and Instructional Techniques

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Physical activity in individuals with Down syndrome: Abnormalities, their implications for exercise, and suggestions for appropriate activities and instructional techniques

Physiological Abnormalities

Down Syndrome (DS), or Trisomy 21, is a condition in which there is an extra copy of the 21st chromosome and is the most common form of mental retardation (Sanyer, 2006). Individuals who have this genetic disorder have a number of physical and mental differences from those without Down Syndrome, which can be aided by the addition of exercise to an individual's routine. This is particularly important, since these individuals are living longer than ever before and need to maintain at least a functional level of physical fitness, if not more, to help prevent diseases related to sedentary lifestyles and to maintain the ability to perform activities of daily living (Fernhall, 2003; Sanyer 2006). However, many people do not know how to work with this population or do not know about some of the health concerns that need to be taken into consideration when working with these individuals, which decreases their ability to partake in many forms of exercise (Sanyer, 2006). The purpose of this paper is to better inform people about the physiological and psychological differences associated with DS, precautions that must be taken when those with DS partake in physical activity, and to recommend appropriate forms of exercise and techniques that may be helpful in working with this population.

Individuals with Down Syndrome suffer from both mental and physical disabilities. While there can be many physical issues associated with this disorder,

only some pertain to the areas of sport and exercise. These individuals tend to have hypermobile joints and/or ligament laxity, as well as hypotonic muscles, muscles that can stretch far past a normal point (“Down Syndrome,” 2007). These factors make them more susceptible to atlanto-axial instability (AAI), which is present in between 10-40% of this population (Sanyer, 2006). AAI is a disorder involving ligament laxity between the C1 and C2 vertebrae, which makes it easier for the vertebrae to move out of place and cause severe damage to the spinal cord (“Down Syndrome,” 2007). However, only 1-2% of the population suffers from clinical symptoms that require treatment, such as neck pain and tilt, gait abnormalities, hypertonicity of the lower extremities, weakness, and bowel or bladder incontinence, which are associated with spinal cord compression. These symptoms usually present themselves before the child reaches 10 years of age, and are more frequent in females than in males (Sanyer, 2006).

In addition to AAI, inherent joint laxity makes people with DS more susceptible to scoliosis, joint dislocations, patello-femoral instability, metatarsus primus varus (MPV), and flat, pronated feet (*pes plantus*) (“Down Syndrome,” 2007; Sanyer, 2006; Mik, 2008). Hip dislocations in particular are seen in approximately 1.5%-7% of this population (Mik, 2008). They are thought to be caused by laxity in the joint capsule and by low muscle tone (Mik, 2008). Hip dislocations can be surgically or non-surgically treated. However, there is a higher risk of wound infection in the DS population, making surgical procedures, although often times more effective, also more risky (Mik, 2008). Patello-femoral instability is seen in about 20% of the population, and as mentioned previously, is

probably caused in part by ligament laxity, in addition to hypotonia of the muscles (Mik, 2008). This instability can often lead to patellar dislocations or subluxations (Mik, 2008). Metatarsus primus varus and pes plantus (flat feet) are also common, which can lead to chronic pain and instability. Severe cases of MPV may need to be treated surgically; however, pes plantus and mild cases of MPC can be effectively managed non-surgically using orthotics (Mik, 2008).

The cardiovascular and respiratory systems of individuals with Down Syndrome (IDS) also tend to be underdeveloped. Between 40-50% of IDS have cardiac abnormalities such as pulmonary hypertension, right to left shunting, and/or chronic hypoxia (Sanyer, 2006). However, even those without these abnormalities have a lower minute ventilation, about a 10% lower heart rate and subsequently lower peak oxygen consumption levels, even when compared to other individuals with mental retardation who do not have Down (“Down Syndrome,” 2007). More specifically, many of these individuals present with chronotropic incompetence; their cardiovascular system is unable to match the metabolic needs of their body. This is not just present during submaximal and maximal aerobic activity, but lower heart rates and blood pressures have also been observed in individuals with Trisomy 21 during isometric contractions (Fernhall & Ottenstetter, 2003). Pitetti et al. found that compared to individuals with mental retardation without DS, those with DS had significantly lower mean peak VO_2 , VE, and HR, lower peripheral vascular resistance (PVR), and a higher Q, QI and left ventricular work index (LVWI) (Pitetti et al., 1992).

The exact cause of this is not known; however, there are multiple speculations on what may cause this blunted cardiovascular effect during exercise. One possibility is that there is a decreased sympathetic nervous system response, or impaired vagal withdrawal. A study conducted by Fernhall et al. showed a decreased HR and BP response to isometric hand contractions and cold pressor tests in individuals with Down Syndrome. It is believed that HR changes in response to cold pressor tests are due entirely to sympathetic nervous system activation, and a blunted response is due to a decreased sympathetic response (Fernhall et al., 2003). The blunted response to the isometric contraction was also believed to be due to a decrease in sympathetic activation, rather than to obesity, since the decreased response was seen in all DS subjects regardless of BMI, and when compared to a control subject with the same BMI, the blunted response was still seen (Fernhall et al., 2003). Additionally, it is thought that decreased baroreceptor sensitivity could also be a cause of chronotropic incompetence in these individuals (Heffernan, Baynard, Goulopoulou, Giannopoulou, Collier, Figueroa, et al., 2005). A final theory as to why HR responses are decreased in those with Down Syndrome is that they have decreased catecholamine responses. A study conducted by Fernhall et al. showed that while there was no difference in norepinephrine and epinephrine levels between individuals with and without Trisomy 21 pre-exercise, following maximal exercise there was a large difference. Those without DS showed increases of approximately 1000 pmol/L in epinephrine post post-exercise, to a mean level of approximately 225 pg/mL, whereas those with DS showed no significant change in epinephrine levels.

Furthermore, those without Down Syndrome showed increases in norepinephrine levels of approximately 15 mmol/L to a concentration of 3000 pg/mL, while those with DS showed increases of only about 2-3 mmol/L, to a final value of about 1000 pg/L (Fernhall et al., 2009).

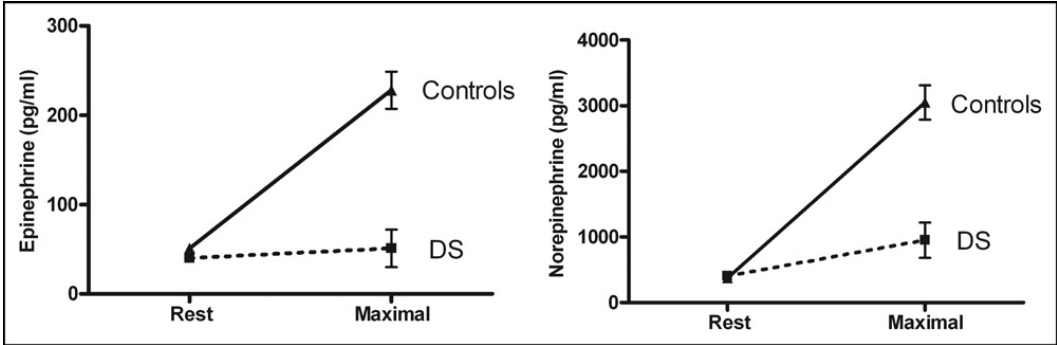


Figure 1: Catecholamine response to exercise in a person with DS and a control, from rest to maximal exercise. (Fernhall et al., 2009)

A study conducted by Rimmer et al. demonstrated significant increases in cardiovascular capacity and strength in adults with Trisomy 21 following a 12-week cardiovascular and strength training program (Rimmer et al., 1995). Subjects trained for 30-45 minutes on a cycle ergometer, treadmill, recumbent stair climber or elliptical to a prescribed HR and performed strength training exercises at 70% of their 1 RM for 15-20 minutes, 3 days per week. Subjects in the control group showed significant gains in peak VO_2 , normalized peak VO_2 , peak HR, max workload, time to exhaustion, bench press 1RM, leg press 1RM, left and right hand grips, and slight improvements in body weight, BMI and skinfold measurements as depicted in the following table:

Table 1: Fitness measures pre- and post-test in exercise and control groups

Outcome variable	Exercise				Control			
	Pretest		Posttest		Pretest		Posttest	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Cardiovascular								
Peak VO ₂ (ml·min ⁻¹)**	1205	285	1375	298	1165	330	1097	340
Peak VO ₂ (ml·kg ⁻¹ ·min ⁻¹)**	15.4	4.0	17.8	4.6	14.7	4.5	13.6	4.5
Peak heart rate (beat/min ⁻¹)**	133	19	144	18	133	21	129	21
Time to exhaustion (sec)*	364	96	462	122	419	116	409	126
Max workload (W)**	70	19	89	20	73	19	70	23
Respiratory ex- change ratio	1.07	0.08	1.13	0.10	1.05	0.10	1.01	0.12
Strength								
Bench press (lbs)***	70.5	35.9	100.7	44.9	54.4	29.6	59.9	33.6
Leg press (both, lbs)***	230	97	320	87	223	97	208	97
Hand grip (left)	21.0	7.8	21.6	8.7	18.4	6.3	17.8	7.0
Hand grip (right)	20.7	7.8	22.0	8.1	18.1	7.9	19.0	7.7
Body composition								
Body weight (kg)**	80.5	20.0	79.5	19.9	76.8	18.1	78.5	17.9
BMI (kg·m ²)	35.2	8.7	34.7	9.2	33.9	7.6	34.4	7.1
Total skinfold mea- sure (mm)	95.6	32.5	88.7	29.7	102.3	37.5	100.5	33.4

* $p < .05$. ** $p < .01$. *** $p < .001$ (ANCOVA).

(Rimmer et al., 1995)

Another study found that following an incremental maximal exercise test, performed on a cycle ergometer, individuals with DS showed a lower than expected blood lactate concentration (Eberhard, Etteradossi & Debu, 1997). Individuals in this study showed normal resting levels of blood lactate with a mean concentration of 1.23 mmol/L. Post maximal exercise levels, however, were lower than value typical of non-disabled individuals, with a mean blood

lactate concentration of 4.63 mmol/L, when measured 2 minutes after the termination of the test (Eberhard et al., 1997). They also found that free fatty acid levels (FFA) decreased from .30 mmol/L at rest to .12 mmol/L following the maximal exercise test. Following an endurance exercise test, however, FFA levels increased 207% from resting levels. Based upon this information the authors proposed that there is delayed FFA mobilization at the start of exercise, which could contribute to the decreased aerobic capacity of these individuals (Eberhard et al., 1997).

Comparative studies between IDS who participate in the Special Olympics and those who are sedentary show differences in aerobic capacity. The mean value of VO_2 peak was 34.3 mL/kg/min in the trained group and 27.4 mL/kg/min in the sedentary individuals (Balic et al., 2000). It was proposed that the length of training could have caused this difference, as the special Olympians had been training for at least 1 year, whereas other studies with conflicting results involve a shorter training time (Balic et al., 2000).

While some studies have shown no change in cardiorespiratory fitness of individuals with DS following a training regimen, many articles which have reviewed these studies show that overall training benefits can be seen, and also argue that, even if they are not seen, exercise can still improve the health of these individuals and improve their ability to perform activities of daily living (Dodd & Shields, 2005). It is also theorized that decreased muscle strength may lead to decreased VO_2 peak measurements; muscular fatigue may set in and the test may

be terminated before the cardiorespiratory system is fully stressed (Lewis et al., 2005).

Studies also show improvements in performance measures, without improvements in VO₂ max (Lewis et al., 2005; Miller et al., 1993; Varela et al., 2001). A 16-week rowing training regimen met 3 days a week and consisted of a 10 10-minute warm warm-up, followed by rowing between 55%-60% VO₂ peak for weeks 1-4, and at 70% VO₂ peak for weeks 4-16, initially for a duration of 15 minutes during weeks 1-6, which then increased by 5 minutes every 2 weeks following. The session was finished with a 10-minute cool down. While no significant changes in VO₂ peak or peak HR were observed, subjects significantly increased their performance on a treadmill and rowing ergometer graded exercise test post-training (Table 2).

Table 2: Time, distance and grade reached on a treadmill graded exercise test pre- and post- training

Group	Time		Distance		Grade (%)	
	Mean	SD	Mean	SD	Mean	SD
Exercise						
Before	12.6	1.9	974.8	178.0	14.4	2.2
Following	16.0	1.3*	1207.3	148.5*	18.1	1.8*
Control						
Before	12.9	3.1	958.9	162.0	14.7	3.4
Following	12.9	2.8	963.0	149.0	14.3	3.6

* Exercise group was significantly higher when compared to control group following exercise, $p < .01$.

(Varela et al., 2001)

Table 3: Time, distance and resistance reached on rowing ergometer graded exercise test pre- and post- training

Measure	Exercise				Control			
	Before		Following		Before		Following	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Time ^a	7.86	1.05	9.62	0.97*	7.84	0.76	7.31	1.52
Distance ^b	2825	745	3370	744*	2728	634	2462	775
Resistance ^c	1.70	0.11	1.87	0.10*	1.73	0.10	1.65	0.18

^a Minutes. ^b Total turns of fan wheel. ^c Kg.
 * Exercise group significantly higher than the control group following exercise, $p < .05$.

(Varela et al., 2001).

Despite the fact that no rise in VO_2 peak was shown, the increase in performance is still a significant benefit derived from the exercise training protocol. It increases the ability to perform activities of daily living and can have a positive effect on job performance, social and recreational activities, thus increasing overall quality of life.

Individuals with Trisomy 21 may also have upper airway obstructions due to anatomical differences (Pueschel, 1990). These obstructions are surgically repaired, if necessary; however, when not repaired, they can cause arterial hypoxemia, and alveolar hypoventilation, which can also decrease VO_2 (Pueschel, 1990; Sanyer, 2006).

Individuals with DS tend to have poor balance and difficulty crossing midline (“Down Syndrome,” 2007). Difficulty crossing midline is theorized to be a result of muscle hypotonia and weakness. This poor balance is often caused by the hypotonia, a decreased motor neuron pool excitability, seen in this population, particularly in the abdominal muscles (Winders, 1999). However, research has also been done which suggests that it is not hypotonia which causes the balance

deficits, but rather that it is caused by defects within higher brain centers (Shumway-Cook & Woollacott, 1985). These balance deficits cause alterations in gait, such as shorter step lengths, increased flexion at foot contact, decreased single limb support and increased hip flexion; these alterations increase the energy cost of gait (Lewis & Fragala-Pinkham, 2005).

Despite the possibility that the balance problems seen in these individuals could be caused by defects in higher brain centers, studies have shown an increase in balance following a 6 month, low intensity, treadmill walking program in older adults with DS (Carmeli et al., 2002). Subjects exercised, as tolerated, 3 times a week, in sessions which initially lasted 10-15 minutes, and then treadmill time was increased up to 45 minutes, in a controlled environment. Balance was measured using a “timed up and go” (TUAG) test, in which subjects got up from an arm chair, walked 9 meters, and then returned to the chair; longer times (30s +) could be indicative of strength and balance problems. Following the protocol, the TUAG test time improved significantly by 9.1%, indicating an improvement in balance. They also found improvements in the time subjects were able to walk (+150%), the speed at which they could walk (+86%), and the distance they walked (+180%) (Carmeli et al., 2002). These improvements in functional tasks are especially important for these individuals, as they are living longer than they have in previous years. This is a significant improvement in their quality of life, which can be achieved while undergoing even a low intensity training program (Carmeli et al., 2002).

A case study, performed on a 10.5-year-old female with Trisomy 21 showed an improvement in her gross motor score on the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP). The Gross Motor Scale consists of four subtests to determine running speed and agility, balance, strength, and bilateral coordination. A composite score is then determined by examiners. Her score increased from 2 to 19 following a 6-week training program that consisted of aerobic training, initially 2x/week, for 10-15 min at 60% HRmax, progressing to 3x/week, for 45-60 min at 80% HRmax. The program also included full body strength training exercises, initially 2x/week for 10-15 min, progressing to 3x/week for 30-45 min (Lewis et al., 2005). The subject also showed an improvement in power output on a modified Margaria-Kalamen power test from 14 kgm/sec to 22 kgm/sec and improvements in muscular strength (Lewis et al., 2005). Table 4 summarizes the results seen following this training regimen.

Table 4: Performance measures pre- and post-training for a 10.5-year-old female

Measure	Pretraining	Posttraining
Submaximal treadmill test, peak VO_2	17.6 ml/kg/min	18.6 ml/kg/min
Body mass index	28.2 kg/m ²	28.2 kg/m ²
Flexibility		
Sit and reach	WNL, touched toes	Maintained
Ankle dorsiflexion with knee extension	WNL, 0-20 deg	Maintained
Shoulder backward reach	WNL, finger tips touch	Maintained
Hip internal rotation	Slight decrease 0-30 deg bilaterally	Maintained
BOTMP gross motor subtests		
Composite point score	2	19
Margaria-Kalamen step test (mean of three trials)	14 kg · m/sec	22 kg · m/sec
Strength		
Trunk flexion	0 sit ups, 3 eccentric sit ups with assistance	3 sit ups, 16 eccentric sit ups without assistance
Trunk extension	3 reps holding each for 3 sec	12 reps holding each for 5 sec
Hip extension	8 reps (R), 7 reps (L) 0 lb	2 sets of 10 reps with 3 lb
Hip adduction	9 reps bilaterally, 0 lb	2 sets of 10 reps with 3 lb
Hip abduction	1 set of 10 reps with 0.5 lb	1 set of 10 reps with 3 lb
Knee extension	1 set of 10 reps with 3 lb	1 set of 10 reps with 5 lb
Shoulder flexion	1 set of 10 reps with 1 lb	1 set of 10 reps with 4 lb
Shoulder abduction	1 set of 10 reps with 0.5 lb	1 set of 10 reps with 4 lb

WNL = within normal limits; BOTMP = Bruininks-Oseretsky Test of Motor Proficiency; reps = repetitions.

(Lewis et al., 2005).

Functional gains have also been noted following resistance training programs. A 10-week resistance training program consisting of 3 sets of 10 of chest press, biceps curl, triceps push-down, leg press, leg extension, and leg flexion exercises were performed by 12 individuals with DS. The training elicited a 90% increase in 10RM training load when averaged for the 3 lower body exercises, and a 42% increase in 10RM training load when averaged for the 3 upper body training exercises. Improvements in functional ambulatory tests were also seen. There was a 9% decrease in time to rise from a chair (30 cm seat height), and a 7% decrease in time to rise 5 times from a chair (43 cm seat height). Time to ascend and descend stairs also decreased 6% and 18%, respectively (Cowley et al., 2007). The hypotonicity seen in this population can lead to functional deficits, which could be decreased by resistance training.

Overweight problems are also common among this population, which may contribute to the higher incidence of insulin resistance which is seen. One study found that of 283 individuals surveyed, 45% of males, and 55% of females with Trisomy 21 were overweight or obese (Rubin, 1997). Another study which compared matched non-DS controls to those with DS found a higher mean BMI in both males and females with DS (Melville et al., 2005). Numerous other studies show similar results (Rubin, 1997; Melville et al., 2005). Many studies also suggest that sedentary lifestyles, combined with improper diets, may be the primary cause (Pitetti, 2006). A lower resting metabolic rate (RMR) was also seen in prepubescent children with DS (Luke et al., 1994). While aerobic training does not increase RMR significantly, those with a higher muscle mass have a

greater RMR, suggesting that strength training may also help to decrease the incidence of obesity (Lewis et al., 2005). Hypothyroidism, a common disorder associated with DS, can also cause weight gain (Lewis, 2005).

It was found that after a 12-week aerobic training program, which met 3 times a week, for 30 minutes the first two weeks, 45 minutes the second two, and 60 minutes the last 8, and included both land and water aerobics, the fat mass of the subjects decreased significantly. The fat mass of the obese individuals dropped from $31.8\% \pm 3.7\%$ to $26.0\% \pm 2.3\%$, and of the overweight individuals from $25.03\% \pm 1.6\%$ to $19.53 \pm .9\%$, showing how effective an exercise regimen such as this can be for maintaining a healthy body composition (Ordonez, Rosety & Rosety-Rodriguez, 2006).

A study conducted in the Netherlands found that the incidence of diabetes in children with Down Syndrome was estimated to be 335 in 100,000, whereas the incidence in their age-matched counterparts without Trisomy 21 was 40 in 100,000 (Ruwaard et al., 1994). With obesity, and even more so its common precursor, inactivity, being major risk factors for diabetes, exercise is all that much more important for these individuals, who often suffer from both (Sullivan et al., 2005; Hawley, 2004). The following table from an epidemiological study, shows that in 68,500 adults, obesity increased as the percentages of individuals with diabetes did, possibly suggesting comorbidity, and that the percentage having diabetes is higher in inactive adults than active ones.

Table 5: Prevalence of diabetes and comorbid cardiovascular diseases by weight by obesity and activity levels

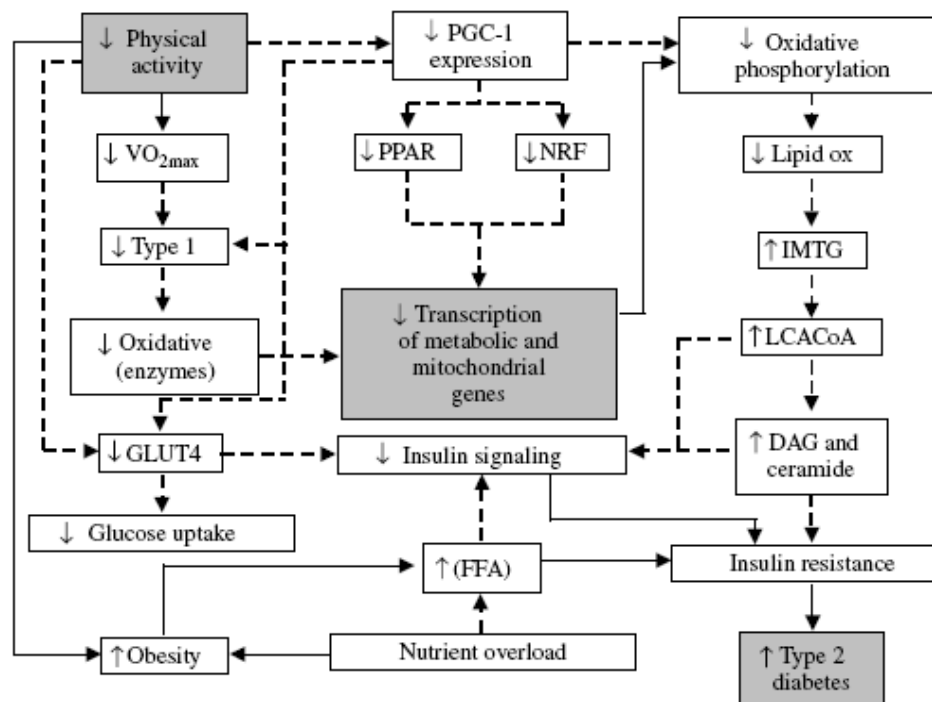
Health condition	All adults*	BMI			
		Normal	Overweight	Obese, class I and II	Obese, class III
<i>n</i>	68,500	24,444	23,730	14,538	2,252
Diabetes	6.3 ± 0.16				
Active	4.4 ± 0.15	2.2 ± 0.16	4.6 ± 0.22	8.7 ± 0.45	14.1 ± 0.19
Inactive	8.7 ± 0.26	4.5 ± 0.28	8.0 ± 0.36	13.7 ± 0.55	22.1 ± 0.15
Diabetes and heart disease	2.2 ± 0.08				
Active	1.2 ± 0.08	0.7 ± 0.09	1.2 ± 0.13	2.5 ± 0.25	3.0 ± 0.75
Inactive	3.4 ± 0.14	1.8 ± 0.18	3.3 ± 0.22	5.3 ± 0.33	8.2 ± 0.92
Diabetes and hypertension	4.1 ± 0.12				
Active	2.5 ± 0.10	1.1 ± 0.10	2.5 ± 0.16	5.7 ± 0.36	9.1 ± 1.46
Inactive	5.8 ± 0.21	2.5 ± 0.20	5.1 ± 0.29	9.6 ± 0.45	15.3 ± 1.27
Diabetes and hyperlipidemia	1.8 ± 0.09				
Active	1.3 ± 0.09	0.6 ± 0.09	1.3 ± 0.11	2.7 ± 0.29	2.9 ± 0.77
Inactive	2.4 ± 0.14	0.9 ± 0.15	2.2 ± 0.21	4.4 ± 0.33	6.3 ± 0.80

Data are % ± SE. *Total equals all adults, including those underweight (BMI <18.5 kg/m²).

(Sullivan et al., 2005)

The mechanism by which physical activity acts to decrease insulin sensitivity and increase type II diabetes is shown in Figure 2.

Figure 2: Cascade thought to explain the relationship between inactivity and insulin resistance.



(Hawley, 2004)

High cholesterol is also associated with an increased risk for diabetes (ACSM, 2006). Exercise training programs have been found to improve metabolic measures, such as cholesterol, in individuals with Trisomy 21. Eberhard et al. found that following an endurance training program, levels of HDL cholesterol increased, and levels of VLDL cholesterol decreased, although not significantly (Eberhard et al., 1997). Exercise can be an effective and important tool in managing diabetes (Hawley, 2004). Exercise can lead to decreased body weight, increased lean body mass, and increased insulin sensitivity due to glucose uptake by active muscles (Hawley, 2004). Managing these factors decreases the risk of

cardiovascular disease, as each is identified as a primary risk factor for cardiovascular disease (Lewis et al., 2005; Sanyer, 2006).

Additionally, both children and adults with DS have been found to have osteoporosis (Angelopoulou et al., 2000). A study comparing the bone mineral density (BMD) of males in Tanner stage V of sexual development, including males with Trisomy 21 and other forms of mental retardation, and a control group, found that the BMD of individuals with Trisomy 21 was significantly lower than that of individuals with other forms of mental retardation, and lower than that of the control group without mental retardation. This study also compared quadriceps strength of these individuals and found that this significantly predicted BMD in individuals with Down Syndrome. The authors suggested that muscle strengthening exercises may be effective in increasing BMD, since one of the forces which acts to stimulate osteoblast activity is muscle contraction. However, further studies may be necessary to determine whether this would be an effective treatment for those with Trisomy 21 (Angelopoulou et al., 2000). Yet another study of 38 adults with Down Syndrome found that 55% had fractured a long bone and 30% had fractured vertebra as a result of osteoporosis (Van Allen, 1999).

Research has also shown higher levels of oxidative stress in individuals with DS (Jovanovich, Cements & McLeod, 1998). When levels of 8-Hydroxy-29-Deoxyguanosine and malondialdehyde (as Thiobarbituric Acid Reactive Substances), markers of oxidative stress, were compared between children with DS and their similarly aged non-Down Syndrome siblings, the children with DS showed higher levels of both of these substances (Jovanovich, 1998; Gerli et al.,

1990). Higher levels of super oxide dismutase (SOD) have also been seen in this population, with levels up to 50% greater than those without DS, since the genetic coding for this enzyme is found on the 21st chromosome, and is therefore present in an extra copy in these individuals (Eberhard et al., 1997; Jovanovich et al., 1998; Gariova et al., 2004; Gerli et al., 1990). This is thought to be a cause of increased oxidative stress. SOD converts the reactive oxygen species (ROS) superoxide into H₂O₂, which is then made into water by catalase (CAT) and glutathione peroxidase (GPx) (Gariova et al., 2004). Due to the increased levels of SOD, there is an increased activity of GPx, but the activity of CAT seems to be unaltered, which may result in an increased amount of H₂O₂; this can cause oxidative damage to cells, particularly when converted to hydroxyl radicals (Gariova et al., 2004; Javier 2006). The ratio of SOD/(CAT+GPx) is increased in individuals with Trisomy 21, and is thought to increase the cells' sensitivity to ROS, rather than the levels of individual enzymes (Muchova et al., 2001). Glutathione (GSH) is responsible for the destruction of harmful peroxides, such as H₂O₂; however, when levels are too high, GSH is oxidized, forming GSSG. The ratio of GSH to GSSG is another indicator of oxidative stress, which is higher in individuals with DS (Gariova, 2004).

Increased oxidative stress can also be caused by higher levels of β -amyloid plaques seen in DS (Teller et al., 1996). The increased plaques are caused by the over-expression of the amyloid precursor protein (APP), which is caused in a manner similar to that of the increased SOD levels; the gene for APP is coded on the 21st chromosome, which is present in triplicate, causing increased

levels of β -amyloid. In vitro, these plaques have been shown to cause neuronal damage and necrosis, which is proposed to be caused by oxidative stress (Thomas, 1996). In vitro evidence shows that β -amyloid plaques cause epithelial damage and constriction, which is prevented by the addition of anti-oxidants (Thomas, 2006).

The increased oxidative stress seen in those with Trisomy 21 is thought to cause the higher prevalence of certain diseases in this population. Many develop Alzheimer's disease in their 30s and 40s, and all individuals with DS (IDS) over age 30 develop brain lesions that are characteristic of Alzheimer's disease, which is not typical of non-DS populations (Kolata, 1985). β -amyloid plaques are also determined to be a cause of Alzheimer's disease, and are seen in all older individuals with DS (Selkoe, 1996). IDS also exhibit higher levels of autoimmune disorders and cataracts, both of which can be caused by oxidative stress (Jovanovich et al., 1998; Muchova et al. 2001). A study conducted by Eberhard et al. found that after a 12-week moderate intensity training regimen, which consisted of activities performed daily in a physical education (PE) class, and 2 days a week of progressive cycle ergometer training at 60% of the subject's VO_2 max, with sessions lasting up to 2 hours, SOD levels decreased to those of matched non-DS controls (Eberhard, 1997). Assuming increased SOD levels are the main cause of the increased levels of these diseases and early aging in this population, exercise could help to combat them. Additionally, after a 12-week training program which met 3 day/week and consisted of a 15 min warm up, 20 min cardiovascular activity at 60-75% of peak HR, which increased by 5 min

every 3 weeks, and a 10 min cool down, it was found that GPx activity increased significantly (Javier, 2006). An increase in GPx activity with exercise could increase the breakdown of peroxide to water and decrease its formation into damaging hydroxyl radicals, thus decreasing oxidative stress (Javier, 2006).

IDS suffer from infections more frequently than those without DS, and respiratory diseases in particular are a main cause of mortality in this population (Ugazio, 1990). Table 6 depicts how much higher a risk the DS population is for certain infections and malignancies than non-DS populations.

Table 6: Incidence of mortality due to various causes compared to age and matched non-DS populations

	1949-59	1960-71
Respiratory diseases	× 124	× 62
Infectious diseases	× 52	× 12
Cardiac diseases	× 11	× 6
Malignancies	× 2	× 1

(Mikkelsen et al., 1975)

It is important to note, however, that these data were collected at a time when institutionalization rates were high for this population, which further increases the risk of infection (Ugazio, 1990). Despite this, however, it is still thought that impaired immune function is the cause of an increased incidence of infection and of increased mortality from infections (Ugazio, 1990).

It is proposed that high levels of SOD contribute to immune dysfunction in IDS (Ugazio, 2000). Once macrophages and neutrophils engulf an antigen they produce ROS, such as superoxide, to digest it. Low levels of superoxide have been found in those with Trisomy 21, presumably due to high levels of SOD

converting superoxide into H_2O_2 and decreasing the ability of macrophages to destroy pathogens (Ugazio, 2000). The decrease in SOD levels seen following exercise might allow for increased antigen destruction and improved immune function.

Additionally, IDS exhibit abnormally low levels of natural killer (NK) cell activity and impairment of T-cell activity, both of which are important in protecting the body against intracellular pathogens. This could be one explanation for their poor ability to handle viral infections (Ugazio, 2000).

During and following acute moderate to vigorous exercise (50-85% VO_2max), levels of immune cells, particularly NK cells and neutrophils, are elevated and can remain elevated for as long as 24 hours post-exercise (Dishman et al., 2003). This rise may be due to an increase in inflammatory cytokines, such as IL-6, which are seen post-exercise (Dishman et al., 2003; Pedersen & Hoffman-Goetz, 2000). However, it is important to note that vigorous exercise is thought to temporarily weaken the immune system (Dishman et al., 2003; Pedersen et al., 2000). There is mixed evidence, however, on the effects of exercise on immune response, and the effects are thought to depend on the intensity and duration of exercise, as well as on the length of the rest periods between repeated bouts of exercise (Pedersen et al., 2000). The evidence is not as clear about the effects of chronic exercise on the immune system. Many studies show increases in NK cell activity in trained subjects as opposed to untrained subjects, but information on lymphocyte proliferation and neutrophil function is quite variable (Pedersen et al., 2000).

Animal studies show [a](#) higher survival rate in animals exposed to a pathogen,

particularly ones causing respiratory diseases, following exercise, than in sedentary animals (Pedersen et al., 2000). Additionally, epidemiological studies show decreased numbers of upper respiratory tract infections (URTI) in those who regularly perform moderate levels of exercise. However, in accordance with evidence that suggests indicates suppressed immune function following vigorous exercise, URTI symptoms were reportedly increased following strenuous bouts of exercise (Pedersen et al., 2000). Since NK cell activity in particular is decreased in IDS, it is possible that an increased activity level could promote increased NK cell activity. The high incidence of mortality from respiratory tract infections, could also make exercise induced increases in immune function particularly helpful, since both animal and epidemiological studies on humans show decreased symptoms of, and mortality from, respiratory tract infections (Pedersen et al., 2000).

Precautions

Due to some of the physiological differences in these individuals, certain measures need to be taken to ensure their safety, and certain things need to be understood about them. First, they should be screened for AAI prior to participating in any contact sports, or sports that could require them to have their neck in a precarious position, and extra caution should be taken while participating in physical activities in general. It is recommended that they avoid sports that put them at greater risk for spinal cord injury and head and neck trauma, such as diving, swimming with a diving start, football, soccer or

gymnastics (Sanyer, 2006). They should also avoid warm ups such as neck rolls. Since the ligament laxity which causes AAI can also lead to pronated and/or flat feet, metatarsus primus varus, patello-femoral instability and an increased risk for joint dislocations, it is even more important for them to be wearing the proper attire, and to make sure they are performing exercises with the right form (“Down Syndrome,” 2007). Depending upon the situation, activities that require less impact on their joints may also be more appropriate, particularly if the individual is overweight and displays signs and symptoms of joint instability. A physician may recommend the use of orthotics, braces or physical therapy prior to initiating an exercise regimen, in an effort to reduce the risk of orthopedic injury (Sanyer, 2006).

Due to their often poor balance and difficulty crossing midline, it is important for a coach or trainer working with IDS to understand that they may not be able to perform certain drills as easily as others, such as grapevines (Down Syndrome,” 2007). They also must realize that they may not be able to reach the same levels of fitness as those without Down Syndrome, particularly where cardiovascular exercise is concerned. IDS may not show the same training effects as their non-DS peers, possibly due to the same decreased sympathetic activity that is thought to cause a blunted HR response to exercise (Sanyer, 2006). For those who exhibit chronic hypoxia, right left shunting, and pulmonary hypertension, a physician may recommend activities that do not demand a high cardiac output, which could increase hypoxia (Sanyer, 2006).

Furthermore, these individuals have a higher incidence of vision disorders (Pueschel, 1990). Approximately 70% of children with Trisomy 21 have refractive errors, 50% have strabismus, 35% have congenital nystagmus, and 20% have a blocked tear duct (Pueschel, 1990). It is important that they be regularly evaluated by an ophthalmologist and that proper precautions be taken when they participate in sport and exercise, because untreated or undiagnosed visual impairments could increase the likelihood of injury (Pueschel, 1990).

Those working with this population should also be aware of the thyroid disorders which are common. Most often, hypothyroidism is seen (Said et al., 2007). Some of the signs of hypothyroidism, many of which can affect physical performance, are fatigue, weakness, muscle cramps/aches, weight gain or difficulty losing weight, cold intolerance, depression, irritability and memory loss (Lewis, 2005).

It is also important that fitness professionals work closely with other health care providers, such as physicians and physical therapists, in an effort to determine what the safest and most effective exercise plan is (Rimmer, 1999).

Cognition and Behavior

Intellectually, individuals with Down syndrome are usually classified as mild to moderately mentally retarded, typically having an average IQ around 50, and many studies show that they will not develop past the mental age of 6-8 years old (Dereyeh, 2001; Pitetti, 2006). There is also evidence that they have a shorter attention span than their non-mentally retarded counterparts, as well as memory

deficits, which would make learning new skills more difficult for them (Dereyeh, 2001). However, it has been shown that their ability to process and remember visual input is greater than their ability to process and remember verbal input (Fidler, 2005). They have very few social-cognitive disabilities; however, they may have difficulty perceiving emotions based upon facial expressions, yet they have the same feelings and ability to form relationships as the average person (“Frequently,” 2008).

Certain behavioral tendencies are characteristic of those with Down Syndrome. IDS are commonly described as stubborn, possibly due to frustration in learning a task, or because of motivational issues (Fidler, 2005). This stubbornness can also be a product of frustration with people having difficulty understanding them (many have speech impairments) or because of the fact that they feel separated from others or want to do what the other kids are doing, rather than their modified task (“Special,” 2006). IDS also show a higher incidence of task avoidance and attention seeking behavior, both through positive means (i.e. “cute” behaviors, clapping, blowing raspberries) and negative means (i.e. tantrums) (Feeley, 2006). Often, they display learned helplessness because they have received too much aid from others throughout their lives and feel that they cannot complete tasks without that outside help (“Special,” 2006).

Psychological Benefits and Recommendations

It has been shown repeatedly that exercise can help increase the health of IDS by increasing their low cardiovascular and respiratory capacities. Exercise

may attenuate the increased chance of obesity and insulin resistance and may increase stability in joints, which leads to benefits similar to those seen in non-DS individuals' health (Menear, 2007). However, because of their disorder, these individuals often do not get adequate exercise, and until recently, health promotion in individuals with intellectual disabilities has rarely been addressed, as healthcare was focused on preventing disability rather than preventing or reducing secondary health conditions (Rimmer, 1999). The issue is most notably addressed in the *Healthy People with Disabilities 2010* initiative, which categorizes its goals into four main areas. The first involves increasing participation by decreasing environmental limitations, including those in the physical, social, learning, economic and political environments, and increasing education. The second involves increasing access to health care and decreasing disparities in quality of care. The third requires increasing physical access to the environment and the infrastructure. The final category focuses on healthcare promotion and the prevention of secondary diseases (Marge, 1998).

A survey of caretakers of 150 individuals with mental retardation, 75 of whom had Down syndrome, was conducted on the amount of leisure time physical activity (LTPA) that these individuals participated in. The survey found that 13% of all the participants participated in no LTPA, 49% participated in little to no LTPA (physical activity of 3.5 METs or above less than 3 times/wk), 45% participated in the recommended level of LTPA (physical activity of 3.5 or greater METs 5 or more times/wk) and 1% participated in regular vigorous LTPA (physical activity of 6 or more METs 3 or more times/wk) (Draheim, Williams &

McCubbin, 2002). The physical activity levels found for only those with Down Syndrome were not significantly different from those found with all participants, which demonstrates the high levels of sedentary behavior amongst this population. Rimmer et al. found that less than 10% of individuals with intellectual disabilities participate in physical activity a minimum of 3 days a week (Rimmer et al., 1995).

In part, the sedentary behavior often seen in this population may be due to the modifications that must be made by their parents, coaches, teachers, or personal trainers in order to teach and work with them, as well as to a lack of opportunities and motivation to be physically active (Meneer, 2007). For example, one of the most common models of disability is the Medical Model, which many people use as a way to conceptualize disability, even if they do not realize it. This model focuses on disability as a problem with the individual. Disabled individuals are seen as deviating from society's standards of what is "normal" and are in need of special accommodations, or need to be separated from everyone who is "normal" in order to succeed. Again, this model perceives disability as a problem with the individual (Ben-Moshe et al., 2005). The Social Constructivist Model, however, sees the construct of disability as a way of understanding individual differences from the societal norm. The impairments, or physiological differences in individuals, are not actually seen as a disability until the impairment causes an inaccessibility issue. Because of this, instead of having the individual change to prevent the inaccessibility, society changes to prevent it. This is the model that is being promoted by disability rights activists (Ben-Moshe et al., 2005).

It was found that significant predictors of exercise participation in IDS were age (the younger had an increased probability of participation), the caregiver's perceived benefits of exercise and the number of access barriers (Heller et al., 2002). It was also found that the perceived benefits of exercise differed between IDS and their caregivers, and that the perceived benefits of exercise by IDS were not predictors of exercise participation. Educating caregivers about the benefits of exercise may have more of an impact on actual participation than educating those with DS. Additionally, following the goals of *Healthy People with Disability 2010*, increasing facility access, as well as increased instruction on how to exercise, could also positively influence the exercise habits of IDS, as those were two of the main cited access barriers (Heller, 2002).

This points to the discussion of another problem that faces the involvement of those with Down Syndrome in sport, which is how to integrate IDS into a regular sports team, both in terms of safety, as well as fairness to the overall team. This is particularly an issue for individuals who have the cognitive ability to understand the "real" rules of the game, but physically, may not have the ability; however, it can be done.

Lyndon LaPlante, for example, was a high school football player with Down Syndrome in Texas. While he was only able to play during certain times in practice, he was still on the team, and his coach "could see the passion in his eyes about how he really loved football and loved being around those guys" (Athlete, 2005). His senior year, thanks to his coach and the cooperation of the opposing

team and officials, they were even able to have him make a 99-yard touchdown during a game, which while it did not officially count, still meant everything to this student. As he stated afterwards, “I carried a 99-yard touchdown. I looked like Emmitt Smith out there” (Athlete, 2005).

However, while it is possible for them to participate in team activities, it is hard to find the “right” place for IDS, since many places and parents are very hesitant to allow these individuals on regular teams. The study conducted by Menear, who interviewed parents, illustrated many of the concerns and difficulties with integrating these individuals into “mainstream” sports environments. One mother stated, “[T]hat [is] one of my biggest concerns because my child is so strong, so agile, and so able to play with kids his age physically and too strong for kids that are his age mentally, so there’s no fit for him in an organized team activity” (Meaner, 2007, p. 64). Yet another mother commented, “My son has the mental skills but he could never play on a school team because it is so competitive. He’s just not at that level at all. And there’s no in-between. There’s school and there’s sports for kids with special needs and he wants no part of the rule adaptations because he understands the regular rules” (Meaner, 2007, p. 64). A father also described how his son wouldn’t even participate in physical activity or anything seen simply as “exercise” unless a sibling or friend was with him. Numerous other parental comments alluded to this same behavior (Meaner, 2007). One student I worked with who had DS and was very fit, particularly anaerobically, saw going to the gym and working out as his special time with his father. He would always come in and excitedly say, “I’m going to the gym with

Daddy! Me and Daddy are gonna go get strong together!” He loved to work out, and would do so even without his father present, because it was his bonding time, and he wanted to make his dad proud by showing him how strong he was. This also illustrates how sports can benefit this population by increasing their social interactions, sense of belonging and psychological health.

A study conducted to assess the perceived physical and academic competence, as well as the perceived acceptance, of children with Down syndrome found that while these individuals scored higher than their counterparts in the areas of physical and academic competence, they scored lower in perceived acceptance (Begley, 1999). IDS also perceive the greatest benefits of exercise to be looking better and feeling better emotionally, as compared to their care givers, who cited health improvements as the greatest benefit (Heller et al., 2002).

Yet another study assessed the attitudinal and psychosocial effects that a 12-week training program had on those with Down syndrome. It showed that not only were their attitudes towards exercise increased, but so was their self-efficacy, positive outlook on final expectations, feeling of community integration and life satisfaction. They also showed a decrease in cognitive-emotional barriers and had slightly lower rates of depression, a mental illness which is prevalent in this population (Heller, Hsieh & Rimmer, 2004; Tuomo, Tervo-Maatta, Taanila, Kaski, & Livanainen, 2006). It was also shown that when comparing pre- and post-, at home exercise, individuals with developmental disabilities showed higher levels of self-perception and adherence to exercise routines when they worked out in a group (Fragala-Pinkham, Haley, Rabin & Kharasch, 2005). If the social aspect is

so important for these individuals, yet it can be hard to find a place for them on a team because of their mental and physical differences, how can they get involved?

One answer to this question is to get them involved in individual sports such as swimming. Sports like this allow them to be a part of a team, while at the same time participating at their own level, without “interfering” with the participation of others, and allowing for physical and psychological health benefits. The individual who understands the rules and wants to be a part of a “regular team” can be, and if they are not physically at the same level as the other people, it doesn’t matter, because their performance does not affect that of the other team members’, or pose a safety problem for anyone. In a situation like this, it would also be far easier to put the individual into a competition and give them that experience. In a sport like swimming, where points are given to the team depending upon the individual performances of the members in each race, they could afford to put the disabled individual in. Even though IDS are not likely to win their individual races, the team could still win, and they would still be able to experience that feeling. In this situation, they could also feel as if they directly contributed to the victory, whereas if they were on something like a soccer team, they might only have the opportunity to sit on a bench. The parents of these children have also mentioned a greater need for them to participate in individual sports for these very reasons, in addition to the fact that if they only need to have one person with them, rather than a whole team of people, to participate in an activity, they are far more likely to do so, and do so often (Menear, 2007). A sport such as swimming, or even bike riding, would also be good for them since

they show joint instability and these are low-impact activities. Joint instability, however, does not mean that an individual sport such as track is not also a viable option as well.

A second option would be to get them involved in less competitive forms of sport. Recreational programs would be perfect for this. They could have the opportunity to play and interact with others, while not having the intense competitive side. They would still receive all the same social and physical benefits as if they participated on a school team; however, while winning the game would still be important, there may not be as big a difference in the competitive nature of the participants, and because the win-loss record of the team wouldn't decide the coach's job, the coach would also be more likely to give the disadvantaged player more playing opportunities.

A third, and more obvious option, particularly for those individuals who may not understand the rules of regular games, is specialized sports programs with modified rules. The individuals would still be getting the social interactions that they crave, while allowing them plenty of physical activity and playing time, putting no one at a disadvantage and giving them the opportunity to win "all on their own." The difficulty here is being able to find, or start, a program like this and have enough participants; this results in few, if any, easily accessible options like this for IDS (Menear, 2007).

It is also possible to involve IDS in forms of exercise that are non-competitive, but still incorporate a social aspect. An exercise class, for example, would allow for social interactions but also fitness benefits, without the worry of

winning and losing. It would be much easier to place IDS with an appropriate group of individuals as well. These classes wouldn't even have to be made up entirely of students with Down Syndrome; they could be integrated into regular exercise classes. Even if the individual may be physically more mature than the average 8-year-old, they could still be placed with that age level if they are mentally at that level, with no negative effect for either group.

Involving individuals with Down Syndrome in dance classes is also a good alternative to competitive sport. This again allows for all the social and physiological benefits, while giving them an opportunity to perform and be in the spotlight, but with less of a fear of failure. Some dance studios, such as the TurnOut Movement Arts Studio, in Springfield, Illinois, even have specialized dance programs for individuals with Down Syndrome (Naumovich, 2007). Studio director, Tracey Sims, began the program while she was working towards her degree in dance therapy. Dance can be beneficial to this population, as it improves their motor planning, sequencing and direction-following skills, while giving students the ability to express themselves (Naumovich, 2007). Individuals with Down Syndrome tend to show an improved memory capacity using imagery techniques, which also makes dance an optimal choice for them (De la Iglesia, Buceta & Campos, 2004). Most importantly, however, is that the students love to dance. One mother recounts how “no matter how tired [her son] is, he always gets fired up when it's time to go to [dance] class” (Naumovich, 2007).

While these ideas are all very feasible, one of the many challenges comes with being able to not only get IDS involved in these activities, but also in

coaching/teaching this group of people. As discussed earlier, stubbornness can be a very common characteristic amongst this population, as can avoidance and attention-seeking behaviors. One of the possible reasons for these behaviors is a learning style that these individuals have developed, which manifests as the child ages. They seem to perform these behaviors, particularly stubbornness and avoidance behaviors (positive or negative), when they are faced with situations that they believe are too hard, and at which they cannot succeed. IDS have experienced so many failures that they not only feel they need help to succeed, but that, even then, they cannot succeed at all, and they would rather avoid the whole task than make the attempt (Wishart, 2001). It has also been shown that when they do succeed, this population tends to view the success as being due to external, uncontrollable factors, such as assistance, rather than due to internal ones that they have control over (Pepi, 2005).

Those with Down Syndrome have been found to have delays with, and an incomplete perception of, cause and effect relationships. An outcome of this is that they tend to be less motivated by goal-setting techniques, particularly ones that may take a longer time to achieve (Fidler, 2006). However, if someone takes the time to work with them, waits for them to understand the concept and set their own goals, those with lesser degrees of retardation can benefit from these techniques (Hanrahan, 1998). Also, as discussed earlier, IDS tend to have short-term memory problems, and they respond to and remember visual instructions better than verbal ones. This could be due in part to hearing problems, since one

study showed that approximately 75% of children with Down Syndrome experience hearing problems at some point in childhood (“Improving,” 2008).

When working with these individuals, it is important to look at all these factors and set things up in a way that works best for them, also realizing that behaviors and abilities are going to vary from individual to individual. First and foremost, they need to enjoy themselves. Since the social aspect of physical activity is what motivates them to participate, they need to be allowed time to interact and “chit chat.” When instructing them, break skills and ideas down into simple, easy-to-achieve parts and slowly build up to the final product. Finding an easy-to-understand, and meaningful reason for each part may help to motivate them, since they may have difficulty seeing the means to the end for each step. Making sure they have a peer with them doing the same skill, and even having both do the broken-down version of the skill, may help prevent an unwillingness to attempt the new skill. In addition, since many of them can have hearing difficulties, make sure that you speak clearly, so they are more likely to hear and understand you.

Demonstrating the skill and using visual instructions, either alone or in conjunction with verbal ones, would also allow them to not only remember what they are or are supposed to be doing, but also to repeat the action more successfully. This case was shown in a study on gross motor acquisition, in which they first instructed individuals using both verbal and visual techniques, and then, after a few days time, assigned them to groups that asked them to perform a task while being given either verbal or visual instruction. The group

receiving visual instruction increased their performance from the time they were first taught the skills, whereas the verbal group actually showed decreases in performance (Meegan, Maraj, Weeks & Chua, 2006).

Higher instances of “pretend play” have also been noticed amongst this population. It may be useful to set up a situation for them to get them to participate more or be more interested in what is going on, which has also been shown to help decrease their attention problems (Fidler, 2006). For example, you could have them imagine that they are in a championship game and need to be performing their best so they can win, or have the ball and are about to shoot on goal and break a tie. Imagery techniques, and even more so, drawing techniques (where the person is shown something and then draws it), have also been shown to dramatically increase memory capacity amongst those with Down syndrome (De la Iglesia, Buceta & Campos, 2004). When one is trying to teach new tasks, it can be useful to combine these techniques for the best possible outcome, along with basic repetition. Imagery techniques can also be used to decrease pre-competition anxiety with IDS (Hanrahan, 1998).

Since those with Down syndrome have not commonly been observed to participate in physical activities without some sort of external reasoning, it is important to find ways to keep them motivated and interested in the activity. External rewards can be another good motivator for this group (“Information,” 2007). Finding out something the person likes and setting up a reward system based on that, even if it’s something along the lines of getting to take a friend to the movies, can be a motivating factor. Trying to “push” these individuals, either

physically or mentally, could unmotivate them, as could redundant activities. If they find the activity too hard or uninteresting, that is when behavioral problems start to manifest themselves. Setting them up for success, giving them warranted praise and stressing their achievements are other good strategies. They tend to shy away from situations where they believe they will fail, so showing them that they have succeeded and giving them the attention that they seek out for positive behaviors will help improve, not only overall behavior, but also enjoyment of the activity and will make them want to continue participating and learning (“Special,” 2005). Since they tend to attribute their successes to external factors, pointing out the ways that they themselves produced the success (i.e., hard work, practicing, perseverance), could hopefully help to change this attitude and build confidence, while again, increasing their wanting to perform the activity. In addition, pointing out the specifics of what they did to make that achievement possible would also be important because of the difficulty they have with recognizing cause-effect relationships: if they know what they did to succeed, they are more likely to repeat that behavior in the future, especially if they receive attention for it.

In addition, just as with any athlete, it is important for IDS to build a relationship with their coach, or instructor, and for that person to speak with them if they seem “off.” This population feels the same emotions and moods as everyone else, and it is important to take that into consideration when working with them. This comes into play when reprimanding them or when they become stubborn or exhibit avoidance behaviors. They feel frustrated, just as everyone

else does, when they have difficulty succeeding at a task. When this happens, evaluate the situation. Perhaps break down the task into smaller steps as discussed before, so they can readily succeed and not fear failure. Reassuring them that they can do it, and pointing out all the other “hard” tasks that they have achieved may also help. Finally, just giving them a break, switching gears and letting them choose another activity instead, to do for a while, may be what they need to get them happily participating again. I have been in this situation and gone through these same steps while working with kids who have DS; sometimes all they needed was a little break, and they were more than willing to go back to the activity afterwards.

Conclusion

IDS can benefit immensely, both physically and psychologically, from regular participation in exercise. Often inaccessibility, a lack of perceived benefits from exercise, a lack of knowledge on the part of fitness providers about health considerations and how to work with this population contribute to the low levels of activity in IDS, in addition to the neglect of health promotion to individuals with intellectual disabilities. However, these individuals are more than capable of participating in sports and exercise activities, particularly when proper coaching techniques are applied, and when the person working with them understands the cognitive and behavioral differences of this population, so that they can properly gear their teaching strategies to these individuals. This can allow those participating to derive the greatest psychological benefits, while still

providing them with the health benefits and regular exercise that many of them lack.

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Physical activity in individuals with Down syndrome: Abnormalities, their implications for exercise, suggestions for appropriate activities and instructional techniques:

A Summary

Down Syndrome (DS), or Trisomy 21, is a condition in which there is an extra copy of the 21st chromosome. Individuals who have this genetic disorder have a number of physical and mental differences from those without Down Syndrome. Many of the physical issues associated with Down Syndrome can be aided by the addition of exercise to an individual's routine. However, many people do not know how to work with this population or about some of the health problems that need to be taken into consideration when working with them. The purpose of this paper is to better inform people about the physiological and psychological differences associated with DS, the health risks for those with DS as far as exercise is concerned, and to make recommendations for appropriate forms of exercise and techniques that may be helpful in working with this population.

The cardiovascular system of those with DS is often underdeveloped, has anatomical defects and lacks the same capacity as those without DS. The cardiovascular abnormality which has the greatest impact on exercise is termed chronotropic incompetence, which describes the inability of the cardiovascular system to meet the demands of the body's tissues. The heart rate of individuals with Trisomy 21 does not increase as much during exercise as those without Down Syndrome. The exact cause for this is not known; however, it is speculated

that it is a result of either nervous system dysfunction, hormonal dysfunction (lower levels of epinephrine and norepinephrine), or a decreased sensitivity of blood pressure receptors. This cardiac dysfunction means that individuals with DS do not have the same ability to exercise as those without it, due to a decrease in the ability of the heart to get needed oxygen and nutrients to the muscles. This is also thought to be the cause of the lower $VO_2\text{max}$, or maximal oxygen utilization, seen in these individuals as well, particularly combined with the lower minute ventilation that is also often seen. While individuals without DS can increase their $VO_2\text{max}$ about 10-15% with aerobic training, the evidence is mixed for the effect in those with Trisomy 21. This variation in ability to increase $VO_2\text{max}$ with training, which is not typically seen in a non-DS population, may also be due to anatomical differences in their upper airway, which can obstruct airflow; these changes will not disappear with training, so airflow will still be decreased, effectively decreasing the oxygen that is able to enter the lungs. However, despite the mixed evidence about the ability of training to increase $VO_2\text{max}$, performance measures, such as the amount of time individuals can walk before they reach exhaustion, still improved. This is particularly important for the quality of life of these individuals, since it will give them independence and a greater ability to maintain that independence as they grow older. Poor balance, which is common in those with DS, can be improved through exercise, which can effectively decrease injury due to falls. It is also important, however, that those working with individuals with DS be aware that they may not have the same fitness level, or training effects as those without DS.

This population also has a greater ligament laxity, making their joints less stable and putting them at a greater risk for certain orthopedic injuries. The most serious of these injuries is atlantoaxial instability (AAI). AAI is characterized by an increased distance between, and movement of, the first two vertebrae, and puts one at a greater risk for vertebral dislocation and spinal cord injury. All individuals who have not been screened for this should be, prior to the initiation of an exercise regimen. Ligament laxity also places them at a greater risk for hip dislocations, instability at the knee which can lead to dislocations of the knee cap, flat feet and bunions. It is important that those working with this population be aware of these issues and take the necessary precautions, such as assuring that they are wearing the proper attire, particularly footwear, and performing all skills correctly. Based on the presence or severity of one or more of these conditions sport-specific considerations need to be made (i.e., someone with AAI should not dive into a pool).

Overweight problems are also more prominent amongst individuals with DS than those without. The primary cause for this is sedentary lifestyles and improper diets. However, lower resting metabolic rates (RMR), or the amount of calories burnt at rest to sustain life, not taking into account those utilized to digest food, have also been seen in prepubescent children with DS. Evidence shows that increasing the activity levels of individuals with Trisomy 21 will not only help them to lose weight, but by increasing muscle mass, can also help to raise their RMR, since muscle tissue requires more energy than fat tissue. Additionally, obesity, and even more so inactivity, have been shown to be risk factors for

diabetes, which has an elevated incidence in DS populations. Depending on the severity of the diabetes, some individuals are able to control it with exercise alone, since exercise helps to increase insulin sensitivity. Exercise has also been shown to decrease cholesterol levels in those with DS, which, along with obesity and diabetes, is a risk factor for developing cardiovascular disease.

Osteoporosis is another common medical condition found in this population, which is proposed to be a cause of the high incidence of long bone fractures. Weight-bearing exercise stimulates the body to build more bone, helping to reverse the effects of osteoporosis. A close link between muscle strength and bone mineral density has been shown in individuals with DS. It is proposed that increasing muscle strength may also help to reverse these effects as well. However, in severe cases of osteoporosis, high impact exercise should be avoided as it could lead to fractures.

There is also a higher incidence of Alzheimer's in those with Trisomy 21, and it has been shown that all individuals with DS exhibit Alzheimer's-like lesions on their brain after the age of 30. It is believed that this is due to the high levels of oxidative stress that are typical in these individuals. In the body, reactive oxygen species (ROS) are converted by an enzyme called superoxide dismutase (SOD) into peroxides, which are then converted to water by the enzymes catalase (CAT) and glutathione peroxidase (GPx). Individuals with DS have been reported to have as much as 50% more SOD than those without DS. This leads to an increase in GPx activity to try to break down the higher levels of peroxides, but an increase in CAT activity is not seen. However, when peroxide

levels are too high, glutathione is oxidized to glutathione disulfide (GSSG), a marker of oxidative stress that is elevated in this population, as peroxides also cause oxidative stress. In addition to causing Alzheimer's, higher levels of oxidative stress can also cause autoimmune disorders and cataracts, which both have a higher incidence in populations with DS. Exercise training, however, has been shown to decrease the levels of SOD to normal or near-normal levels in those with Trisomy 21.

Individuals with DS are more susceptible to, and have higher rates of, mortality due to infection. They often have a lower number of natural killer (NK) immune cells and T-cell dysfunction, leading to a decreased ability to fight off infection. Furthermore, the ROS produced by immune cells to digest pathogens are thought to be converted to peroxides by the high levels of SOD, further impairing immune function. While the evidence of the effects of exercise on the immune system is mixed and dependent upon the frequency, duration and intensity of exercise, most studies show increased levels of NK cells as a result of exercise. Additionally, exercise can act to decrease SOD levels in those with DS, which could counteract the impairment of immune function due to the neutralization of ROS used to digest pathogens.

Intellectually, these individuals are usually classified as mild to moderately mentally retarded, and many studies show that they will not develop past the mental age of 6-8 years old. There is also evidence showing that they have a shorter attention span than their non-mentally retarded counterparts, as well as memory deficits, which would make learning new skills more difficult for

them. However, it has been shown that their ability to process and remember visual input is greater than their ability to process and remember verbal input. They also have few, if any, social-cognitive disabilities.

Certain behavioral tendencies are also seen in this population.

Stubbornness is common, and is thought to stem from frustration with a task or frustration with others around them, since they can often have speech impairments leading to difficulties communicating, motivational issues, or feelings of separation from others through a desire to do what others are doing. Avoidance behaviors that are either positive, such as cute behaviors like blowing raspberries, or negative, such as throwing tantrums, are also seen. Often, they also display signs of learned helplessness, or a belief that they cannot succeed on their own.

Studies have shown that physical activity can improve measures of mental health in those with DS as well. After training regimens, they had increased levels of self-efficacy, a positive outlook on final outcomes, decreased levels of mental illness, a decrease in cognitive emotional barriers, more positive attitudes towards physical activity, and higher levels of self-perception.

Despite the benefits can have for both the physical and mental well-being of those with Trisomy 21, it has been shown that this population does not get an adequate amount of exercise. For caregivers, the two biggest obstacles to physical activity in this population are finding appropriate forms of exercise and knowing how to work with these individuals.

Individuals with DS are recognized to be very social, and many parents have made note that their children only show an interest in physical activity when

peers or siblings are participating. This brings up one of the problems in involving these individuals, which is how to integrate them into mainstream sports and activities. Many parents find that their children are either too old physically to be a part of the activities of those who are the correct mental age, or vice versa, which poses health and performance risks to all involved. Additionally, while some individuals are happy to participate in modified sports, others who have the ability to understand unaltered rules want nothing to do with these activities. One of the ways around this is to have them be a part of an “individual team sport,” such as swimming or track. This would allow these individuals to be a part of a team, and even participate in competitions, without posing a physical risk to any involved or a performance risk to the team if it is not a close game. This allows them to be a part of a “mainstream” team, and still be able to participate in competitions. Recreational programs that are less competitive can also have this effect as well. Having them participate in activities that are non-competitive, such as dance or fitness classes, is also a good option. They can be a part of a group with people of any age and be successful participants. Dance in particular allows people to freely express themselves, which can have a therapeutic effect. Unplanned physical activities such as family hikes, walks, bike rides or pick-up games with other kids are also viable forms of exercise.

When working with those with DS, it is important to take their cognitive differences into account. As mentioned previously, they are better able to remember visual information than verbal information. When one is instructing them, it may help to combine these techniques by describing what you are doing

while demonstrating it, or providing visual representations of a skill when attempting to teach and practice it. Breaking skills down, repeating each step and just going slow can also prove to be very useful when instructing those with DS. Additionally, these individuals can have difficulty seeing cause and effect relationships, so techniques used with other athletes, such as goal setting, are often not as effective a tool. When some of the behavioral issues commonly seen become a problem, it is important to evaluate the situation and try to get to the root of the problem, whether it be frustration or otherwise. Furthermore, this population has a tendency to attribute success to external factors, rather than to their hard work and skill, so it is important to make them aware that it is what they are doing that is producing successes.

Individuals with DS can benefit from the effects of exercise, both in the short and long term, and are capable of participating in numerous forms of physical activity, despite the fact that most do not. A lack of appropriate activity choices and knowledge of sports professionals are the greatest barriers to physical activity for this population. However, with the proper education of professionals and a willingness to make accommodations, those with DS can fully participate in physical activities and derive health benefits that can greatly increase their quality of life.