Daily Physical Activity for Children and Youth

A Review and Synthesis of the Literature

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Executive Summary

In August 2003, the Minster of Learning, the Honourable Dr. Lyle Oberg, announced plans to implement a Daily Physical Activity (DPA) Initiative in all schools in Alberta.[1] Starting in September 2005, school authorities began implementing plans to ensure that all students in grades 1–9 are physically active for a minimum of 30 minutes a day through activities that are organized by the school.

Significant evidence suggests that Canadian children are not active enough for optimal health and wellness. The expected outcome of the DPA Initiative is to increase the activity levels and healthy habits of students and, in part, address related issues such as chronic disease.

Alberta Education has committed to evaluating the impact of the DPA Initiative on students' physical activity levels and the development of healthy habits. As part of the first tier of the evaluation study, this literature review is designed to:

- identify data collection tools that are appropriate for use with children and youth in a school setting and are capable of reliably measuring the short-term, intermediate and long-term impacts of the DPA Initiative
- identify promising practices in school-based physical activity interventions with outcomes similar to those of the DPA Initiative that could be used in Alberta schools.

Levels of Physical Activity in Children

A number of studies suggest that physical activity patterns established during childhood and youth are important in laying the foundation for activity habits in the future.[2,3,4,5,6] At the same time, recent data suggest that physical inactivity is common amongst Canadian children and youth. The results of the 2000/01 Canadian Community Health Survey (CCHS) indicate that more than half of Canadian youth (56%) aged 12–19 are physically inactive.[7] The Canadian Fitness and Lifestyle Research Institute (CFLRI) estimates that approximately 82% of youth are not active enough to meet international guidelines for optimal growth and development.[8]

Benefits of Physical Activity for Children and Youth

Although gaps still exist in the literature, there is evidence that physical activity is an integral component of health and wellness in children. Potential benefits of physical activity include:

- chronic disease risk reduction
- obesity risk reduction
- enhanced cognitive function and academic performance
- enhanced body image and self-esteem.

Recommended Daily Levels of Physical Activity for Children and Youth

Physical activity guidelines specifically targeted for children and youth are a relatively recent development. Since the early 1990s, recommendations for daily levels of physical activity for children and youth have been developed by a number of different governments, agencies and organizations.[9,10,11,12,13,14,15,16,17,18,19] Some areas of consensus between the differing recommendations include the following:

- Children and youth should accumulate at least 60 minutes of physical activity on a daily basis.[9,10,11,12,13,14,15,16,17,18,19]
- Much of a child's activity will be achieved through short bouts rather than continuous activity.[13,14,18] For optimal benefits, at least 5% of the accumulated minutes should be in bouts of 15 minutes or more.[14]
- Children and youth should engage in a variety of different types and intensities of physical activity.[9,10,11,12,13,14,15,16,17,18,19]
- Children should be encouraged to participate in a wide range of activities, including lifestyle activities, sports, aerobic activities, muscular strength and endurance activities, and flexibility activities.[9,10,11,12,13,14,15,16,17,18,19]
- Children and youth should be actively encouraged to reduce the amount of time spent in sedentary activities.[10,12,13,14]
- Extended periods of time spent on sedentary pursuits are associated with decreased physical activity levels and an increased risk of overweight and obesity.[10,11,13,14,17]
- Children and youth should participate in activities that are age-appropriate.[9,14,18]

Measuring Physical Activity in Children and Youth

Valid and reliable assessment measures are critical for identifying relevant trends in the activity patterns of young people and for determining the impact of intervention programs and curriculum implementation. Measures of physical *fitness* have been used for many years with children; however, these measures may not accurately reflect levels of physical *activity*.

A number of different measurement techniques have been developed to specifically assess physical activity levels in children and youth. These measures can be organized into two categories, according to the type of information they provide: 1) subjective or self-report instruments and 2) objective instruments. No one measure is capable of capturing all of the aspects related to physical activity; each has some advantages and some disadvantages.

1. Subjective Instruments

Self-report instruments such as questionnaires, surveys and journals ask respondents (or in the case of younger children, an adult proxy) to describe or report their recent involvement in physical activity. Self-report instruments are a straightforward means for population health researchers to gather information on the physical activity levels of children and youth in school and, depending on the instrument, outside of school as well. These instruments are generally reliable and valid, are relatively simple and inexpensive to administer, and are appropriate for use in population studies; however, they are generally not reliable in children under the age of 10.

2. Objective Instruments

Objective instruments quantify levels of physical activity, producing data that are not influenced by recall ability, ethnicity, culture or socioeconomic status. Some objective instruments can also measure the duration, intensity and patterning of daily physical activity in children and youth. Common objective instruments include pedometers, accelerometers and heart rate monitors.

Accelerometers and pedometers are relatively simple to use and are reliable and valid measures of physical activity in children. Accelerometers can provide a rich, comprehensive profile of physical activity behaviour that describes the total amount and intensity of physical activity, when and how physical activity is accumulated, and when periods of inactivity occur.[20] Pedometers, which measure only ambulation (e.g., walking or running), provide a much more general assessment of physical activity levels; however, data collected from pedometers and acclerometers are correlated.[21] Because of the significant difference in cost between the two devices and the significant work required to analyze data from accelerometers, pedometers have been a more practical choice for use in large population studies.

Heart rate monitors can be used to estimate energy expenditure and assess patterns of physical activity. Relatively few studies have explored the reliability and validity of these devices in children and youth specifically and the findings of those that have are limited.[22,23] The data that do exist show significant variation in the reliability and validity of heart rate monitors to estimate energy expenditure and assess physical activity levels in children.[22,23] Recent work has partnered heart rate monitoring with the use of accelerometers, a strategy that seems to enhance estimates of physical activity levels.[24,25,26]

Promising Practices in School-based Physical Activity Interventions

A number of Canadian organizations have compiled informal lists of promising practices for promoting physical activity in schools. These practices are not necessarily supported by a significant body of empirical evidence; rather, they are practical suggestions that have been derived from anecdotal accounts. Some common themes that run through the promising practices identified by these different organizations include:

- the benefits of having physical education specialists lead physical education programming in schools[27]
- the valuable contribution physical education classes can make to the overall activity levels of children and youth and to decreasing the risk of both overweight and obesity[28]
- the value of simple yet novel approaches to increasing physical activity in schools[29]
- the importance of making physical activity fun for children and youth[29]
- the benefits linked to implementing Comprehensive School Health initiatives that include a strong physical activity component[30]
- the need to foster inter-sectoral partnerships to support active living in schools[27]
- the important role policy change can play with respect to creating school environments that support physical activity and discourage sedentary behaviours[27]

- the research-supported value of active commuting (e.g., cycling, walking, skateboarding to school each day)[31,32]
- the need to position physical activity and physical education as enjoyable, valued element of school life, while avoiding the negative effects of practices that involve using physical activity as a form of punishment, or withholding physical education classes to discipline children and youth in schools.[33]

Summary and Recommendations

Based on this comprehensive synthesis of relevant literature, the following recommendations have emerged.

1. Some type of self-reporting instrument should be used to assess physical activity as a component of the DPA data collection. These types of instruments represent a straightforward, cost effective means of gathering reliable and valid information on the physical activity levels of children and youth in school and, depending on the instrument, outside of school as well. Self-report instruments most appropriate for use include the Self-Administered Physical Activity Checklist (SAPAC) and the Physical Activity Questionnaire for Children (PAQ-C).

2. Pedometers should be used to objectively measure physical activity levels in children and youth involved in DPA. The relatively low cost and ease of use of these devices, coupled with their high reliability and validity in measuring physical activity in children, make pedometers well suited to the DPA's data collection.

3. Self-report and objective measures should be used in combination to optimize and enrich the quality of the data collected from participants in DPA.

4. Strategies should be developed to better evaluate and disseminate promising practices in school-based physical activity interventions developed both in Alberta and elsewhere.

Definitions

This literature review uses a number of terms related to physical activity and research design. The following definitions help to clarify the meaning of these terms.

Physical Activity: Movement of the body that expends energy, such as participation in physical education (including all dimensions of the program), community events and leisure activities.

Physical Education: The Alberta Kindergarten to Grade 12 physical education program is a core subject with the aim to enable individuals to develop the knowledge, skills and attitudes necessary to lead an active, healthy lifestyle. As such, physical education programs are an integral component of the total school experience for students.

Daily Physical Activity (DPA): In Alberta, daily physical activity involves all students in grades 1 to 9 being physically active for a minimum of 30 minutes daily through activities that are organized by the school.

Exercise: A subset of physical activity defined as "planned, structured, and repetitive bodily movement done to improve or maintain one or more components of physical fitness.[34]"

Physical Fitness: A set of attributes that people have or achieve that relates to the ability to perform physical activity.

> Health-related physical fitness components; e.g., aerobic fitness, muscular strength, body composition
>
> Performance-related physical fitness components; e.g., muscular power, speed, agility, balance, reaction time

Reliability: The consistency with which a test or an observer measures what is intended to be measured, and the extent to which the measurements are repeatable.[35]

Validity: The degree to which an instrument measures what is intended to be measured.[35]

Introduction

In 2003, the Minster of Learning, the Honourable Dr. Lyle Oberg, announced plans to implement a Daily Physical Activity (DPA) Initiative in all schools in Alberta .[1] The Initiative came in response to a growing awareness of the implications of physical inactivity on short- and long-term health and development in children and youth.

The initiative is limited to grades 1–9; however, Alberta Education (formerly Alberta Learning) has committed to exploring ways to increase the physical activity of students in grades 10 to 12 within the context of a larger K–12 Healthy Alberta Schools Initiative.

Alberta Education has established the following flexible policy statement to guide school boards and individual schools in implementing the DPA Initiative, while allowing for significant latitude in the approach used.[36]

Goal

- *The goal of Daily Physical Activity (DPA) is to increase students' physical activity levels. DPA is based on the belief that healthy students are better able to learn and that school communities provide supportive environments for students to develop positive habits needed for a healthy, active lifestyle.*

Policy Statement

- *Starting in September 2005, school authorities shall ensure that all students in grades 1 to 9 are physically active for a minimum of 30 minutes daily through activities that are organized by the school.*

Guiding Principles:

- *Schools have the responsibility of creating and nurturing a learning environment for students that supports the development of the life-long habit for daily physical activity and for healthy lifestyles.*
- *Daily physical activities should:*
  - *vary in form and intensity*
  - *take into account each student's ability*
  - *consider resources available within the school and the larger community*
  - *allow for student choice.*

Procedures:

- *School authorities have the flexibility to use instructional and/or non-instructional hours to implement Daily Physical Activity.*
  - *Physical education classes are an appropriate strategy to meet the daily physical activity requirement.*
  - *DPA should be offered in as large a block of time as possible but can be offered in time segments adding up to the minimum 30 minutes per day (e.g., two fifteen minute blocks of time for a total of 30 minutes).*

- – *DPA can be incorporated throughout the day and integrated into other subject areas.*
- *School authorities will monitor the implementation of the DPA to ensure that all students are active for a minimum of 30 minutes daily.*
- *Exemptions from DPA may be given by the principal under the following conditions:*
  - – *religious beliefs—upon written statement from the parent to the principal*
  - – *medical reasons—certification to principal by a medical practitioner indicating in which activities the student is not able to participate.*

Alberta Education has committed to supporting schools as they begin implementation of the DPA Initiative through resource development, professional development and an increase in base funding. In addition, the Ministry will assess students' physical activity levels through partnership with the Canadian Fitness and Lifestyle Research Institute (CFLRI). This literature review is a component of this assessment process and is designed to:

- identify data collection tools that are appropriate for use with children and youth in a school setting and are capable of reliably measuring the short-term, intermediate and long-term impacts of the DPA Initiative
- identify promising practices in school-based physical activity interventions with outcomes similar to those of DPA Initiative that could be used in Alberta schools.

Research Methodology

Alberta Education reviewed relevant scholarly literature to identify data collection tools or methods that could reliably measure the impacts of the DPA Initiative, were appropriate for use with children and youth in Kindergarten to Grade 12 (approximate ages of 5-18 years) and were able to measure physical activity. Peer-reviewed research literature was identified through the ERIC, Medline, PsycINFO, Physical Education Index and Sport discus databases. Key search words or phrases included "physical activity and children or youth," "assessment of physical activity and children," "measurement of physical activity and children," "accelerometer and children or youth," "pedometer and children or youth" and "physical activity surveys and children." The search period was limited to the years 1997–2005 in order to focus on the most current research findings; however, some key references from before 1997 were included in the review. Experts in the fields of nutrition and metabolism, physical activity or active living research and programming, and school-based physical education also identified a number of relevant references and sources of information.

The behavioural framework of Sallis, Owen and Fotheringham was used as a lens for locating and assessing literature during the review.[37] This framework recognizes that specific behaviours are associated with increased risk of disease or conversely with improved health and wellness. It describes a systematic, five-phase approach to examining studies on health behaviour that culminate in evidence-based, population health interventions. The five phases of the framework are:

1. Establish links between behaviours and health.
2. Develop measures of the behaviour(s).
3. Identify influences on the behaviour.
4. Evaluate interventions to change the behaviour.
5. Translate research into practice.[37]

This review will speak to all of the five phases, with the exception of the third phase. Exploring influences on behaviour, while interesting, is beyond the scope of this review.

Part 1: Physical Activity in Children

Regular physical activity is recognized as a key determinant of health and wellness. Strong evidence indicates that low levels of physical activity are linked with:

- morbidity and mortality in adults, particularly the risk of chronic diseases such as type II diabetes, heart disease, osteoporosis and certain types of cancer
- the risk of overweight and obesity in adults.

Surveillance and monitoring are fundamental to developing evidence-based programs and initiatives to combat obesity and reduce the risk for chronic disease. Recognizing this, the Chronic Disease Prevention Alliance of Canada (CDPAC) has recommended that Canada develop a comprehensive, coordinated surveillance system to monitor and communicate obesity and overweight rates and impacts dietary practices and physical activity and social trends and environmental factors.[38]

Information on physical activity levels during childhood and adolescence is scarce. The lack of longitudinal data, in particular, makes it difficult to draw conclusions about how physical activity levels early in life track into adulthood and influence chronic disease risk. These kinds of studies are challenging to design and expensive to undertake. Furthermore, much of the research has focused on increases in physical fitness rather than increases in physical activity. As a result, less is known about the impact of physical activity on the health of children, both short- and long-term, as compared to adults.

Despite the challenges and information gaps observed in the literature, there is evidence to support the belief that physical activity is an integral component of health and wellness in children and youth.

Establishing a Foundation for Life-long Activity

Evidence linking physical activity and chronic disease risk reduction has spurred interest in further research about how childhood physical activity patterns track into adulthood. Tracking refers to the continued importance of a specific behaviour within a specific group over time.[39] Although research data are limited, significant low to moderate correlations have been observed in a number of studies.[2,3,4,5,6,39] These findings suggest that physical activity patterns established during childhood and youth are important in laying the foundation for activity habits in the future.

Participation in Physical Activity by Children and Youth: Current Trends

Recent findings suggest that physical inactivity is common among Canadian children and youth. The results of the 2000/01 Canadian Community Health Survey (CCHS) indicate that more than half (56%) of Canadian youth aged 12-19 are physically inactive.[7] The Canadian Fitness and Lifestyle Research Institute (CFLRI) estimates that as much as 82% of this population may not have been active enough to meet international guidelines for optimal growth and development.[8]

This trend toward inactivity in children may be going unnoticed by parents and caregivers. A 2002 Environics survey conducted for the Canadian Paediatric Society found that a majority (60%) of Canadian adults with children between 6 and 14 years of age believe that their children are adequately physically active.[40] In addition, 66% of those with children in the home agree that their children have enough time and opportunity to be physically active while at school.[40] The media attention given to childhood obesity since these studies may have increased parents' awareness of the importance of physical activity; nonetheless, these findings bear consideration given that parental support and modelling are key factors in the physical activity of children and youth.[41,42]

Physical activity levels and preferred activities vary by age and gender. Key differences that bear consideration include the following.

- Girls are less active than boys at all ages;[8] 36% of girls compared to 52% of boys are considered active enough for optimal health benefits.[8] This gap is evident in younger school age children and persists (and widens) during adolescence.[8] For example, 44% of girls versus 53% of boys aged 5–12 years are considered active enough, while 30% of adolescent girls and 40% of adolescent boys report sufficient levels of physical activity.[8]
- Among younger school aged children (5–12 years), boys are more likely than girls to play golf, snowboard, skateboard and participate in team sports (e.g., soccer, football, hockey, basketball or baseball); girls are more likely than boys to participate in social dancing, skating, gymnastics, ballet or other dance classes, and play on playground equipment.[8] Similar preferences exist among teenagers, with girls participating more in social dancing, cross-country skiing, exercise classes or aerobics, and ballet or other dance classes, and boys participating more in activities such as bicycling, golf, snowboarding, skateboarding, weight training and team sports.[8]
- Bicycling is the most reported physical activity among younger school age children (5–12 years), followed by swimming, playing on playground equipment (e.g., swings, slides, teeter-totters), then walking.[8] Most of these activities are also popular with adolescents, although the proportion of teenagers participating in each activity is typically much lower.[8] Teens cite higher levels of participation in a number of activities that relatively few younger children partake in, including alpine skiing, weight training, volleyball, social dancing, badminton, golf, tennis, football, basketball, exercise classes and snowboarding.[8]

Benefits of Physical Activity for Children and Youth

Physical activity during childhood and adolescence is thought to positively affect a number of factors related to the risk for chronic disease later in life. While conclusive evidence is still lacking, potential benefits have been observed in some short-term cross-sectional studies and also in controlled interventions involving children engaged in specific physical training programs. There is also evidence, in some cases, to suggest that these benefits track into adulthood, thereby reducing chronic disease morbidity and mortality. Potential health benefits of physical activity include reduced risks of obesity, cardiovascular disease, diabetes and osteoporosis. Physical activity may also result in enhanced academic performance and psychosocial benefits.

Obesity Risk Reduction

Canada currently lacks a comprehensive surveillance system to monitor trends in overweight and obesity in both children and adults. Few Canadian studies have objectively assessed body weight, relying instead on self-reported data, which is subject to bias and reporting errors. A lack of consensus with respect to the definitions and measures used to assess and classify body weight, both in Canada and internationally, has also presented challenges.

Despite these confounding issues, recent reports suggest a growing trend towards overweight and obesity in Canadian children and youth, with the prevalence escalating dramatically over the past two decades. Nationally representative studies of Canadian children indicate that since 1981 BMI values have increased at a rate of nearly 0.1 kg/m^2 per year for both genders at most ages.[43] Tremblay and Willms found that the prevalence of overweight (defined as a BMI greater than the 85^{th} percentile for age and gender) among boys increased from 15% in 1981 to 35.4% in 1996 and among girls from 15% to 29.2%. The prevalence of obesity (defined as a BMI greater than the 95^{th} age and gender specific percentile) in children more than tripled during this same period, from 5% in 1981 to 16.6% for boys and 14.6% for girls in 1996.[43]

Childhood obesity cannot be reduced to a simple, easily solved problem; multiple behavioural, environmental, social and physiological factors influence energy balance. However, changes in dietary intake (energy intake) and physical activity levels (energy expenditure or output) are likely causally related to overweight and obesity in children. While more research is needed to fully assess the impact of these lifestyle measures on obesity risk in children, what is known about the relationship between physical activity and obesity is compelling.

Physical activity patterns of children and youth have been linked to the development of obesity, particularly in the Canadian context. Recent work by Janssen, Katzmarzyk and colleagues suggests that physical inactivity and sedentary behaviours, such as television viewing, are strongly related to obesity in Canadian adolescents.[44] Other data indicate that children who report relatively low levels of physical activity are significantly more likely to be overweight or obese than more active children of similar age and gender.[45,46] Obese children also appear to be more likely to engage in sedentary activities than otherwise similar healthy weight children.[44] Conversely, participation in both organized and unorganized sport, and maintaining relatively high levels of physical activity over time, appear to offer some protection from obesity.[47] Based on these findings, it would seem prudent to encourage children to be as physically active as reasonably possible.

Reducing overweight and obesity would likely also decrease the risk of a number of chronic diseases and medical conditions both directly or indirectly. Overweight and obesity in children and adolescents are correlated with the development of dyslipidemias, hypertension, impaired glucose tolerance, menstrual irregularities, asthma, orthopedic injuries and obstructive sleep apnea.[48,49,50,51] Obesity in childhood and adolescence is also an independent risk factor for adult obesity.[52] Recent research indicates that the probability of childhood obesity persisting into adulthood increases from approximately 20% at four years of age to approximately 80% by adolescence.[52] Furthermore, links have been made between adolescent obesity and an increased risk for health problems during adulthood. Adolescent overweight has been shown to increase overall morbidity as well as mortality from coronary heart disease.[53] Particularly concerning is evidence that overweight in adolescence is a more powerful predictor of lifetime health risk than overweight in adulthood.[53]

Mental health may also be impacted by weight problems. Obese children and adolescents report significantly lower health-related quality of life compared to healthy weight children.[54] In addition, overweight and obese children are significantly more likely than their healthy weight peers to report suffering from peer-directed social marginalization, verbal harassment and bullying.[55] Problems with depression and low self-esteem are associated with these kinds of weight disturbances, particularly if they persist into adolescence.[56]

Cardiovascular Disease Risk Reduction

Cardiovascular disease (CVD) is the leading cause of death for Canadians.[57] Typically, the clinical symptoms of heart disease do not appear until middle age; however, evidence of atherosclerotic disease and organ changes related to high blood pressure can be observed in childhood and adolescence and predict, in part, risk for CVD later in life.[58]

Physical activity may lower the risk of cardiovascular disease in several ways. Blood lipid profiles are related to the risk for cardiovascular disease (CVD) in adults. In particular, high levels of total cholesterol (TC) and LDL cholesterol (LDL-C) and low levels of HDL cholesterol (HDL-C) are understood to increase the risk for CVD. Physical activity imparts positive changes to blood lipid profiles in adults and is thought to have a similar effect in children and youth. For instance, cross-sectional studies have shown that increases in physical activity and energy expenditure are associated with higher levels of HDL-C (so-called “good” cholesterol) in children and adolescents of both sexes in a dose-related manner.[59,60,61] The impact of physical activity on total cholesterol (TC) or LDL-C (so-called “bad” cholesterol) levels is less clear. Some studies have shown reductions in TC and LDL-C levels, but this has not been universally observed.

Diabetes Risk Reduction

Type II diabetes is a complex metabolic disorder with genetic, social and behavioural risk factors. The prevalence of type II diabetes is increasing in the United States, particularly among Aboriginal youth.[62] No comparable Canadian data are available; however, given the similarities between Canadian and American populations, this increase is cause for concern.

Type II diabetes appears to be mediated by multiple physiological mechanisms that provoke insulin resistance syndrome; however, increased body fat is strongly associated with the risk factors that promote insulin resistance.[63] Strong correlations exist between overweight and obesity during childhood and the risk for type II diabetes.[64,65,66] Recent Canadian data from the Quebec Family Study support these correlations.[63] The same survey indicates that insulin resistance syndrome, a condition believed to be a precursor to Type II diabetes, in which the body does not use the insulin hormone it produces effectively, is highly prevalent in youth as young as nine years of age due, in part, to overweight and obesity.[63]

Physical activity impacts on the risk for type II diabetes by affecting insulin sensitivity and glucose tolerance. Impaired glucose tolerance and decreased insulin sensitivity are precursors to type II diabetes.[65] Recent studies have demonstrated a positive relationship between physical activity and improvements in glucose tolerance.[67,68] Physical activity is correlated with lower fasting insulin and greater insulin sensitivity in healthy children.[63] In addition, physical activity has shown promise in improving insulin sensitivity in children of type II diabetics.[63]

Osteoporosis Risk Reduction

One in four Canadian women and one in eight Canadian men will develop osteoporosis during their lifetime.[69] The risk of developing symptomatic osteoporosis later in life is influenced to a large extent by the level of peak bone mass that is attained in early adulthood. While genetics and diet are considered key determinants of bone mineral density (BMD), physical activity patterns throughout life also play a role.

Intervention studies demonstrate that weight-bearing activity can produce significant increases in BMD in children and youth.[70,71,72,73,74] Particularly interesting are the results of a recent Canadian study involving a school-based “jumping” program (e.g., tuck jumps, hopping, skipping) as part of regular physical education classes.[74] This relatively simple intervention yielded significant increases in BMD equalling nearly 4.5%.[74] Further research is needed to clarify if regular physical activity early in life confers benefits in terms of osteoporosis risk reduction, as longitudinal studies focusing on this issue are non-existent (notwithstanding a handful of retrospective studies of elite dancers, gymnasts and soccer players).

Enhanced Academic Performance

Physical activity appears to have benefits that go beyond health and well-being. Although well-designed, randomized, controlled trials are lacking, a number of studies document relationships between physical activity and enhanced academic performance.[75,76,77,78,79] For example, a 2001 study of almost 8,000 children between the ages of 7 and 15 years observed significant positive correlations between self-reported physical activity and results of standardized fitness tests with academic performance.[76] Similarly, results from the California Physical Fitness Test (2004) reveal strong positive relationships between physical fitness and academic achievement.[79]

Psycho-social Benefits

The relationship between physical activity and psycho-social outcomes in children is, to some degree, ambiguous and the data should be interpreted with caution. The available data come largely from short-term studies involving small samples. Longitudinal data – the type needed to comprehensively assess the impact of physical activity on variables such as self-esteem and body image – are virtually non-existent. Notwithstanding this limitation, the available research supports a role for sport and physical activity in enhancing self-esteem, feelings of competence and reduced initiation of high-risk health behaviours in children and youth.[80,81,82,83,84] A recent meta-analysis by Ekeland and colleagues suggests that exercise has positive short-term effects on self-esteem in children and young people.[80] Other research demonstrates that active adolescents are significantly less likely to initiate risky behaviours such as smoking and drug use, and significantly more likely to express confidence in their future health.[84]

The lowered risks associated with participation, coupled with the potential psycho-social and physical benefits, suggest that interventions to increase the activity levels of children and youth are warranted.

Recommended Daily Levels of Physical Activity for Children and Youth

Physical activity guidelines specifically targeted for children and youth are a relatively recent development. Before the early 1990s, physical activity levels in children were often assessed against adult guidelines without consideration of the inherent differences in activity patterns between children and adults. Observational studies of children suggest a typical pattern is very short bursts of intense physical activity interspersed with varying intervals of low and moderate intensity physical activity. Most adult-centred physical activity guidelines (past and present) do not reflect this reality and, as a result, are not valid comparative standards for children and youth.

Determining the level of physical activity needed to optimize growth and development in children and youth has been the subject of considerable discussion over the past 5 to 10 years. The growing awareness that children are likely not active enough to support health and wellness has driven the development of physical activity guidelines by governments and non-governmental organizations around the world.[9,10,11,12,13,14,15,16,17,18,19] These guidelines are summarized in Appendix 1.

Some areas of consensus can be found amongst the differing recommendations. These areas include general agreement on the following:

- Children and youth should accumulate at least 60 minutes of physical activity on a daily basis.[9,10,11,12,13,14,15,16,17,18,19]
- Much of a child's activity will be accumulated through short bouts rather than continuous activity.[13,14,18] To accrue optimal benefits, as much as 50% of the accumulated minutes should be in bouts of 15 minutes or more.[14]
- Children and youth should engage in a variety of different types and intensities of physical activity.[9,10,11,12,13,14,15,16,17,18]
- Children should be encouraged to participate in a wide range of activities, including lifestyle activities (e.g., walking to school, yard work), sports, aerobic activities (e.g., cycling, running, jumping), muscular strength and endurance activities (e.g., climbing, jumping, lifting) and flexibility activities (e.g., stretching, dance, reaching).[9,10,11,12,13,14,15,16,17,18]

- Children and youth should be actively encouraged to reduce the amount of time spent engaged in sedentary activities.[10,12,13,14]
- Extended periods (e.g., two hours or more per day) of time spent on sedentary pursuits (e.g., television viewing, computer use) are associated with decreased physical activity levels and an increased risk of overweight and obesity.[10,11,12,13,14,17]
- Children and youth should participate in activities that are age-appropriate (e.g., playground games, cycling, dance, martial arts, swimming, cross-country skiing, walking to school, some chores and yard work).[9,14,18]

While it is useful to note these areas of general agreement, it is essential to recognize that current guidelines for physical activity in children and youth lack a strong empirical or experimental base. Additional study is needed to establish activity guidelines that are truly evidence-based.

Guidelines for optimum physical activity levels in children and youth must recognize that children are not "little adults." Natural patterns of activity in children vary considerably from those observed in adults. Moreover, physical activity offers children benefits that, in some cases, differ from those that accrue for adults, such as development of basic motor skills. The past decade has seen the rise of physical activity recommendations that recognize age-related differences in physical activity requirements. As a result, it is now possible to compare children to standards that better reflect their unique needs.

Part 2: Measuring Physical Activity in School Age Children

Growing recognition of the benefits of physical activity for children and youth has fostered a need for valid and reliable assessment measures. Such measures are critical for identifying relevant trends in the activity patterns of young people and for determining the impact of intervention programs.

Measures of physical *fitness* have been used for many years with children. These measures focus on assessing very specific training outcomes such as improvements in endurance, strength, agility and flexibility. Because of this, the outcomes of fitness testing cannot be considered proxy measures for physical *activity*.

A number of different measurement techniques have been developed to specifically assess physical activity levels in children and youth, each offering some advantages and some limitations. These measures can be grouped into two categories according to the type of information they provide: 1) subjective or self-report measures and 2) objective measures. Subjective measures include:

- questionnaires or surveys (print or electronic, self-completed or interviewer administered)
- diaries or journals (print or electronic)
- checklists.

Objective measures include:

- accelerometers
- direct observation
- doubly labelled water
- heart rate monitors
- indirect calorimetry
- pedometers.

Both subjective and objective measures can offer useful information; however, the reliability and validity of the information gleaned from the different measures depends on some factors that can be controlled (e.g., proper positioning of pedometers) and some that cannot (e.g., the age of the children being studied).

The preferred type of measure to assess physical activity varies depending on the goals, objectives, budget and design of the study. For example, direct observation of children engaged in physical activity by trained researchers offers valid and reliable data; however, direct observation is a very labour intensive measure that is extremely expensive to implement. Because of this, direct observation is best suited to studies involving relatively small numbers of subjects who are active in settings that allow for monitoring of the participants.

Subjective Instruments

Subjective or self-report instruments ask the respondent (or in the case of younger children, an adult proxy) to describe or report their recent involvement in physical activity. Respondents are typically asked to record or track time spent on varying types of physical activity on a day-to-day basis or to recall their participation over the course of days, weeks or even months. Diaries, journals, questionnaires and surveys are all commonly used self-report instruments to assess physical activity. Self-report instruments have a number of advantages but also some disadvantages in terms of assessing physical activity in children and youth.

Advantages of Self-report Instruments

Self-report instruments have a number of appealing characteristics. These instruments:

- are non-invasive and relatively inexpensive
- are generally reliable and valid, especially when used with older children and teens
- can be administered in a variety of ways, from print questionnaires to Internet surveys or diaries
- can be delivered with varying levels of support from self-completion to parent or caregiver completion to administration by a trained interviewer, making it possible to obtain information on children of varying ages and cognitive abilities
- in the case of questionnaires and surveys, can be edited to target specific populations of children, or to better address specific research questions.

Disadvantages of Self-report Instruments

The main disadvantage of self-report instruments is the potential for less reliable or valid data than objective instruments would gather. Because they are subjective, self-report instruments may be influenced by factors such as recall ability, ethnicity, culture or socioeconomic status. Evidence supporting the reliability and validity of common self-report instruments used to assess physical activity levels in children is inconsistent. Sample populations differ significantly by age, gender and social economic status between the available studies, which makes comparisons challenging. As well, literature suggests that self-reports tend to overestimate physical activity, resulting in lower validity. For example, physical activity questionnaires "may tend to overestimate time or intensity," however, the magnitude of the overestimate is not typically published. Self-reported physical activity data tend to overestimate leisure-time energy expenditure, through the possible inclusion of non-active time (such as waiting for lifts when alpine skiing).[85]

The purpose and design of the instruments themselves also vary considerably. For example, the Previous Day Physical Activity Recall (PDPAR) assesses previous-day participation in physical activity performed outside of school hours only, while the Self-Administered Physical Activity Checklist (SAPAC) measures previous day activity before, during and after school.[86] In addition, both of these tools assess time spent on sedentary activities, while other self-report instruments do not.

Several factors may influence reliability and validity, including the following.

- The time period children are expected to recall. Measuring physical activity patterns over time (e.g., one week to one month or more) in children is desirable, as this approach captures habitual behaviours and identifies trends; however, the accuracy of children's recall may be questionable, particularly if they are required to recall activity occurring over several days, weeks or months.[87]
- The age of the respondents. As might be expected, recall and questionnaire completion ability correlate with age, with higher correlations for older children and adolescents.[87]
- The characteristics of the instrument itself.[87] Instruments targeted at children living in urban locations may not reflect the experiences of children who reside in rural communities. Similarly, gender differences in activity preferences and access must be factored into the design of an instrument if it is to yield reliable and valid data.
- The instrument's ability to measure the sporadic nature of physical activity in young people. High intra-day and inter-day variations in physical activity pattern are the norm for children, which make it very difficult to draw meaningful conclusions from data collected over the short term.[22] In addition, instruments that focus largely on structured leisure time activities may not capture the play-based, random movement that is characteristic of physical activity in children.[87]

The published reliability and validity data for a number of commonly used instruments (Appendix 2) offer some insights into how each performs. All of the instruments identified during this review offer moderate or moderate to high levels of reliability in children and youth ages 10 to 18 years. With the exception of the SAPAC (moderately reliable) and the PAQ-C (highly reliable), which have been tested on 9- to 10-year-old children, reliability of these instruments for younger children has not been well demonstrated. Evidence demonstrating the reliability of any of the self-report instruments described in Appendix 2 with children younger than nine is lacking.

Validity for all of the instruments ranges from low to moderate, depending on the validation standard and the sample population. The PDPAR is unique in demonstrating validity in children younger than nine years of age. Evidence supporting the validity of the other instruments in younger school age children is lacking.

Selection Considerations for Self-report Instruments

Given their advantages, it is generally prudent to include some type of self-report instrument as a component of population studies to assess physical activity; however, the decision to use a self-report instrument and the choice of a specific type of questionnaire or survey should be based on well-defined research objectives. Researchers must consider the unique characteristics of their study sample (e.g., total numbers, age, gender, ethnicity, literacy levels) and the depth of information they hope to glean when selecting a particular instrument. For example, an instrument appropriate for use in a study focused on deriving a reliable estimate of energy expenditure by children might not be appropriate for use in a study aimed at obtaining general information about activity behaviours such as frequency, duration and type.

If children in Kindergarten to Grade 4 are to be included in the data collection process, careful consideration should be given to the choice of self-report instrument. Studies using self-report instruments with children younger than 10 years of age have revealed insignificant validation coefficients, indicating that the instruments are not measuring what they are intended to measure in this population of children.[15,88,89] These results have led to recommendations that caution against the use of self-report measures in children younger than ten.[15,88,89]

Although not an ideal solution, a previous day recall measure could be considered if a self-report instrument were to be used with children in Division I or early Division II. While validity is lacking, these kinds of instruments, by their design, enhance recall in younger children by limiting the time frame to the preceding day.[86,90] The SAPAC, in particular, should be explored in that it assesses activity levels before, during and after school hours, unlike other previous day recall instruments like the PDPAR.

It is unlikely that a previous day recall questionnaire could capture all of the information needed for a sound evaluation of the DPA Initiative. Even in older children and youth, where there is moderate to high reliability and validity for these instruments, they are limited by their inability to assess habitual activity patterns. This limitation could be overcome by administering the PAQ-C in conjunction with the SAPAC.

The PAQ-C has demonstrated high reliability and moderate validity in children 9 to 18 years of age. It is capable of assessing the frequency of activity that occurs at school or outside of school, and reflects activities and settings that are typical for Canadian children. It does not, however, explore the time spent on sedentary activities. This situation could, in part, be resolved by co-administration of the SAPAC.

The reliability and validity of the PAQ-C with children under the age of nine has not been established. Although not an ideal remedy to this problem, parents or caregivers could act as proxies for their younger children in completing the questionnaire. Alternatively, the combined SAPAC/PAQ-C could be used solely with older children and youth, while the SAPAC on its own could be administered to children less than 10 years of age (approximately Kindergarten to Grade 4).

Providing “live” support during the implementation of the combined questionnaires should be considered. Administering the questionnaire to small groups of children (each providing a personal response) would allow larger numbers of students to be surveyed in a discreet amount of time. Project staff could assist with the organization of this process and offer appropriate guidance to the students, particularly those in Division I, as they work through the questionnaire(s). This, in turn, might help to spare staff resources within the schools and enhance the quality of the responses provided by the children.

Objective Instruments

Objective measures of physical activity quantify the level, and with some devices, the duration, intensity and patterning of daily physical activity in children and youth in ways that are not influenced by recall ability, ethnicity, culture or socioeconomic status. As a result, objective measures can provide important insights into the true activity levels of young people.

Advantages of Objective Instruments

Objective instruments offer some advantages over self-report instruments in assessing physical activity levels and patterns in children and youth. These instruments rely upon an objective, impersonal measurement. They are not subject to human influence and, as a result, the data they collect are generally more reliable than those gleaned through subjective methods. In addition, some objective instruments (e.g., accelerometers) provide quantitative data, which, like self-report instruments, allow descriptive assessment of activity patterns to be formulated.

Disadvantages of Objective Instruments

Objective instruments are also subject to several limitations. Most notably, they have a high cost compared with self-reports, which means they are generally not well suited to large population studies that would require the purchase of hundreds of devices. In addition, devices such as heart rate monitors, accelerometers and pedometers must be worn consistently and in a prescribed method to gather reliable data. Some study participants may view adhering to these requirements as inconvenient.

Types of Objective Instruments for Assessing Physical Activity in Children and Youth

A number of different instruments exist to objectively measure physical activity but not all are appropriate for use in large, population-based studies. For example, while highly accurate energy expenditure data can be gleaned from doubly labelled water studies, indirect calorimetry or direct observation, the cost and inconvenience associated with using these instruments render them impractical for use in surveillance research like the DPA data collection. Other measures, such as pedometers, accelerometers and heart rate monitors, while not as accurate, cost less to implement and may be better suited for use with large groups of children and youth. Recognizing the need to make what Welk has termed an "accuracy-practicality trade-off," this section of the literature review will focus only on those objective measures that could realistically be used in the data collection for the DPA initiative: accelerometers, pedometers and heart rate monitors.[22] Appendix 3 summarizes recent work to assess the reliability and validity of these three devices (either alone or paired) for children.

Accelerometers

Accelerometers are a type of motion sensor. They are small in size and typically worn at the hip, wrist or ankle. These instruments generate accelerations, which are measured and recorded by a sensor embedded within the device, in response to either vertical movement (uniaxial) or movement in several planes (triaxial). Acceleration is defined as the change in velocity over time.[91] Because accelerometers link movement to time, these devices can be used to assess physical activity patterns.

Accelerometers can provide a rich, comprehensive profile of physical activity behaviour that describes the total amount and intensity of physical activity, when and how physical activity is accumulated, and when periods of inactivity occur.[92] They can be worn during most types of physical and daily activity, including activities such as swimming, diving or bathing for some newer waterproof models (e.g., Actical, Mini Mitter Inc., Bend, OR). When in place, they continuously monitor and record frequency, time and intensity of physical activity by the wearer. They can also record the proportion of time spent at a given level (intensity) of activity. Energy expenditure can be extrapolated from the time, intensity and frequency data that accelerometers capture. Accelerometers, particularly the triaxial type, are reasonably reliable and valid measures of physical activity in children. The degree to which this is true depends on the comparative criterion; however, both uniaxal and triaxial motion sensors appear to give consistent, objective measures of differing types of activity common to children and youth.

Despite their potential benefits, accelerometers are not without limitations. The reliability of data collected with accelerometers is impacted by their positioning on the body. Young children, in particular, may have difficulty positioning accelerometers properly on their own.[91] In addition, the potential exists for research subjects to physically tamper with the controls on some models of these devices (some models counter this issue by not having accessible controls or read out panels).[91] Because both positioning and tampering can significantly influence the reliability and validity of accelerometers, care must be taken to control for these factors. Cost may also limit the use of accelerometers to assess physical activity, depending on research design—compared to some other objective instruments, accelerometers are relatively expensive (retail cost = approximately $500 - $1000 CAD/unit), which can make their use in population studies impractical. Finally, they are not descriptive and cannot offer information about the type of activity performed.

Pedometers

Pedometers or step counters are another type of motion sensor, though much simpler than accelerometers in design and function. These lightweight devices are typically worn at the hip and provide a measure of activity by “counting” the number of times a spring suspended lever arm moves up and down in response to ambulation (e.g., walking, running).[93] This information is recorded and displayed as steps are taken.

Pedometers have several advantages. Firstly, they appear to be reliable and valid objective measures of activity in young people. While few studies have explored the reliability of using pedometers with children, those that have show high intraclass correlations over the time the pedometer is worn, suggesting reactivity by the children to the device is low.[94] Comparisons between pedometers and triaxial accelerometers show moderate to high correlations between the two measures for structured and "free-play" activities, suggesting they are comparable with respect to assessing classroom and recreational activities.[94,95]

Furthermore, while a recognized goal for children has yet to be agreed upon, criterion referenced standards for physical activity (measured as steps/day) related to body composition have been suggested.[96] These criteria for the minimum number of steps/day that children should take (12,000 steps/day for girls age 6 to 12 years and 15,000 steps/day for boys of the same age) provide a basis for goal setting that researchers and health promotion specialists can use to assess physical activity levels in young people.[96] Retail costs for pedometers are significantly lower than that of accelerometers (approximately $30 CAD/unit). Some pedometers offer additional features beyond simple step counting. By entering data on stride length, weight, height and age, these specialized pedometers use mathematical extrapolations to estimate energy expenditure and/or distance travelled.

Pedometers also have several limitations. As a general rule, they do not assess intensity, frequency, type or duration of activity. At least one recent model attempts to address this. The less expensive models that are more popular in research because of their cost do not store data over extended periods of time. To counter this problem, research subjects are generally required to log or diary the number of steps recorded each day, a task they generally do not find burdensome.

Pedometers are also limited in their ability to measure certain types of activity. They do not reliably detect motion that is limited to the upper body or seated activities, or lower body activities such as cycling or rowing. Pedometers cannot be worn in water and, this fact combined with their measurement solely of ambulation results in a lack of capacity to assess activities such as swimming, diving or water play. They may not be able to reliably detect steps during slow walking (< 60 m/min) or in individuals with gait abnormalities (as sometimes observed in frail, older adults).[91,97] Extra body fat, particularly in the abdominal region, may also impact a pedometer's ability to detect steps in that it can interfere with correct placement of a pedometer on the hip.[98]

A final drawback of pedometer use is the issue of potential tampering. Pedometer readings can be increased, depending on the device, by simply holding it in the hand and shaking. In addition, the wearer can also delete the step count displayed on the device's read-out screen by pushing an easily identified button. This feature of pedometers, which is not seen in other devices such as the accelerometer, could affect the reliability of data; however, children generally do not react to or interfere with devices after the first day of use.

Heart Rate Monitors

Heart rate monitors are relatively simple devices that can be used to indirectly estimate:

- frequency of physical activity
- intensity of physical activity
- duration of physical activity
- energy expenditure from physical activity.

Positioned over the chest and underneath clothing, these belt-like devices measure variations in heart rate. Since heart rate increases with increases in activity, heart rate data have the potential to be extrapolated to provide an estimate of energy expenditure and to assess physical activity patterns over time.[20] Linear regression equations are used to extrapolate heart rate data to measures of oxygen consumption and, ultimately, energy expenditure.[22] Assessment of physical activity patterns is derived by documenting changes in absolute heart rate measures over time.[20,22]

The reliability and validity of heart rate monitoring as an objective measure of both energy expenditure and activity levels of children and youth is uncertain. Relevant data are sparse despite the fact that they have frequently been used as an assessment tool. Relatively few studies have explored the reliability and validity of these devices in children and youth specifically and the findings of those that have are limited by relatively small sample sizes.[25,26,99,100] The data that do exist show significant variation in the reliability and validity of heart rate monitors to estimate energy expenditure and assess physical activity levels in children (Appendix 3).

Heart rate monitors provide a valid measure of heart rate in children;[22] however, they may not be able to accurately estimate energy expenditure and physical activity levels because heart rate is influenced by a wide range of factors that are unrelated to physical activity.[22] Heart rate is dynamic and known to be influenced by a number of different factors. Body temperature, food intake, body posture, medications, individual cardio-respiratory fitness level, genetics and physical activity can all influence heart rate and, as a result, can confound estimates of physical activity and energy expenditure derived through heart rate monitoring.[20,22] In addition, the ability of heart rate monitors to accurately estimate energy expenditure and assess physical activity patterns during low intensity and extremely high intensity activity has been questioned.[20,22] Under these conditions the linear relationship between heart rate and energy expenditure (measured by oxygen consumption) weakens and so too does the ability of heart rate to accurately estimate and describe physical activity patterns.[20,22]

The flex-HR method was developed in the 1980s to address the problem of intra-individual (within person) variations in heart rate and to the known limitations of heart rate monitoring as a means to identify bouts of very low level or very high-level activity.[101] This method establishes an individual heart rate standard (or flex HR) for each subject being studied by comparing heart rate at rest and at work with measures of oxygen consumption (VO_2).[101] While time-consuming and potentially costly to establish, creation of individual flex HRs for each research subject addresses the limitations of heart rate monitoring and, as a result, enhances the validity and reliability of data related to energy expenditure estimates and assessments of physical activity patterns derived from these devices.[101]

Selection Considerations for Objective Instruments

The use of either accelerometers or pedometers can strengthen population health studies by providing an objective measure of activity in the children involved in the initiative. In addition, they can validate and compliment data collected through self-report measures. Accelerometers provide a richness of data that pedometers do not, but significant work is required for data analysis. While both are reliable and valid measures in children, the significant differences in cost make pedometers a much more appealing choice for population studies.

Ideally pedometers are worn at all times for a full seven-day period (including week and weekend days), except during sleep, swimming, bathing or activities where the device might pose a safety risk (e.g., gymnastics). Training and instruction in pedometer use is needed if these tools are to be used successfully. Instruction on positioning of pedometers, as well as their day-to-day use (e.g., where and when to use their pedometer, estimating steps or recording activity for periods when a pedometer could not be worn) is essential. In addition, research subjects need to be provided with a simple tracking diary or log book in which to record the number of steps taken each day. Careful consideration should be given as to how and where this tracking would occur—completing the tracking diaries during class time would likely garner better results than asking the children to record their steps at home, where support for the process cannot be assured.

Heart rate monitors are non-invasive, easy to operate and relatively inexpensive, making them attractive to use in population studies; however, their validity and reliability as a means to accurately assess physical activity patterns in children has not been well established.[25,26,94,95] The relative lack of data and the variation observed in the studies that do exist raise concerns about using heart rate monitors to measure physical activity. If heart rate monitoring were to be used to measure physical activity patterns, calculating flex HR for all subjects would help to limit the impact of these confounding factors. Also promising is recent work that partnered heart rate monitoring with the use of accelerometers, a strategy that seems to enhance estimates of physical activity levels.[25,26,94,95]

Part 3: Promising Practices in School-based Physical Activity Interventions

Rationale for School-based Interventions

The physical environment in which an individual lives is increasingly being recognized as a mediator of physical activity levels in both children and adults.[102,103,104,105,106] Schools are a key environment in which to target children and youth with health promotion interventions for several reasons:

- Children spend significant amounts of time in the school environment.[107]
- Schools serve the majority of children and youth, making them an appealing venue for population health initiatives.[107]
- Teachers, coaches and other school staff have the potential to exert considerable influence on physical activity in children.[102,107]
- Schools offer access to facilities and equipment that support many forms of physical activity.[107]

These factors have led to the implementation of school-based physical activity interventions in Canada and internationally. In some cases, these interventions have been large, highly structured, randomized controlled trials. Others have been implemented on a much smaller, less formal scale.

Results of School-based Interventions

The results of school-based interventions have been mixed. Some have shown short-term increases in physical activity levels of children;[108,109] however, very few have demonstrated a sustained effect post-intervention. These findings do not suggest that school-based physical activity programs are not effective, but rather that issues with research design, measurement and evaluation have made it challenging to draw conclusions from the small amount of data that exists.

Although the data are limited, several researchers have conducted meta-analyses of relevant studies, including:

- Stone and colleagues' (1998) review of 12 Kindergarten to Grade 12 school-based interventions, including many that combined multiple components[110] (summarized in Appendix 4)
- Lister-Sharp and colleagues' (1999) analysis of health promotion in schools, including eight reviews related to the impact of interventions in school environments[111] (Outcomes in these studies focused on measures of fitness, not physical activity.)
- Kahn et al's review of 13 recent studies examining the impact of school-based physical education on both physical activity and physical fitness levels in children[107]
- Matson-Koffman and colleagues' (2005) review of literature from 1970 to 2003 related to the impact of policy and environmental interventions on physical activity levels and nutritional status in children and youth.[27]

Key findings from these reviews include the following.

- Most interventions resulted in some improvements in knowledge and attitudes related to physical activity.[110]
- The impact of interventions on physical activity levels varies. Many of the studies, particularly those focused on elementary school age children, reported mild success in increasing activity levels through modified physical education classes. Some, but not all, of the studies also showed increases in out-of-school physical activity.[107.]
- School-based fitness—versus physical activity—programs increase students' levels of fitness.[109]
- School-based physical education appears to be effective in increasing levels of physical activity and improving physical fitness.[27]
- School-based interventions that target physical education classes can positively impact physical activity levels in children.[27]

- Interventions that involve trained PE teachers and those that increase the length of time students are able to be physically active provide the strongest evidence of influencing these behaviours.[27]
- Parent involvement is a marker of success for interventions targeting healthy eating and physical activity. In Lister-Sharp et al's review, all of the studies of interventions involving parents showed a positive impact on at least one outcome.[111]

Although these findings are useful, Stone et al and Lister-Sharp et al both caution that their findings are largely based on self-report measures that may be subject to bias and problems with recall. Stone et al also note that the collection of school studies is limited for several age groups and that special attention is needed with respect to programming targeted at girls in particular. Programs for middle schools were also found to be lacking.

Physical Activity Interventions in Canadian Schools

Although physical activity interventions have been launched in Canadian schools, there is little information available on their results in the published literature. Both the evaluation of these programs and the dissemination of results appear to be issues. For example, a review of literature relating to integrated approaches to promote healthy weights conducted by the Centre for Health and Policy Studies at the University of Calgary identified 43 population-level, school-based studies from around the world.[112] Of these 43 studies, only six were based in Canada, and the information on these interventions was weak.[112] Study design was an issue for several of the interventions and evaluation/outcome data were not reported in all cases.[112] This situation presents significant challenges in terms of identifying evidence based, promising practices occurring in the Canadian context.

While few in number, studies of school-based physical activity interventions in Canada do lend support for the value of such programs. For example, analysis of the findings from the Annapolis Valley Health Promoting Schools Project (AVHPSP) indicate that students in schools that implement intensive, integrated nutrition and physical education programs have significantly lower rates of overweight and obesity, healthier diets, and are more physically active than students from schools without such programs.[29,113] Physical education, in particular, was correlated with significant decreases in the risk of both overweight and obesity, a finding that demonstrates the value of physical education classes to the health of children.

Promising Practices

Based on their review of existing studies, Stone et al offered several recommendations for future work in this area, including the following:[110]

- Develop more reliable and valid self-report measures of physical activity for different development age groups, and use more observations and objective measures in conjunction with self-report measures.
- Establish school policies and environments to provide space, equipment and supervision to promote physical activity before and after school and during lunch and recess periods.
- Provide appropriate resources for more emphasis on mastery of fundamental skills in children. A strong basic skill set is essential for exercising choices for leisure-time activities across the life span.
- Introduce more non-curriculum based intramural (within the school) and extramural (between schools) activities that service all students.
- Increase pre-service and inservice training opportunities for teachers on the fundamentals and importance of physical activity, fitness and physical education.
- Increase efforts to institutionalize programs shown to be effective so that they are a routine part of school programs, policies and resource allocation.

A number of Canadian organizations have also compiled informal listings of promising practices for promoting physical activity in schools. It is important to recognize that the promising practices identified by these organizations are not necessarily supported by a significant body of scientific evidence. Instead, many of these practices are practical suggestions for increasing physical activity in schools that have been derived from anecdotal accounts. Examples of organizations offering this kind of promising practice information include:

- EverActive Schools (Alberta)
  http://www.everactive.org
- Schools Come Alive! (Alberta)
  http://www.schoolscomealive.org
- Action Schools! BC
  http://www.actionschoolsbc.ca
- Saskatchewan In-Motion
  http://www.saskatchewaninmotion.ca

- Canadian Association for Health, Physical Education, Recreation and Dance
  http://www.cahperd.ca
- Living School – Building Healthier Communities
  http://www.livingschool.ca/
- Active Healthy Kids Canada
  http://www.activehealthykids.ca/programs.cfm

Common themes run through the promising practices identified by these different but like-minded organizations. Examples include:

- the benefits of having physical education specialists lead physical education programming in schools[27]
- the valuable contribution physical education classes can make to overall activity levels in children and youth and to decreasing the risk of both overweight and obesity[28,29]
- the value of simple yet novel approaches to increasing physical activity in schools[29]
- the importance of making physical activity fun for children and youth[29]
- the benefits linked to implementing Comprehensive School Health initiatives that include a strong physical activity component[114]
- the need to foster inter-sectoral partnerships to support active living in schools[27]
- the important role policy change can play with respect to creating school environments that support physical activity and discourage sedentary behaviours[27]
- the value of active commuting (e.g., cycling, walking, skateboarding to school each day). Recent studies indicate that active commuting can significantly increase physical activity levels in children and youth.[31,32]
- the need to position physical activity and physical education as an enjoyable, valued element of school life, while at the same time avoiding the negative effect of practices that involve using physical activity as a form of punishment, or withholding physical education classes to discipline children and youth in schools.[33]

Next Steps

Interest in school-based physical activity interventions is currently high, in large part due to the trend towards physical inactivity, overweight and obesity in children and youth. Researchers in Alberta and other jurisdictions are currently engaged in a variety of school-based physical activity and health promotion interventions. Ultimately, these research activities will allow promising and best practices for promoting physical activity in schools to be elucidated.

Recommendations and Conclusion

This literature review explored the multiple benefits that regular physical activity confers to children and youth. In addition, it examined methods to assess or measure physical activity levels in schools, both subjectively and objectively. Finally, it described promising practices that have been identified in the scientific literature and elsewhere that might serve as a "blue print" for action on enhancing physical activity in schools. From a synthesis of this information, the following recommendations are derived.

1. That some type of self-report instrument should be used to assess physical activity as a component of DPA data collection. These types of instruments represent a straightforward, cost effective means of gathering relatively reliable and valid information on the physical activity levels of children and youth in school and, depending on the instrument, outside of school as well. Self-report instruments most appropriate for use include the Self-Administered Physical Activity Checklist (SAPAC) and the Physical Activity Questionnaire for Children (PAQ-C).
2. That pedometers should be used to objectively measure physical activity levels in children and youth involved in the data collection for DPA. The relatively low cost and ease of use of these devices, coupled with their relatively high reliability and validity in measuring physical activity in children make pedometers well suited to the DPA's data collection.
3. That self-report and objective measures should used in combination to optimize and enrich the quality of the data collected from participants in DPA.
4. That strategies should be developed to better evaluate and disseminate promising practices in school-based physical activity interventions developed both in Alberta and elsewhere.

Physical activity is a complex behaviour that is influenced by multiple determinants. Some of these determinants are amenable to individual change. Others, however, will require broad-scale societal changes if children and youth are to achieve current recommendations for physical activity. Environmental change holds particular promise; however, changing the environments in which children live, play and learn—such as schools—will take time, the injection of appropriate resources and the adoption of policies and practices that position active living as a priority with a school community.

Appendix 1: Summary of Physical Activity Guidelines for Children and Youth

Organization	Highlights of Recommendations
International Consensus Conference on Physical Activity Guidelines for Adolescents (1993) [9]	• All adolescents should be physically active daily, or nearly every day, as part of play, games, sports, work, transportation, recreation, physical education or planned exercise in the context of family, school and community activities. • Adolescents should engage in three or more sessions per week of activities that last 20 minutes or more at a time and that require moderate to vigorous levels of exertion.
Public Health Agency of Canada and the Canadian Society for Exercise Physiology:[10] Canada's Physical Activity Guide for Children Canada's Physical Activity Guide for Youth (2002)	• Inactive children and youth should increase the amount of time they currently spend being physically active by at least 30 minutes more per day and decrease the time they spend watching TV, playing computer games and surfing the Internet by at least 30 minutes per day. • The increase in physical activity should include a combination of moderate activity (such as brisk walking, skating and bike riding) with vigorous activity (such as running and playing soccer). • The guidelines recommend that inactive children and youth accumulate this increase in daily physical activity in periods of at least 5 to 10 minutes each. • Over several months, children and youth should try to accumulate at least 90 minutes more physical activity per day and decrease by at least 90 minutes per day the amount of time spent on non-active activities such as watching videos and sitting at a computer.
International Association for the Study of Obesity (IASO):[11] Consensus Statement – Physical Activity to Prevent Unhealthy Weight Gain (2002)	• Moderate intensity activity of approximately 45 to 60 minutes per day, or 1.7 PAL (Physical Activity Level)* is required to prevent the transition to overweight or obesity [in adults]. • For children, even more activity time is recommended. • A good approach for many individuals to obtain the recommended level of physical activity is to reduce sedentary behaviour by incorporating more incidental and leisure-time activity into the daily routine. *PAL is an indirect measure of energy expenditure. Basal metabolic rate [the amount of calories per hour required to support essential body functions (breathing, heart beating, etc.) at rest] reflects a PAL of 1.0. Additional physical activity [sitting, standing, walking, running, etc.] produces linear increases in energy expenditure and PAL values above 1.0. Sedentary adults would be expected to have PAL values of approximately 1.5-1.60. PAL values of 1.7 or higher can be accrued through 30 to 60 minutes bouts of moderate daily physical activity.
United States Department of Health and Human Services, and the United States Department of Department of Agriculture:[12] Dietary Guidelines for Americans (2005)	• Engage in regular physical activity and reduce sedentary activities to promote health, psychological well-being and a healthy body weight. • Children and adolescents should engage in at least 60 minutes of physical activity on most, preferably all, days of the week.
Department of Health and Aging (Government of Australia): [13] Physical Activity Recommendations for Children and Young People (2004)	• Children and young people should participate in at least 60 minutes (and up to several hours) of moderate- to vigorous-intensity physical activity every day. • Children and young people should not spend more than two hours a day using electronic media for entertainment (e.g., computer games, Internet, TV), particularly during daylight hours. • The recommendations are intended to identify the minimum level of physical activity required for good health in children and young people from 5 to 18 years of age.

Appendix 1: Summary of Physical Activity Guidelines for Children and Youth (Continued)

Organization	Highlights of Recommendations
National Association for Sport and Physical Education (NASPE) (USA): [14] Physical Activity for Children: A Statement of Guidelines for Children Ages 5-12 (2004)	• Children should accumulate at least 60 minutes, and up to several hours, of age-appropriate physical activity on all, or most days of the week. • Children should participate in several bouts of physical activity lasting 15 minutes or more each day. • Children should participate each day in a variety of age-appropriate physical activities designed to achieve optimal health, wellness, fitness and performance benefits. • Extended periods (periods of two hours or more) of inactivity are discouraged for children, especially during the daytime hours.
Health Education Authority (UK): [15] Recommended Amounts and Types of Physical Activity (2004)	• All young people should participate in physical activity of at least moderate intensity for one hour per day. This hour can be made up from a variety of activities across the day, including organised sport, play, walking or cycling to school, physical education or planned exercise.
National Centre for Chronic Disease Prevention and Health Promotion: [16] Physical Activity and Health: A Report to the Surgeon General (1996)	• People of all ages should include a minimum of 30 minutes of physical activity of moderate intensity (such as brisk walking) on most, if not all, days of the week. It is also acknowledged that for most people, greater health benefits can be obtained by engaging in physical activity of more vigorous intensity or of longer duration.
Canadian Association for Health, Physical Education, Recreation and Dance (CAHPERD): [17] Position Statement on Quality Daily Physical Education (QDPE) (1988)	• Quality Daily Physical Education (QDPE) in every school is essential to successfully reversing the inactivity crisis plaguing Canadian children and youth. • All children and youth in Canada must receive physical education through compulsory Kindergarten to Grade 12 QDPE programs. • All students must receive their physical education from teachers who are qualified to teach the subject. • The minimum acceptable criteria for the delivery of physical education in Canadian schools are those set out by CAHPERD. • School must provide a minimum of 150 minutes of physical education class instruction and activity per week per student.
President's Council on Physical Fitness and Sports: [18] President's Active Award Standards (2003)	• Youth (ages 6 to 17) must participate in 60 minutes of physical activity a day, for at least five days of the week, for a total of six weeks OR • Youth (ages 6-17) must accumulate at least 13,000 steps/day (males) OR 11,000 steps/day (females) for at least five days of the week, for a total of six weeks.
Institutes of Medicine: [19] Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Protein and Amino Acids (Macronutrients)(2002)	• For children and adults: "to prevent weight gain as well as to accrue additional, weight-independent health benefits of physical activity, 60 minutes of daily moderate intensity physical activity (e.g., walking/jogging at 4 to 5 mph) is recommended, in addition to the actives required by a sedentary lifestyle."

Appendix 2: Reliability and Validity of Self-report Instruments for Assessing Physical Activity in Children and Youth

Instrument	Characteristics	Reliability	Validity	Supporting Reference(s)
Adolescent Physical Activity Recall Questionnaire (APARQ)	• Self-administered, 1 week recall of physical activity including activity before school, at school, after school and on weekends • Examines frequency and duration of activity. • Intensity of activity is not assessed. • Assesses energy expenditure for organized sport and unorganized activities • Measures seasonal variations in activity (winter vs. summer) as well as variations between time spent in organized sport and unorganized activities. • Does not assess time spent engaged in sedentary behaviours. • Target Audience = Youth (~13-18 years)	Overall: Moderate to High Sample: Adolescents in grades 8 and 10 • N=226 (both grades) Test-retest reliability at 2 weeks: ***Winter Responses*** Total Energy Expenditure: • r = 0.64 (Grade 8) • r = 0.81 (Grade 10) Organized Sport: • r = 0.49 (Grade 8) • r = 0.88 (Grade 10) Unorganized Activity: • r = 0.64 (Grade 8) • r = 0.74 (Grade 10)	Overall: Low to Moderate Comparison of energy expenditure and aerobic fitness: • r = 0.147 (Grade 8) • r = 0.139 (Grade 10)	Booth, et al (2002)[115]

Adapted from: McCormack G. Giles-Corti B; (2002)[116]

Appendix 2: Reliability and Validity of Self-report Instruments for Assessing Physical Activity in Children and Youth (Continued)

Instrument	Characteristics	Reliability	Validity	Supporting Reference(s)
Modifiable Activity Questionnaire for Adolescents (MAQA)	• Self-administered recall of physical activity before, during and after school, as well as on weekends. • Questionnaire is divided into two sections: – 1) 7-day recall of physical activity, – 2) 12-month recall for activities undertaken at least 10 times/year. • Adapted from the Youth Risk Behaviour Survey Questionnaire and the Past Year Leisure Time Physical Activity Questionnaire. • Assesses total time (in hours) per week spent on various types of activity. • MET-hours can be derived from the time assessment. • Explores time spent engaged in a selection of sedentary activities (e.g., television, video, computer) • Target Audience: Youth (~13 – 18 years)	Overall: High Sample: Adolescents aged 15 to 18 years. • N = 100 Test-retest reliability at 1 month and 1 year: Hours per week engaged in leisure physical activity: • r = 0.79 (1 month) • r = 0.66 (1 year) MET-hours/week* • r = 0.85 (1 month) • r = 0.72 (1 year) Hours spent at vigorous activity**: • r = 0.91 (1 month) • r = 0.72 (1 year) *Activity hours/week multiplied by MET factor **Defined as >6 MET	Overall: Moderate to High Validated against Past Year Leisure Physical Activity data to averaged data from past 4 weeks: Hours per week engaged in leisure physical activity: • r = 0.55 (males) • r = 0.82 (females) MET-hours/week: • r = 0.57 (males) • r = 0.83 (females) Hours spent at vigorous activity: • r = 0.67 (males) • r = 0.73 (females)	Aaron, et. al (1995)[83]

Adapted from: McCormack G. Giles-Corti B. (2002) [116]

Appendix 2: Reliability and Validity of Self-report Instruments for Assessing Physical Activity in Children and Youth (Continued)

Instrument	Characteristics	Reliability	Validity	Supporting Reference(s)
Physical Activity Questionnaire of Children (PAQ-C)	• Self-administered, 7-day recall. • Activities are presented on a 5-point Likkert scale. This allows for creation of a composite score that is used a measure of activity. • Assesses frequency of participation in different types of activities rather than duration. • Includes activities performed both in and out of school • Segregates weekday participation from weekend participation • Does not explore time spent engaged in sedentary behaviours. • Target Audience: Children, Grade 4+	Overall: High Sample: • Children, aged 9 to 14 years • N = 84 Test-retest (1-week): • r = 0.75 (males) • r = 0.82 (females)	Overall: Moderate Validated against: Seven-day Activity Recall • r = 0.46 Leisure Time Exercise Questionnaire: • r = 0.41 Caltrac accelerometer • r = 0.39	Crocker, et al (1997) [89] Kowalski, et al (1997)[117]

Adapted from: McCormack G. Giles-Corti B. (2002) [116]

Appendix 2: Reliability and Validity of Self-report Instruments for Assessing Physical Activity in Children and Youth (Continued)

Instrument	Characteristics	Reliability	Validity	Supporting Reference(s)
Physical Activity Questionnaire for Adolescents (PAQ-A)	• A modified version of the PAQ-C. • Self-administered, 7-day recall. • Activities are presented on a 5-point Likkert scale. This allows for creation of a composite score that is used as a measure of activity. • Assesses frequency of participation in different types of activities rather than duration. • Includes activities performed both in and out of school • Segregates weekday participation from weekend participation • Does not explore time spent engaged in sedentary behaviours. • Target Audience: Youth (~13-18 years)	Similar to PAQ-C.	Overall: Moderate Sample: • Youth, in grades 8 to 12 • N = 85 Validated against: Leisure Time Physical Activity Questionnaire - Question 1: • r = 0.57 Question 2: • r = 0.62 Caltrac accelerometer: • r = 0.33	Kowalski, et al (1997)[118]

Adapted from: McCormack G. Giles-Corti B. (2002)[116]

Appendix 2: Reliability and Validity of Self-report Instruments for Assessing Physical Activity in Children and Youth (Continued)

Instrument	Characteristics	Reliability	Validity	Supporting Reference(s)
Leisure Time Exercise Questionnaire (LTEQ)* *Also known as the Godin-Shephard Activity Survey	• Self-administered, 7-day recall of physical activity. • Assesses weekly frequencies for strenuous (MET = 9), moderate (MET = 6) and mild (MET = 3) exercise that is engaged in for 15 minutes or more during free (out of school) time. • A weighted score is assigned to each respondent based on total weekly activity determined by intensity.	Overall: High Sample: • Grade 5 Children (N = 36) • Grade 8 Youth (N = 36) • Grade 11 Youth (N = 30) Test-retest (2-weeks): • r = 0.69 (Grade 5) • r = 0.80 (Grade 8) • r = 0.96 (Grade 11)	Overall: Moderate to High Validated against: 7-day recall of physical activity: • r = 0.57 (Grade 5) • r = 0.60 (Grade 8) • r = 0.32 (Grade 11) Low skinfolds: • r = 0.76 (all grades) High skinfolds: • r = 0.41 (all grades)	Sallis, et al (1993)[119] Sallis (1991)[120] Godin G. and Shephard R. J. (1985)[121]

Adapted from: McCormack G., Giles-Corti B. (2002)[116]

Appendix 2: Reliability and Validity of Self-report Instruments for Assessing Physical Activity in Children and Youth (Continued)

Instrument	Characteristics	Reliability	Validity	Supporting Reference(s)
Past Year Leisure Time Activity Questionnaire (PTLAQ)	• Self-administered questionnaire. • Explores physical activity over the proceeding 14 days, and participation in competitive sport over the proceeding 12 months. • Assesses both frequency and duration of activity. • Does not assess intensity of activity. • Can be used to estimate mean relative energy expenditure for week(s), month(s) or the full year (in MET).	Overall: Moderate Sample: • Youth – age 12 years (N = 201) • Youth – age 13 years (N = 341) • Youth – age 14 years (N = 369) • Youth – age 15 years (N = 264) Test-retest (1 year): • r = 0.55 (all age groups)	Overall: Low Validated against: A physical fitness score (1 mile walk/run timed test, stratified by age) Hours per week and physical fitness score: • r = −0.32 (12-year-olds) • r = −0.28 (13-year-olds) • r = −0.45 (14-year-olds) • r = −0.37 (15-year-olds) MET hours per week and physical fitness score: • r = −0.33 (12-year-olds) • r = −0.31 (13-year-olds) • r = −0.47 (14-year-olds) • r = –0.40 (15-year-olds)	Aaron, et al (1993)[122] Baranowski (1988)[123]

Adapted from: McCormack G., Giles-Corti B. (2002)[116]

Appendix 2: Reliability and Validity of Self-report Instruments for Assessing Physical Activity in Children and Youth (Continued)

Instrument	Characteristics	Reliability	Validity	Supporting Reference(s)
Previous Day Physical Activity Recall (PDPAR)	• Self-administered, previous day recall of physical activity. • Assesses activities performed during 30-minute blocks of time outside of school only. • Measures both active and sedentary behaviours • Intensity is assessed through perceived exertion. • Total energy expenditure can be calculated from data on duration and intensity of activity. • Energy expenditure for specific activities can be calculated from data on duration and intensity of activity. • Energy expenditure at specific times or points during the day can also be assessed.	Overall: High Sample: • Youth – age 14 years (N = 90) Test-retest (1 hour): • r = 0.98	Overall: Moderate to High Sample: • Children – 7 to 12 years (pedometer and accelerometer) • Youth – 16 to 18 years (heart rate monitoring) Validated against: Pedometer: • r = 0.88 Caltrac accelerometer: • r = 0.77 Heart rate monitoring*: • r = 0.53 (mean) *Validity was assessed by comparing correlations between percentage heart rate range (HRmax-HRrest) and estimated energy expenditure from the PDPAR	Weston, et al (1997)[124]

Adapted from: McCormack G., Giles-Corti B. (2002)[116]

Appendix 2: Reliability and Validity of Self-report Instruments for Assessing Physical Activity in Children and Youth (Continued)

Instrument	Characteristics	Reliability	Validity	Supporting Reference(s)
Self-Administered Physical Activity Checklist (SAPAC)	• Self-administered, previous day recall of physical activity before, during and after school. • Also tested as an interview version (Physical Activity Checklist Interview or PACI) • Provides a total estimate of the number of minutes spent engaged in activities lasting longer than five minutes. • Measures time spent engaged in sedentary behaviours. • Measures time spent in moderate to vigorous activity. • MET score is calculated from data on time and intensity of activities	Overall: Moderate Sample: • Grade 5 Children (N = 97) Intraclass correlations based on comparisons of the results from the self-reported and interviewer-led recalls where the only difference between the two was the method of administration: • ICC (range): 0.64 – 0.79.	Overall: Low to Moderate Validated against: Heart rate monitoring and number of activities: • r = 0.28 Heart rate monitoring and minutes of moderate to vigorous activity (MVPA): • r = 0.58 Heart rate monitoring and MVPA METs: • r = 0.59 Accelerometer and number of activities: • r = 0.02 Accelerometer and minutes of MVPA: • r = 0.30 Accelerometer and MVPA METs: • r = 0.32	Sallis, et al (1996) [125]

Adapted from: McCormack G., Giles-Corti B. (2002)[116]

Appendix 3: Reliability and Validity of Accelerometers, Pedometers and Heart Rate Monitors for Assessing Physical Activity in Children and Youth

Instrument(s)	Characteristics	Reliability	Validity	Supporting Reference(s)
• Computer Science and Applications (CSA) Accelerometer** • Tritrac Accelerometer • Yamix Digiwalker Pedometer	Sample: • Boys, 8–10 years (N = 21) Protocol—Type or context of activities: • Walking and running on a treadmill • Playing catch • Hopscotch • Drawing • Sitting Validated against: • Indirect calorimetry (SVO2)	Not applicable – Validation study	*Walking and treadmill running:* SVO2 and CSA Accelerometer • r = 0.809 SVO2 and Tritrac Accelerometer • r = 0.934 SVO2 and Pedometer (hip)* • r = 0.772 *Games:* SVO2 and CSA Accelerometer • r = 0.881 SVO2 and Tritrac Accelerometer • r = 0.934 SVO2 and Pedometer (hip)* • r = 0.931	Louis, et al (1999) [24] * Pedometer was also positioned at the wrist and ankle. Data shown here is limited to readings for the pedometer placed on the hip as this is the most commonly used site. ** The CSA accelerometer (model 7164) is also known as the MTI accelerometer or the Actigraph accelerometer.
• Tritrac Accelerometer • Yamix Digiwalker Pedometer	Sample: • Children, 7–12 years (N = 10) Protocol: • Classroom-based structured activity session • Freeplay in recreational area Validated against: • Direct observation	Not applicable – Validation study	*Classroom-based structured activity session*: Direct observation and Tritrac Accelerometer • r = 0.70 Direct observation and Pedometer • r = 0.80 *Freeplay in recreational area*: Direct observation and Tritrac Accelerometer • r = 0.94 Direct observation and Pedometer • r = 0.97	Kilanowski, et al (1999)[126]

Adapted from: McCormack G., Giles-Corti B. (2002) [116]

Appendix 3: Reliability and Validity of Accelerometers, Pedometers and Heart Rate Monitors for Assessing Physical Activity in Children and Youth (Continued)

Instrument(s)	Characteristics	Reliability	Validity	Supporting Reference(s)
• CSA Accelerometer*	Sample: • Phase 1 – no subjects – instrument study • Phase 2 – preschool children (N = 10) • Phase 3 – preschool children (N = 11) Protocol: • 3 phase study • Phase 1 – Measurement of inter-instrument difference. CSA attached to mechanical accelerometer. • Phase 2 – Effect of CSA placement (hip – left or right side) on measures during play. CSA (2) attached to child's hip for 2 days. Sides were changed between 1st and 2nd day. • Phase 3 – Comparison of CSA accelerometer to Children's Physical Activity Form (CPAF) and direct observation during structured play (e.g., rest, standing, skipping, jumping, running, playing on gymnastic equipment). CSA was worn during structured play period.	Inter-instrument: • r = 0.98 to 0.99 Left hip versus right hip placement • r = 0.92 CSA accelerometer-CPAF • r = 0.87	Not assessed.	Fairweather, et al (1999)[127] * The CSA accelerometer (model 7164) is also known as the MTI accelerometer or the Actigraph accelerometer.

Adapted from: McCormack G., Giles-Corti B. (2002) [116]

Appendix 3: Reliability and Validity of Accelerometers, Pedometers and Heart Rate Monitors for Assessing Physical Activity in Children and Youth (Continued)

Instrument(s)	Characteristics	Reliability	Validity	Supporting Reference(s)
• CSA Accelerometer*	Sample: • Children, ages 7 to 15 years (N = 31) Protocol: • Physical activity measured over three days (unstructured and free-living activities). • Accelerometer worn at the hip. • 60-second sampling period. • Assessed mean movement counts per day and number of minutes spent at >256-counts/ minute/day. (Moderate physical activity was defined as a CSA count >256 counts/min.) Validated against: • Heart rate (HR) telemetry • Activity diary.	Diary (Day 1 and Day 2) with CSA counts: • r = 0.49 Diary (Day 1 and Day 3) with CSA counts: • r = 0.53 Diary (Day 1 and Day 2) with CSA counts >256-counts/min/day: • r = 0.38 Diary (Day 1 and Day 3) with CSA counts >256-counts/min/day: • r = 0.43	CSA and mean net HR: • r = 0.57 CSA counts >256-counts/min/day with HR minutes >60% reserve: • r = 0.5	Janz, et al (1994)[128] * The CSA accelerometer (model 7164) is also known as the MTI accelerometer or the Actigraph accelerometer.

Adapted from: McCormack G., Giles-Corti B. (2002) [116]

Appendix 3: Reliability and Validity of Accelerometers, Pedometers and Heart Rate Monitors for Assessing Physical Activity in Children and Youth (Continued)

Instrument(s)	Characteristics	Reliability	Validity	Supporting Reference(s)
• Caltrac Accelerometer	Sample: • Children, Grade 3 (N = 27) • Children, Grade 4 (N = 21) Protocol: • Physical activity measured in school and after school (1 day). • Both free-living and structured activities were assessed. • Children completed an interviewer-administered 1-day recall of physical activity. • Heart rate telemetry where moderate activity (MA) was defined as 180% of resting HR and vigorous activity (VA) was defined as 200% of resting HR. Validated against: • Heart rate (HR) telemetry • Activity diary	Not assessed.	Grade 3 students: Caltrac and HR: • r = 0.70 (MA) • r = 0.80 (VA) Grade 5 students: Caltrac and HR: • r = 0.57 (MA) • r = 0.50 (VA)	Simons-Morton, et al (1994)[129]

Adapted from: McCormack G., Giles-Corti B. (2002)[116]

Appendix 3: Reliability and Validity of Accelerometers, Pedometers and Heart Rate Monitors for Assessing Physical Activity in Children and Youth (Continued)

Instrument(s)	Characteristics	Reliability	Validity	Supporting Reference(s)
• CSA Accelerometer*	Sample: • Children, Grades 1–3 (N = 92) • Children, Grades 4–6 (N = 98) • Youth, Grades 7–9 (N =97) • Youth, Grades 10–12 (N = 94) Protocol: • Normal daily activity measured for 7 consecutive days. • CSA accelerometer worn at hip collecting at 1-minute intervals.	Intraclass reliability (d) = days Grades 1 to 3 • Alpha = 0.46 (1 d) • Alpha = 0.77 (4 d) • Alpha = 0.86 (7 d) Grades 4 to 6 • Alpha = 0.49 (1d) • Alpha = 0.79 (4 d) • Alpha = 0.87 (7 d) Grades 7 to 9 • Alpha = 0.33 (1d) • Alpha = 0.66 (4 d) • Alpha = 0.77 (7 d) Grades 7 to 9 • Alpha = 0.31 (1d) • Alpha = 0.64 (4 d) • Alpha = 0.76 (7 d) Number of days required to achieve Alpha = 0.70 – 0.90: • Grades 1 to 3 = 2.7 to 10.6 days • Grades 4 to 6 = 2.4 to 9.4 days • Grades 7 to 9 = 4.8 to 18.6 days • Grades 10 to 12 = 5.1 to 19.8 days	Not assessed.	Trost, et al (2000)[130] * The CSA accelerometer (model 7164) is also known as the MTI accelerometer or the Actigraph accelerometer.

Adapted from: McCormack G, Giles-Corti B (2002) [116]

Appendix 3: Reliability and Validity of Accelerometers, Pedometers and Heart Rate Monitors for Assessing Physical Activity in Children and Youth (Continued)

Instrument(s)	Characteristics	Reliability	Validity	Supporting Reference(s)
• CSA Accelerometer* • Tritrac R3D Accelerome	Sample: • Children, ages 9 to 11 years. Protocol: • Assessed physical activity from light to vigorous, structured and free-play activities. • Accelerometers worn at hip. • Activities were classified by intensity, and METs were calculated. Validated against: • Heart rate telemetry (HR) • Calculated METs	Intraclass correlations (last three minutes of activity): HR (range) • r = 0.92 – 0.99 CSA (range) • r = 0.59 – 0.94 Tritrac (range) • r = 0.60 – 0.96	CSA and Tritrac: • r = 0.86 CSA and HR • r = 0.64 CSA and METs • r = 0.43 Tritrac and HR • r = 0.73 Tritrac and METs • r = 0.66	Ott, et al (2000)[94] * The CSA accelerometer (model 7164) is also known as the MTI accelerometer or the Actigraph accelerometer.
• RT3 Accelerometer • Tritrac R3D Accelerome	Sample: • Nineteen boys (age: 9.5 +/- 0.8 yr) and 15 men (age: 20.7 +/- 1.4 yr) Protocol: • Walked and ran on a treadmill, kicked a ball to and fro, played hopscotch and sat quietly. • RT3 was worn on the right hip; boys also wore a Tritrac on the left hip. Validated against: • Measured sVO2	Not assessed	RT3 with sVO_2 • r = 0.87 (boys) Tritrac with sVO_2 • r = 0.87 (boys)	Rowlands, et al (2004)[131]

Adapted from: McCormack G., Giles-Corti B. (2002) [116]

Appendix 3: Reliability and Validity of Accelerometers, Pedometers and Heart Rate Monitors for Assessing Physical Activity in Children and Youth (Continued)

Instrument(s)	Characteristics	Reliability	Validity	Supporting Reference(s)
• Actical • Actigraph	Sample: • 32 children and youth, ages 7-18 years Protocol: • Subjects performed structured physical activities in a supervised setting. Validated against • Energy Expenditure assessed via direct calorimetry (calorimetry room – 4 h) and indirect calorimetry (metabolic cart testing – 1h) • Heart rate	• Not assessed	Actical with Energy Expenditure: • r = 0.83 Actical with Activity Energy Expenditure: • r = 0.85 Actical with heart rate: • r = 0.60 Actigraph with Energy Expenditure: • r = 0.79 Actigraph with Activity Energy Expenditure: • r = 0.82 Actigraph with heart rate: • r = 0.63	Puyau, et al (2004)[132]

Adapted from: McCormack G., Giles-Corti B. (2002) [116]

Appendix 3: Reliability and Validity of Accelerometers, Pedometers and Heart Rate Monitors for Assessing Physical Activity in Children and Youth (Continued)

Instrument(s)	Characteristics	Reliability	Validity	Supporting Reference(s)
• Heart rate monitor	Sample: • 19 Children: 9 boys, 10 girls; mean age = 8.5 years Protocol: • Subjects performed activities of daily life wearing heart rate monitor to assess TEE (1 day TEE). Validated against • TEE assessed via direct calorimetry (calorimetry room – 1 day) and 2 week TEE measured by doubly labelled water method.	• Not assessed	• TEE_{HR} 10.4%>TEE calorimeter • TEE_{HR} 12.3%>TEE_{DLW}	Emons, et al (1992)[133]
• Heart rate monitor	Sample: • 40 volunteers (22 boys, 18 girls) ages 6 to 7 years Protocol: • Subjects performed activities of daily life wearing heart rate monitor to assess TEE (12 hour TEE). Validated against • Not validated.	• Not assessed	• Not validated. • Heart rate patterns show that the boys are more physically active than the girls.	Gilliam, et al (1981)[134]

Adapted from: McCormack G., Giles-Corti B. (2002) [116]

Appendix 3: Reliability and Validity of Accelerometers, Pedometers and Heart Rate Monitors for Assessing Physical Activity in Children and Youth (Continued)

Instrument(s)	Characteristics	Reliability	Validity	Supporting Reference(s)
• Heart rate monitor	Sample: • 13 children; 6 obese; 7 healthy weight; Protocol: • Subjects performed activities of daily life wearing heart rate monitor to assess TEE (1 day TEE). Validated against • Total daily energy expenditure was assessed by means of the doubly labelled water method (TEE_{DLW}) and of heart rate monitoring (TEE_{HR}).	• Not assessed	• TEE_{HR} was significantly ($P < 0.05$) higher than TEE_{DLW} in obese children (9.47 +/- 0.84 MJ/d vs 8.99 +/- 0.63 MJ/d), whereas it was not different in non-obese children (8.43 +/- 2.02 MJ/d vs 8.42 +/- 2.30 MJ/d, P = NS). • The difference of TEE assessed by HR monitoring in the obese group averaged 6.2 +/- 4.7%.	Maffeis, et al (1995)[135]
• Sport tester PE 3000 heart rate monitor	Sample: • 36 Children: 7.9.12.15 years Protocol: • Subjects performed activities of daily life wearing heart rate monitors (2-3 days) to assess TEE. Validated against • 10-15 day TEE measured by doubly labelled water method	• Not assessed	• HR TEE discrepancies ranged from -16.7% to +18.8% with 23 values lying within +/- 10% of DLW TEE estimates.	Livingstone, et al (1992)[136]

Adapted from: McCormack G., Giles-Corti B. (2002) [116]

Appendix 4: School-based Physical Activity Intervention Programs

Study	Sample	Intervention Characteristics	Outcomes – Physical Activity
Cardiovascular Health in Children (CHIC)[137]	Grades 3-4 (N = 1,274)	• Social Cognitive Theory Framework • American Heart Association health curriculum and specially designed PE program • 2 years in duration	↑ Physical Activity
Child and Adolescent Trial for Cardiovascular Health (CATCH) [109]	Grades 3-5 (N = 5,105)	• Social Cognitive Theory Framework • Organizational/policy changes in school • Lunch program • Modified PE program • Modified health curricula • PE Specialists and/or trained teacher • 2 ½ years in duration	↑ Total Energy Expenditure ↑ Rate of Energy Expenditure during PE ↑ Total Vigorous Physical activity ↑ Out of School Activity Effects sustained post-intervention
Sports, Play and Active Recreation for Kids (SPARK)[138]	Grades 4-5 (N = 955)	• Social Cognitive Theory Framework • Self-management education • PE led by specialists or trained teacher • 2 years in duration (for PE)	↑ Moderate to vigorous activity in PE ↑ Fitness No change in self-management No change in out of school activity
Nebraska School Study[139]	Grades 3-5 (N= 200)	• Social Cognitive Theory Framework • Modified PE curriculum • Lunch program • Policy change • Nutrition Education • 2 years in duration	↑ Classroom physical activity ↓ Out-of-school activity
Go for Health[140]	Grades 3-4 (N = 409)	• Social Learning Theory Framework • Modified PE curriculum • Lunch program • 2 years in duration	↑ Moderate to vigorous activity in PE ↑ Self-efficacy for PE No change in out of school activity
Oslo Youth Study[108]	Grades 5-7 (N=828)	• Social influences and self-management • Policy development • Family involvement • Nutrition Education • Tobacco reduction • Modified PE program	↑ Physical activity (boys only) Effects sustained post-intervention
Know Your Body (KYB) Program[141]	Grades 4-5 (N = 1,400)	• Social Cognitive Theory Framework • American Heart Association health curriculum • Tobacco reduction • Modified PE curriculum • Led by trained classroom teacher	↑ Physical activity

Appendix 4: School-based Physical Activity Intervention Programs

Study	Sample	Intervention Characteristics	Outcomes – Physical Activity
Australia School Project[142]	Grades 9-12 (N = 3,200)	• No theory stated • Specialized physical health, substance abuse and emotional health curricula • 2 years in duration	↑ Out of school physical activity
Southwest CV Curriculum Project[143]	Grade 5 (N = 2,018)	• Social Learning Theory Framework • Modified PE curriculum • Nutrition education • Tobacco reduction • Parent and peer involvement • 2 semester duration	↑ Physical activity
Slice of Life[144]	Grade 9 (N = 270)	• Social Learning Theory Framework • Modified PE curriculum led by trained peers or experts • Nutrition education • School policy change • 1 semester (10 sessions) duration	No impact on physical activity levels
Stanford Adolescent Heart Health Program[145]	Grade 10 (N = 1,447)	• Social Cognitive Theory Framework • Modified PE curriculum • Peer involvement • Nutrition education • Tobacco reduction • Stress reduction • Problem solving • 8 week duration	↑ Physical activity
Project Active Teens[146]	Grade 9 (N = 599)	• Social Cognitive Theory Framework • Conceptual PE • PA labs • Modified PE curriculum	↑ Moderate to vigorous activity in PE (boys) ↓ Inactivity (more for girls)
Action Schools BC[147]	Grades 4 – 7 (N = 565)	• Social Ecological Framework • Modified PE curriculum • Community involvement • Teacher training • Enhanced school activities • Nutrition education • 3 month intervention	↑ Physical activity
Children's Lifestyle and School Performance Study (CLASS)/Annapolis Valley Health Promoting Schools Project[28,29,113]	Grade 5 (N = 5517)	• Nutrition Education • Modified curriculum (PE and Nutrition) • Enhanced access to facilities for physical activity • Community support and activities • Enhanced school activities	↑ Physical activity

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