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Physical and Metabolic Fitness of Children and Adolescents with Intellectual Disability - How to Rehabilitate?

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1. Introduction

1.1 Physical activity and physical fitness of individuals with intellectual disability

Physical activity is defined as any bodily movement produced by skeletal muscles and resulting in a substantial increase over the resting energy expenditure. The energy expenditure can be measured in kilocalories. Physical activity in daily life can be categorized into occupational, sports, conditioning, household, or other activities (Caspersen,1985). There is a large number of techniques for the assessment of physical activity in children and adolescents which can be divided into 5 categories: direct observation, self-reports (diaries, recall questionnaires, interviews), physiological markers (heart rate), calorimetry and motion sensors (WHO,1995; Montoye,1996).

Exercise is a subset of physical activity that is planned, structured, and repetitive and purposive in the sense that improvement or maintenance of one or more components of physical fitness is an objective (WHO,1995).

Physical fitness is generally defined as " the ability to perform daily tasks without fatigue" (WHO,1995). Warburton (2006) also defined physical fitness as a physiologic state of well-being that allows one to meet the demands of daily living or that provides the basis for sport performance, or both.

All people have their own individual fitness needs and physical fitness is as important for the individuals with intellectual disability as it is for individuals without intellectual disability. However, for persons with mental retardation an appropriate level of physical fitness is critical, because their disabling condition itself may interfere with their activities like their ability to move efficiently (Rimmer,1994; Horvat,2002; Warburton,2006). Furthermore, the fitness level of people with mental retardation regardless of age and/or the measurement procedures is generally lower in comparison to their peers from general population (Rimmer,1994; Fernhall, 1996; Cumella,2000; Pitetti,2001; Pitetti,2002; Pitetti,2004; Temple,2006). Physical fitness and regular physical activity are key factors in health and well being of all individuals. Health-related physical fitness involves the components of physical fitness related to health status, including: cardiovascular and respiratory endurance, musculoskeletal fitness (muscular endurance and muscular strength), body

composition, flexibility and metabolic fitness (WHO,1995; Warburton,2006). These components can be measured by means of various laboratory and field tests.

Nevertheless, both physical activity and physical fitness are strong predictors of risk of death (Meyers,2004). There is a significant relationship between physical activity and physical fitness in youth without ID (Malina,2001). This relationship between physical activity and physical fitness ranges from weak to high (Frey,2008); as both may influence health during childhood and adolescence, as well as throughout life (Malina,2001). The potential relationship between childhood and adolescent activity and adult activity assumes that physical activity tracks from childhood through adolescence into adulthood (Malina, 2001). Physical activity and physical fitness relationship have not been thoroughly investigated in youth with intellectual disability, but it is reasonable to assume that the same association in youth without intellectual disability would also apply to youth with intellectual disability (Frey,2008).

2. Benefits of physical activity

Many national and international health organizations such as World Health Organization (WHO), United States Department of Health and Human Services (USDHHS) and American College of Sports Medicine (ACSM) have reported that children and adolescents with or without either intellectual disability or obesity can improve their health and quality of life by including moderate amount physical activity most days of the week and that additional benefit could be attained with greater amounts of activity(USDHHS 2001, 2005; Fernhall 2003; Spear,2007; Donnelly 2009). Positive effects of regular physical activity are more wide-ranging than the mere absence of disease (Temple, 2008). Physical activity maintains the structure and function of the body organs, reduces anxiety and depression (Dunn,2001), enhances social inclusion, and a sense of belonging (Temple,2008). Some common chronic diseases, including cardiovascular diseases (Dale,2002), hypertension (ACSM,1993), type 2 diabetes (Helmrich,1994), osteoporosis (Warburton,2001), and cancer (Wannamethee,1993) can be prevented or delayed if adolescents develop a physically active life style and continue to be active as adults (Lotan, 2004; Temple,2008). Physical activity has been shown to improve body composition (Slattery,1992) by reducing overall adiposity (Bodde,2009), improve aerobic fitness and endurance (Stanish,2008), help maintaining muscle mass (Bodde,2009), and to have positive effects on fat metabolism (Wannamethee,1993; Berg,1997; Temple,2008). In addition, physical activity can help improve bone health and can enhance physical, mental and social wellbeing, as well as quality of life (Temple,2008).

3. Barriers of physical activity in people with intellectual disability

Because of the contribution of sedentary living to obesity and chronic health conditions, it is critical to understand determinants of physical activity for people with intellectual disability to inform policies and recommendations (Bodde,2008). Thus, studying barriers is an essential precursor to the implementation of successful physical activity interventions for people with intellectual disability. Quite few studies examined the barriers to physical activity in people with intellectual disability (Messent,1999; Frey,2005; Stanish,2006; Temple,2007; Bodde,2009). In general, barriers and facilitators to physical activity fall into five categories: (1) demographic and biological factors; (2) psychological, cognitive, and emotional factors; (3) behavioral attributes and skills; (4) social and cultural factors; and (5) physical environment factors (Stanish,2006; Bodde,2009). For people with intellectual

disability, the very recent review by Bodde&Seo (2009) revealed that there were many common themes among the social and environmental barriers for physical activity. These barriers include: cost (availability of resources, built environment, money), transportation (lack of transportation to an exercise facility), lack of support (unavailability of staff for assistance, restricted policies, lack of opportunities), and risk assessment concerns (safety issues such as unsafe areas or streets in which to walk) (Stanish,2006; Bodde,2009). Each of these main barriers is modifiable with the help of agencies and service providers. In addition, personal or population specific barriers especially in adolescents with intellectual disability also exist, those which should receive great attention when considering implementing physical activity program for this specific population. These barriers include low fitness level, increased risk of obesity, difficulty in teaching people with intellectual disability motor skills, poor motivation (Lotan,2004; Ahorni,2005). Furthermore, other personal barriers faced by people with intellectual disability are similar to those of the general population such as age, lack of self-efficacy, lack of interest, time, money and preference for sedentary activities (Stanish,2006; Bodde,2009). Physical activity of adolescents with intellectual disability could be increased when all these barriers removed.

4. Physical fitness and physical fitness assessment in people with intellectual disability

Most of the literature consistently showed that people with intellectual disability are less fit than their peers without intellectual disability and their physical fitness levels are generally low and decline to great extent with age, which placing them at greater risk of poor health (Table 1).

Children and adolescents with intellectual disability have more specific lower levels of peak oxygen consumption (peakVO₂: in general 45-55% of predicted values), have lower time to exhaustion in different field tests as running, walking. Also muscular strength and strength endurance is lower in this children compared to their peers without intellectual disability. Fernhall and Pitetti (2000) reported that muscular strength, time to exhaustion and peakVO₂ are strongly associated in adolescents with intellectual disability. They concluded that the lower levels of muscular strength is the determining factor of stopping maximal exercise tests as running or cycling. Another interesting finding reported by Pastore et al. (2000) was that the cardiac response in these children to exercise (increase in heart rate) was significantly lower than in their peers. This was the case especially for those with Down Syndrome. This is called chronotropic incompetence, which is a reflection of autonomic dysfunction and strongly intervening with physical performance every day. So, focusing on physical activity programs that could enhance the improvement of the physical fitness for this population (especially the cardiovascular fitness or endurance) is necessary. Assessing the present physical fitness levels of people with intellectual disability can target individuals in need of intervention and provide the current fitness levels to serve as a starting point to set goals for improving fitness levels (Draheim,1999).

Physical work capacity can be defined as the maximal or peak work rate reached during some form of a work performance test, usually a test designed to measure aerobic or cardiovascular capacity (Fernhall,2002). There are three forms of work capacity tests:

1. Maximal effort tests:

These tests are considered to be the best measurements of physical work capacity. The gold standard for maximal effort tests is a test of maximal oxygen uptake (VO₂max) (Draheim,1999;

Study	Participants	Testing (maximal exercise test)	Relative VO ₂ peak (ml/kg/min)	Peak Heart rate (beats/min)
Bar-Or et al. (1971)	89M, 32F (7-15)	treadmill	M: 48-51 F: 42-47	195-205
Fernhall et al. (2001)	9M, 8F (14)	treadmill	39	182
Fernhall & Pitetti (2000)	15M, 11F	treadmill	35	
Fernhall et al. (1996)	13M, 10F (15)	treadmill	M: 33 F: 26	M: 174 F: 180
Fernhall et al. (1998)	22M, 12F (14)	treadmill	37	186
Maksud & Hamilton (1974)	61 (10-13)	cycloergometer	39	187
Pitetti & Fernhall (1997)	17M, 12F (14)	treadmill	M: 37 F: 30	M: 183 F: 188
Pitetti et al. (2000)	12M, 11F	treadmill	M: 46 F: 32	M: 187 F: 182
Teo-Koh & McCubbin (1999)	45	treadmill	41	189
Yoshizawa et al. (1975)	75M, 53F	cycloergometer	M: 41-44 F: 33-36	M: 184-187 F: 181-186
Fernhall & Tymeson (1987)	11M, 3F	treadmill	27	171
Millar et al. (1993)	15	treadmill	26	166-173
Guerra et al. (2003a,b)	15M, 11F (15.3 ± 2.7)	treadmill	32	165+/-14.7
Baynard et al. (2004)	7M, 6F (18.5 ± 2.3)	treadmill	27	161
Elmahgoub et al. (2009)	12M, 18F (14-22)	cycloergometer	18-39	138-198
Elmahgoub et al. (2011)	18M, 27F (14-22)	cycloergometer	17-42	133-198
Elmahgoub et al. (2009)	12M, 18F (14-22)	cycloergometer	18-39	138-198
Elmahgoub et al. (2011)	18M, 27F (14-22)	cycloergometer	17-42	133-198

Table 1. Aerobic capacity in children with intellectual disability (Fernhall and Pitetti 2001, added with recent literature)

Fernhall,2002), in which oxygen uptake is typically measured through indirect calorimetry. The test can be conducted on various work ergometers such as treadmills, cycles, and arm and rowing ergometers. Protocols for testing usually start at low work rates and increase incrementally at set time intervals until the test is terminated because the subject can no longer continue because of fatigue. Heart rate and blood pressure are typically measured in addition to oxygen uptake. Ideally, a "plateau" in oxygen consumption with an increase in work rate should be observed at the end of the test to ascertain that maximal effort has been reached. A plateau is difficult to achieve in children, however, other parameters are often used instead, including subjective judgment of whether or not the child is exhausted, maximal heart rates close (-10 beats) to predicted maximum ($220 - \text{age}$), and respiratory exchange ratios (RER) above 1.0. Unfortunately, many of these parameters do not work well when testing children. The common formula for predicting maximal heart rate ($220 - \text{age}$) is invalid in children because the maximal heart rate of children does not change from age 5 years through adolescence. The respiratory exchange ratios might also be below 1.0 even during attainment of a plateau in oxygen consumption; thus, these variables might work well to substantiate maximal effort in adults, but they do not work well in children. Consequently, the term VO_2max should only be used when a plateau in VO_2 concomitant with an increase in work rate has been produced. Because a "true" VO_2max is difficult to achieve in children, most of the time the term VO_2peak is used. VO_2peak denotes the highest VO_2 attained during test without producing a plateau. Heart rate or respiratory exchange ratio achieved at peak effort are often used to substantiate that a maximal effort was produced even though a plateau in VO_2 was not achieved. Subjective signs of exhaustion such as inability to keep up with the treadmill speed or to maintain pedal frequency, severe hyperventilation, or the subject's refusal to continue are typically used as indicators that maximal effort was produced even though a plateau in VO_2 was not observed. VO_2peak is usually similar to true VO_2max in children. Most studies of children who have disabilities report VO_2peak . The drawback to VO_2peak or VO_2max testing is that it requires a well-equipped laboratory with expensive equipment and trained personnel. The maximal effort testing process is a time-consuming and impractical for fitness program usage, particularly when a large number of participants are to be tested (Fernhall,1998). Despite this, maximal and peak oxygen uptake testing is a common form of work capacity testing performed in children and adolescents who have intellectual disability.

The results of the maximal effort test are dependent on sufficient familiarization, exercise mode, protocol selection, and motor control of the individual (Fernhall,2002). Furthermore, there are also many disability specific concerns or problems that can influence the test results including: learning factors such as task understanding; maintaining adherence to a set cadence; movement limitation; or lack of motivation necessary to produce a maximal effort (Seidl,1987; Lavay,1990; Pitetti,1993; Rintala,1995). Nevertheless, the validity and reliability of the VO_2max test have been established in children and adolescents with intellectual disability (Fernhall,1990; 1993; 1998; Pitetti,2000).

Maximal work capacity testing can also be conducted without actual measurements of VO_2 . In this case, the subject will perform the test using a standard protocol (typically a Bruce or a Balke protocol) with heart rate and blood pressure measurements, and VO_2peak is predicted based on the maximal work rate reached, because work rate is linearly related to oxygen uptake. The prediction is highly dependent on the protocol used, however, and there is large individual variation. The formulas are also population-dependent and are not accurate if subjects are allowed to hold on to the handrail during treadmill testing (the most common form of testing). There are no predictive formulas available for children who have

disabilities. Although change in response to interventions can be measured as long as the same protocol is used pre- and post- intervention, comparisons between studies and populations become difficult without validated formulas for prediction of VO_2 max.

2. Submaximal tests:

In this test, the maximal effort is predicted from the submaximal data obtained or the response to a specific submaximal work rate is observed. Submaximal exercise tests for the purpose of predicting VO_2 max are usually performed on a cycle ergometer using a standardized protocol. The VO_2 max is predicted based on the heart rate response to each work rate used because the heart rate response is linearly related to the work rate, and the work rate is linearly related to oxygen uptake. The test is usually stopped when the subject reaches 80% of predicted maximal heart rate, and the maximal work rate is derived by extrapolating the heart rate out to the predicted maximal heart rate and the work rate predicted to be associated with achievement of maximal heart rate. The prediction accuracy of these tests is moderate at best, and they work best in adult populations. McCubbin et al (1997) has conducted study to validate the use of submaximal Astrand-Ryhming test. They concluded that submaximal Astrand-Ryhming test is significantly correlated with VO_2 peak. Although these tests have been used in children who have intellectual disability, their use has not been validated in this population. Considering that many children or adolescents who have intellectual disability have lower than expected maximal heart rates and possible metabolic disorders, the assumptions made when predicting VO_2 max from submaximal exercise testing are often violated. These tests tend to grossly over predict VO_2 max in children who have disabilities, and therefore cannot be recommended at this time for use in these children.

Submaximal testing can also be used to evaluate physiological responses at submaximal work rates without the purpose of predicting VO_2 max. Typically, responses are evaluated at a certain percent of maximal capacity, or an absolute work rate can be selected. It is also common to evaluate the work rate, or heart rate, achieved at the anaerobic threshold as indicators of submaximal work capacity. This might be a more appropriate form of testing to evaluate responses to work intensities encountered in daily life; thus, the ecological validity of these tests is excellent. This is a common approach when comparing the physiological responses of different populations (children with and without disabilities). For instance, the heart rate response of two groups of children could be compared at 75% of maximum and at 3 miles per hour when walking on a treadmill over a specified time period. This approach is also commonly used when testing the efficacy of various forms of interventions. For instance, the cardiovascular and metabolic responses to a 3-mile-per-hour treadmill walk before and after surgical correction of a congenital heart problem will yield information on the response to a physical activity that is typically encountered in daily life. The exercise mode, intensity, familiarization, test reliability, and outcome variables selected need to be carefully considered based on the disability and the information that is desired from the test.

3. Field-based tests:

In this test the aerobic capacity is predicted from field-based performance. Field tests are typically run/walk tests for a specified time or distance and VO_2 max can be predicted based on the time of completion or the distance covered. The following field tests are the most frequently recommended for individuals with intellectual disability: the 1.5-mile run, 1-mile walk (Rockport Fitness Walking Test), the modified Leger and Lambert shuttle run (20-m

shuttle run, Progressive Aerobic Cardiovascular Endurance Run (PACER)), the modified Canadian step test and 6 minute walk test (Montgommery,1992; McCubbin,1997; Fernhall,2000). Each test type has advantages and disadvantages with regard to ease of administration, costs and the ability to predict VO₂ max.

For children and adolescents with intellectual disability, the most common tests are:

- The 0.5-mile or 1-mile runs, in which the performance time is used to predict VO₂max. During these tests the children are asked to run the required distance as fast as they can. For appropriate performance, practice and a sense of pacing are required.
- The Rockport One Mile Walk Test (RMWT) has also become popular for use in children and adolescents with intellectual disability. This test involves walking only, but the heart rate must also be measured immediately upon test completion and both the walk time and heart rates are used in the formula to predict VO₂max.
- The 20-meter progressive shuttle run has become a popular testing option for children and adolescents with intellectual disability. This test involves paced, 20- meter runs that have a slow starting pace with a gradually increasing pace every minute. The concept is similar to a graded exercise test, with a slow start followed by incrementally increasing work rates. External pacing is provided by playing a tape, thus relatively little practice is required. The number of laps or the finishing pace is used to predict VO₂max.
- The six-minute walk test is commonly used to measure the physical performance in adults (Enright,1998; 2003), as well as in children with and without diseases (Geiger,2007; Morinder,2009). There is convincing evidence that six-minute walk test is a reliable and valid measure of functional exercise capacity in healthy and obese children and adolescents without intellectual disability (Li,2005; Morinder,2009). It is often chosen because it is easier to administer, better tolerated and better reflects activities of daily living than other walk tests (ATS,2002; Takken,2009). Therefore it also has been used often in clinical settings for adults as well as children and adolescents with intellectual disability. Validity and reproducibility has been proved recently in this population by Elmahgoub et al. (2011). According to the American Thoracic society (ATS,2002) the six minute walk test has to be performed in a 20-m-long plane corridor. Instructions should be given standardized, with standardized sentences and time points (every minute) (Enright,2003). However, in this population this is not possible. Therefore, In the study of Elmahgoub (2011) the participants were encouraged continuously with standardized sentences. The distance covered at the end of six minutes is measured to the nearest meter. The reproducibility expressed by ICC was 0.82, indicating good reliability. The Standard Error of Mean (SEM) came to 29.8m, resulting in a significant relevant difference (SRD) of 82.6 m. This is higher as reported by Enright (2003) and the American Thoracic Society guidelines and probably due to the continuous encouragement and the specific problems of understanding in this population.

One of the most difficult problems of testing individuals with intellectual disability is determining whether poor comprehension or poor motor development is the reason for their inability to perform a specific task. It is difficult to determine whether a client with intellectual disability understands directions given during test situations (Rimmer,1994). The person with more severe form of intellectual disability, the less likely he or she will understand for example the concepts of speed and endurance. A study by Lavay et al (1995) listed factors that may affect on field-test assessment of people with intellectual disability.

These factors were: limited ability to understand and follow test directions, poor movement proficiency, limited motivation, lack of proper pacing techniques, low levels of training experiences and limited familiarity with tests. There are also other factors to be considered in the evaluation, such as body size, body composition, and predisposition of the participants' respiratory infection (Rintala,1995). All these factors may negatively affect assessment of people with intellectual disability.

5. Exercise training programs for people with intellectual disability

Supervised exercise training is an important issue in increasing physical activity in people with intellectual disability. In the following pages the effects of exercise training (Table 2) on body composition, physical fitness and where possible metabolic fitness will be described. Under metabolic fitness we understand those elements that are a risk factor for cardiovascular disease and/or diabetes (insulin resistance).

Overall in literature it is reported that exercise training has positive effects on health-related physical fitness. Chanias et al. (1998) published in a meta-analysis 16 controlled studies, including 698 subjects, and 5 uncontrolled studies, including 133 subjects, and reported effects and effect sizes on health-related physical fitness components. They reported that there was a slight positive effect of exercise training on body composition, expressed as BMI or fat and fat free mass (cohen's $d = 0.05$), medium effect on flexibility and muscular strength (cohen's $d = 0.33$ resp. 0.46), a large effect on cardiovascular endurance and muscular endurance (cohen's $d = 0.99$ resp. 1.29). In this meta-analysis however different exercise modes (endurance, strength, flexibility training, muscular endurance, with a large variability concerning volume, frequency and intensity (heterogeneity was reported as significantly large) and adolescents as well as adults were combined. Effects on metabolic fitness was not reported.

Comparing the different modes the largest bulk of data are gathered after endurance training.

Endurance training or sub-maximal training is defined as any physical activity where the predominant means of ATP resynthesis is by aerobic metabolism provided by dynamic and continuous activities with large muscle groups. Common examples are swimming, running, cycling, hiking. Aerobic exercise training programmes are considered the best way to improve cardio-respiratory capacity and achieve maximal fatty oxidation (Leijssen,2002). To ensure aerobic activity, exercise sessions are performed at an intensity slightly below the anaerobic threshold (Wasserman,1972; Spurway,1992). In children, adolescents and adults with overweight or obesity without intellectual disability, it has been proven that this type of exercise has beneficial effects on body composition by means of decreasing fat mass, increasing aerobic capacity by means of an increasing peakVO₂ and by decreasing cardiovascular risk (more optimal lipid profile and reduced blood pressure) and insulin resistance (Pedersen,2002). Thereby, according to the American College of Sports Medicine and the American Heart Association, regular aerobic physical activities have been recommended as an effective strategy for general population to promote and maintain a good health status (ACSM,2002).

In people with intellectual disability literature has been focusing on people with Down Syndrome.

In this population Gonzales-Aguero (2010) reported in a narrative review different positive effects on health related components in children and adolescents with Down Syndrome.

Table 2. Studies concerning physical training including children and adolescents with intellectual disability (based on Gonzalez-Aguero et al. 2010 added with recent literature from 2010-2011).

Study	Participants	Control	Outcome measures	Training
<i>Aerobic training</i>				
Rosety-Rodriguez et al; (2011)	31M (16.3 ± 1.1)	7, no exercise	Allantoin (marker of oxidative stress)	12-week training programme, three sessions per week, consisting of warm-up (15 min) followed by a main part (20-35 min (increasing 5 min each 3 weeks)) at a work intensity of 60-75% of peak heart rate
Ordonez et al. (2006)	22M (16.2 ± 1)	No	Anthropometric measurements	12-weeks; intensity level based on HR; 30-60 min per session, three sessions per week
Varela et al. (2001)	16M (21.4 ± 3)	8, no exercise	Anthropometric measurements; treadmill or rowing ergometer peak-graded exercise test	16 weeks; rowing ergometer; intensities (55-70% peak VO ₂); 15 to 25 min per session; 3 sessions per week
Millar et al. (1993)	3F; 11M (17.7 ± 3)	4; no exercise	Walking treadmill test	10-week jogging training; 65-75% HRmax; 30 min per session; 3 sessions per week
<i>Strength training</i>				
Weber and French (1988)	3F; 11M (13-18)	No	Muscular strength	Two groups: group A performed a 6-week (3 times a week) weight training treatment at 80% 1RM; group B performed a 6-week (3 times a week) strength treatment 15 min per session
<i>Combined aerobic and strength exercise training</i>				
Lewis and Fragala-Pinkham (2005)	1F (case-study)	No	Anthropometric measurements, submaximal treadmill stress test, modification of Margaria-Kalamen test, 10RM to upper and lower limbs	6-weeks; Aerobic intensity 60-80% HRmax; 10-60 min per session; 2 to 3 sessions per week. Strength intensity increased by the number of repetitions and weight; 10-45 min per session, 2 to 3 sessions per week
Elmahgoub et al. (2009)	30 adolescents (14-22)	15; no supervised exercise	Anthropometric measurements; aerobic capacity by maximal ergocycle test; 6 minute walk test; 1RM of upper and lower limb; hand grip strength, muscle endurance; sit-to-stand; lipid profile	10-weeks circuittraining (mixed endurance and strength); 3 sessions per week; Aerobic intensity starting at 60% HRR increasing up to 75% of HRR; Strength intensity starting at 60% of 1RM increasing up to 80% of 1RM
Elmahgoub et al. (2011)	45 adolescents (14-22); 15 adolescents trained 3 times a week for 10 weeks; 15 adolescents trained 2 times a week for 15 weeks;	15; no supervised exercise	Anthropometric measurements; aerobic capacity by maximal ergocycle test; 6 minute walk test; 1RM of upper and lower limb; hand grip strength, muscle endurance; sit-to-stand; lipid profile	10-weeks circuittraining (mixed endurance and strength); 3 sessions per week; Aerobic intensity starting at 60% HRR increasing up to 75% of HRR; Strength intensity starting at 60% of 1RM increasing up to 80% of 1RM 15-weeks circuittraining (mixed endurance and strength); 2 sessions per week; Aerobic intensity starting at 60% HRR increasing up to 75% of HRR; Strength intensity starting at 60% of 1RM increasing up to 80% of 1RM

Concerning body composition data have been focusing on body mass index, fat and fat free mass. Varela (2001) and Millar (1993) reported no effects on body composition, while Ordonez (2006) reported a significant decrease in fat mass. They concluded however that the studies are nonconclusive due to the contradictory outcomes.

Concerning effects on aerobic fitness also here data are contradictory. Varela (2001) found a tendency towards positive results, Ordonez (2006) and Millar (1993) reported no significant cardiovascular effects. All of them discussed that the training period and/or intensity was perhaps too small (ranging from 10 to 16 weeks) and postulated that adaptations may require longer training periods and/or higher training intensities.

Concerning metabolic fitness, only one study described the effect of exercise training on oxidative stress (Rosety-Rodriguez, 2006). They found a significant positive effect and concluded that this was a clinically relevant effect, because reducing oxidative stress results in a decreased cardiovascular risk and risk for insulin resistance and diabetes.

Another important training mode discussed in literature concerning positive effects on health related benefits in people without intellectual disability is strength or resistance training. By definition, the term *strength training* (also known as *resistance training*) refers to a specialized method of physical conditioning that is used to increase one's ability to exert or resist force. The term strength training should be distinguished from the competitive sports of weightlifting, powerlifting, and bodybuilding. In this method the intensity of the exercises are above the anaerobic threshold and thereby the energy supply will be done by the phosphate system and the lactic anaerobic pathway (with production of lactate).

In children and adolescents with intellectual disability the amount of literature is very scarce. Only one study was found with exercised youth with Down Syndrome with a training program focused exclusively on strength. Weber and French (1998) studied a group of 14 adolescents with Down Syndrome and designed two strength training programs: a weight training treatment and a strength exercise treatment. The participants performed 10 tests to evaluate their muscular strength before and after the treatment program. The results of this study were very unclear and found that the group that performed the weight training program achieved significant improvement in muscular strength.

In the most recent guidelines of the American College of Sports Medicine (2009) it is stated that not only aerobic training is positive for health related benefits, but also strength components should be integrated in the program.

Until recently only one case study has investigated the effect of a combined cardiovascular and strength training. Lewis and Fragala-Pinkham (2005) trained a 10 year old child with Down Syndrome 30 to 60 minutes of moderate- to high-intensity exercise five to six days per week for six weeks with an exercise program combining aerobic and strength training. After the training period, the results showed improvements in aerobic and anaerobic capacity. Effects on body composition were not observed.

Recently two studies of our group (Elmahgoub, 2008; 2010) were added to the literature. In the first study children and adolescents with intellectual disability, but not Down Syndrome, were randomly included in an exercise training program (combination of endurance and strength) or in a control group (no supervised exercise training program). The participants trained three times a week for 10 weeks. Before and after the training program body composition, physical fitness (endurance and strength) and metabolic fitness (lipid profile)

were evaluated. After the training program there was a significant decrease of BMI and fat mass, a significant increase of relative peak VO₂ and mechanical efficiency (peak VO₂/Watt) and 1repetition maximum of upper and lower limb (maximal strength), and a significant improvement of the lipid profile (increase of High Density Lipoproteines and decrease of Low Density Lipoproteins/total cholesterol levels), indicating that this training mode has a positive effect on physical fitness and cardiovascular risk and risk for insulin resistance. The effects of this study was larger compared to what was reported in the literature before. In the discussion, the authors mention that this is possibly due to the fact that this training program was integrated in the school program and that this program was supervised by trained physiotherapists, resulting in highly motivated children and adolescents. However, the physiotherapists mentioned that the supervision of the training program was too intensive and in a second study Elmahgoub et al. (2011) evaluated if training twice a week for a period of 15 weeks could result in a comparable effect as three times a week for 10 weeks (same total volume). A total of 45 overweight and obese adolescents with intellectual disability aged 14-22 years with a total intelligence quotient 45-70 received combined exercise training 3 times a week (CET3) for 30 sessions (10 weeks; n = 15), twice a week (CET2) for 30 sessions (15 weeks; n = 15), or no training (10 weeks; n = 15). Groups were matched for age, sex, and education form. Before and after the intervention period, indices of body composition, physical fitness and lipid profile have been evaluated. Compared to the control group, CET3 resulted in a significant improvement of physical fitness, obesity indices, and lipid profile of the participants. Comparing CET2 with CET3, no significantly different evolutions were noticed, except for lower limb strength in favor of exercising 3 times a week. In conclusion, exercising 2 times a week, which is more feasible and practical for participants and guidance, has the same health beneficial effects as 3 times per week in overweight and obese adolescents with ID in short-term training.

Concerning interval or sprint training in adolescents with ID, no data are available.

This last item is interesting because the supervision of children and adolescents with intellectual disability is demanding a lot of energy for those who will supervise the program (physiotherapists or movement scientists). Especially for those with moderate to severe intellectual disability it is necessary to train one on one and therefore very intensive to guide. If it is possible to gain health related effects with a lower frequency, but the same total volume this can be realized in school programs.

6. Conclusions

Children and adolescents with intellectual disability are a unique population in relation to their health-related physical fitness variables. Body composition in this specific population is, in general, less healthy than that observed in their peers without intellectual disability, as proven by higher body mass index and fat mass and lower levels of lean mass. Additionally these children have lower physical activity, lower levels of aerobic capacity and muscle strength which results in a decreased physical fitness level. Both elements result in a worse lipid profile which is an increase in cardiovascular risk profile.

To counter these problems a healthy diet is necessary, but also increase in physical activity, for instance by supervised exercise training is essential. Based on the literature available also here a combination of endurance and strength training is the most optimal form to encounter the different risk profiles seen in this population.

7. References

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