Physical Activity And Play In Children Who Are Obese

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Introduction

Although rises in paediatric obesity are multi-factorial in origin, lifestyle changes in physical activity-related energy expenditure and increased consumption of energy-dense foods are considered to be of direct influence(1). Active play, movement and physical activity are essential for healthy growth and development in childhood. From infancy, physical challenges are required for the acquisition of basic motor skills. As motor skill improves through early childhood, play and physical activity are core drivers for the development of health-related fitness and both contribute to daily energy expenditure and assists with maintenance of a healthy body weight throughout growth. Finally, low levels of physical activity during childhood have been associated with morbidity and mortality in adulthood(2). The following chapter introduces the reader to a number of concepts including:

- The importance of physical activity for health-related fitness
- The relationship between physical activity and obesity
- Physical activity in weight management
- Measurement of physical activity
- Barriers to physical activity in children who are obese

Physical activity and health-related fitness in childhood

Health-related physical fitness (HRPF) includes: cardiovascular endurance; muscle strength and endurance; flexibility; coordination; body composition and metabolic components(3). The relationship between physical activity (PA) level and physical fitness in children does not appear to be as clear as that observed in adults(4). Some studies have indicated a weak relationship between physical activity and cardiorespiratory endurance in children, with activity accounting for only 21% of the variation in physical fitness(5). Other studies have observed stronger associations between PA and fitness in adolescents(6, 7). The type of PA is important for cardiorespiratory health whereby moderate and vigorous PA leads to greater gains (8-11). Research suggests that two or more weekly sessions of moderate PA or one weekly session of vigorous PA are needed to produce increases in cardiorespiratory fitness(12). Similarly, PA can positively influence cardiometabolic factors such as diastolic blood pressure, triglyceride, glucose and lipoprotein levels (13-15).

Studies have described a positive relationship between physical activity and muscular health in children, including muscle strength and muscle flexibility (7, 16-18).

Similarly both activity and lean body mass have been shown to be strong predictors of bone mass accrual in children(19). Some authors posit that the relatively lower bone mass associated with childhood obesity may represent a reduced physical activity level within this population(20). Indeed it has been observed that bone strength is decreased in sedentary children who are overweight(21) and reductions in bone strength have been observed to increase the risk of fractures in this group (22).

Standing balance is an important component of physical fitness and everyday function and children engaging in low levels of play and physical activity are reported to have reduced balance capacity

(23),which is an important risk factor for injury and fracture incidence (24, 25). Balance dysfunction and impaired motor skill may influence children's interest in physical activity if they associate exercise with negative experiences such as falling or injury. From the literature it appears that PA can positively influence motor development and motor skill when performed at least three times per week (18, 26, 27), Finally, there is evidence that PA has a positive impact on mental health in childhood (levels of depression, self-worth, anger expression and perceived physical appearance) (28, 29) particularly when performed at a vigorous intensity (30, 31).

Physical activity and adiposity in childhood

Physical activity (PA) contributes to daily energy expenditure and is important for the maintenance of a healthy body weight throughout growth. To date, studies investigating the association between PA and obesity vary according to the methods used to measure activity and obesity. For example, in a large population-based study Ekelund et al. reported that children who accumulated under one hour of moderate daily PA (measured by activity monitor), were significantly more overweight than those who accumulated more than two hours of PA daily(1). No association was observed between PA and body mass index (BMI) as a measure of body fatness. In a cross-sectional study an association between PA measured by questionnaire and BMI in 12-year old girls was observed ($p<0.01$)(32). In addition, these authors described a strong negative association between structured PA and waist circumference as a measure of abdominal fat (girls $p<0.0001$, boys $p<0.01$). In addition, an inverse relationship between percentage body fat and physical activity level has been reported by Ball *et al.* and Rush *et al*. (33, 34). Deforche *et al*. assessed the physical fitness and PA in 3,214 obese and non-obese schoolchildren who were lean or obese where obesity was based on BMI and the sum of skin-fold measurement and PA was assessed by questionnaire (35). No differences were seen between groups for leisure time PA but non-obese boys were participating in significantly more sports ($p<0.05$). A UK-based study used accelerometry and also reported that children who were obese were less active compared to lean peers(36).

Identifying the components of PA (light, moderate and vigorous exercise) and their individual effects is important for the establishment of a dose-response relationship (37). Children involved in relatively high levels of activity often have less adiposity than more sedentary youth (38-42). Further, research in this area has observed significant gender effects. Accelerometers have been used to define physical activity in terms of intensity and studies have observed that children who are obese spend less time than healthy-weight peers in vigorous and hard activity(43). Similarly studies report that boys spend greater time in vigorous activity compared to girls(44).

Work by Tudor-Locke *et al.* (2004) determined cut-off points for the number of steps per day related to healthy body composition in children six to 12 years of age measured by pedometry. Resulting data observed that girls who took <12,000 steps/day and boys who took <15, 000 steps/day were more likely to be overweight or obese. When the number of steps/day were translated into time spent in physical activity data revealed that those children partaking in <120 min/day (girls) and <150 min/day (boys) were more likely to be overweight.

It can be understood from the literature that PA during childhood is important to ensure healthy development and to assist with weight management. Increasing PA is a key element in the treatment and prevention of childhood obesity and it is imperative that the barriers that limit time spent in PA are addressed, if children are to be adequately motivated to move. Exercise programmes should be developed according to an individual's ability, as interventions that are not tailored to the fitness levels of obese participants may contribute to discouragement of future involvement in PA and lower self-efficacy.

Play and physical activity in childhood weight management

Independent of any effect on weight, the positive health effects of PA justify its inclusion in weight management programmes. Initial assessment will provide the clinician with information related to factors, which may influence the child's current or past level of PA. PA level is influenced by familial and social factors (45) time spent in sedentary pursuits, peer-group activity, individual motivation, age, gender and physical barriers to movement (46, 47). As such, it is advisable for the clinician to understand a child's barriers to partaking in PA so that appropriate suitable PA can be recommended. The child's gender and age are of vital importance as work by Martinez Vizcaino et al. (48) reported that aerobic and strength training undertaken three times per week for 90 minutes reduced body fat percentage in girls, but not in boys. Similarly, Riddoch et al. (49) observed that an extra daily15 minutes of MVPA at age 12 provided a 14% reduction in fat mass in boys, but only a 7% reduction in girls at age 14. The type of PA which has been shown to reduce adiposity in children includes: endurance activities (50), aerobic activities (51), sport-based games (52-54), sports training (55, 56), active play (57), plyometric exercises (58), resistance training (59, 60) and active gaming (61).

When working with children who are clinically obese, it is important that assessment facilitates the following:

a) Ascertaining what level of activity a child engages through standardised measurement
b) Exploring any barriers to participating in active play and
c) Developing an appropriate treatment plan for each child.

In order to assess a child and prescribe activity appropriately, the World Health Organization International Classification of Functioning, Disability and Health Framework (ICF) can be a useful aid (62). Using this framework, '*functioning*' encompasses the following: the body's structures and physical functions (e.g. the respiratory and musculoskeletal systems); the *activities* the child undertakes (e.g. jumping and running); and the *level of participation* the child experiences (e.g. joining in with physical education class). The term 'disability' refers to any *impairment* to the body's structures/functions (e.g. breathlessness or foot pain with exercise), to *activity restrictions* (e.g. being unable to run) or to *participation*

Table 1 Physical activity guidelines*

Age	Type	Frequency	Benefit
< 12 months	Supervised floor-based play in safe environments (e.g. tummy time, games with parents and siblings to encourage reaching, grasping, pulling and pushing.	**Daily** for 5-15 minute play sessions.	Supports brain development. Builds strong bones and muscles. Improves movement and co-ordination skills. Promotes social skills through interactions with people.
1-5 years	Supervised games with parents and other children which promote reaching, stretching, crawling, running, kicking, throwing and catching	Daily for **at least** three hours (short bouts of 10-20 minutes spread throughout the day)	Builds strong hearts, bones and muscles. Improves balance and co-ordination skills. Helps achieve and maintain a healthy weight. Encourage self-confidence and independence.
5-12 years	Moderate to vigorous intensity physical activity** including high impact activities to promote bone health (e.g. skipping, jumping, running & dancing). **(activities that cause the child to get warm, go red and start to sweat)	**At least 60 minutes per day.** On at least three days per week, children should engage in high impact activity.	Supports concentration and learning Builds strong bones and muscles. Improves movement and co-ordination skills Improves balance and co-ordination skills. Helps achieve and maintain a healthy weight. Encourage self-confidence and independence. Helps the child to make new friends and to develop social skills.
13-17 years	Moderate to vigorous intensity physical activity**	**At least 60 minutes per day.**	Supports concentration and learning

	**(activities that cause the child to get warm, go red and start to sweat) including high impact activities to promote bone health (e.g. skipping, jumping, running & dancing); active transportation, organised and non-organised sports, games, physical education and other activities at home, school, work and in the community.	On at least three days per week, children should engage in high impact activity.	Builds strong bones and muscles. Improves balance and co-ordination skills. Helps achieve and maintain a healthy weight. Encourage self-confidence and independence. Helps the child to make new friends and to develop social skills. improve cardiometabolic health, enhances mental health and wellbeing, Supports cardiorespiratory fitness

*adapted from Australia's Physical Activity and Sedentary Behaviour Guidelines(63)

limitations (e.g. sitting out of physical education class). When a child attends a clinical setting the assessment process will yield initial information regarding the activities (e.g. cycling, playing football, walking to school) the child engages in. In some cases, children will be reaching the recommended levels of daily physical activity (table 1) and will be participating fully in a fun active life. In other cases however, the assessment may reveal that the child is not engaged in enough active play and the aim of the assessment will be to identify the child's barriers to activity and participation (e.g. motor skill difficulties, financial difficulties, not having someone to play with).

Measurement of Physical activity

The measurement of physical activity level can be considered as a proxy indicator of functional health and will often be conducted in tandem with measurement of physical fitness (e.g cardiorespiratory exercise testing). For further information on cardiorespiratory exercise testing in children who are obese please see the relevant chapter. Measuring physical activity accurately in childhood is challenging however as levels of play vary on a day-to-day basis and children engage in intermittent spontaneous bursts of movement (64) which can be difficult to recall.

As children grow older their levels of activity generally decline, particularly in girls (34, 65). By assessing the level of active play, active commuting and engagement in physical activity the clinician can develop an age-appropriate treatment plan for each child being treated for obesity. Physical activity can be measured using subjective tools such as activity questionnaires and objectively by motion sensors such as pedometers and accelerometers. Regardless of the method chosen, it is essential that the outcome measure is age-appropriate and has established psychometric properties. Table 2 describes a number of

measures, which have published relating to reliability and validity in paediatric populations. The outcome measures included in the table are not exhaustive and further details can be accessed at the National Collaborative on Childhood Obesity Research website (http://nccor.org/nccor-tools/measures/index.php).

Table 2 Reliable and valid outcome measures for use in the assessment of childhood physical activity

Type	Name
Objective electronic measurement	ActiGraph 7164(66, 67) Actical(68) Actiheart(69) ActivPAL(70) Actiwatch AW16(71) New Lifestyles NL-1000 Accelerometer(72) SenseWear Armband (73) Yamax Digiwalker SW701 Pedomete(74)
Subjective computer-based measurement	Computer Delivered Physical Activity Questionnaire (CDPAQ) Computerized Physical Activity Recall
Subjective questionnaires for 2-5 year olds	Children's Leisure Activities Study Survey (75) Preschool-age Children's Physical Activity Questionnaire (Pre-PAQ)(76)
Subjective questionnaires for 6-17 year olds	Children's Leisure Activities Study Survey (75) Children's Physical Activity Questionnaire (cPAQ) for 9 and 10 Year Olds (77) Physical Activity Diary(78) Physical Activity Questionnaire (PAQ-C) for Older Children(79) Physical Activity Questionnaire for 9 to 14 Year Olds(41) Physical Activity Screening Measure for Adolescents in Primary Care Settings(80) Three Day Activity Recall for 7 to 15 Year Olds(81)

In addition the inclusion of activity-related questions in the clinic assessment form is vital. The following questions may be helpful to integrate with clinic forms:

- Does parent/s consider child to be physically active?
- Does child walk/cycle to school?
- Is walking/cycling to school possible?
- How many minutes of PE does child do in school?
- Does child partake in PE?
- How many minutes of play/activity does the child do each day? Do they sweat/turn red or get warm with this activity?
- Is the child involved in any after-school activities?
- Does the child have a safe place to play?
- Does child report any barriers to becoming more active (pain, breathlessness, falls, embarrassment)?

- Who could help the child to have more fun and be more active?

Barriers to Physical activity in children who are obese

In the clinical setting, referrals for obesity management are often made following a child's presentation to the healthcare service for investigation of breathlessness and difficulty with exercise. Persistent inverse relationships between cardiorespiratory fitness (relative VO2max) and obesity level have been reported in children indicating that fitness relative to body mass declines as obesity increases (82-85). In addition, absolute cardiorespiratory fitness is impaired in adolescents with severe obesity(86). As such, weight–bearing activities such as walking and running may be restricted for children who are obese and they may not be able to cover the same distance as similarly–aged children of healthy weight. In turn, children may not be able to participate equally alongside children of healthy weight in games and sports and games may require modification (e.g allowing regular breaks).

Referrals to healthcare services for weight management are often prompted by a child's report of pain and discomfort with exercise. A number of studies have investigated the presence of pain in children who are obese(87) and have reported that children with obesity are nearly two to four times more likely to report musculoskeletal pain compared to children of a healthy weight(88-91). In particular pain is most often reported in the lower limbs(92). Biomechanical changes in bony alignment can also be associated with pain and the various orthopaedic conditions, which can limit physical activity, are described in other chapters.

The development of fundamental motor skills is essential if children are to enjoy physically active games and become masters of movement. Development of obesity at a young age can have a deleterious effect on the attainment of basic movement skills. In a Swiss study BMI was negatively associated to running ability in pre-schoolers(93). Similarly, a German study reported that boys who were obese had lower skill attainment compared to boys who were overweight or of a healthy weight. In two large studies, preschool children (94) and adolescents(95) who were obese had lower gross motor scores compared to overweight and healthy weight children. In general weight-bearing motor skills (jumping, hopping, skipping and climbing) are more difficult for children who are obese compared to object-control skills (catching, throwing, kicking)(96)

Pain, bony alignment and impaired muscle strength and balance can all impact on the functional activity of gait. Dynamic stability is affected through impairments in ability to correct anteroposterior and medio-lateral balance(97, 98). Subsequently, children who are obese walk at a slower pace and spend more time in the stance phase of gait(99, 100). This slowing effect can limit the distance covered by children who are obese when compared to lean peers(101). In addition, impaired dynamic balance and strength can restrict the daily activity of moving from sit to stand(102).

Considering the structural and functional impairments described above it is understandable that children who are obese report lower health-related quality of life compared to lean peers(103, 104).

Physical activity interventions

Increasing active play, physical activity level and physical fitness are aims of most obesity intervention programmes.. Physical activity can benefit children who are obese by increasing their lean body mass, increasing energy expenditure, improving their appetite and energy intake control, and improving their metabolic and psychological profiles(105). Independent of any effect on weight, the above changes justify the promotion of physical activity in children. In order to support a child in increasing these indices, interventions should consider the physical impairment that most often present in this group. A goal setting approach is useful to encourage gradual increases in the child's activity level. Activities that are perceived as fun by the child should be targeted and efforts should be made to ensure that the child has someone to be play actively with. Recommending games with parents, siblings and friends will help a very inactive child to become more confident in active play.

Treatment aims should be to preserve fat-free mass and to improve fitness parameters. As such, facilitating basic motor skill and balance will be important to improve confidence in movement, reduce the risk of falls and to improve self-efficacy. Studies integrating motor skill components (e.g. hopping, skipping, jumping, single-leg stance and ball skills) can improve motor skill capacity (106, 107). Where standardized group treatment is offered, activity sessions should aim to establish movement and exercise as an enjoyable and rewarding experience. Games sessions should be fun, be tailored to the ability and preferences of the participants and should preserve lean mass, increase aerobic activity and improve motor skill in a safe and secure environment (without the child feeling 'slow' or 'self aware'). Fun group games should favour aerobic activities which promote fat oxidation but with the minimal perceived exertion. Research suggests that adolescents who are obese exhibited maximal fat oxidation rates at 41% VO2max, which corresponded to 58% HRmax (108) and that short bouts (30-60 s) at 100% VO2peak or 100% heart rate favours improvements also on aerobic power (109).

The physical activity guidelines for children (table 1) should be followed with regard to the type and amount of activity needed per week. Clinicians should keep in mind that children who are obese will likely need to perform shorter age-appropriate bouts of activity dependant on their baseline level of fitness. As weight begins to reduce it will be necessary for the child to maintain or even increase their level of activity due to concomitant reductions in bodily energy expenditure (for further information see chapter on energy expenditure). It is likely that children would need more than 60 mins of moderate-vigorous activity per day to prevent weight regain (110, 111).

When prescribing activity for children who are obese the following principles should be followed:

- Use FITT guidelines and advise on the Frequency, Intensity, Type and Time of activity that is needed
- Tailor the prescribed activity to the ability, age, gender and preferences of the child
- Take socioeconomic factors into account (e.g. safety of the childs environment, financial contraints)
- Use SMART goal setting to plan specific, measurable, achievable, realistic and timed activity goals

- Use 'gain-framed' messages to highlight the effect of increasing activity and fitness (e.g. being able to keep up with peers in school, being picked for teams)
- Use a problem-solving approach to overcome the child's barriers to engaging in activity
- Provide appropriate educational information to the parent/child on the importance of activity for childhood health and development
- Encourage parents and families to meet with other families for group activities outside of the treatment programme

For children with severe obesity, non-weight bearing activities may be an appropriate initial undertaking. Due to the reduced physical performance on tasks involving horizontal acceleration or vertical lifting of the whole body weight, weight bearing activities may be very difficult, may cause pain and may negatively affect reduce the child's motivation to continue. Recumbent cycling, stationary cycling, rowing ergometry and swimming are all suitable activities, though consideration should be given to the weight limits of any exercise equipment. In addition, children with severe obesity may not wish to use public swimming area secondary to embarrassment. As such, hospital hydrotherapy facilities or rental of swimming pools for bariatric patients may be indicated.

As a child progresses through treatment, attention should be given to activities that promote core stability and cardiorespiratory endurance. Similarly bone building activities such as jumping and skipping can be introduced and continued at least three times per week. Gradual increases in the time spent doing activity should be promoted and age-appropriate daily activity goal charts using stickers or rewards may be useful to support motivation. Similarly, pedometers, accelerometers or smartphone applications may be useful aids for encouraging self-monitoring of active play and physical activity. As the child becomes more accustomed to moving, it is useful to advise that the child try a variety of games, sports and activities. They should be encouraged to keep trying new games as it is usual to find new activities difficult when first undertaken. In addition, the whole family should be encourage to move more, to commute actively where possible and to spend family-time doing fun activities.

For children who are wheelchair users or have limited mobility following surgical procedure activity and games may need to be modified.

Overall the physical activity interventions should be designed to:

- Preserve lean body mass
- Be tailored on the basis of preferences of the child
- Be aerobic
- Be realistic in intensity and duration
- Be fun
- Develop a level of activity that can be maintained after the supervised component of treatment has ended

The individual components of sessions should include:

- Warm-up games

- Games directed at improving fundamental motor skill including locomoter skills (e.g. single-leg stand, hopping, jumping, sliding) and object-control skills (e.g. throwing and catching overhand and underhand, striking, dribbling and kicking)
- Games directed at building muscular strength and flexibility
- Games directed at improving core stability, static and dynamic balance
- Games directed at improving cardiorespiratory endurance
- Games directed at improving posture and gait
- Games and exercises aimed at preparing the child for participation in team sports, and organized games

In addition to the promotion of active play and physical activity, sedentary pursuits should also discouraged. Television viewing and screen time have been directly related to the degree of obesity in childhood(112). Similarly, treatment should address the nutritional health of the child (see relevant chapters) and should promote sleep. Short sleep duration has been shown to be associated with childhood obesity and cardiovasulcar health(113) and when a child increases their level of activity imporvements in sleep will often be observed.

Summary

It can be understood from the literature that physical activity during childhood is imperative in order to ensure normal health and development. Increasing play, activity and fitness are key elements in the treatment and prevention of childhood obesity. TO promote successful treatment of obesity and it is crucial that physical and psychosocial limitations to moving be addressed.

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