HEALTH-RELATED PHYSICAL FITNESS AND ITS RELATIONSHIP TO OBJECTIVELY MEASURED PHYSICAL ACTIVIY IN CHILDREN

by

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ABSTRACT

During childhood, physical activity (PA) builds the foundation for a healthy body and is an important determinant of chronic disease risk. Recent reports indicate that children in Canada do not participate in sufficient amounts of PA for optimal health and well-being. Furthermore, certain ethnic groups may be at higher risk of developing chronic disease due to extremely low levels of PA and physical fitness. Literature delineating the relationship between PA and health-related physical fitness in children is inconsistent and has been inhibited by PA measurement tools. Objective measures of PA may overcome many of the limitations associated with other PA measurement tools. The purpose of this investigation was to objectively measure habitual PA, examine differences in PA and health-related physical fitness between Asian and Caucasian children, and determine the relationship between PA and health-related physical fitness. One-hundred seventy boys (n = 79) and girls (n = 91) in grades 4 and 5 from five schools in the Greater Vancouver Region participated. Measures of body composition (Body Mass Index and waist circumference), vascular health (blood pressure), resting heart rate, musculoskeletal fitness (grip strength, sit-and-reach, curl-ups and push-ups) cardiorespiratory fitness (Leger shuttle run) and habitual PA (via accelerometry) were obtained over a 1-week period. Results indicated that boys participated in 134 minutes and girls accumulate 114 minutes of moderate-to-vigorous physical activity (MVPA) per day. Only 30 minutes and 15 minutes per day were accumulated in bouts exceeding 5 minutes in duration in boys and girls respectively. During the school day the percentage of time spent in MVPA for recess, lunch hour and Physical Education class was 28%, 35% and 13% in boys and 18%, 27% and 16% in girls. Caucasian girls accumulated more MVPA per day, had significantly higher counts per minute and had higher aerobic fitness than Asian girls ($p<0.05$). There was no significant difference in musculoskeletal fitness. Caucasian boys had significantly higher counts per minute, higher aerobic fitness, and significantly higher musculoskeletal fitness scores ($p<0.05$) than Asian boys. Physical activity did not significantly predict cardiorespiratory or musculoskeletal fitness in either boys or girls. This investigation demonstrated that physical activity during the school day was low. Caucasian boys and girls obtained higher PA and fitness levels than Asian boys and girls. These findings suggest that all children may be at higher risk for health complications associated with low levels of PA, especially those of Asian ethnicity.

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ABBREVIATIONS

AS! BC	Action Schools! BC
BMI	body mass index
BP	blood pressure
CSEP	Canadian Society for Exercise Physiology
CVD	cardiovascular disease
DBP	diastolic blood pressure
EE	energy expenditure
HR	heart rate
KKD	kilocalories per kilogram
MVPA	moderate-to-vigorous physical activity
PA	physical activity
PE	physical education
SBP	systolic blood pressure
SD	standard deviation
TEE	total energy expenditure
U.K.	United Kingdom
WC	waist circumference

OPERATIONAL DEFINITIONS

Accelerometer: A device worn on the body that provides an objective measurement of physical activity. It consists of piezoelectric technology that when accelerated, emits a voltage that is proportional to the acceleration of the body. The resulting information provides health-related information about physical activity such as frequency, intensity and duration (1).

Action Schools! BC (AS! BC): A best-practice physical activity model designed to assist elementary schools in creating individualized action plans to promote healthy living. It provides resources and recommendations for the creation of individualized Action Plans that integrate physical activity and healthy eating into the school environment (for more information visit www.actionschoolsbc.ca).

Active: Having an average daily energy expenditure (EE) between 3.0 – 5.9 kilocalories per kilogram (KKD) of body weight. Walking for one hour per day would result in an EE of approximately 3.0 KKD (2).

Bouted Activity: Any activity that is accumulated in durations of 5 minutes or more and is related specifically to original data from this document.

Canadian Society for Exercise Physiology (CSEP): A non-profit organization composed of professionals interested and involved in the scientific study of exercise physiology, exercise biochemistry, fitness and health (for more information visit www.csep.ca).

Cardiovascular/Cardiorespiratory Fitness: The ability to transport and use oxygen during prolonged, strenuous exercise or work. It reflects the combined efficiency of the lungs, heart, vascular system and exercising muscles in the transport and use of oxygen (3).

Children: Children refer to boys and girls between the ages of 5 – 12.

Compliance: The act of adhering to the physical activity guidelines set forth by a governing body.

Epoch: The time period over which accelerometer counts are averaged (4).

Ethnicity: A term which represents a shared history, sense of identity, geography and cultural similarities amoung individuals (5).

Fractionalization: Method of segmenting the time spent at different intensities of physical activity.

Health-Related Physical Fitness: The components of physical fitness that are related to health status, including cardiovascular fitness, musculoskeletal fitness, body composition and metabolism (3).

Inactive: Values of average daily EE less than 1.5 KKD. Walking for no more than one quarter hour would result in an EE less than 1.5 KKD (2).

Kilocalorie: the quantity of heat required to raise the temperature of 1 kg (1 L) of water 1° C (specifically from 14.5 to 15.5° C) (6).

Moderately Active: Having an average daily EE between 1.5 – 2.9 KKD. Walking for one half hour per day would result in an EE of approximately 1.5 KKD (2).

Musculoskeletal Fitness: The fitness of the musculoskeletal system, encompassing muscular strength, muscular endurance, muscular power, flexibility, back fitness and bone health (3).

Physical Activity: All leisure and non-leisure body movements resulting in an increased energy output from the resting condition (3).

Physical Fitness: A physiologic state of well-being that allows one to meet the demands of daily living or that provides the basis for sport performance, or both (3).

Race: A term which implies biological traits indicative of meaningful genetic similarities in a group of individuals (5).

Sporadic Activity: Any activity data that is accumulated in durations lasting less than 5 minutes and is related specifically to original data from this document.

Tracking: The maintenance of relative rank or position within a group over time (i.e., those participating in the least amount of PA as children will participate in the least amount of PA as adults). As a general guide, correlations <0.30 are considered low; those between 0.30 and 0.60 are moderate; and those >0.60 are high (7).

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CHAPTER I

Introduction

Ninety-one percent of Canadian children are not meeting Canada's Physical Activity Guidelines for Children and Youth (8). This is an indication that many of Canadian children are not physically active enough to maintain an optimal health status (9). Physical activity (PA) is required to maintain normal growth and development and health-related physical fitness (3) throughout childhood.

Routine PA is an effective primary and secondary preventive strategy against many types of chronic disease (3, 10). During childhood, PA builds the foundation for a healthy body and can help to reduce the onset of risk factors associated with poor health (11-13). Physical activity is also an important determinant of coronary heart disease risk in youth (14) such that risk decreases in a graded fashion as PA level increases (15). Clearly, a physically active lifestyle is an important component of a child's regular routine.

In Canada, evidence indicates that certain ethnic groups are accumulating extremely low levels of regular PA (16-18). Studies have reported that both Asian girls and boys participate in less PA than age-matched Caucasian peers (17, 18). In Britain, investigations have also reported that Asian children have lower cardiorespiratory fitness than their Anglo-Saxon counterparts (19). Low levels of PA and low cardiorespiratory fitness are both associated with cardiovascular disease risk (14) and suggest that children of Asian ethnicity may be a group more vulnerable to ill health. It is therefore important that PA and fitness be evaluated in children of different ethnic backgrounds to target preventative measures appropriately.

Literature delineating the relationship of PA to components of health-related physical fitness is inconsistent in children. There is an increasing amount of evidence demonstrating that body composition is inversely related to habitual PA (20-22). No relationship has been reported between PA and vascular status (measured as blood pressure) (14, 23, 24). Weak-to-moderate relationships have been detected between PA and musculoskeletal fitness (25, 26) and recent studies have shown significant positive relationships between PA and aerobic fitness (27-29). In adults, relationships between PA and components of health-related physical fitness have been well-established whereby PA is associated with more favourable outcomes (3, 30).

To date, limitations associated with PA measurement tools have inhibited the analysis of PA and health in children (15). The tempo of children's activity is one of rapid change and is typically unstructured and sporadic in nature (31). These factors make capturing activity difficult in this population. As well, children have less developed cognitive skills than adults and are less able to effectively use traditional methods of PA measurement such as self-report questionnaires (32). Therefore, PA assessments for children must be improved to advance research in childhood PA (32) and its connection to health benefits.

Objective measures of PA are able to overcome many of the limitations associated with various other PA measurement tools. To accurately assess children's activity patterns, the evaluative instrument must be sensitive enough to detect, code, or record sporadic and intermittent activity (32, 33). The accelerometer is a unique and useful piece of technology that is able to capture and store activity patterns in small time intervals over a period of days or weeks. It can also provide a measure of important health-related dimensions of PA (frequency, intensity, duration). These advantages make the accelerometer an ideal tool to use for the assessment of PA in children, especially when examining relationships to health-related physical fitness or cardiovascular health.

Accordingly, the purposes of this investigation were to obtain an objective measure of habitual PA in Canadian children, examine the differences in PA and health-related physical fitness between Asian and Caucasian children, and determine the relationship between PA and health-related physical fitness. We hypothesized that:

1) The majority of children in the present investigation will not meet Canada's Physical Activity Guidelines for Children and Youth. This hypothesis is based on reports from Health Canada stating that less than 50% of children achieve optimal amounts of PA (9).
2) Caucasian children will have higher PA levels than Asian children living in the same geographical location and will achieve higher health-related physical fitness scores. This is based on current evidence which indicates that individuals of Asian ethnicity are less active than Caucasian individuals (16, 17, 34) and achieve lower scores on cardiorespiratory fitness tests (19).
3) Children that participate in more moderate-to-vigorous physical activity (MVPA) per day will have higher health-related physical fitness scores. This hypothesis is

based on previous literature reporting positive relationships between PA and various components of health-related physical fitness (25, 26, 29).

The present investigation was conducted in collaboration with Action Schools! BC (AS! BC). This initiative is a best practices PA model designed to assist elementary schools in creating individualized school action plans to promote healthy living. The vision of AS! BC is to integrate PA into elementary schools to achieve long-term, measurable and sustainable health benefits. This is a comprehensive study that was being conducted in order to assess the health status of children in British Columbia and to determine whether the AS! BC model is an effective means to positively change school environments, health-related behaviours and the health of children when delivered across geographically diverse regions and cultures over a three year period.

The participants of the PA (by accelerometry) component of the AS! BC initiative were a sub-sample of 1459 students and included a multi-ethnic population of 579 children in grades 4 to 5 from schools (n = 9) in the Greater Vancouver Region. Measurements were collected throughout the school year from students enrolled in schools participating in the AS! BC initiative. All participants were a part of the full evaluation component of the AS! BC initiative which, in addition to the measures being taken for the proposed investigation, included questionnaires about family history, nutritional intake and knowledge, PA participation, and psycho-social health. One hundred seventy children (79 boys; 91 girls) from five schools were retained for this investigation. Measurements of body composition (body mass index and waist circumference), vascular health (resting blood pressure), resting heart rate, musculoskeletal fitness (grip strength, curl-ups, pushups, and sit-and-reach), cardiovascular fitness (Leger shuttle run), and physical activity (accelerometry) were obtained over a 1-week period.

Following the Introduction, a Review of the Literature will be presented in Chapter 2, which is relevant to the specific hypotheses of the present investigation. A detailed Methodology will be presented in Chapters 3, followed by the Results and Discussion in Chapters 4 and 5, respectively. Finally, nine appendices are included; A) ethics forms for the investigation, B) Health History Questionnaire, C) musculoskeletal fitness test protocols, D) average 'on' and 'off' times used to classify valid days of accelerometry wear, E) information sheet for parents and/or guardians of participants, F) Activity Log,

G) summary of outcome variables in girls and boys, H) summary of outcome variables in children without valid accelerometry data, I) abstract entitled 'Capturing physical activity tempo in elementary-school-aged children, J) abstract entitled 'Physical activity and antecedents of cardiovascular disease risk in children,' K) statistical analyses, and L) raw data. Upon completion of this thesis, this data will be submitted for publication in Medicine & Science in Sport & Exercise as three separate manuscripts.

CHAPTER II

Literature Review

Throughout childhood PA is required to maintain normal growth and development, health-related physical fitness (3), and to establish lifestyle patterns that will reduce the risk factors for health complications later in life (13). Physical activity is also an important determinant of coronary heart disease risk in youth (14) such that risk decreases in a graded fashion as PA level increases (15). A physically active lifestyle is an important component of children's regular routine and plays a critical role in children's health. In the following review, children's general activity patterns, physical activity guidelines for children, ethnic differences in PA, and PA in relation to health-related fitness are discussed.

2.1 Physical Activity Patterns in Children

Children display unique PA patterns in which activity is highly transitory and is rarely sustained for periods greater than 10 minutes in duration (35). There are specific times of the day and days of the week in which activity is more likely to be observed in children (35, 36). Age and gender are two factors consistently recognized in the literature as affecting PA levels in children (37, 38). Although there are numerous guidelines currently available in which to assess PA in children; very few of the recommendations are reflective of children's actual behaviour. As such, the purpose of this section is to examine in further detail the general physical activity patterns of children, as well as physical activity guidelines commonly used to assess PA in children.

2.1.1 General Physical Activity Patterns

The tempo of children's PA is one of rapid change. Activities at all levels of intensity are highly transitory and have a mean duration of 6 seconds as determined by direct observation in children ages 6 – 10 years of age (31). Children's PA consists of short bursts of intense activities that are interspersed by brief intervals of low or moderate intensity activity (31). Hoos et al. (35) estimated that children (ages 8 – 11 years) spend approximately 19% of their total active time on high intensity activities, such as playing or running outside, and over half of their waking time in low intensity activities, such as playing computer games, even though they change activities and the level of intensity at frequent intervals (31, 35). More recently, Baquet et al. (39) observed that children only spent approximately 10% of their time in activities of moderate intensity or greater and a mere 2.4% of that time was spent in vigorous activity (39).

Moderate-to-vigorous PA has been most commonly observed during school break times and seems to be less prominent during the after-school hours(40) and during physical education (PE) lessons (40-42). Sleap and Warburton (40) have shown that only 31% of children performed a sustained 5 minute bout of MVPA and even fewer participated in a bout sustained for 10 minutes during PE lessons (40), a time when it is assumed that children are achieving substantial amounts of quality exercise. The amount of time allocated to PE in British Columbia for grades 4 and 5 students is on average, 40 minutes three times per week. It is estimated that during each PE session, children is only likely to be aerobically active for 6% of the allotted 30-40 minutes of time (42). The recommendations from the British Columbia Ministry of Education are to spend approximately one half of PE time (15 – 20 minutes) practicing activities that encourage active living and enhance health (43). This evidence suggests that these guidelines are not being met. Despite participating in greater amounts of MVPA during recess than during PE, more than 50% of recess time is spent in activities of light or sedentary intensity (44). Although children participate in more activity during the school day, the total amount of PA during that time period is still unacceptably low. Also somewhat alarming is the finding that PA outside of school hours (40, 45) and on weekends was low (36, 46). Since children spend significantly more time at home than at school this suggests that children will engage in sedentary activities more often unless the stimulus or opportunity to be active is a part of a regimented schedule (40).

Existing data indicates that there may be substantial variation in PA levels in adults and children. Physical activity monitored over the course of a week may be precise but may not represent usual activity (47). In adults, anywhere from two to nine PA measures are recommended throughout the year (depending on the measurement tool) to obtain reliable measures of PA (47). Similarly, in children there is substantial instability in PA levels over a one year period as measured by accelerometry even with 6 or 7 days of wear per collection time (48). Kristensen et al. (36) found that there was a significant variation in activity depending on the day of the week and month of the year PA was measured in 8 to 10 year old children . The greatest amount of intra-individual variation occurred on the weekends. During the winter months (36, 48) or during less pleasant months (49) less activity was accumulated. However, in an environment without marked seasonal variability, seasonality plays a limited role in PA levels and a single measure of PA is sufficient to estimate habitual activity levels (50).

Significant gender differences are common in PA levels. Boys display higher levels of PA than girls of the same age (11, 38, 51) and boys spend significantly more time in vigorous PA than girls (11, 39, 52). Boys also participate in a greater number of longer bouts of higher intensity activity (39). Rowlands et al. (53) suggested that vigorous intensity PA may explain the differences in total activity between genders. Sleap and Warburton (40) found no difference in PA levels between boys and girls aged 5-11 years, however their findings showed that boys primarily played games such as soccer and girls were more likely to participate in games such as dancing, gymnastics and netball.

There is a trend for the total amount of PA to decline in both genders as a function of age whereby girls show a more rapid decrease in levels than boys (37, 38, 46). A decrease in PA of 83% from age 9 or 10 to age 18 or 19 has been reported in girls (54). Part of this decline in PA can be attributed to increased demands being placed on children throughout the education process, specifically with time spent sitting at school and amount of homework given to be completed after school (45). Behavioural research has suggested that girls participate in less PA than boys due to less social support from family members and friends, lower self-efficacy and activity competence scores, and less enjoyment in sporting activities (55-57).

2.1.2 Guidelines for Physical Activity

When assessing PA patterns in children it is important to clearly define what 'being active' is (32) and to understand how PA is accumulated in order to determine compliance with a specific PA guideline (1). Conclusions regarding PA status are heavily dependent on the PA guidelines selected to examine the population of interest (58). There are currently numerous variations of guidelines available and there is currently debate as to which set is optimal for children (52) (see Table 2.1 for a description of the guidelines).

Table 2.1. Description of physical activity guidelines for children.

Source	Guideline	Description
Health Canada & Canadian Society for Exercise Physiology	60 minutes of moderate activity and 30 minutes of vigorous activity each day. Accumulate activity in bouts of 5-10 minutes. Decrease sedentary activity by 90 each day.	Examples of moderate activity are brisk walking and bike riding. Examples of vigorous activity are running or playing soccer.
Healthy People 2010, goal 22.6	30 minutes of moderate activity on 5 or more days of the week. Accumulate in bouts of at least 1 minute.	Activity of an intensity of 3 or more METs.
Healthy People 2010, goal 22.7	20 or more minutes of vigorous activity that promotes the development of cardiorespiratory fitness on at least 3 days of the week	Activity of an intensity of 6 or more METs.
United States	30-60 minutes of accumulated moderate intensity activity per day.	Moderate intensity activity on most or all days of the week.
International Consensus Conference on Physical Activity Guidelines for Adolescents	20 minutes of moderate-to-vigorous activity at least 3 times per week in addition to minimal amount of activity (i.e. 30 minutes of moderate activity)	Daily activity as part of lifestyle activities.
American College of Sports Medicine Opinion Statement	20-30 minutes of vigorous activity per day.	Recreational and fun aspects of activity should be emphasized.
United Kingdom Expert Consensus Group	60 minutes of activity that is at least moderate intensity per day.	Activity of an intensity of 3 or more METs on at least 5 days per week.

The American College of Sports Medicine (ACSM) developed the first formal guidelines for adolescents and children based on adult guidelines. This organization recommended that children achieve 20 – 30 minutes of vigorous exercise each day (59). It is assumed, however, that the PA requirements for optimal health in children are different than those needed by adults (32) because children are less physically developed and typically do not engage in the same types of activity patterns (35). For example, adults are more likely to participate in structured activities such as a 30 minute jog whereas children are more apt to engage in unplanned games throughout the day

(40). Investigations by Sleap and Warburton (40) indicate that only 8-14% of 5 – 11 year-old children regularly participate in aerobic exercise bouts that exceed 10 minutes in duration. In contrast, Armstrong and Welsman (46) determined (using heart rate monitoring) that 89% of boys and 69% of girls beginning school achieved one 10-minute bout of PA over the measurement period of 3 days. Almost all children achieved at least one 5-minute bout. Sustained 20 minute bouts of either moderate or vigorous activity were rare in all age groups (46). According to this evidence, a bout of activity prescribed to children should be no greater than 10 minutes in duration.

Health Canada and the Canadian Society for Exercise Physiology (CSEP) created revised PA guidelines for children and youth in 2002 (9) that address some of the issues present in other guidelines. These guidelines state that children should incorporate an additional 60 minutes of moderate PA and 30 minutes of vigorous PA into their current daily routines. Consistent with current research, they recommend that the PA be accumulated in bouts of 5 – 10 minutes throughout the day. These guidelines also recommend that children decrease their current amount of time spent in sedentary activities by 90 minutes per day. This recommendation is under the assumption that children spend more than 90 minutes per day involved in sedentary activities. These guidelines are based on expert opinion and are in accordance with international guidelines which state that between 3.0 – 5.9 KKD need to be expended daily to be considered active (2).

The wide variation in guidelines used to determine PA levels makes obtaining the prevalence of compliance in children extremely difficult. Furthermore, uncertainty in the accuracy of these measures is increased due to the numerous limitations associated with data acquisition of PA (58). For example, Pate et al. (58) examined the compliance of students (grades 1-12) to three different PA guidelines: Healthy People 2010, Objective 22.7; Healthy People 2010, Objective 22.6; and United Kingdom Expert Consensus Group (refer back to Table 2.1). The percentage of students meeting the specific criteria of the three guidelines were ≤ 3%, 90% and 69.3%, respectively. Using accelerometry, Riddoch et al. (38) found that virtually all 9 year old children meet the United Kingdom Expert Consensus Group PA recommendations and Janz et al. (60) also found that most children were meeting the PA guidelines put out by the International Consensus Conference on Physical Activity for Adolescents. Conversely, Armstrong et al. (52) determined through heart-rate monitoring that many children have adopted the sedentary lifestyle that is associated with a decrease in cardiovascular health and are therefore not participating in acceptable amounts of PA. This clearly demonstrates the confusion in the current literature associated with determining PA levels in children.

2.1.3 Summary

Children's activity is typically intermittent and sporadic in nature between the ages of 5 – 11 years of age (31). It consists of short bursts of intense activity interspersed with intervals of low activity (31) and is quite variable over a 1-year period (36, 48). Children are the most active during school break times (61) however recent evidence indicates that activity during this time is still quite low (44). Boys are consistently more active than girls (38, 51) and with age, there is a decrease in activity levels (37, 38).

There are numerous guidelines available and there is currently debate as to which provide children with the optimal amount of PA for positive health status. It has been recommended that guidelines for children be tailored to their unique PA patterns (32). Determining the prevalence of PA in children is difficult due to the use of various guidelines. Accordingly, the first objective of this investigation was to measure habitual PA and determine the percentage of children meeting the Canadian Physical Activity Guidelines for Children and Youth. These guidelines are currently the only ones available that are tailored specifically to the intermittent activity patterns in children. We hypothesize that the majority of children will not meet these guidelines.

2.2 Ethnicity, Physical Activity and Physical Fitness

Various reports indicate differences in unfavourable health behaviours between ethnic groups (16, 34). This illustrates the need to obtain measures of PA and fitness in a group of multicultural children. It is also important to identify vulnerable groups at higher risk of developing chronic health complications for both personal and public benefits. In Vancouver there is a large population of Asian individuals however, the literature describing the difference in PA levels and health-related physical fitness between Asian and Caucasian children is sparse. Available data demonstrate a less-favourable health profile in Asian children compared to the Caucasian children (19, 62).

This section will examine the existing literature and compare PA and fitness between Caucasian and Asian children.

2.2.1 Ethnic Differences in Physical Activity

Data describing differences in PA between Caucasian and Asian ethnic groups of all ages residing within the same city are limited and reports are conflicting. Information obtained from the Canadian Community Health Survey (2000/01 and 2003) on adults indicated that the prevalence of PA was lowest in South and West Asian groups and highest in Caucasian groups. South Asian groups are include East Indian, Pakistani, and Sri Lankan, while West Asian groups are includef Afghan and Iranian (16).

Differences in PA between ethnic groups in youth have been detected but are not consistent across studies. In a Vancouver-based investigation, MacKelvie and colleagues (17) reported that 9 – 10 year old Caucasian females participated in significantly more loaded PA (defined as activity with a higher impact than walking) and considerably more extracurricular sporting activities than age-matched Asian girls. Data from the National Longitudinal Study of Adolescent Health in the United States showed that a substantial number of Asian females (n = 922, grades 7 -12) accumulated less than two 20-minute sessions of MVPA per week (34). Conversely, McKay et al. (18) found no difference in PA between Asian and Caucasian girls living in the same geographical location.

Information from the National Longitudinal Study of Adolescent Health indicated that in adolescents boys (n = 6701, grades 7 -12) the difference in PA between ethnic groups was present but small (63). MacKelvie et al. (64) reported no difference in PA between Asian and Caucasian boys. However, in an earlier study conducted in Vancouver, significant differences in PA were found. Asian boys were 15% less active than Caucasian peers (18).

Despite discrepancies between studies, there is a trend for Caucasian children to participate in more PA than age-matched Asian children. Since the investigations in children utilized questionnaires requiring activity recall, it is possible that PA is not accurately measured. With a less subjective and more sensitive instrument to measure PA, a more clearly defined trend may emerge in both boys and girls. Furthermore, ethnic differences in PA have been reported to persist into adulthood (65) suggesting that in Canada, the low levels of PA will continue throughout the lifespan unless interventions are implemented. This highlights the importance of further examining the ethnic differences in PA.

2.2.2 Ethnic Differences in Health-Related Physical Fitness

Limited research has been conducted on the components of health-related physical fitness (musculoskeletal and cardiorespiratory fitness) and how they differ between Asian and Caucasian children living in the same geographical location. In the United Kingdom, lower levels of physical fitness in Asian as compared to Anglo-Saxon children have been observed (66). Children of Indian (South Asian) background achieved lower scores than children of other ethnicities in the cardiorespiratory test (power output against load at 85% of the maximum heart rate) utilized in the study (19). In previous investigations from our study group, it was documented that Caucasian children completed more laps in the 20 m Leger shuttle run test, indicating higher aerobic fitness, than Asian children (67). No differences in weight status or vascular health between ethnicities were reported, however, the latter study demonstrated a less favourable cardiovascular health profile, as measured by heart rate variability, in the Asian children (67). The trends were the same for boys and girls in both investigations.

2.2.3 Summary

There is a trend for Caucasian children to participate in greater amounts of PA than age-and-sex-matched Asian peers. In Britain and Canada, Asian children are less aerobically fit than Caucasian children. However, for the most part, no studies have looked at the difference in musculoskeletal fitness between Caucasian and Asian children. In a multicultural city such as Vancouver, these observations warrant further investigation. Accordingly, the second objective of this study was to examine ethnic differences in PA levels and health-related physical fitness. We hypothesize that Caucasian children will have higher PA levels and will achieve higher health-related physical fitness scores than Asian children.

2.3 Physical Activity in Relation to Health-Related Physical Fitness

Physical activity and health-related physical fitness are independent indicators of health status. In children, PA and components of health-related fitness have only a weak to moderate relationship (7). This is attributed to the difficulty in obtaining measurements in children, the variable nature of children's PA, normal growth and development, and the effect of social, cultural, and environmental factors. There is keen interest in establishing this relationship because research suggests that if PA and fitness are established in childhood, the active children will become active adults and benefit from positive health outcomes (25). The following section reviews the current literature describing the relationships between PA and components of health-related physical fitness.

2.3.1 Physical Activity and Weight Status

Body mass index (BMI) and waist circumference (WC) are both well-established predictors of CVD risk factors amoung children. Body mass index is thought to be a good indicator of overall adiposity whereas WC is an indicator of visceral adipose tissue (68, 69). Evidence in adults indicates that WC can predict health risk beyond that predicted by BMI alone (69). In adults, risk for CVD increases in a graded fashion with a move from one BMI category to the next BMI category. Within each BMI category, those with a high WC have a less favourable cardiovascular profile than those with a normal WC (70). Even though preliminary research in children has demonstrated patterns similar to those of adults, the added variance above that predicted by BMI alone or WC alone was minimal and of no clinical significance (69) . In this investigation, BMI and WC were first used to predict risk factors for coronary artery disease (blood lipids, glucose, and insulin levels) in children (n = 2597, ages 5 – 18 years). In the second analysis children were stratified according to weight status and risk factors were compared for groups with low and high WC values (69).

Weight status also remains stable over time. Indicators of obesity and adipose tissue distribution (BMI, WC, Sum of 5 Skinfolds) remained relatively constant across a seven-year time span in the Canadian population (14). In a four year study in Texas the strongest predictor of BMI at the end of the study was BMI at the beginning of the study (71). This data implies that the risk factors associated with adiposity will also track from childhood into adulthood and therefore, will predict adult CVD outcomes (72). Thus, it is imperative to target children with preventative strategies and intervention initiatives to reduce the incidence of adult obesity and cardiovascular complications (73).

With the use of more objective PA measures, there is an increasing amount of evidence demonstrating that body composition, assessed either by BMI or percentage fat, is inversely correlated with habitual PA. Children in the top tertile of PA have statistically significantly lower BMI scores and lower percentage body fat than children in the lowest tertile of PA (20, 22, 27, 74) (see Table 2.2).

In an international comparison of overweight and PA in children, it was observed that the likelihood of being overweight was significantly lower in a dose-response relationship with higher PA levels as measured by self-report (74). Similar evidence was discovered in a cross-sectional investigation between objectively measured PA and obesity measured as fat mass (assessed by dual x-ray absorptiometry) and BMI (75). There is a trend for children who spend the most time engaged in MVPA to have healthier body composition profiles than those children who spend the least amount of time participating in MVPA (22, 76). Dencker and colleagues (77) reported that it was time spent specifically in vigorous activity and not moderate activity that was linked to low obesity status. The relation between body composition and PA levels are generally not gender specific, with both boys and girls demonstrating the same trends. A few studies have detected gender differences in this relationship but it is not consistent between studies (22, 27, 78). Girls typically carry more fat than boys and are also typically less active (27).

Table 2.2. Description of investigations examining the relationship of PA and weight status. PA=physical activity, HR=heart rate, BMI=body mass index

Author (Year)	Subjects	Measurement Tools	Results
Raitakari et al. (1997)	N = 2358 Boys = 1114, Girls = 1244 Age: 9-24 years	Height, weight, subscapular skinfold, PA questionnaire.	Higher PA levels were associated with lower BMI in males and skinfolds in males and females.
Rowlands et al. (1999)	N = 34 Boys = 17, Girls = 17 Ages: 8.3–10.8 years	Height, weight, skinfolds, Tritrac RT3 accelerometer, pedometer (worn 6 days), HR telemetry (worn 1 day).	PA measures from the Tritrac and pedometer had significant inverse correlations with fatness.
Ekelund et al. (2001)	N = 82 Boys = 42, Girls = 40 Age: 14.8 years	Height, weight, skinfolds, HR monitoring (3 days) converted to total energy expenditure.	No significant relationships between PA variables and body fat.
Abbott & Davies (2004)	N = 47 Boys = 23, Girls = 24 Age: 5-10.5 years	Height, weight, ^{18}O dilution space (body fat), doubly –labelled water (10 day urine collection), Tritrac R3D (worn for 4 days).	PA was significantly inversely correlated with percentage body fat and BMI.
Janssen et al. (2005)	N = 137593 No gender differenentiation Age: 10-16 years	Self-report questionnaire to obtain height, weight, PA.	Significant inverse relationship between PA and BMI classification in 29/34 countries.
Dencker et al. (2006)	N = 248 Boys = 126, Girls = 101 Age: 8.6-11.0 years	Height, weight, dual energy x-ray absorptiometry, Actigraph accelerometer (worn 4 days).	Children with higher percentage body fat were significantly less active. Only vigorous PA was linked to obesity status.

2.3.2 Physical Activity and Vascular Status

Epidemiological studies have demonstrated that physically inactive adults have higher blood pressure (BP) than their physically active counterparts and have an increased risk of developing hypertension (30). Since hypertension is a primary risk factor for CVD, the diagnosis, treatment, and prevention of high BP is important (79). Wareham et al. (30) suggests that low habitual energy expenditure (PA) is closely related to increasing BP and that it would only take a 30 minute walk most days of the week to achieve a significant drop in systolic blood pressure (SBP) values in the adult population. Over a seven-year span in the Canadian population the best predictor of BP at the end of the seven years was the baseline BP measure (79). In females, PA levels were also a significant predictor of follow-up BP (79). Interventions aimed at increasing PA levels (and consequently decreasing the prevalence of CVD risk in children) have the potential to result in long-term health benefits.

In the Cardiovascular Risk in Young Finns Study, there were no differences in systolic or diastolic blood pressure between active and inactive children (14) which would suggest that PA has little effect on vascular health in children or that the detrimental effects of an inactive lifestyle on the vascular system are not advanced enough to be detected by measures of BP in children. Other investigations have also found that daily PA in youth was not related to either SBP or diastolic blood pressure (DBP) (23, 24) or the associations found were weak (80). Some studies have noted a lower BP in the more active children. When body fat was accounted for in these studies, the relationship disappeared (12). Studies examining changes in BP, both SBP and DBP, measures over time are equivocal with some detecting a secular increase and others reporting a decrease in children (81). A difference has been detected between genders with boys having a slightly higher SBP than girls of the same age (82).

2.3.3 Physical Activity and Musculoskeletal Fitness

High levels of musculoskeletal fitness in adults are associated with positive health status (83) and are also related to independence, and functional performance in elderly individuals (3, 83). In Japanese men poor muscular fitness was associated with an increased risk of mortality (84) and in work by Katzmarzyk and Craig (85), an increased risk of all-cause mortality was found in men and women in the lower quartile for sit-up performance. Handgrip, another indicator of musculoskeletal fitness, is also a significant predictor of mortality in adult men (86). Although current evidence states that musculoskeletal fitness is protective against CVD risks and complications, more research is required to clarify the distinct relationships between the various measures of musculoskeletal fitness and the health-related benefits they provide. Recent data suggests that increasing musculoskeletal fitness may help to prevent unhealthy weight gain in the Canadian population (87). The relationship between musculoskeletal fitness and PA is inconsistent in children and has not been researched extensively. A few studies have demonstrated a significant but weak-to-moderate relationship between PA and various measures of musculoskeletal fitness (25, 26). Longitudinal studies of adolescents demonstrate a positive influence of habitual PA on upper body muscular endurance (88).

In children, grades 4 to 6, it was found that tracking for sit-and-reach and pull-ups was high, and for sit-ups was moderate over a three year time period (89). In the Canadian population, there is moderate-to-high stability of sit-ups, grip strength, and sit-and-reach over a seven-year time frame (84). This study suggested that musculoskeletal fitness tracks better than PA levels and that the stability increases in adulthood. There are however, consistent decreases throughout the years in all measures of musculoskeletal fitness indicators beginning at approximately the mid-teens to early 20's (84).

2.3.4 Physical Activity and Cardiorespiratory Fitness

Evidence supporting the importance of childhood physical fitness and PA as protective against health-related complications is becoming increasingly prevalent (60). Cardiorespiratory fitness and PA are thought to be important determinants of CVD risk in youth (14). Since both cardiorespiratory fitness and PA track at moderate levels across the lifespan (7) early measurement and prevention is imperative to increase PA and fitness in later years (60). It is already established that low cardiorespiratory fitness in adults is a strong predictor of CVD and all-cause mortality (3). Fortunately, even when CVD risk factors are present in men, high levels of cardiorespiratory fitness offer some degree of protection against premature mortality (7).

In cross-sectional and longitudinal studies and in studies of large sample size ($n \geq 186$) it has been demonstrated consistently that more active youth perform better in cardiovascular endurance tasks (7, 27, 90). Recent studies of varying sample sizes have been more consistent in detecting a significant relationship between aerobic fitness and PA in children when objective measurement tools were utilized. This relationship becomes stronger when aerobic fitness is related to time spent in vigorous PA as opposed to all time spent in PA (29, 91), but this also is not consistent across studies (28). The relationship between aerobic fitness and PA levels was found to be similar between genders (27, 29, 60, 92) despite boys attaining higher aerobic fitness scores and PA levels than girls (see Table 2.3).

2.3.5 Summary

In children, there is increasing evidence of a positive relationship between weight status and PA (21, 22), and cardiorespiratory fitness and PA (26, 29). To date, there is no evidence of a relationship between vascular health and PA (12) and the relationship between musculoskeletal fitness and PA is weak to moderate at best (25, 26). These trends are generally similar in both genders. Measurement of both PA and fitness components are difficult in children and may partially explain why stronger relationships have not been detected. As such, the third objective of this investigation is to determine the relationship between PA and health-related physical fitness using an objective PA measurement tool. We hypothesize that children that participate in more MVPA per day will have higher health-related physical fitness scores.

Table 2.3. Description of investigations examining the relationship between PA and cardiorespiratory fitness. EE=energy expenditure, TEE=total daily energy expenditure, AEE=activity energy expenditure, PWC150=physical working capacity at a heart rate of 150bpm, HR=heart rate.

Author (Year)	Subjects	Measurement Tools	Results
Dencker et al. (2006)	N = 477 Boys = 140, Girls = 108 Age: 8-11 years	BMI, self-evaluated Tanner Stage, MTI model 7164 accelerometer (worn 4 days), indirect measurement VO_{2peak} on cycle ergometer.	A weak but significant relationship between VO_{2peak} and mean daily PA. The correlation between VO_{2peak} and vigorous PA was stronger.
Rowlands et al. (1999)	N = 34 Boys = 17, Girls = 17 Age: 8.3-10.8 years	Height, weight, skinfolds, Trirac Rt3 accelerometer, pedometer (worn 6 days), HR telemetry (worn 1 day), endurance time on Bruce Maximal Protocol Test.	Output measures from Tritrac and pedometer were significantly and positively correlated with aerobic fitness. HR had a weaker correlation to fitness.
Ekelund et al. (2001)	N = 82 Boys = 42, Girls = 40 Age: 14.8 years	Height, weight, skinfolds, HR monitoring (3 days) converted to TEE, indirect measures of VO_{2peak} on treatmill, maturity.	VO_{2peak} was significantly and positively related to AEE.
Pate et al. (1990)	N = 1558 Boys = 776, Girls = 782 Grades: 3-4	2 questionnaires, 1 completed by teacher and 1 by parent (PA), skinfolds, 1.6km run/walk time test.	PA and physical fitness were significantly and positively associated.

2.4 Motor Performance in Childhood

Throughout middle childhood and adolescence, differences exist between genders and age groups in motor performance (93), which affects the ability of the children to participate in PA and perform the health-related fitness tasks. Thus, the relationship between habitual PA and fitness may be confounded by changes associated with normal growth and maturation (25). Cross-sectional data has indicated that more active boys have better levels of motor performance (94). Performance steadily improves in boys until 17 or 18 years of age and in girls, performance plateaus at 14 years of age (95). Until age 14, girls' performance is on average within one standard deviation of boys' performance. Excess body fat negatively affects motor performance, especially when movement of the entire body is required. However, the bigger child is typically the stronger child (93). This section examines the development of the components of health-related physical fitness throughout childhood and adolescence.

2.4.1 Muscular Strength and Endurance

Strength increases linearly with chronological age and follows a growth pattern that is similar to the growth spurt pattern that occurs in adolescence (96, 97). There are sex differences in the development of strength (95, 97), with boys demonstrating greater strength than girls (93) and having greater gains in performance (98). For example, grip strength in males increases by over 300% from ages 7 to 17 years (99) whereas grip strength in females increases by approximately 260% (100). This difference in strength is not substantial until after approximately 13 years of age (97). Sex differences may be due in part to the greater size and fat-free mass advantage of boys. In addition, boys tend to demonstrate greater strength per unit of muscle area than girls (93).

Increases in muscular endurance are similar to those in strength and occur until around age 17 in boys and age 13-15 in girls as measured by the flexed arm hang (98) and sit-up test (101). Performance in boys exceeded that of girls in both tests (98). In the flexed arm hang boys improved by 143% from ages 5 to 10 whereas girls improved only 97% during the same time span (98).

2.4.2 Cardiorespiratory Fitness

Maximal oxygen consumption, a measure of aerobic endurance, improves until the late teens (102), however when reported relative to body weight values remain stable in boys from 8 to 18 years at around 48 – 50 $ml \cdot kg^{-1} \cdot min^{-1}$ but decline in girls from 45 – 35 $ml \cdot kg^{-1} \cdot min^{-1}$ (102). Between the ages of 10 – 12 years, boys' values are approximately 12% higher than girls. More specific to performance tests of aerobic endurance, running speed increases linearly from 5 years until 17 years in boys and 11 or 12 years in girls with only a slight change thereafter (93). After 9 years of age males have better running scores than females. In tests of maximal oxygen consumption and running speed, the performance difference between males and females becomes magnified during adolescence (93).

2.4.3 Flexibility

In males, flexibility as measured by the sit-and-reach test, declines after age 8 until approximately age 12 after which it increases until age 18. In females, flexibility increases to age 14 years (93). The differential increase in flexibility in boys and girls at ages 13 and 11 respectively, parallels their respective growth spurts in trunk length (98). Overall, males experience a net loss in flexibility whereas females experience a slight increase to age 14 or 15 (98). Females are more flexible than males at all ages (93, 98).

2.4.4 Summary

Motor performance may affect the ability of children to perform PA and components of the health-related physical fitness tests, thereby confounding the relationship between PA and fitness. Boys outperform girls on most tasks, excluding flexibility, and this difference becomes magnified throughout adolescence. Performance in girls typically plateaus around ages 12 to 14 whereas boys continue to improve until age 17 or 18.

More research is needed to provide a clear and definitive relationship between PA levels in children and measures of health-related physical fitness. As well, research specifically aimed at examining the difference in PA patterns and health-related fitness variables within ethnic groups are in need because there is the potential for genetic susceptibility to cardiovascular risk factors in some populations. Motor performance affects the ability of children to participate in and perform various physical tasks and therefore is an important consideration when examining these relationships in children.

2.5 Assessing Physical Activity

Objective measures of PA need to be obtained from children in order to correctly assess their current level of PA and its relationship to measures of health-related physical fitness. Assessing PA in children is more challenging than in adults due to the unique developmental and behavioural aspects of children. A study by Bailey et al. (31) found that while observing children 95% of the vigorous activities lasted less than 15s and 95% of the rest periods were less than 15s. From this data the author deduced that short, intermittent bouts of vigorous activity with frequent rest periods of longer duration are typical of children. Similarly, Baquet et al. (39) determined that 80% of the MPA bouts and over 93% of the VPA bouts in children lasted less than 10s. Although there are many instruments available for PA measurement, few are able to capture children's activity accurately. The following section describes methods available for monitoring PA and reviews the strengths and limitations of each.

2.5.1 Self-Report

Questionnaires and surveys have traditionally been used to measure PA levels and although these methods appear to be acceptable to use in adult studies, their accuracy with respect to children is highly questionable (103). It has been documented that children less than 12 years of age are not able to recall activities accurately or quantify the time-frame of activity (104). This is because children have less developed cognitive skills and therefore are less able to effectively use self-report questionnaires. Vigorous PA is generally overestimated using self-report methods due to a child's exaggerated perception of time and/or effort and the difficulty in correctly capturing sporadic bouts of activity (32, 105). However, PA of moderate intensity can be achieved through many daily activities which are not typically thought to contribute to PA, are non-planned, less memorable and quantifiable, and therefore more likely to be underestimated by self-report methods utilized with children (15, 38).

2.5.2 Direct Observation

Direct observation of PA has distinct advantages over other methods of assessing PA with the most significant one being the high resolution at which PA is recorded. Trained observers have the ability to measure the duration, intensity, and frequency of specific activities in a variety of environments and are also able to capture sporadic or short bouts of activity (31). This method allows for comprehensive information to be gathered about the subject's PA patterns. The limitations of this technique are that it requires a substantial amount of time for adequate staff training and data collection (31) and is therefore costly (46). In addition, subject reactivity may be problematic due to the presence of a trained observer (46). The observation technique is not feasible in large investigations due to time constrictions. Also, studies utilizing direct observation as the method of assessing PA are less than 12 hours in duration (21). This eliminates the possibility of looking at habitual PA patterns and temporal or seasonal variations.

2.5.3 Heart Rate Monitoring

Heart rate (HR) monitoring has been accepted as a valid and reliable measure of PA but it is an indirect measure that indicates the relative stress placed on the cardiovascular system (106). It is based on the assumption of a linear relationship between HR and oxygen consumption. Heart rate data is strongly related to energy expenditure, can be utilized in large studies and can collect data in small time intervals over a relatively long time period (32, 51). This linear relationship between HR and oxygen consumption allows intensity of activity to be determined. Unfortunately this relationship is no longer linear at high intensities of activity and is therefore less accurate during vigorous activity. Another downfall of this method is that HR is sensitive to emotional stress, environmental stress, and body position. As well, since HR response tends to lag behind changes in physical movement, the rapid transitions between intensity of movement in children may be masked (51, 105).

2.5.4 Pedometers

Pedometers provide an objective measure of total step counts over a given period but most do not have the ability to look at frequency or intensity of PA, time stamp the step counts (32) or store data for extended periods (107). Newer models are time-stamped, thus overcoming some of the previous limitations. They are not able to record counts during cycling or increases in energy expenditure due to increased load or movement up an incline (46). They are also known to underestimate vigorous intensity PA (53) and are relatively easy to tamper with. They are however, inexpensive, re-usable and non-reactive tools suitable for use in large-scale investigations (108).

2.5.5 Indirect Calorimetry

Under controlled laboratory conditions indirect calorimetry is used to determine energy expenditure associated with resting metabolic rate, the thermic effect of food, and the thermic effect of exercise (32). More recently, portable, lightweight metabolic systems have been introduced. They can be used under free-living conditions but this is still too cumbersome to be undertaken with children (46) and is not a feasible option in a large scale study. A major limitation of this technique is its inability to examine the specifics of PA patterns (32).

2.5.6 Doubly-Labeled Water

Doubly-labeled water is considered to be the gold standard measurement of energy expenditure or PA in free-living situations (46). Doubly-labeled water gives a direct measure of carbon dioxide production and disappearance rates of the isotopes in the urine, blood, or saliva (4). This yields estimates of energy expenditure, taking the thermic effect of food into consideration. It is based on the difference in rates of turnover of hydrogen and oxygen in body water (4). It is non-invasive and can measure activity over a period of 1 - 2 weeks (32) and has low reactivity (46) but is also expensive (32). An important consideration is that energy expenditure is a physiological consequence of PA and the two are distinct constructs so it cannot directly measure PA (46). Using this method it is impossible to determine specific PA patterns (32, 46).

2.5.7 Accelerometry

To accurately assess children's activity patterns, the instrument must be sensitive enough to detect, code, or record sporadic and intermittent activity (32, 109). The accelerometer is a unique and useful piece of technology that is able to capture and store activity patterns in small time intervals over an extended period of time. This device is also small and unobtrusive, (110) permitting participant freedom of movement. The accelerometer is able to measure the intensity of body or body segment accelerations through some form of piezoelectric or piezoresistive acceleration sensor technology (1). The sensor consists of a piezoelectric element and a seismic mass. When the sensor undergoes acceleration the seismic mass causes the piezoelectric element to bend and a voltage signal that is proportional to the applied acceleration is emitted (4). Recorded accelerations are converted to a quantifiable digital signal referred to as a 'count' (46). Frequency-filtering techniques are incorporated into the units to exclude accelerations unlikely to be generated by human movement (1).

The accelerometer is able to measure important health-related dimensions of PA such as frequency, duration, and intensity of movement, and provide a chronological recording of these components (103). A downfall of this device is that not all activity is reflected in acceleration and deceleration such as upper body movements, movement up an incline, and cycling (32, 110). Despite these limitations the accelerometer has been found to be a valid tool to use when measuring PA in children (103, 111) because the most common activities participated in by children are locomotor in nature (such as soccer, brisk walking, and general play or chasing games) (40).

2.5.8 Summary

Numerous tools are available to assess PA, each associated with specific limitations and strengths. The accelerometer appears to be an ideal measurement tool to use for assessment of children in field studies due to its ability to capture sporadic activity in short time intervals over extended time periods.

A robust and accurate PA measurement tool, such as the accelerometer, is required to obtain a thorough understanding of the unique PA patterns observed between ethnic groups and to examine the relationship between PA and various components of health-related physical fitness in children.

CHAPTER III

Methodology

3.1 Participants

Participants were a sub-sample of the 1459 involved in the AS! BC initiative and included a multi-cultural group of 579 boys (n = 284) and girls (n = 295) in grades four to five (ages 8 to 11) from schools (n = 9) in the Greater Vancouver Region. Of these children, 36 students were absent on the day the activity monitors were distributed, 11 technical errors occurred with the devices, seven children moved between the time of consent and data collection, and one child refused to wear the device. From this group, 106 of the children wore the monitor during a week in which a Professional Development Day occurred. Initial examination of the data suggested that the Professional Development Day altered the PA profile and therefore these children were removed from the analysis. One school (n = 44) wore the monitors over a different time period (Friday to Tuesday) due to technical difficulties. As a result the children had only one full weekday of wear and thus, were also removed from the analysis. Children (n = 12) with less than 3.5 days wore the monitor for an average of two hours less per day and were also removed. In the remaining group of children, only those that wore the monitor during the average 'on' and 'off' times were retained for analysis. One of these children was removed due to physiologically unlikely BP data (143/128), two participants had BP readings that exceeded 120/80, three children had no data for the health-related physical fitness measures, and 17 children were of ethnic groups other than Caucasian or Asian. One-hundred seventy participants (n = 79 boys and n = 91 girls) from five schools were retained for the final analysis. Written informed consent was obtained from the parents and/or local guardians of the children. The investigation was carried out according to the ethical guidelines set by the University Clinical Research Ethics Board for research involving human participants (see Appendix A for ethics forms).

3.1.1 General Participant Characteristics

Birth-date, gender and ethnicity were provided by the parents and/or guardians on the Health History Questionnaire (see Appendix B). Children's ethnicity was determined, for example, as being North American and/or European if both parents or all four grandparents were born in North America or Europe. If the ethnicity data provided on the questionnaire was not clear or was incomplete the child was asked to classify their parents and grandparents birthplace to determine ethnicity. If the information was still incomplete, any child that had, for example, both parents or all four grandparents born in Canada (and/or Europe) the child was considered 'North American/European'. For the purposes of this investigation, children were classified as: 1) Caucasian (European decent), 2) Asian (South, East and Southeast) or 3) other. Only children in the first two classifications were used in the analysis because the sample lacked sufficient participants from other ethnic groups.

3.2 Cardiovascular Disease Risk Assessments

3.2.1 Anthropometry

Height (cm) was measured to the nearest 1 mm with a portable stadiometer. Weight (kg) was recorded to the nearest 0.1 kg on an electronic scale (SECA Germany). Shoes were removed for both of these measures. Two measurements of height and weight were averaged for analysis. BMI (kg/m^2) was calculated from these measures. Classifications of our participant's weight to height status was defined by internationally established values (112). Waist circumference was taken midway between the iliac crest and the bottom of the ribcage with an anthropometric tape (113). This measure was taken over top of a light shirt. Two measurements were taken and averaged for analysis.

3.2.2 Vascular Health

Participants had their BP taken using an automatic sphygmomanometer (left arm). Resting heart rate was obtained simultaneously. Systolic and diastolic BP (mmHg) and resting HR (bpm) measurements were used in these analyses. Children with resting BP above the 95^{th} percentile (120/80) were excluded from further testing.

3.2.3 Musculoskeletal Fitness

The musculoskeletal fitness component of this investigation was comprised of grip strength, push-ups, curl-ups and sit-and-reach. The assessment protocols are modified versions of those developed by CSEP (114). For a detailed description of testing instructions refer to Appendix C. Children were asked to complete as many push-ups and curl-ups as possible. Maximum grip strength was determined by summing the maximum score from the greater of two trials of the right and left hand. Sit-and-reach scores were determined by the maximum distance reached over two trials. Maximum grip strength (kg) and sit-and-reach (cm) scores were used in these analyses.

3.2.4 Cardiovascular Fitness

Cardiovascular fitness was measured via the shuttle run which has been found to be reliable in children (115). For the Leger shuttle run, the children were required to run back and forth between a 20 m distance and touch the 20 m line simultaneously with a sound signal that emitted from a prerecorded tape. The starting speed is 8.5 km/hr and is increased by 0.5 km/hr every minute. The test was completed when the child was not able to maintain the set pace. The total number of laps performed by each child was recorded and further used in the analysis. The shuttle run permitted as many as 15 - 20 children to run simultaneously.

3.2.5 Physical Activity

Physical activity was measured objectively for 5 days using the GT1M Activity Monitor. It is designed to ascertain normal human movement without impeding activity (103) and has been shown to provide valid and reliable estimates of childhood PA (71). The GT1M is small and compact weighing 27 g and has dimensions of 3.8 x 3.7 x 1.8 cm. It is equipped with 1 Megabyte of non-volatile flash memory and a rechargeable 3.7 V Lithium Ion battery. It is designed to detect acceleration signals ranging in magnitude from 0.05 to 2.00 *g* with a frequency response of 0.25 – 2.50 Hz. This frequency is able to detect normal human motion and reject motion from other sources such as riding in a vehicle. Each sample is summed over a user-specified epoch (116). For this investigation the epoch was set at 15 seconds and provided both acceleration and step-counts. A short epoch was chosen in order to capture the short bouts of higher intensity activity performed by children.

The activity monitor was attached to an elastic belt and worn at the waist above the iliac crest. Participants were asked to wear the monitors for 5 consecutive days (3 weekdays and 2 weekend days) for 12 consecutive hours each day (8 am-8 pm was the suggested time interval) as this is within the four to seven day recommended time frame for obtaining a reliable estimate of habitual PA (r = 0.80) (117). The children were instructed to remove the monitors at night and while swimming, bathing, or showering.

The GT1M Activity Monitor measured the duration, frequency, and intensity of PA which was assessed throughout the weekday and weekend days. Specifically for this project, the outcome variables used were: 1) average counts per day, 2) average counts per minute, 3) average MVPA accumulated per day, 4) average MVPA accumulated per weekday, 5) average MVPA accumulated per weekend day, 6) average sporadic MVPA accumulated per day, 7) average minutes of MVPA accumulated in bouts of 5 minutes or more, and 8) MVPA accumulated throughout the school day. Age-specific cut points were obtained from Trost et al., (118) who performed a rigorous calibration study on children of similar age with indirect calorimetry as the criterion measure. Since these cut points were established using 1 minute epochs, the values were divided by 4 for use with the shorter epoch length utilized in this investigation (see Table 3.1 for cut-points and classification of PA).

Table 3.1. Age-specific classification of physical activity intensity by METs and counts (per 15 seconds). Cut-points obtained from Trost et al. (118).

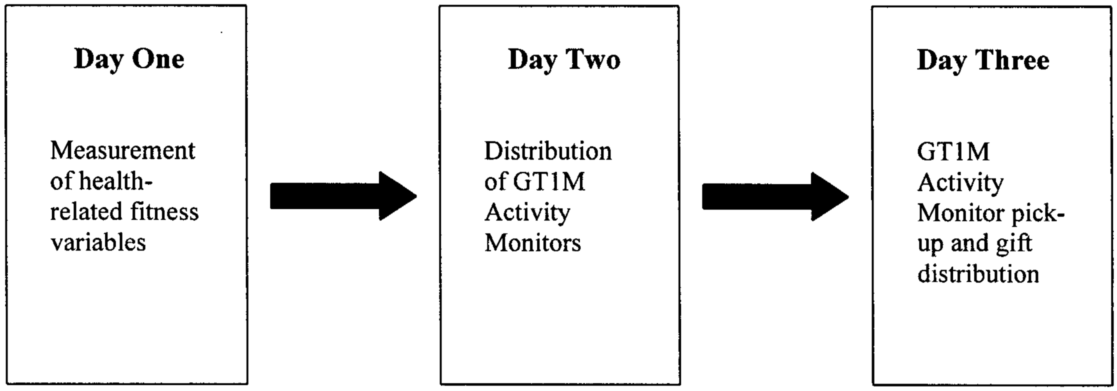
Intensity	METs	Counts (8 yrs)	Counts (9 yrs)	Counts (10 yrs)	Counts (11 yrs)
Sedentary	<1.5	0-49	0-56	0-62	0-70
Light	1.5-2.99	50-200	57-226	63-254	71-283
Moderate	3-5.99	201-827	227-874	255-293	284-976
MVPA	3+	201-32767	227-32767	255-32767	284-32767
Vigorous	≥6	828-32767	875-32767	924-32767	977-32767

3.3 Procedure

Participants were evaluated over a one week period. A trained research team of approximately three to four AS! BC investigators conducted anthropometry, vascular health, musculoskeletal fitness and cardiovascular fitness measures. For each day of measurements, children were temporarily excused from their classrooms in groups of 10 to 15 at a time. Testing took place in the gymnasium of the school. Day 1 consisted of measurements of anthropometry, vascular health, musculoskeletal fitness, and cardiovascular fitness (see Figure 3.1). Day 2 involved the distribution of GT1M Activity

Monitors to all of the participating children in the school. Day 7 consisted of monitor pickup and gift distribution to the children who returned the monitors

Figure 3.1. Schematic of testing procedure.

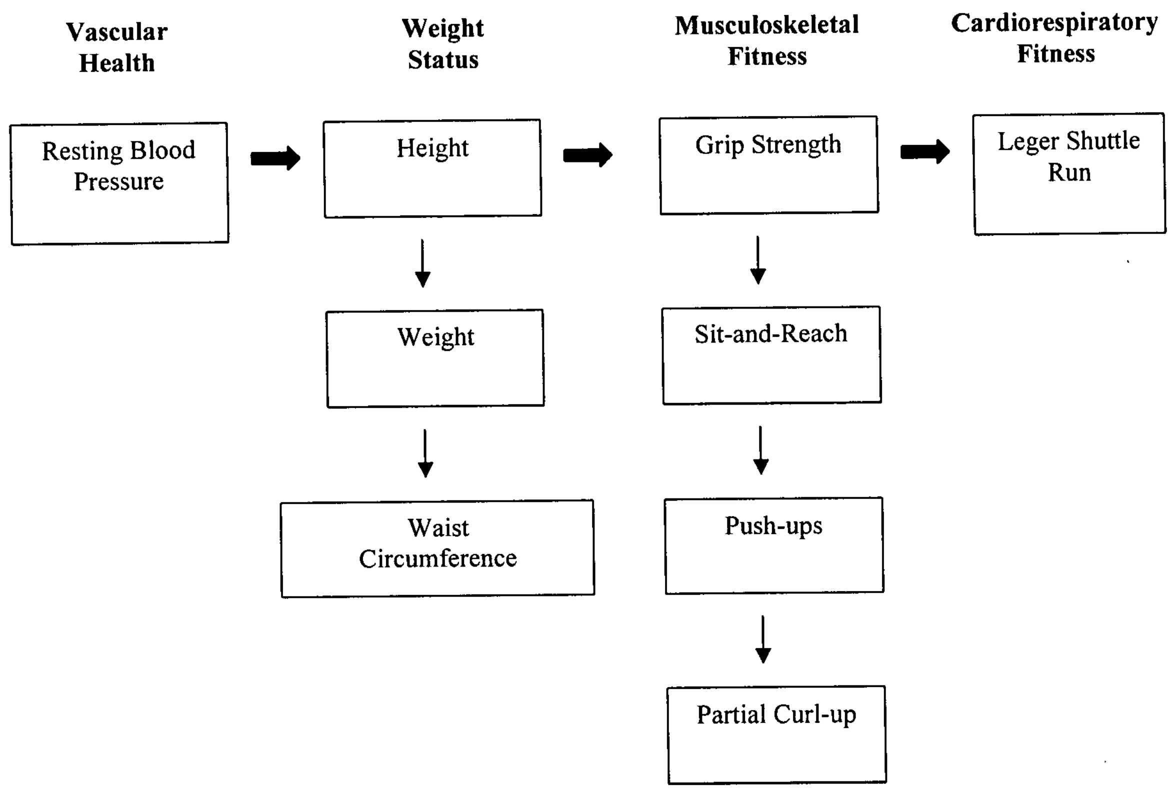


3.3.1 Day 1: Weight Status, Vascular Health and Health-Related Physical Fitness Measures

The first day of assessments comprised of anthropometry, vascular health, musculoskeletal fitness and cardiorespiratory fitness measurements (see Figure 3.2). Measurements of weight and WC are potentially sensitive issues with some children. To help alleviate any emotional anxiety children may experience during these measurements, each child had his or her weight status taken individually to ensure privacy.

Vascular health measurements were taken prior to physical testing. Musculoskeletal testing (i.e., grip strength, push-ups, curl-ups and sit-and-reach) was conducted next, followed by the shuttle run. It is important that the shuttle run be completed last because it requires maximal physical exertion and the fatigue the children experience after it is completed may negatively affect the musculoskeletal tests. These tests took approximately one hour.

Figure 3.2 Day 1: Schematic outlining the testing procedure.



3.3.2 Day 2: Activity Monitor Distribution

Day Two always occurred on a Wednesday. On this day schools were entered in the morning and up to 75 students were fitted with monitors. Each classroom of students that participated in the study was given a detailed talk instructing them as to how and when the monitors needed to be worn. Then each child was individually fitted with a monitor and given an information package for their parent(s)/guardian(s). This took approximately 30 minutes per classroom.

Parents/guardians were provided with an information letter and contacted by phone on the evening that their child was fitted with a monitor to provide an opportunity for clarifications to be made about the purpose and desired outcome of the study and for general questions (see Appendix E for information letter). The parents were also asked to complete a log which indicated the time the monitor was placed on the child in the morning and the time it was removed in the evening, the times (if any) that the monitor was removed during the day, as well as any unusual circumstances in which the child's regular routine was significantly affected (i.e., illness, weather) (see Appendix F for log).

3.3.3 Day 7: Activity Monitor Pick-Up

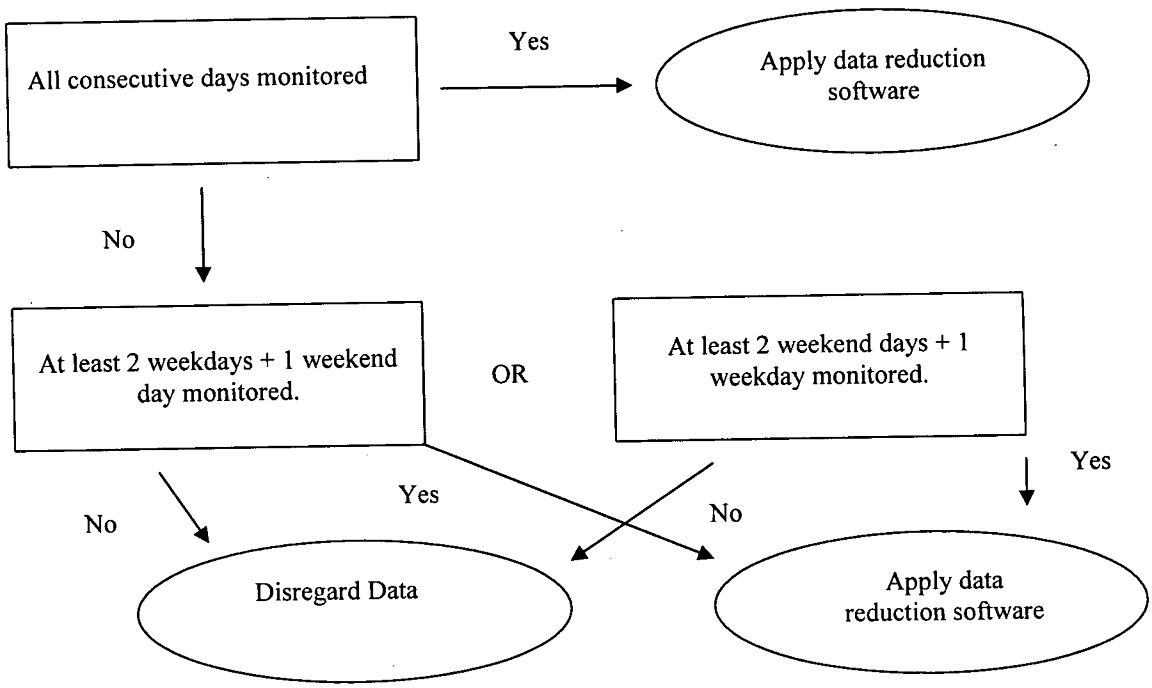
Monitors were returned to researchers the following Monday morning at the school. In exchange for returning the monitor the students were given a small gift and had their name entered into a draw for a larger prize.

3.3.4 Physical Activity Data Reduction

After each week of data collection, the data were immediately downloaded to a laboratory computer. Data were then scanned for spurious measures, malfunctioning units, and compliance with wear guidelines. Monitor on (time the child put the monitor on in the morning) and off (time the child removed the monitor before bed) times were determined using both the log sheets and a visual inspection of the file. In the case where the information on the log sheet did not match the data in the file or the log sheet was not returned, the objective information in the file was used. Only 13% of the participants (54.5% girls and 45.4% boys) with usable PA data did not return the log sheet. The participants were required to wear the monitor for at least 3 days of wear to be valid for analysis (see Figure 3.1) and initially it was decided that 8 hours would constitute a full day of wear (45). However, due to the large variability in the number of hours of wear (the range was 8 – 17 hrs) and hours of the day the monitor was worn, a day was considered valid if it fell within ± 2 standard deviations (SD) of the average 'on' and 'off' time for that day. The average on and off times for each day were calculated to determine the new hours of acceptable wear (see Appendix D for average wear hours per day). If a child wore the monitor too long (i.e., the monitor was put on before the average on time or removed after the average off time) the extra wear time was excluded from the analysis so that all children were wearing the monitor during the same time frame

If files met the criteria for analysis, the data were subjected to custom software designed to optimize and standardize the production of PA outcome variables. This software allows the user to specify cut-points, time periods of interest to be examined, and fractionalizations of PA for further statistical analyses.

Figure 3.3. Decision tree for data reduction.



3.3.5 Statistical Analysis

Means and standard deviations (SDs) were calculated for all outcome variables. All variables were tested for normal distribution (i.e., skewness or kurtosis) and were transformed when necessary. Bivariate correlations were used to determine the relationships between all variables. Analysis of Variance (ANOVA) was chosen to determine if there were any differences in weight status, vascular or health-related physical fitness between the children who had acceptable PA data and those that did not.

T-tests were used to determine if gender differences existed between variables. Analysis of Covariance (ANCOVA) was used to investigate the association between ethnic groups (Caucasian and Asian) and average MVPA per day, counts per minute, and health-related physical fitness scores. The PA outcome variables were chosen to compare an index of the amount and intensity of activity. Previous literature has demonstrated that boys and girls are not a homogenous group (11, 27, 38, 52); therefore, ANCOVAs were performed separately for boys and girls. The covariates were chosen based on their known or observed relationship to PA in children. Factors that may affect the relationship of PA to health-related physical fitness and cardiovascular health in children are: 1) weight (an increase in weight has been related to decreased PA (22, 27, 74)), 2) height (52), and 3) age (as age increases PA decreases (37, 38, 52)).

A musculoskeletal fitness composite score was created using Principal Component Analysis. Variables were transformed into z-scores before being subjected to principal component analysis to standardize units. The first principal component of the musculoskeletal fitness scores (sit-and-reach, curl-ups, push-ups, grip strength) was retained for further analysis. The first principal component explained 39% of the variance in the original variables. The correlations between the original variables and the first principal component are reported as factor loadings representing their percentage contribution to the overall score. The factor loadings were 0.380 (sit-and-reach), 0.762 (curl-ups), 0.678 (push-ups), and 0.612 (grip strength). Push-ups, curl-ups and grip strength contributed significantly to the overall score with sit-and-reach contributing very little. From the factor loadings, a total musculoskeletal fitness score is derived using the following formula (sit-and-reach * 0.380) + (curl-ups * 0.762) + (pushups * 0.678) + (grip strength * 0.612). This score is used to compare musculoskeletal fitness between the ethnic groups and to determine the relationship between PA and musculoskeletal fitness. Initially, analyses were carried out separately for boys and girls, however, since the factor loading was within 0.1 for all components, the components contributed similarly to the overall score and there was approximately only a 1% difference in explained variance between boys and girls, the groups were collapsed into one to create the composite score.

Hierarchical regression was used to estimate the contribution of ethnicity and PA to health-related physical fitness components. Variables were entered in the following order: 1) age, height, weight (control variables), 2) ethnicity (independent variable), 3) counts per minute (independent variable), 4) MVPA per day (independent variable). The order of variable input into the regression analysis was determined through established relationships between age, weight, height (maturity) and the health-related physical fitness components. Ethnicity was entered as the second step in the model and the PA outcome variables was entered last to examine the unique relationship between PA and fitness without the influence of the previous variables.

Intraclass correlation (ICC) was calculated to examine the magnitude of variation between schools. A 1-way ANOVA was run to obtain the sum of squares for between school differences and within school differences for total laps run in the Leger shuttle run, the musculoskeletal fitness score, average counts per minute and average MVPA per day. The calculation of ICC for each variable was as follows:

$$= \frac{\text{Sum of squares for between school differences}}{\text{(Sum of squares for between school + within school differences)}}$$

Data were analyzed using SPSS statistical software, Windows Version 14.0. Significance was set at $p< 0.05$ for all statistical analyses.

CHAPTER IV

Results

4.1 General Subject Characteristics

Descriptive variables for boys and girls that remained in the final analysis are summarized in Table 4.1. Of the 170 children used in the analyses, 17.6% were classified as overweight (56.7% boys and 66.7% Asian) and 3.5% were classified as obese (50% boys and 66.7% Asian) using age and sex-specific cut-off values (119).

Table 4.1. Means and SDs of participant characteristics.
Body Mass Index=BMI, SBP=systolic blood pressure, DBP=diastolic blood pressure, MSK Score=musculoskeletal fitness score.

	N	Boys	N	Girls
Age (years)	79	10.0 ± 0.6	91	10.0 ± 0.6
Height (cm)	79	141.3 ± 7.6	91	141.2 ± 7.5
Weight (kg)	79	36.6 ± 8.0	91	35.3 ± 7.7
BMI (kg/m^2)	79	18.2 ± 2.8	91	17.6 ± 2.6
SBP (mmHg)	77	98.2 ± 7.0	91	96.9 ± 9.1
DBP (mmHg)	77	63.1 ± 7.1	91	62.0 ± 8.9
Heart Rate (bpm)	76	87.2 ± 10.9	89	87.7 ± 12.7
Total Laps	79	25.1 ± 14.8	91	21.3 ± 11.6
MSK Score	79	-.0434 ± 1.4677	91	-.0336 ± 1.8757

There were significant correlations between weight status, the musculoskeletal fitness score, total laps run (Leger shuttle run test) and PA outcome variables (see Table 4.2). There were no significant correlations between vascular health and PA or weight status and PA.

Data were examined for normal distribution and tests to detect skewness or kurtosis were completed. Minutes per day of bouted activity, total laps and BMI were negatively skewed and therefore log transformed. The curl-up and push-up data demonstrated a one-sided distribution and underwent reciprocal transformation.

Table 4.2. Significant correlations between anthropometric, fitness and physical activity variables. (**) denotes p < 0.001, (*) denotes p < 0.05
MSK Score=musculoskeletal composite score, CPM=counts per minute, MVPA=moderate-to-vigorous physical activity

	Height	Weight	Age	MSK Score	Total Laps	CPM	MVPA
Height	1	.752	.461**	NS	NS	NS	NS
Weight	.752**	1	.270**	NS	-.192*	NS	NS
Age	.461**	.270**	1	NS	NS	-.177*	-.306**
MSK Score	NS	NS	NS	1	.507**	.171*	.152*
Total Laps	NS	-.192*	NS	.507**	1	.221**	.189*
CPM	NS	NS	-.177*	.171*	.221**	1	.925**
MVPA	NS	NS	-.306**	.152*	.189*	.925**	1

There were no differences observed in weight status, vascular or health-related physical fitness variables between the groups who met the inclusion criteria for PA data and those who did not (in both the girls and the boys). There were 52 boys and 47 girls who did not have valid PA data of which 38% and 57%, respectively, were Caucasian.

There was no significant difference in weight status, vascular or health-related physical fitness between boys and girls.

4.2 Physical Activity Patterns

On average, the monitors were worn for 13.5 ± 1.1 hours per day with boys accumulating 408499.7 ± 106831.0 and girls accumulating 343807.8 ± 106912.8 counts per day (see Table 4.3 for PA outcome variables in boys and girls).

Boys obtained significantly more counts per minute on average than girls ($p < 0.001$), average MVPA per day ($p < 0.001$), average MVPA per weekend ($p < 0.03$) and weekday ($p < 0.001$), and accumulated more bouted minutes of MVPA than girls ($p < 0.001$). There was no significant difference in minutes of sporadic MVPA between the genders. In both genders, significantly more MVPA occurred on the weekdays than on weekend days ($p < 0.001$). One child (Asian male) met Canada's Physical Activity Guidelines for Children and Youth.

Table 4.3. Means and SDs of all PA outcome variables.
Avg=average, MVPA=moderate-to-vigorous physical activity, PE=physical education.

	Boys (N = 79)	Girls (N = 91)
Avg Hours of Wear Per Day	13.5 ± 1.12	13.4 ± 1.1
Avg Counts Per Day	408499.7 ± 106831.0	343807.8 ± 106912.8
Avg Counts Per Minute	503.6 ± 122.7	429.8 ± 140.7
Avg Minutes of MVPA Per Day	133.9 ± 33.9	113.5 ± 35.9
Avg Minutes of MVPA Per Weekday	149.0 ± 37.4	124.6 ± 40.4
Avg Minutes of MVPA Per Weekend Day	112.7 ± 45.0	98.4 ± 43.9
Avg Minutes of Sporadic MVPA Per Day	104.7 ± 24.0	98.0 ± 27.8
Avg Minutes of Bouted MVPA Per Day	29.2 ± 20.9	15.5 ± 12.5
Total Minutes of School Day MVPA	65.1 ± 21.0	52.4 ± 17.5
Total Minutes of Recess MVPA	5.1 ± 4.3	3.4 ± 3.1
Total Minutes of Lunchtime MVPA	16.5 ± 7.4	12.6 ± 5.2
Total Minutes of PE MVPA	5.3 ± 6.2	6.5 ± 7.1

In boys, 26.7% of morning recess (5.1 ± 4.3 minutes) was spent in MVPA, 35.4% of lunch hour (16.5 ± 7.4 minutes), and only 13.1% of PE (5.3 ± 6.2 minutes). Girls accumulated MVPA for 18.3% of recess time (3.4 ± 3.1 minutes), 27.1% of lunch hour (12.6 ± 5.2 minutes) and 16.0% of PE (6.5 ± 7.1 minutes) in MVPA. Total minutes of MVPA during the school day accounted for 24.6% (65.1 ± 21.0 minutes) and 20.8% (52.4 ± 17.5 minutes) of the total school day in boys and girls, respectively.

4.3 Ethnic Differences in Physical Activity and Health-Related Physical Fitness

Caucasian girls ran significantly more laps than Asian girls in the Leger shuttle run ($p < 0.01$), had significantly higher counts per minute ($p < 0.001$), and average minutes of MVPA per day ($p < 0.001$). There was no significant ethnic difference in the musculoskeletal fitness score for girls.

Caucasian boys ran significantly more laps than Asian boys in the Leger shuttle run ($p < 0.01$), had significantly higher counts per minute ($p < 0.03$) and achieved significantly higher scores on the musculoskeletal fitness score ($p < 0.01$). There were no significant ethnic differences in the average minutes of MVPA per day in boys.

Initially, the difference in each individual component of musculoskeletal fitness was examined between ethnic groups. Due to the large variation in scores between both male and female ethnic groups, the homogeneity of variance tests were not met for push-ups and sit-and-reach in girls and curl-ups and grip strength in boys (see Appendix J).

4.4 Regression Analysis

The variance in health-related physical fitness (total laps run and the musculoskeletal fitness score were examined separately) explained by PA (average counts per minute and MVPA per day) was examined by entering the following independent variables sequentially into a hierarchical regression: 1) age, height, weight, 2) ethnicity, 3) counts per minute and, 4) MVPA per day. Results are presented in Tables 4.4 – 4.5 (girls) and Tables 4.6 – 4.7 (boys). In girls, age, height, and weight accounted for 11.2% of the variance in total laps run in the Leger shuttle run ($p < 0.01$), with ethnicity contributing another 8.3% ($p < 0.03$). Neither counts per minute or MVPA per day contributed significantly to the model. None of the independent variables significantly predicted the musculoskeletal composite score in girls.

In boys, age, height, and weight accounted for 19.7% of the variance in total laps run ($p < 0.001$) and ethnicity accounted for 7.8% more ($p < 0.01$). Neither counts per minute or MVPA per day significantly contributed to the model. Ethnicity was the only independent variable that significantly contributed to the prediction (8.4%) of the musculoskeletal composite score ($p < 0.01$).

Two other composite scores were created to: 1) examine the relationship between the combination of musculoskeletal fitness components and total laps run to PA and 2) examine the relationship of a composite score of all health-related physical fitness components and PA (see Appendix J). The correlation between both of these fitness scores and PA was lower than the individual components of health-related physical fitness and PA and the correlation between PA and the musculoskeletal composite score reported. The factor loadings of the individual components within the final score can explain this. For example, in the composite score that included all health-related physical fitness components, BMI and WC had the highest factor loadings. Body mass index and WC had very weak and non-significant correlations to PA. When these more heavily-weighted components were added to the rest of the scores, the components (such as total laps) that were more highly correlated to PA became diluted.

Forward stepwise regression was also used to examine the relationship between PA and health-related physical fitness. The same independent variables that were entered into the hierarchical regression (height, weight, age, ethnicity, MVPA per day and counts per minute) were entered simultaneously into the stepwise equation. In girls, weight and ethnicity significantly predicted fitness and in boys, height, weight, and ethnicity predicted fitness (see Appendix J).

4.5 Intraclass Correlation

Intraclass correlations were as follows: 0.27, 0.07, 0.07, and 0.07 for total laps run, musculoskeletal composite score, average counts per minute and average MVPA per day, respectively.

Table 4.4. Results of hierarchical multiple regression model for cardiorespiratory fitness (total laps run in the Leger Shuttle Run test) in Asian and Caucasian girls. CPM=counts per minute, MVPA=moderate-to-vigorous physical activity.

Fitness	Variable in Model	Standardized Beta	Unstandardized Beta	Adjusted R^2	R^2 Change
Total Laps Run	Height ($p < 0.02$)	.349	.025	0.112	0.141
	Weight ($p < 0.002$)	-.461	-.033	0.112	0.141
	Age ($p < 0.03$)	-.258	-.234	0.112	0.141
	Ethnicity ($p < 0.03$)	-.250	-.275	0.189	0.083
	CPM ($p < 0.28$)	.369	.001	0.179	0.000
	MVPA ($p < 0.28$)	-.358	-.005	0.181	0.011

Table 4.5. Results of hierarchical multiple regression model for musculoskeletal fitness in Asian and Caucasian boys.
CPM=counts per minute, MVPA=moderate-to-vigorous physical activity.

Fitness	Variable in Model	Standardized Beta	Unstandardized Beta	Adjusted R^2	R^2 Change
Musculoskeletal Score	Height ($p < 0.26$)	.189	.044	-0.008	0.025
	Weight ($p < 0.85$)	-.030	-.007	-0.008	0.025
	Age ($p < 0.99$)	.001	.003	-0.008	0.025
	Ethnicity ($p < 0.37$)	-.105	-.368	0.014	0.033
	CPM ($p < 0.96$)	-.016	.000	0.045	0.040
	MVPA ($p < 0.46$)	.259	.013	0.040	0.006

Table 4.6. Results of hierarchical multiple regression model for cardiorespiratory fitness (total laps run in the Leger Shuttle Run test) in Asian and Caucasian boys. CPM=counts per minute, MVPA=moderate-to-vigorous physical activity.

Fitness	**Variable in Model**	**Standardized Beta**	**Unstandardized Beta**	**Adjusted R^2**	**R^2 Change**
Total Laps Run	Height ($p < 0.01$)	.459	.036	0.164	0.197
	Weight ($p < 0.001$)	-.614	-.045	0.164	0.197
	Age ($p < 0.64$)	-.055	-.053	0.164	0.197
	Ethnicity ($p < 0.01$)	-.274	-.322	0.235	0.078
	CPM ($p < 0.78$)	-.069	-.001	0.233	0.008
	MVPA ($p < 0.45$)	.187	.003	0.229	0.006

Table 4.7. Results of hierarchical multiple regression model for musculoskeletal fitness (composite score) in Asian and Caucasian boys.
CPM=counts per minute, MVPA=moderate-to-vigorous physical activity.

Fitness	**Variable in Model**	**Standardized Beta**	**Unstandardized Beta**	**Adjusted R^2**	**R^2 Change**
Musculoskeletal Score	Height ($p < 0.06$)	.362	.071	0.048	0.084
	Weight ($p < 0.16$)	-.248	-.046	0.048	0.084
	Age ($p < 0.23$)	-.151	-.370	0.048	0.084
	Ethnicity ($p < 0.004$)	-.340	-1.008	0.123	0.084
	CPM ($p < 0.40$)	-.225	-.003	0.129	0.017
	MVPA ($p < 0.74$)	.089	.004	0.118	0.001

CHAPTER V

Discussion

5.1 Physical Activity Patterns in Children

5.1.1 General Physical Activity Patterns

The general trends in our data are consistent with published literature (40, 120). In boys, almost 80% of average MVPA per day is spent in sporadic activity and in girls almost 90%, illustrating the highly transitory nature of children's PA. Similar to our results, Sleap and Warburton (40) and Epstein and colleagues (51) reported that children accumulated approximately two hours per day of MVPA, however very little of this time was spent in sustained bouts of activity. Significantly more activity occurred throughout the weekdays as compared to the weekend days. In boys, approximately 150 minutes of MVPA per day were achieved on the weekday compared to 115 minutes on the weekend day. The average accumulated amount of MVPA per day on the weekdays was 125 minutes in girls compared to 100 minutes on the weekend.

Recommendations from British Columbia and the United States mandate that 50% of PE time should be dedicated to active time (43, 121). Stratton and Mullen (122) extended these recommendations with the suggestion that recess time should also consist of 50% active time. We found that total minutes of MVPA during the school day accounted for 24.6% and 20.8% of the total school day in boys and girls, respectively. In boys, 26.7% of morning recess was spent in MVPA and in girls, 18.3%. During lunch hour (which includes both a lunch and recess time) boys spent 34.5% of the time in MVPA and girls spent 27.1%. During PE girls accrued MVPA for 13.1% of class and boys 16.0%. The boys are recording a similar number of minutes of MVPA during recess and PE despite PE being twice the length of recess. This indicates that boys participate in greater amounts of PA during free play times as opposed to structured class time dedicated to PA. Our data shows that children in Vancouver are not meeting the recommendations for activity participation during either PE or recess times. In the U.K., percentage time observed in MVPA at recess was 32.9% in boys and 25.3% in girls (44). These percentages are higher than our observations but still far from achieving the guidelines. These results become even more alarming considering that it is during these school break times when MVPA has been most commonly seen in children (40).

Schools in California report that 40% of a 30 minute PE class is dedicated to MVPA (123), and although this is still below recommended levels, it is much higher than that reported in British Columbia. We found that 13% (boys) and 16% (girls) of the allotted PE time was spent in MVPA whereas Parcel et al. (42) estimated that children were aerobically active for 6% of PE time. Using pedometers to assess PA, it was found that the steps accumulated during PE accounted for 8 and 11% of total steps per day in boys and girls, respectively (124).

It is clear that PE class is not providing sufficient opportunity for PA and insufficient PA is occurring during recess. Recent research has shown that children who were least active during the school day were also the least active after school hours and on the weekend days (61). This information highlights the necessity of school-based interventions to supplement regular school day activity and to provide children with the skills to be more active throughout the whole day.

5.1.2 Gender Differences in Physical Activity and Health-Related Physical Fitness

We found that boys participated in significantly more MVPA per day and on average, had higher counts per minute (indicating more time spent in PA of higher intensity) than girls. Gender differences in PA have been fairly well-established with boys displaying higher levels of PA than girls of the same age (11, 34, 36, 38, 51) and boys spending significantly more time in vigorous PA than girls (11, 39, 52). Evidence has also shown that boys participate in a greater number of longer bouts of higher intensity activity than girls (39). Specifically in this investigation, boys accumulated double the amount of bouted MVPA minutes than did girls. Rowlands et al. (53) suggested that vigorous intensity PA may explain the differences in activity that occurs between genders. In addition, our results also imply that time spent in bouted MVPA also accounts for the disparity between boys and girls since we found no significant difference between average minutes of sporadic MVPA per day. This information suggests that boys may be more likely than girls to participate in structured, planned PA at high intensities.

Boys generally perform better in cardiorespiratory fitness tests (26, 27, 60, 125) and in musculoskeletal fitness tests (26, 98) than age-matched girls. Although our observations were not found to be significant, there was a trend for boys to complete more laps in the shuttle run test. Our group previously reported no significant differences in cardiovascular fitness between boys and girls in a similar group of participants (67). The results of other studies may not be directly comparable to the present study due to differences in cardiorespiratory and musculoskeletal tests and participant characteristics.

5.1.3 Physical Activity Guidelines

Our data from Vancouver is even more alarming than that reported in the 2007 Report Card on Physical Activity for Children & Youth. They found that only 9% of Canadian children met the guidelines while in our study, only one child met the guidelines of 90 minutes of MVPA per day. Despite boys participating in approximately 134 minutes and girls accumulating 114 minutes of MVPA per day, only 30 and 15 minutes of average MVPA per day in boys and girls, respectively was accumulated in activities lasting 5 or more minutes in duration. In other words, boys on average are only accumulating one third of the amount recommended and girls, one sixth.

In a study of similarly-aged children, Andersen et al. (15) reported more positive data, indicating that the top three most active quintiles of children in the U.K. were achieving over 90 minutes of activity per day in durations of 5 to 10 minutes. Children in the lowest quintile of PA were still accumulating more activity in sustained periods than the children in the present study. Results are not directly comparable due to the difference in cut-points and epoch lengths used between studies. Andersen et al. (15) used a threshold of 2000 cpm from a 1-minute epoch to define MVPA whereas we used age-specific cut-points developed by Trost and colleagues (118). An investigation in Sweden demonstrated the effects on accumulated activity associated with using different epoch lengths. Epoch lengths of 5, 10, 20, 40 and 60 seconds were used and minutes spent in 10-minute bouts were compared. No 10-minute periods of continuous activity were recorded in the 5 and 10-second bouts however, almost 3 bouts were recorded using the 1-minute epoch (126). This difference is quite dramatic and suggests that with the short epoch that was chosen for this study, bouted activity is not as likely to be observed. Furthermore, the magnitude of the epoch effect is amplified in the most highly active children (126) since the 1-minute epoch is known to dilute the children's vigorous intensity (38).

In addition to varying epoch lengths and cut-points, there is no consistency in the interpretation of results from studies determining children's compliance with PA guidelines depending on whether assessments are based on intermittent, accumulated or sustained durations of activity. Methods of PA data acquisition and reduction are highly variable (and the latter is rarely reported) and can have significant effects on the data. In many studies, actual minutes of PA and criteria for qualifying data as acceptable are not published. Finally, guidelines used to assess children's activity level differ between studies (refer back to Table 2.1). Combined, these limitations in make comparisons between studies reporting PA difficult.

Since sporadic activity is typical in children of this age (31) and constitutes such a large percentage of total MVPA time, it is extremely valuable information. Short epochs were used for the collection of the PA data to ensure that the intermittent and short bouts of activity were captured (see Appendix I) . In addition, we utilized accelerometry to measure PA so the data obtained is objective and is both date and time-stamped. We are confident that our data provides an accurate representation of physical activity patterns in the population examined. To determine activity intensity, we used age-specific cut-points developed by a group of influential researchers in the field of accelerometry (118). An investigation comparing the utility of three commonly used cut-points in children documented that these specific cut-points are able to accurately categorize activity into the correct intensity categories (127). In addition, our group analyzed the PA data with custom designed software which allowed us to examine the PA patterns in great detail. For example, we were able to determine the number of MVPA minutes that occurred during each segment of the school day and we were able to fractionalize the MVPA minutes to determine the amount that occurred in bouts. Furthermore, decisions regarding inclusion and exclusion criteria were based on the average day of a child in our study. The average 'on' and 'off' times were calculated for each day and only those children who wore the monitor within those hours were retained in the analysis. Although this decreased our sample size, it also eliminated bias that might occur with variable wear hours. The 'on' and 'off' times that were used to determine valid days are normal wear hours for the children and were not arbitrarily chosen. Thus, the data presented is representing what occurs in an average day for the children. Finally, we examined PA compliance using the only guidelines available that consider the specific characteristics of PA in children. These guidelines are based on expert opinion.

The available data suggesting that children are not meeting the physical activity guidelines support our first hypothesis. Additional reports showing that children are not meeting activity recommendations within the school day provides clear evidence that children are not acquiring enough PA.

5.2 Ethnicity, Physical Activity and Physical Fitness

5.2.1 Ethnic Differences in Physical Activity

We found that Caucasian girls accumulate greater amounts of higher intensity activity (as indicated by the average counts per minute) than Asian girls and participated in significantly more MVPA per day. In a study of 10 year-old Asian and Caucasian girls in Vancouver, Caucasian girls engaged in almost double the number of extracurricular or sport activities and double the amount of loaded activity (defined as activity that has a greater impact than walking) than the Asian girls. The difference in general activity, assessed by the Physical Activity Questionnaire for Children, was only slight (17). Investigations based in the United States also showed Asians participating in less vigorous intensity exercise than Anglo-Saxon individuals (128) and achieving lower scores on PA questionnaires (62). Gordon-Larsen et al. (34) discovered that almost 50% of the Asian girls in their study engaged in 2 or less bouts of MVPA per week. Of the 3 ethnic groups examined, the non-Hispanic white females were most likely to participate in MVPA and the Asian girls were least likely to participate in MVPA. Only one study from the Vancouver region did not exhibit a significant difference in PA between the Asian and Caucasian girls (18).

Results from this investigation indicate that Asian boys participate in less high intensity activity than Caucasian boys. The data indicating that there is no difference in total amounts of accumulated MVPA per day between Asian and Caucasian boys is consistent with data presented by MacKelvie et al. (64) who found, using the Physical Activity Questionnaire for Children, that there was no significant difference in PA between 10 year - old Asian and Caucasian boys in Vancouver. In addition, information from the National Longitudinal Study of Adolescent Health in the United States reported that in adolescent boys, there was minimal difference in PA (as measured by self-report) between Asian boys and boys of other ethnicities (34). Evidence from McKay et al. (18) Vancouver-based study demonstrated that Caucasian boys were significantly more active than their Asian peers and approximately five times as many Caucasian boys participated in extracurricular sport activities (18).

Reasons for these disparities could stem from the methods utilized to obtain estimates of PA. In our investigation, PA data was measured objectively using accelerometry whereas self-report questionnaires were used in the other studies. The benefits of accelerometry are demonstrated in our results. In boys we found a difference in the intensity of activity between ethnic groups in the absence of a difference in MVPA per day. The accelerometer detects acceleration of the body and provides a direct measure of PA intensity in counts. It is therefore better able to capture high intensity activity in comparison to measures of self-report which were used in the other investigations. This eliminates some of the limitations and bias associated with self-report and may be the reason a difference was detected. It is possible that the activity levels of the Asian children in our study were underestimated based on MacKelvie et al. (17) who reported that in general, Asian girls living in Vancouver more commonly participate in swimming lessons than other sports. The accelerometer is not waterproof and therefore is not able to be worn for water-based activities. Despite this, the difference in PA was very highly significant ($p < 0.001$) indicating that very high amounts of swimming would need to be accumulated to account for the difference in PA.

Other factors that may contribute to why Asian children are less active than Caucasian children have been considered within the literature. Psychology research suggests that Asian children (both male and female) perceive a lack of control over engaging in PA and therefore are less likely to participate in PA (129). This lack of control may be due to factors such as being required to allot a greater amount of time to academic endeavors (129). For example, Asian children are twice as likely as Caucasian children to spend time in academic lessons (i.e., music lessons, mathematics, etc.) after school as opposed to sporting activities (18). Specifically in girls, culture may consider strenuous activity to be unacceptable and activity is therefore not encouraged (62). Social factors, such as parental support or level of activity of the parent(s) may also influence PA behaviours in children (130). Positive associations between parental encouragement of PA and children's immediate activity have consistently been shown (131, 132). Statistics Canada reported that Asian men and women in Canada also accumulate lower levels of PA than Caucasian men and women (16), thus there is the potential for this to influence the level of MVPA in Asian children.

5.2.2 Ethnic Differences in Health-Related Physical Fitness

Limited research has been conducted on the components of health-related physical fitness and how those differ between Asian and Caucasian children living in the same geographical location. In the U.K., lower levels of physical fitness in Asian as compared to Anglo-Saxon children have been reported (66). More specifically, in Britain, one third of children of Indian (South Asian) background were unable to complete the cardiorespiratory test (power output against load at 85% of the maximum heart rate) utilized in the study. Moreover, those that did complete the test achieved lower scores than children of other ethnicities (19). This trend was the same for both genders. Although we found that Asian girls completed significantly fewer laps in the Leger shuttle run test than Caucasian girls we found no difference in the musculoskeletal fitness score between ethnicities in girls. In boys, there was a significant difference with the Caucasian boys completing more laps and achieving higher musculoskeletal fitness scores than Asian boys. Our data supports previous research from our group demonstrating lower cardiorespiratory fitness in Asian boys and girls (67).

Significant correlations between PA, (average counts per minute), and total laps run in the Leger shuttle run ($r = 0.230$, $p < 0.001$) suggest that those children who participate in higher intensity activity are more likely to obtain a higher score in the Leger shuttle run. Activity at high intensity is thought to contribute more to healthy levels of cardiorespiratory fitness than lower levels of activity (133). In both the boys and girls, those of Caucasian ethnicity had significantly greater counts per minute than children of Asian ethnicity. In prepubertal children, differences in fitness levels can be partially explained by differences in PA (92). Consequently, this may be one underlying reason why Caucasian children performed better in the shuttle run test. Other possible reasons for the difference in cardiorespiratory fitness between ethnic groups are the same as some of those outlined previously as being reasons for the difference in PA. Asian children are more likely to spend free time engaging in activities with a more academic focus than Caucasian children (18) and cultural norms may discourage participation in vigorous activities which promote physical fitness (62). Furthermore, if

Caucasian children are participating in more organized sport (18), they may be enhancing cardiorespiratory fitness to a greater extent than if they were just being regularly active on their own.

The musculoskeletal fitness score was significantly higher in Caucasian boys than Asian boys. The same reasons that Caucasian boys completed more laps in the shuttle run than Asian boys could explain why Caucasian boys also have a higher musculoskeletal fitness score. The Caucasian girls, despite participating in greater amounts of high intensity activity and total PA, and completing more laps in the Leger shuttle run, did not have a significantly greater musculoskeletal fitness score. Due to a difference in variance between the Caucasian and Asian children (in both boys and girls) some of the individual components of musculoskeletal fitness did not meet the assumption of homogeneity of variance. (see Appendix J for statistics). Therefore, the aggregate score to compare musculoskeletal fitness between ethnic groups was used. The technique that was used weights each of the components based on their relationship to each other and this weighting is used to calculate the final value of the score (refer back to section 3.3.5). It is possible that the use of this composite scoring system masked the individual differences of the various musculoskeletal fitness components between ethnicities in girls. For example, in the formula used, pushups and grip strength were similarly weighted. If the Caucasian girls completed more pushups on average than the Asian girls but there was no difference in average grip strength scores, the difference in pushup scores between ethnicities would be diluted.

The results revealing differences in PA and fitness between Asian and Caucasian children support our second hypothesis. We are confident that the significant differences observed between Asian and Caucasian children were not due to body size or age since differences remained after weight, height, and age were entered as covariates into the ANCOVA. The covariates were chosen based on previous literature or observed relationships in the present dataset. There is a clearly defined relationship between age and PA whereby PA decreases with increasing age (37, 38, 46) and this relationship was detected in the correlations between age and PA variables. Most were significant and negative ($r = -0.160 - (-0.306)$). Height was used as an index of maturity. As individuals mature, PA decreases (52). Finally, a substantial amount of literature has demonstrated that weight is significantly and inversely related to PA (22, 74). Although we found no relationship between weight status and PA, it was still entered based on findings in the literature.

To our knowledge, this is the first study in Canada using accelerometry to compare PA levels between Asian and Caucasian children. It is also the first to examine differences in musculoskeletal fitness between ethnic groups living in the same geographic region. It therefore provides extremely important information regarding fitness and activity in these two diverse groups and will contribute significantly to the limited literature regarding ethnic differences in PA and health-related physical fitness and PA patterning in children.

5.3 Physical Activity and Physical Fitness

5.3.1 Physical Activity and Musculoskeletal Fitness

Investigations relating PA to indicators of musculoskeletal fitness in children report equivocal results (88). Sallis et al. (26) reported that the combination of a physical activity index (multiple measures of PA were taken and combined to create one variable) and gender accounted for 9.1%, 6.7%, and 5.1% of the variance in pull-ups, sit-ups, sit-and-reach scores, respectively in fourth-grade children. In comparison, PA did not significantly predict our aggregate score of musculoskeletal fitness components in either girls or boys. There was little difference in the correlations between the musculoskeletal fitness score and the individual components of musculoskeletal fitness that were significantly related to PA (push-ups was the largest and only musculoskeletal fitness component significantly related to PA) so it is unlikely that the use of the individual components would result in substantial differences to the findings reported. (see Appendix J for statistics). Correlations between the musculoskeletal fitness score and PA in the present study were weak, but significantly related ($r = 0.152 – 0.172$, $p < 0.05$). These relationships are similar to those reported by Katzmarzyk et al. (25) between MVPA (measured by self-report) and individual components of musculoskeletal fitness. One study has also reported no significant relationship between PA and musculoskeletal fitness (assessed as maximal muscle strength of the legs) in children (125).

The fitness variables differ between studies and may represent slightly different domains of musculoskeletal fitness, as did the participants, making direct comparisons difficult and possibly affecting the results. Although measurement of PA was more comprehensive in the investigation by Sallis and colleagues (26) and provided a more holistic picture of the children's PA patterns, the correlations between individual PA components were quite low. The participants in the present investigation were not an ethnically homogenous group and we had less power which could also contribute to the difference.

5.3.2 Physical Activity and Cardiorespiratory Fitness

In contrast to our findings that PA (counts per minute and MVPA per day) did not contribute to the prediction of cardiorespiratory fitness in children, previous research has demonstrated significant findings whereby PA accounts for 10 – 21% of the variance in cardiorespiratory fitness. Dencker and colleagues (29) concluded that the combination of mean daily PA and vigorous PA explained 10% (1% and 9%, respectively) of the variance in VO_{2peak} in a group of 8 to 11 year-old children. Sallis et al. (26) reported that the combination of a physical activity index (multiple measures of PA were taken and combined to create one variable) and gender accounted for 11% of the variance in the mile run test. Pate et al. (134) also used numerous measures of PA combined with age and gender as the independent variables to account for 21% of the variance in the 1.6-km run/walk test.

There are a variety of reasons to explain this difference. None of the studies mentioned entered weight into the regression model. Weight had a weak but significant correlation to total laps run ($r = 0.192$, $p < 0.05$) in the present investigation, significantly contributed to our model ($p < 0.001$ in boys and $p < 0.002$ in girls) and has an established relationship to fitness outcomes in children (125). This information suggests that it may confound the relationship between PA and physical fitness and should be accounted for when explaining the variance between these factors. Participant characteristics also differed; participants of the present study were of two different ethnicities whereas participants of the other studies were a more homogenous group. In the latter study a small percentage of the participants were of different ethnicity than the majority group however, this was not accounted for in the statistical analyses. Ethnicity contributed significantly in the present investigation, accounting for 7.8 – 8.3% of the variance in cardiorespiratory fitness independent of height, weight and age. Different tests of cardiorespiratory fitness were used in the studies however the correlations between MVPA per day and the aerobic fitness tests used were similar between studies. This suggests that the inconsistent results should not be attributed to the measurement tools.

5.3.3 Physical Activity and Physical Fitness

The correlation between the musculoskeletal fitness score and total laps run ($r = 0.507$, $p < 0.001$) is suggestive that the musculoskeletal fitness score may be a better predictor of cardiorespiratory fitness (or vise versa) than measures of PA. (See Appendix J, for statistics). Physical activity is a behaviour (7) and is therefore prone to variation (36) and influence from numerous environmental, cultural (7) and social situations. Levels of PA may be transient and hence, more difficult to relate to a variable or condition at one time period. Physical fitness is a physiological state (7) or attribute (125), making it a more stable entity and less prone to variation and influence from external factors. Physical fitness is thought to develop as a result of prolonged PA. Although fitness does change, measurement at one time point may be more likely to accurately represent the physiological state of an individual. This is indicated by tracking studies which show that physical fitness has higher inter-age correlations and more stability over time than indications of PA (7). Moreover, a recent tracking study in children reported that when sources of variation are controlled, results showed moderate stability of PA (120), thereby demonstrating its more variable nature.

Factors such as biological and behavioural domains of change associated with normal growth and maturation, environmental or cultural settings in which subjects were raised (25), genetics (135), diet, and motivational (26) or psychosocial aspects have also been suggested as contributors to the variance in physical fitness.

5.3.4 Physical Activity and Weight Status

There is an increasing amount of evidence in the literature demonstrating that body composition, assessed either by BMI or percentage fat, is inversely correlated with habitual PA (20, 22, 27, 74). We found no significant relationship between any PA variables and indices of weight status (BMI and WC) and no trends were evident in the data. Prevalence of overweight in this dataset was 6% lower in girls and 12% lower in boys than previously published reports during the pilot phase of this project (136). Thus, there may not have been sufficient numbers of overweight children to detect a difference in PA, especially since the PA data was quite variable. Alternatively, the overweight children in the sample may be as active as normal weight children. In support of our data, one of the major findings in a study by Grund et al. (125) was that there are no differences in PA between normal weight, overweight and obese children.

The measurement tools used should not have contributed to the difference in results between our study and those that did report a significant difference. Indices of weight status used in this investigation (BMI) have been found to be inversely related to PA levels in other cohorts using a variety of tools for PA assessment. It is possible that in this cohort of children, dietary factors may contribute more significantly to the development of overweight in children, or overweight children may be engaging in more PA as a form of weight control (26). Alternatively (or additionally), in overweight or obese individuals, the accelerometer is further from the body's centre of gravity than on a normal weight individual. This results in the accelerometer experiencing greater acceleration for any given movement. It is possible that in the obese children, the accelerometer was recording excessive movement which may contribute to the higher PA.

5.3.5 Physical Activity in Relation to Vascular Health

In normal weight children, PA may have little effect on vascular health as indicated by previous investigations that reported no significant findings (14, 20). When body weight is accounted for, studies that did report lower BP values in more active children found that the relationship disappeared (12). Children with lower PA had greater body fat which was responsible for the high BP values (12). Alternatively, the detrimental effects of an inactive lifestyle on the vascular system may not be advanced enough to be detected by a BP machine. We recently revealed that PA accounts for 6% of the variance in small artery compliance as measured by arterial tonometry (see Appendix G) suggesting that the use of a device more sensitive to blood vessel change may be better able to establish this relationship.

Although the relationships between PA and the components of health-related physical fitness did not support our third hypothesis, our results contribute important information to the existing literature. Various statistical tests were completed to thoroughly examine the data. Within our regression analyses we controlled for factors (height, weight, age and ethnicity) known to contribute to the relationship between PA and physical fitness and we are therefore confident in the data we are reporting. The fitness measures utilized in the present investigation are rigorous, are commonly used in children (115), and provide pertinent information regarding fitness, especially since we utilized a variety of health-related physical fitness tests to obtain a comprehensive profile of the children. As has previously been mentioned in the document, the accelerometer is a sensitive and objective tool that is ideal for PA measurement in children. We did not find PA to be a significant predictor of fitness in children however our results suggest that musculoskeletal fitness may be a stronger predictor of cardiorespiratory fitness than PA.

5.4 Future Directions

This study provides important baseline information for AS! BC to which the effects of the intervention can be compared. Follow-up investigations may provide important evidence regarding the contribution of bouted activity to health outcomes, the implications associated with PA patterning, and between ethnic groups, detect where the difference in activity is occurring. Further exploration of the relationship between musculoskeletal and cardiorespiratory fitness is also warranted.

5.5 Limitations

The method of PA measurement and protocol of obtaining habitual PA data in this investigation is based on the assumption that children's PA habits are relatively constant and that we are able to accurately capture this constant level of PA in only a few days. Due to the immense interest in PA patterning in children, there has recently been substantial research in the numerous sources of natural variation in this behaviour. Kristensen et al. (36, 120) determined several variations that could significantly affect PA levels in 8 to 10 year-olds and Mattocks et al. (48) concluded that intra-individual variation and seasonal variation were substantial. Since we are estimating habitual PA from one time-point, there is the potential for variation error within our data. For example, data collection occurred over the months of early November to early February. In the month of January the city of Vancouver experienced excessive amounts of rain. Previous literature has demonstrated that children are more active during the more pleasant months of the year (36) so during this time period, children may have had lower PA levels than normal. This variation may partially explain why we found no relationship between PA and health-related physical fitness.

The ICC was used to estimate the effects of school on the PA and health outcome measures used in the analysis. For total laps run the ICC was 0.27 suggesting that there was substantial effect of the school. The variation may be due to the school environment or it may indirectly be due to the community the school is in (61). The ICC was low (0.07) for the other components indicating that there was more variation between the participants than between the schools in the data.

5.6 Conclusions

Only one child in the present investigation met the recommendations of Canada's Physical Activity Guidelines for Children. Moreover, children are not meeting activity level recommendations during the school day. Low levels of MVPA suggest that many children in Vancouver may be at risk for poor health due to insufficient PA.

Our results demonstrated that Caucasian children had higher levels of PA and physical fitness than Asian children. Low levels of PA and low fitness levels are important modifiable risk factors for cardiovascular disease risk and are associated with various health complications. The lower levels of PA and fitness in Asian children indicate that this ethnic group may be a vulnerable group at a higher risk for associated cardiovascular and health complications with increasing age.

Physical activity was not a significant predictor of fitness in this cohort of children. Our results suggest that musculoskeletal fitness may be a more powerful predictor of cardiorespiratory fitness (and vise versa).

Combined, these findings suggest that implementation of interventions are warranted to encourage PA participation in children and assist in the prevention of chronic health complications.

Footnotes

1. Raw data is attached in Appendix I.

CHAPTER VI

References

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Action Schools! BC Consent Form for Families

Please read the following with your child, and if you and your child would like to participate please sign the attached form and return the signed form in the stamped, addressed envelope provided. You may keep the other pages for your records.

Procedures. Your child's participation in the Action Schools! BC (AS! BC) Research Study will involve two in-school testing sessions in the Fall and Spring of the next two school years. All children will participate in the Anthropometry and Questionnaire components and a smaller random sample of students will participate in the Cardiovascular Health and Musculoskeletal Fitness component.

1. **Anthropometry:** Measures of height, weight and calf and waist circumference will be taken. Total Time - 10 minutes: Fall and Spring.

2. **Questionnaires:** Your child will be assisted in the completion of questionnaires that will assess their physical activity, nutrition, self-esteem and attitudes and perceptions about physical activity. A trained research assistant will discuss the importance of these assessments with the children. Total Time - 1 hour: Fall, Winter and Spring.

3. **Cardiovascular Health and Musculoskeletal Fitness**: We will evaluate aerobic fitness using a shuttle run in which students repeatedly run 20 meter laps in time with a clearly audible "beep" until they become tired and choose to stop. Musculoskeletal fitness (i.e. muscle strength and power) will be assessed using a hand held dynamometer. A research assistant will provide clear instructions for each procedure to the students. Resting blood pressure and heart rate will be recorded before all fitness procedures. A smaller group of students (25%) will be recruited for this portion of the study.
   Total Time - 45 minutes: Fall and Spring.

Health History Questionnaire:
If you and your child agree to participate in the AS! BC Research Study, you will be asked to complete the attached Health History Questionnaire to determine if there are any health reasons to exclude your child from the research study and to identify any conditions or medications that may affect study outcomes.

Possible Harms:
None.

Consent Form – September 2006

Please fill out both sides of this form and return it in the stamped, addressed envelope provided.
Please keep the other pages for your records.

Parent's Consent Statement:

I/We ____ the
(Please print the name of one or both parents/guardians)

parents/guardians of ______________________________ have received and read all
(Please print child's first and last name)

6 pages of the information letter and consent form and understand the purpose and procedures of the Action Schools! BC Research Study as described.

Please check (✓) one.

___I agree to have my child participate in the 3-year Action Schools! BC Research Study (anthropometry, questionnaires) with the understanding that my child may or may not be randomly selected to participate in the cardiovascular health and musculoskeletal fitness portion of the study.

___ I do not agree to have my child participate in Action Schools! BC Research Study.

I understand that at any time during the 3-year Action Schools! BC Research Study we will be free to withdraw without jeopardizing any medical management, employment or educational opportunities. I understand the contents of all six pages of this form and the proposed procedures. I have had the opportunity to ask questions and have received satisfactory answers to all inquiries regarding this program.

______________________________ ______________________________
Signature of Parent or Guardian Date

____
Printed name of the Parent or Guardian signing above

(Continued on other side)

Child's Statement:

I have talked with my parents/guardians about the Action Schools! BC Program and Research Study and I understand what I will be asked to do. I understand that if I want to I can stop being in the research study at any time and I will still be able to participate in activities at my school. I have had the chance to ask questions and have received satisfactory answers to all of my questions.

____________________________ ____________________________

Signature of Child Date

____

Printed name of child

____________________________ ____________________________

School Name Grade and Division

Action Schools! BC Consent Form for Families

Please read the following with your child, and if you and your child would like to participate please sign the attached form and return the signed form in the stamped, addressed envelope provided. You may keep the other pages for your records.

Procedures. Your child's participation in the Action Schools! BC (AS! BC) Research Study will involve two in-school testing sessions in the Fall and Spring of the next two school years. All children will participate in the Anthropometry and Questionnaire components and a smaller random sample of students will participate in the Cardiovascular Health and Musculoskeletal Fitness and Accelerometer components.

4. **Anthropometry:** Measures of height, weight and calf and waist circumference will be taken. Total Time - 10 minutes: Fall and Spring.

5. **Questionnaires:** Your child will be assisted in the completion of questionnaires that will assess their physical activity, nutrition, self-esteem and attitudes and perceptions about physical activity. A trained research assistant will discuss the importance of these assessments with the children. Total Time – 1 hour: Fall and Spring.

6. **Cardiovascular Health and Musculoskeletal Fitness**: We will evaluate aerobic fitness using a shuttle run in which students repeatedly run 20 meter laps in time with a clearly audible "beep" until they become tired and choose to stop. Musculoskeletal fitness (i.e. muscle strength and power) will be assessed using a hand held dynamometer. A research assistant will provide clear instructions for each procedure to the students. Resting blood pressure and heart rate will be recorded before all fitness procedures. A smaller group of students (25%) will be recruited for this portion of the study. Total Time - 45 minutes: Fall and Spring.

7. **Accelerometers**: We will monitor children's physical activity with accelerometers. Children will wear the accelerometer (on a belt around their waist) from the time they get up until the time they go to bed (approximately 12 hours) for 5 consecutive days. A research assistant will provide clear instructions for how to wear the accelerometer. A small group of students (25%) who participate in the cardiovascular component (item 3 above) will be recruited for this portion of the study. Total time – 45 minutes in the Fall for a session on accelerometer instructions. Accelerometers will be worn for 5 days in the Fall and Spring.

Consent Form – September 2006

Please fill out both sides of this form and return it in the stamped, addressed envelope provided.
Please keep the other pages for your records.

Parent's Consent Statement:

I/We ____ the
(*Please print the name of one or both parents/guardians*)

parents/guardians of ______________________________________have received and read all
(*Please print child's first and last name*)

6 pages of the information letter and consent form and understand the purpose and procedures of the Action Schools! BC Research Study as described.

Please check (✓) one.

___I agree to have my child participate in the 3-year Action Schools! BC Research Study (anthropometry, questionnaires) with the understanding that my child may or may not be randomly selected to participate in the cardiovascular health and musculoskeletal fitness and accelerometer portions of the study.

___ I do not agree to have my child participate in Action Schools! BC Research Study.

I understand that at any time during the 3-year Action Schools! BC Research Study we will be free to withdraw without jeopardizing any medical management, employment or educational opportunities. I understand the contents of all six pages of this form and the proposed procedures. I have had the opportunity to ask questions and have received satisfactory answers to all inquiries regarding this program.

______________________________ ______________________________
Signature of Parent or Guardian Date

____
Printed name of the Parent or Guardian signing above

(Continued on other side)

Child's Statement:

I have talked with my parents/guardians about the Action Schools! BC Program and Research Study and I understand what I will be asked to do. I understand that if I want to I can stop being in the research study at any time and I will still be able to participate in activities at my school. I have had the chance to ask questions and have received satisfactory answers to all of my questions.

Signature of Child

Date

Printed name of child

School Name

Grade and Division

The University of British Columbia
Office of Research Services
Clinical Research Ethics Board – Room 210, 828 West 10th Avenue,
Vancouver, BC V5Z 1L8

ETHICS CERTIFICATE OF EXPEDITED APPROVAL: RENEWAL

PRINCIPAL INVESTIGATOR:	**DEPARTMENT:**	**UBC CREB NUMBER:**
Heather A. McKay		H02-70537

INSTITUTION(S) WHERE RESEARCH WILL BE CARRIED OUT:
N/A
Other locations where the research will be conducted:
N/A

CO-INVESTIGATOR(S):
Kate Reed
Darren Warburton
Patti-Jean Naylor
Karim Miran-Khan
Ryan Rhodes
Heather Macdonald

SPONSORING AGENCIES:
Provincial Health Services Authority - "Action Schools! BC: Hormones & Lipids in Action Schools! BC Children" - "Action Schools! BC"
UBC Start-up Funds - "Action Schools! BC"

PROJECT TITLE:
Action Schools! BC

EXPIRY DATE OF THIS APPROVAL: December 4, 2007 **APPROVAL DATE: December 4, 2006**

CERTIFICATION:
In respect of clinical trials:
1. The membership of this Research Ethics Board complies with the membership requirements for Research Ethics Boards defined in Division 5 of the Food and Drug Regulations.
2. The Research Ethics Board carries out its functions in a manner consistent with Good Clinical Practices.
3. This Research Ethics Board has reviewed and approved the clinical trial protocol and informed consent form for the trial which is to be conducted by the qualified investigator named above at the specified clinical trial site. This approval and the views of this Research Ethics Board have been documented in writing.

The Chair of the UBC Clinical Research Ethics Board has reviewed the documentation for the above named project. The research study, as presented in the documentation, was found to be acceptable on ethical grounds for research involving human subjects and was approved for renewal by the UBC Clinical Research Ethics Board.

Approval of the Clinical Research Ethics Board by one of:

Dr. Bonita Sawatzky, Associate Chair

1.2 How long have you lived in North America? Years: ____________ Months: ____________

1.3 Where did your family live before moving to North America? ______________________________

1.4 How would you classify your family ethnically? (i.e., Caucasian-Canadian, Japanese-Canadian, etc.)

____

ABOUT YOUR CHILD:

Child's birth weight____________________ Circle one: Grams or Lbs/Ozs

2.0 **Nutrition History:**

2.1 Who prepares your child's meals (i.e. mother, father, grandmother, nanny)?______________________

2.2 Does your child drink milk every day?

_____YES: if **yes:**

How many cups per day? _______

Has your child always drank milk every day (after being weaned from breast or bottle)?
yes _______ no _______

if **no**, at what age did she/he start drinking milk every day? _______ years old.

_____NO: if **no:**

Has your child ever drank one or more cups of milk per day (after being weaned from breast or bottle)?

_____ yes: at what age did she/he stop drinking milk every day? ________ years old.

How many cups did he/she drink until that age? ________ cups per day

_____ no : (never drank milk on a daily basis after being weaned)

2.3 Is your child on a special diet? _______ Yes _______ No

If **yes:** _______ vegetarian

_______ low sodium

_______ low cholesterol

_______ other

Please specify: ____

3.0 Medical History and Status:

3.1 Has your child ever been treated for any of the following conditions?

	Yes	No
food allergies	O	O
hypothyroidism	O	O
other allergies	O	O
hyperthyroidism	O	O
asthma	O	O

other conditions (please list)____

____

____

3.2 Is your child currently taking any medications? ________ Yes ________ No

If **yes**, what medication(s) is your child taking? ________________________________

____

____

What are these medication(s) for? ____

____

____

3.3 Has your family doctor ever said that your child has a heart condition and that he/she should only do physical activity recommended by a doctor? _______Yes _______No

3.4 Does your child complain of chest pain when they are doing physical activity? _______Yes _______No

3.5 In the past month, has your child complained of chest pain when they were not doing any physical activity? _______Yes _______No

3.6 Does your child have a bone or joint problem that could be made worse by a change in their physical activity? _______Yes _______No

3.7 Does your child lose their balance because of dizziness or do they ever lose consciousness? _______Yes _______No

3.8 Do you know of any other reason why your child should not participate in physical activity? _______Yes _______No

4.0 **Bone History:**

4.1 Has your child ever been hospitalized, confined to bed or had a limb immobilized (i.e., arm in a cast)?
________ Yes ________ No

If **yes:** list condition, approximate date and time involved
(Example: wrist fracture summer, 1990 10 weeks)

Reason	**Date**	**Time Involved**

4.2 Is there a history of wrist, hip, or spine fractures in your family? ________ Yes ________ No

If **yes:** indicate who was affected

______ mother
______ maternal grandmother
______ maternal grandfather
______ father
______ paternal grandmother
______ paternal grandfather

4.3 Is there a history of osteoporosis in your family? ________ Yes ________ No

If **yes:** indicate who was affected

______ mother
______ maternal grandmother
______ maternal grandfather
______ father
______ paternal grandmother
______ paternal grandfather

4.4 Is there a history of any other bone disease in your family?
________ Yes ________ No

If **yes:** please indicate the family member(s) affected

1. ________________________________
2. ________________________________

What is the name of the condition(s) affecting this family member?

1. ________________________________
2. ________________________________

5.0 **Physical Activity:**

5.1 How would you rate the physical activity level of your child?
Physical activity is defined as vigorous activity that makes them sweat and/or breathe hard.
________ Inactive
________ Sometimes active
________ Moderately active
________ Often active
________ Very active

THANK YOU FOR YOUR PARTICIPATION

Appendix C

Sit-and-Reach

The participant will begin by performing two 15 second stretches per leg before proceeding to the sit and reach measurement. The participant will remove their shoes and sit with their feet flat against the sit and reach block. Their feet will be placed just wider than the width of the sliding mechanism. The participant will place one hand on top of the other and situate their fingertips at the edge of the sliding mechanism. As they breathe out, the participant will reach forward as far as possible keeping their legs straight. This measurement will be repeated and the highest score (cm) will be recorded (137).

Grip Strength

The participant will stand holding the dynamometer in their hand with the arm holding the dynamometer abducted 45° from their body. While breathing normally, they will squeeze the dynamometer as hard as possible. Two measurements will be taken for each hand and the highest score on either hand will be recorded (137).

Push-ups

The participant will lie in a prone position and place their hands on the floor just wider than their shoulders (finger tips pointing forward). Their feet will be placed together and their legs and body will be held in a straight line. The participant will begin with their body lifted off of the floor with only their hands and toes in contact with the ground. Using their toes as a fulcrum the participant will bend their arms to lower their body towards the floor. They will lower their body until their arms reach a 90° angle at the elbow joint after which, they will straighten their arms to return to the starting position. The participant will complete as many consecutive push-ups as possible in a rhythmical fashion. The push-up assessment will be terminated for the following reasons: volitional fatigue, incorrect technique for more than two consecutive push-ups, inability to maintain a rhythmical pace (137).

Curl-ups

The participant will lie supine with their arms at their sides, knees bent to 90°, feet together and flat on the floor. They will curl their body upwards while sliding their fingers along the ground towards their feet. The participant will curl-up until their fingers have travelled 10cm from their starting position. Curl-ups will be performed keeping pace with the rhythm of a metronome. The metronome pace will be set at 40 bpm. The participants will perform as many curl-ups as possible. The curl-up assessment will be terminated for the following reasons: volitional fatigue or inability to curl-up the required 10 cm (137).

Appendix D

Table D.1 Average 'on' and 'off' times for each morning and evening during the measurement of habitual physical activity.

Day of the Week	Morning (on time)	Standard Deviation	Range	Evening (off time)	Standard Deviation	Range
Wednesday	N/A	N/A	N/A	21:44:00	0:58:00	20:45:45-22:42:00
Thursday	7:38:00	0:44:55	6:53:15-8:23:00	21:20:00	1:11:00	20:09:00-22:31:00
Friday	8:06:00	1:06:27	6:59:30-9:12:30	21:58:30	1:26:45	20:31:00-23:39:00
Saturday	9:04:30	1:25:45	7:38:45-10:30:15	22:01:15	1:37:45	20:23:30-23:39:00
Sunday	9:15:07	1:24:36	7:50:30-10:39:45	21:14:44	1:15:15	19:59:30-22:30:00

Appendix F

Action Schools! BC

ACTION SCHOOLS! BC 5-DAY ACTIVITY LOG – Spring 2006

Name: ______________________________ School: ______________________________
Grade : __________ Division: __________

Directions:

1) Please have your child wear the motion sensor under their clothing.

2) The motion sensor should be fitted snugly on the waist with the sensor positioned in the front above the hip. The belt should feel comfortable but not floppy.

3) The motion sensor should be worn for 12 hours (8 AM – 8 PM) and should only be removed during that period if the child is going swimming, having a bath or a shower. It is not waterproof.

4) Please note the time when the motion sensor is first put on the child and when it is taken off daily on the log on the reverse side of this form as well as anything that affected your child's movement patterns on any given day.

5) The motion sensor is like a smart 'pedometer' but it is very valuable. Please have your child put on the motion sensor on Monday morning to take it into school and an AS! BC researcher will collect them from the classroom.

Thank you very much for you help!

Monitor:	Wednesday	Thursday	Friday	Saturday	Sunday
Dates					
On Time AM					
Off Time PM					
Did weather change your routine?	No	No	No	No	No
	Yes	Yes	Yes	Yes	Yes
Did illness change your routine?	No	No	No	No	No
	Yes	Yes	Yes	Yes	Yes
Was motion sensor removed during wear time?	No	No	No	No	No
	Yes	Yes	Yes	Yes	Yes
If yes, what time?	__:__ to __:__	__:__ to __:__	__:__ to __:__	__:__ to __:__	__:__ to __:__
Why was the monitor removed?					
Any problems? Please explain.					

Appendix G

Table E.1 Description of health-related physical fitness and physical activity data in Caucasian and Asian girls.
BMI=body mass index, MVPA=moderate-to-vigorous physical activity.

Variable	N	Caucasian Girls	N	Asian Girls
Age (years)	38	10.0 ± 0.6	53	10.0 ± 0.6
Height (cm)	38	141.5± 7.6	53	140.9 ± 7.5
Weight (kg)	38	35.4 ± 6.4	53	35.2 ± 8.6
BMI (kg/m^2)	38	17.6 ± 2.0	53	17.5 ± 3.0
Waist Circumference (cm)	38	62.6 ± 5.7	53	62.9 ± 7.9
Systolic Blood Pressure (mmHg)	38	96.7 ± 9.3	53	97.0 ± 9.0
Diastolic Blood Pressure (mmHg)	38	62.0 ± 9.7	53	62.0 ± 8.4
Pulse Rate (bpm)	36	86.8 ± 14.0	53	88.4 ± 11.8
Total Laps Run	38	26.0 ± 13.0	53	18.0 ± 10.0
Sit-and-Reach (cm)	38	26.0 ± 10.0	53	29.0 ± 7.0
Curl-ups	38	14.0 ± 18.0	53	9.0 ± 9.0
Push-ups	38	6.0 ± 9.0	53	2.0 ± 5.0
Grip Strength (kg)	38	33.0 ± 8.0	53	32.0 ± 7.0
Musculoskeletal Fitness Score	38	0.3852 ± 2.3157	53	-0.2762 ± 1.0910
Average Counts Per Minute	38	499.1 ± 158.3	53	380.1 ± 102.0
Average MVPA Per Day	38	127.0 ± 40.8	53	103.9 ± 28.6

Table E.2 Description of health-related physical fitness and physical activity data in Asian and Caucasian boys.
BMI=body mass index, MVPA=moderate-to-vigorous physical activity.

Variable	N	Caucasian Boys	N	Asian Boys
Age (years)	35	10.0 ± 0.6	44	10.0 ± 0.6
Height (cm)	35	142.4 ± 6.5	44	140.4 ± 8.3
Weight (kg)	35	36.2 ± 7.4	44	36.9 ± 8.5
BMI (kg/m^2)	35	17.7 ± 2.3	44	18.6 ± 3.0
Waist Circumference (cm)	35	63.4 ± 6.6	44	65.7 ± 8.0
Systolic Blood Pressure (mmHg)	34	97.3 ± 7.0	43	98.9 ± 7.0
Diastolic Blood Pressure (mmHg)	34	62.1 ± 6.0	43	63.9 ± 7.9
Pulse Rate (bpm)	33	85.3 ± 10.5	43	88.7 ± 11.1
Total Laps Run	35	31.0 ± 15.0	44	21.0 ± 12.0
Sit-and-Reach (cm)	35	24.0 ± 6.0	44	25.0 ± 7.0
Curl-ups	35	21.0 ± 22.0	44	8.0 ± 7.0
Push-ups	35	7.0 ± 8.0	44	4.0 ± 5.0
Grip Strength (kg)	35	36.0 ± 6.0	44	34.0 ± 7.0
Musculoskeletal Fitness Score	35	0.5858 ± 1.6407	44	-0.4660 ± 1.1581
Average Counts Per Minute	35	540.2 ± 120.6	44	474.5 ± 117.8
Average MVPA Per Day	35	140.1 ± 32.5	44	129.0 ± 34.6

Appendix H

Table E.3 Description of health-related physical fitness data in children without physical activity data.
BMI=body mass index.

Variable	N	Boys	N	Girls
Age (years)	52	10.0 ± 0.5	46	9.8 ± 0.8
Height (cm)	50	141.4 ± 6.9	47	141.0 ± 7.3
Weight (kg)	50	37.3 ± 9.7	46	35.6 ± 6.8
BMI (kg/m^2)	50	18.5 ± 3.4	46	17.8 ± 2.8
Waist Circumference (cm)	50	65.6 ± 9.4	47	62.2 ± 6.6
Systolic Blood Pressure (mmHg)	47	96.5 ± 9.5	41	96.2 ± 10.8
Diastolic Blood Pressure (mmHg)	47	63.3 ± 8.6	41	63.5 ± 11.1
Pulse Rate (bpm)	46	89.9 ± 12.5	41	89.6 ± 12.8
Total Laps Run	48	26.6 ± 13.3	42	23.3 ± 12.1
Sit-and-Reach (cm)	49	24.0 ± 7.0	42	28.0 ± 7.0
Curl-ups	49	13.0 ± 15.0	42	11.0 ± 8.0
Push-ups	49	7.0 ± 8.0	42	5.0 ± 5.0
Grip Strength (kg)	48	35.0 ± 7.0	42	32.0 ± 7.0
Musculoskeletal Fitness Score	48	0.1016 ± 1.6751	42	0.0729 ± 1.1230

Appendix I

Capturing Physical Activity Tempo in Elementary School-Aged Children

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The tempo of children's activity has been documented to be sporadic and rapidly changing. These characteristics make data acquisition in this age group challenging. Accelerometers are popular in the assessment of physical activity in youth however data is commonly captured in 1 minute epochs, consequently masking sporadic activity. Therefore, the purpose of this investigation was to determine the tempo of children's physical activity using a 15 second epoch with a specific emphasis on the time spent in moderate-to-vigorous intensity physical activity (MVPA; ≥3 METs). To assess habitual physical activity, children (8-11 yrs) wore a GT1M activity monitor at the hip during waking hours over a 5 day period. All children were part of a larger investigation (Action Schools! BC). To be included in the analysis, children were required to wear the monitor for at least 8 hours per day on at least 4 days. One hundred fifty-seven children met the criteria. Age-specific cut-points developed by Trost and colleagues were revised for use with 15 second epochs and data was analyzed using customized software. Our results indicate that children spend 15% of their monitored time in MVPA. Eighty-five percent of the total time spent in MVPA was accumulated in bouts of activity less than 5 minutes in duration and on average, these bouts lasted only 31 seconds. Eight percent of the activity bouts lasted between 5 and 10 minutes; 5% in 10 to 20 minute bouts; and 2% in bouts lasting greater than 20 minutes. Only 29% of the children registered at least 1 bout lasting greater than 20 minutes, while 68% registered at least 1 bout of activity lasting 10 to 20 minutes and 97% accumulated activity in bouts of 5 to 10 minutes in duration. The results of this investigation suggest that a 15 second epoch has sufficient resolution to detect the sporadic activity that is typical of children.

Appendix J

Physical Activity and Antecedents of Cardiovascular Disease in Children

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Background: Reduced arterial compliance is an important predictor of cardiovascular disease. It precedes the development of traditional cardiovascular disease risk factors. In adults, increased physical activity is associated with improved arterial compliance. However, it is unknown whether regular daily physical activity in children exerts a similar positive influence on arterial compliance.

Purpose: The primary purpose of this investigation was to examine the relationship between moderate-to-vigorous physical activity (MVPA) and arterial compliance in children.

Methods: To assess habitual physical activity, children (n=115, 8-11 yrs) wore a GT1M Activity Monitor for 13 hrs (on average) daily over a 5 day period. We also obtained concurrent measures of blood pressure (mmHg), arterial compliance (small and large artery, ml/mmHg) and weight status (Body Mass Index, kg/m^2). Data were analyzed using Pearson Partial Correlation.

Results: 16.5% were classified as overweight and 5.2% were hypertensive. MVPA (counts per minute corresponding to ≤3 METS) accounted for approximately 6% of the variance in small artery compliance independent of Body Mass Index, systolic blood pressure, age and gender.

Conclusion: There was a positive relationship between MVPA and vascular health in this group of generally healthy children. This extends our previous findings by showing that objectively measured physical activity is also predictive of vascular health. An intervention designed to test the *effect* of MVPA on arterial compliance would further delineate this relationship.

Appendix K

Table K.1. T-tests performed between genders. (*) denotes significance. MVPA=moderate-to-vigorous physical activity

Variable	Boys (Mean)	Girls (Mean)	Significance Level
Musculoskeletal Fitness Score	0.1501	-.1303	$p < 0.26$
Total Laps	25.0	21.0	$p < 0.06$
Sit-and-Reach (cm)	25.0	28.0	$p < 0.06$
Grip Strength (kg)	35.0	32.0	$p < 0.04$
Height (cm)	141.3	141.2	$p < 0.89$
Weight (kg)	36.6	35.3	$p < 0.25$
Body Mass Index (kg/m^2)	18.2	17.6	$p <0.12$
Systolic Blood Pressure (mmHg)	98.0	97.0	$p < 0.28$
Diastolic Blood Pressure (mmHg)	63.0	62.0	$p < 0.23$
Heart Rate (bpm)	87.0	88.0	$p < 0.86$
Counts Per Minute	503.6*	429.8	$p < 0.001$
Minutes of MVPA Per Day	133.9*	113.5	$p < 0.001$
Minutes of MVPA Per Weekday	149.0*	124.6	$p < 0.001$
Minutes of MVPA Per Weekend Day	112.7*	98.4	$p < 0.04$
Minutes of Sporadic MVPA Per Day	104.7	98.0	$p < 0.09$
Minutes of Bouted MVPA Per Day	29.2*	15.5	$p < 0.001$

Table K.2. ANOVA performed between girls with and without valid physical activity data.

Variable	Girls Without PA Data (Mean)	Girls With PA Data (Mean)	Significance Level
Age (years)	9.8	10.0	$p < 0.09$
Height (cm)	141.0	141.2	$p < 0.71$
Weight (kg)	35.6	35.2	$p < 0.58$
Total Laps	23.0	21.0	$p < 0.68$
Musculoskeletal Fitness Score	0.0729	-0.0336	$p < 0.16$

Table K.3. ANOVA performed between boys with and without valid physical activity data.

Variable	Boys Without PA Data (Mean)	Boys With PA Data (Mean)	Significance Level
Age (years)	10.0	10.0	$p < 0.82$
Height (cm)	141.4	141.3	$p < 0.59$
Weight (kg)	37.3	36.6	$p < 0.42$
Total Laps	27.0	25.0	$p < 0.70$
Musculoskeletal Fitness Score	0.1016	-0.0434	$p < 0.43$

Table K.4. ANOVA performed between schools to determine intraclass correlation. MVPA=moderate-to-vigorous physical activity

Variable	Between Schools Variance	Within Schools Variance	Total Variance	Intraclass Correlation
Counts Per Minute	1.073	13.901	14.974	0.07
Musculoskeletal Fitness Score	17.030	226.045	243.075	0.07
Body Mass Index (kg/m^2)	0.188	3.363	3.551	0.07
Total Laps	14.700	39.933	54.633	0.27
Minutes of MVPA Per Day	1.074	14.631	15.705	0.07

Table K.5. ANCOVA used to examine differences between Caucasian and Asian boys. Age, weight and height were entered as covariates.
MVPA=moderate-to-vigorous physical activity

Variable	Significance Level	Levene's Test (Significance)
Musculoskeletal Fitness Score	p < 0.007	p < 0.09
Total Laps	p < 0.03	p < 0.84
Curl-ups	p < 0.04	p < 0.001
Push-ups	p < 0.20	p < 0.62
Sit-and-Reach (cm)	p < 0.28	p < 0.66
Grip Strength (kg)	p < 0.31	p <0.01
Systolic Blood Pressure (mmHg)	p < 0.36	p < 0.19
Diastolic Blood Pressure (mmHg)	p < 0.69	p < 0.23
Heart Rate (bpm)	p < 0.19	p < 0.92
Body Mass Index (kg/m^2)	p < 0.22	p < 0.08
Waist Circumference (cm)	p < 0.24	p < 0.09
Counts Per Minute	p < 0.03	p < 0.68
Minutes MVPA Per Day	p < 0.12	p < 0.41

Table K.6. ANCOVA used to examine differences between Caucasian and Asian girls. Age, weight and height were entered as covariates.
MVPA=moderate-to-vigorous physical activity

Variable	Significance Level	Levene's Test (Significance)
Musculoskeletal Fitness Score	p < 0.09	p < 0.01
Total Laps	p < 0.01	p < 0.06
Curl-ups	p < 0.32	p < 0.004
Push-ups	p < 0.009	p < 0.23
Sit-and-Reach (cm)	p < 0.78	p < 0.04
Grip Strength (kg)	p < 0.58	p < 0.26
Systolic Blood Pressure (mmHg)	p < 0.79	p < 0.95
Diastolic Blood Pressure (mmHg)	p < 0.97	p < 0.20
Heart Rate (bpm)	p < 0.59	p < 0.29
Body Mass Index (kg/m^2)	p < 0.76	p < 0.004
Waist Circumference (cm)	p < 0.68	p < 0.17
Counts Per Minute	p < 0.001	p < 0.001
Minutes MVPA Per Day	p < 0.001	p < 0.001

Table K.7. Principal Component Analysis in the whole group. One component extracted from the musculoskeletal fitness components.

Component	Eigenvalue	Percentage Variance
1	1.560	38.994

Table K.8. Factor loadings based on one component for the musculoskeletal fitness score in the whole group.

Factor	Factor Loading
Sit-and-Reach	0.380
Curl-ups	0.762
Push-ups	0.678
Grip Strength	0.612

Table K.9. Principal Component Analysis in girls only. One component extracted from the musculoskeletal fitness components.

Component	Eigenvalue	Percentage Variance
1	1.566	39.158

Table K.10. Factor loadings based on one component for the musculoskeletal fitness score in girls.

Factor	Factor Loading
Sit-and-Reach	0.495
Curl-ups	0.758
Push-ups	0.680
Grip Strength	0.534

Table K.11. Principal Component Analysis in boys only. One component extracted from the musculoskeletal fitness components.

Component	Eigenvalue	Percentage Variance
1	1.585	39.616

Table K.12. Factor loadings based on one component in the musculoskeletal fitness score in boys.

Factor	Factor Loading
Sit-and-Reach	0.435
Curl-ups	0.744
Push-ups	0.654
Grip Strength	0.643

Table K.13. Principal Component Analysis in the whole group. One component extracted from the musculoskeletal and cardiorespiratory fitness components.

Component	Eigenvalue	Percentage Variance
1	2.098	41.952

Table K.14. Factor loadings based on one component in the musculoskeletal and cardiorespiratory fitness score in the whole group.

Factor	Factor Loading
Sit-and-Reach	0.351
Curl-ups	0.686
Push-ups	0.828
Grip Strength	0.467
Total Laps	0.774

Table K.15. Principal Component Analysis in the whole group. Two components extracted from all health-related physical fitness components.

Component	Eigenvalue	Percentage Variance
1	2.479	35.416
2	1.817	25.959

Table K.16. Factor loadings based on two components for the total health-related physical fitness score.

Factor	Factor Loading (Component 1)	Factor Loading (Component 2)
Sit-and-Reach	0.356	0.118
Curl-ups	0.504	0.463
Push-ups	0.664	0.486
Grip Strength	-0.037	0.767
Total Laps	0.666	0.415
Body Mass Index	-0.770	0.533
Waist Circumference	-0.787	0.535

Table K.17. Forward stepwise regression of cardiorespiratory fitness in girls.

Fitness	Variables in Model	Standardized Beta	Unstandardized Beta	Adjusted R^2	R^2 Change
Total Laps	MSK Score ($p < 0.001$)	.460	.618	.184	.193
	Weight ($p < 0.006$)	-.257	.139	.242	.066

Table K.18. Forward stepwise regression of cardiorespiratory fitness in boys. CPM=counts per minute, MVPA=moderate-to-vigorous physical activity, MSK=musculoskeletal

Fitness	Variables in Model	Standardized Beta	Unstandardized Beta	Adjusted R^2	R^2 Change
Total Laps	Weight ($p < 0.01$)	-.375	-.697	.400	.446
	Height ($p < 0.17$)	.210	.412	.400	.446
	CPM ($p < 0.70$)	.083	.010	.400	.446
	MVPA Per Day ($p < 0.49$)	.148	.065	.400	.446
	MSK Score ($p < 0.001$)	.528	5.284	.400	.446
	Ethnicity ($p < 0.63$)	-.049	-1.447	.400	.446

Table K.19. Hierarchical regression of health-related physical fitness component in boys.
CPM=counts per minute, MVPA=moderate-to-vigorous physical activity, HRPF=health-related physical fitness

Fitness	Variables in Model	Standardized Beta	Unstandardized Beta	Adjusted R^2	R^2 Change
Total HRPF Score	Weight ($p < 0.001$)	-.579	-.216	.157	.189
	Height ($p < 0.01$)	.439	.173	.157	.189
	Age ($p < 0.91$)	-.013	-.067	.157	.189
	Ethnicity ($p < 0.003$)	-.330	-1.967	.243	.093
	CPM ($p < 0.46$)	-.191	-.005	.233	.000
	MVPA Per Day ($p < 0.45$)	.198	.017	.229	.006

Table K.20. Hierarchical regression of health-related physical fitness component in girls. CPM=counts per minute, MVPA=moderate-to-vigorous physical activity, HRPF=health-related physical fitness

Fitness	Variables in Model	Standardized Beta	Unstandardized Beta	Adjusted R^2	R^2 Change
Total HRPF Score	Weight ($p < 0.001$)	-.352	-.143	.043	.075
	Height ($p < 0.01$)	.321	.133	.043	.075
	Age ($p < 0.91$)	-.108	-.557	.043	.075
	Ethnicity ($p < 0.003$)	-.202	-1.269	.111	.076
	CPM ($p < 0.46$)	.122	.003	.130	.028
	MVPA Per Day ($p < 0.45$)	.067	.006	.120	.000

Table K.21. Hierarchical regression of push-ups in boys. CPM=counts per minute.

Fitness	Variables in Model	Standardized Beta	Unstandardized Beta	Adjusted R^2	R^2 Change
Push-ups	Weight ($p < 0.008$)	.461	.895	.147	.191
	Height ($p < 0.32$)	-.182	-1.395	.147	.191
	Age ($p < 0.94$)	-.010	-.066	.147	.191
	Ethnicity ($p < 0.17$)	.169	-1.269	.156	.020
	CPM ($p < 0.75$)	.037	.003	.146	.001

Table K.22. Hierarchical regression of push-ups in girls. CPM=counts per minute.

Fitness	Variables in Model	Standardized Beta	Unstandardized Beta	Adjusted R^2	R^2 Change
Push-ups	Weight ($p < 0.53$)	-.098	-.192	.095	.136
	Height ($p < 0.48$)	.118	.901	.095	.136
	Age ($p < 0.23$)	.136	.901	.095	.136
	Ethnicity ($p < 0.04$)	.259	.212	.153	.064
	CPM ($p < 0.27$)	-.122	-.162	.155	.012

Table K.23. Hierarchical regression of curl-ups in boys. CPM=counts per minute.

Fitness	Variables in Model	Standardized Beta	Unstandardized Beta	Adjusted R^2	R^2 Change
Curl-ups	Weight ($p < 0.001$)	.250	.410	.062	.110
	Height ($p < 0.01$)	-.159	-1.034	.062	.110
	Age ($p < 0.91$)	-.074	-.425	.062	.110
	Ethnicity ($p < 0.003$)	.222	.153	.086	.035
	CPM ($p < 0.46$)	.042	.059	.075	.001

Table K.24. Hierarchical regression of curl-ups in girls.
CPM=counts per minute.

Fitness	Variables in Model	Standardized Beta	Unstandardized Beta	Adjusted R^2	R^2 Change
Curl-ups	Weight ($p < 0.001$)	.128	.228	.053	.096
	Height ($p < 0.01$)	-.243	-1.691	.053	.096
	Age ($p < 0.91$)	.210	1.267	.053	.096
	Ethnicity ($p < 0.003$)	.039	.029	.049	.006
	CPM ($p < 0.46$)	-.147	-.177	.055	.017

Table K.25. Hierarchical regression of sit-and-reach in boys.
CPM=counts per minute.

Fitness	Variables in Model	Standardized Beta	Unstandardized Beta	Adjusted R^2	R^2 Change
Sit-and-Reach	Weight ($p < 0.53$)	.108	.154	.120	.165
	Height ($p < 0.33$)	-.178	-1.007	.120	.165
	Age ($p < 0.03$)	-.261	-1.304	.120	.165
	Ethnicity ($p < 0.39$)	-.107	-.065	.111	.003
	CPM ($p < 0.14$)	-.177	-.214	.126	.025

Table K.26. Hierarchical regression of sit-and-reach in girls. CPM=counts per minute.

Fitness	Variables in Model	Standardized Beta	Unstandardized Beta	Adjusted R^2	R^2 Change
Sit-and-Reach	Weight ($p < 0.34$)	.154	-.259	.107	.148
	Height ($p < 0.92$)	-.016	-.107	.107	.148
	Age ($p < 0.32$)	-.116	-.665	.107	.148
	Ethnicity ($p < 0.23$)	.155	.110	.104	.007
	CPM ($p < 0.23$)	.138	.159	.109	.015

Table K.27. Hierarchical regression of grip strength in boys. CPM=counts per minute.

Fitness	Variables in Model	Standardized Beta	Unstandardized Beta	Adjusted R^2	R^2 Change
Grip Strength	Weight ($p < 0.71$)	.059	.060	.247	.286
	Height ($p < 0.003$)	.524	2.095	.247	.286
	Age ($p < 0.52$)	-.073	-.257	.247	.286
	Ethnicity ($p < 0.30$)	-.121	-.051	.242	.005
	CPM ($p < 0.34$)	-.105	-.090	.243	.011

Table K.28. Hierarchical regression of grip strength in girls. CPM=counts per minute.

Fitness	Variables in Model	Standardized Beta	Unstandardized Beta	Adjusted R^2	R^2 Change
Grip Strength	Weight ($p < 0.02$)	.306	.352	.397	.425
	Height ($p < 0.003$)	.416	1.877	.397	.425
	Age ($p < 0.56$)	-.055	-.215	.397	.425
	Ethnicity ($p < 0.92$)	-.010	-.005	.394	.004
	CPM ($p < 0.06$)	.174	.136	.412	.023

Table K.29. Hierarchical regression of systolic blood pressure in boys. CPM=counts per minute.

Fitness	Variables in Model	Standardized Beta	Unstandardized Beta	Adjusted R^2	R^2 Change
Systolic Blood Pressure	Weight ($p < 0.006$)	.458	.154	.230	.270
	Height ($p < 0.86$)	.030	.040	.230	.270
	Age ($p < 0.64$)	.055	.066	.230	.270
	Ethnicity ($p < 0.57$)	.068	.010	.223	.004
	CPM ($p < 0.98$)	.002	.001	.212	.000

Table K.30. Hierarchical regression of systolic blood pressure in girls. CPM=counts per minute.

Fitness	Variables in Model	Standardized Beta	Unstandardized Beta	Adjusted R^2	R^2 Change
Systolic Blood Pressure	Weight ($p < 0.20$)	.211	.096	.036	.270
	Height ($p < 0.56$)	.104	.184	.036	.270
	Age ($p < 0.33$)	-.118	-.181	.036	.270
	Ethnicity ($p < 0.99$)	-.002	.000	.029	.004
	CPM ($p < 0.10$)	-.196	-.061	.049	.000

Appendix L

Raw Data

C2E2ID	My ID T1	Gender	sthtC	weightC	BMI	waistC	BPSY	BPDIA
1101	mpama4maf1	M	154.25	43.45	18.26163	70.5	105	64
1168	fqupa5bc1	F	141.5	40.7	20.32739	66.5	99	61
1169	fhusy4maf1	F	141.1	32.8	16.47479	67.2	111	68
1207	mpawi4maf1	M	127.8	24.4	14.93923	55.9	92	61
1233	fscha4wf1	F	138.6	31.6	16.4498	55.15	99	58
1283	fbaha5wf1	F	138.25	31.9	16.69016	60.55	82	55
1325	mkhsa5moc1	M	148.15	33.4	15.21749	62.15	90	51
1349	mdudo5moc1	M	132.7	30.5	17.3204	65.55	96	66
1397	fmoro5bc1	F	140.35	30.85	15.66139	59.05	107	72
1457	fdrma4maf1	F	136.45	27.3	14.66275	58.3	91	52
1491	ffial5bc1	M	154.7	44.95	18.78231	66.35	101	69
1508	mmijo4bc1	M	135.25	31.7	17.32945	57.8	98	66
1844	mfrju5wf1	M	139.8	29.4	15.04295	57.95	99	56
2080	mchma4nc1	M	142.8	49.75	24.39701	79.65	104	65
2124	marki4wf1	M	144.9	39.7	18.90835	65.9	92	66
2147	ferol4maf1	F	133.45	26.9	15.10481	59.35	109	61
2314	mmash4maf1	M	136.85	33	17.62075	63.35	98	66
2345	mdema4moc1	M	144.15	44.9	21.60812	79.45	107	75
2383	fdhsu5moc1	F	145.8	45.05	21.19238	71.9	99	53
2432	myada4maf1	M	141.15	32.1	16.11177	61	100	61
2488	mrami5bc1	M	147.55	40.25	18.48789	64.3	102	69
2521	mgrka5moc1	M	158.15	42.4	16.95225	61.35	90	69
2556	fmcsa5wf1	F	139.5	30	15.41604	58	92	48
2650	fgugo5moc1	F	144.25	33	15.85924	61.9	91	59
2668	falsa5bc1	F	134.6	27	14.903	54.5	92	56
2693	fmoch5nc1	F	146.7	32.6	15.14807	62.6	99	60
2713	mromi5maf1	M	150.2	38.8	17.19855	63.35	102	61
2887	mgolu4maf1	M	145.2	41.45	19.66035	69.9	94	59
2892	fpjal5maf1	F	151.05	34.8	15.25239	58.85	103	68
2921	fmica5maf1	F	140.35	34.1	17.31129	61.4	106	72
3038	fnggl4moc1	F	128.4	26.2	15.89173	60.3	92	57
3161	fchgi5maf1	F	146.45	46.1	21.49424	69.85	108	76
3180	mfejo5wf1	M	147.25	37.3	17.20276	65	99	55
3284	mrojo4moc1	M	132.15	40.4	23.1338	79.05	92	57
3286	mgeda5maf1	M	139.15	28.6	14.77065	57.75	99	73
3292	mtajo4nc1	M	130.05	29.8	17.61958	60.85	102	73
3319	mslmi5maf1	M	147.4	44.8	20.61973	68.6	89	68
3349	mcabr4maf1	M	148.75	72.6	32.81124	94.85	119	79
3411	myoke5maf1	M	156.35	64.2	26.26269	85.35	107	61
3423	fdhpo5moc1	F	143.5	33.55	16.29254	63.2	86	54
3455	mjapr5moc1	M	142.95	37.95	18.57135	68	102	64
3558	fmiam4moc1	F	130.35	27.05	15.92008	54.9	99	50
3594	fsish4bc1	F	130.4	28.7	16.87822	61.45	84	44
3627	fchan4maf1	F	132.6	35.1	19.96274	69.25	93	61
3678	fchgr5maf1	F	135.2	33.8	18.49112	63.75	83	67
3693	fdhma4moc1	F	144.7	32.7	15.61747	55.3	94	60
3758	mvejo4wf1	M	141.05	42.3	21.26151	70.45	102	66
3767	fdhsh4moc1	F	159.3	53	20.88547	72.85	93	60
3810	fshlu5maf1	F	149.55	38.3	17.12482	64.5	110	78

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3811	fjale5nc1	F	148.5	46.55	21.10896	72.6	102	71
3820	mmibr4bc1	M	134.85	28.75	15.81015	57.2	92	64
3826	fwaer5maf1	F	128.25	23.2	14.105	52.9	93	73
3853	mhake5maf1	M	140.55	31.9	16.14838	58.6	87	63
3941	mdupa4moc1	M	137.4	26.7	14.14288	56.75	89	51
3974	frova4nc1	F	136.7	24.9	13.32485	51.7	85	66
4023	fswra5bc1	F	164.2	48.6	18.02561	64.35	104	60
4106	msaka5moc1	M	143	31.1	15.20857	59.05	92	56
4221	msudi4moc1	M	133.05	31.85	17.99201	65.7	96	64
4229	mpabr5maf1	M	143.8	32.95	15.93447	61.25	108	61
4303	fpeha5bc1	F	149.45	40	17.90887	62.6	104	74
4319	mkike5bc1	M	130.25	30.3	17.86023	58.55	91	56
4338	fmema4maf1	F	150.95	37.3	16.36977	65.6	92	46
4427	fjema5wf1	F	135.15	37.6	20.58523	68.35	90	61
4470	fkras5bc1	F	138.05	30.6	16.05642	54.15	91	56
4675	fatpr5moc1	F	154.5	38.9	16.29644	58.55	99	52
4678	fhilu5moc1	F	149.1	43.8	19.70239	62.9	97	68
4866	mleso5wf1	M	149.25	35.2	15.80207	57.1	94	59
4896	flaja4maf1	F	138.55	35.7	18.59753	64.95	95	55
4922	mluli5moc1	M	151.65	54.7	23.78496	78.5	116	67
5014	fdama5moc1	F	150.5	47.75	21.08145	71.8	109	87
5053	fgrti5wf1	F	144.6	38.4	18.36516	68	91	68
5116	fprga5maf1	F	138.05	27.9	14.63967	55.1	95	58
5119	fanel4wf1	F	138.05	36.75	19.28344	65.9	112	76
5125	fhoma5bc1	F	147.75	40.8	18.68982	63.85	93	51
5208	fdech5bc1	F	145.7	39.4	18.55996	62.45	99	68
5216	fgisa5bc1	F	150.45	44.9	19.83636	67.5	99	63
5302	mpoma5bc1	M	140	30.1	15.35714	55.5	101	66
5313	fsujo4maf1	F	149.35	42.3	18.964	68.75	109	68
5323	fhona5maf1	F	133	26.1	14.75493	57.5	100	60
5380	mlipa4bc1	M	126.15	25.2	15.83529	56.5	93	60
5430	flija5moc1	F	145.6	29.45	13.89193	53.45	95	61
5521	marno5moc1	M	152	39.8	17.22645	69.4	94	52
5544	fcsju4wf1	F	142.75	34.9	17.12668	60.45	103	71
5573	mgral4wf1	M	142	36.35	18.02718	64	84	51
5583	fsuan4maf1	F	126.85	27.2	16.90394	56.9	93	53
5689	mgudo4wf1	M	134.6	37.2	20.53302	71.05	100	67
5733	malst5wf1	M	146.65	36.5	16.97183	64.1	99	58
5735	mzhaa5maf1	M	143.3	41.7	20.3069	65.25	107	65
5800	monal4moc1	M	139.15	33	17.04306	59.5	96	60
5805	mfljo5maf1	M	143.55	37.7	18.29511	67.6	96	57
5831	fxizh5maf1	F	146.5	32.3	15.04968	62.6	93	54
5868	mmran5maf1	M	147.25	41.5	19.1398	65.05	102	64
5945	mbada4nc1	M	144.65	47.65	22.7733	72.2	110	71
5949	mmacy5bc1	M	137.35	36.7	19.45399	66.2	89	55
6027	fraal4bc1	F	138.35	34.9	18.23338	62.05	77	47
6039	mliju5bc1	M	130.05	26	15.37279	51.7	98	70
6081	mkaap5moc1	M	141.75	47.4	23.59023	76.2	102	84
6108	fpeje4bc1	F	141.25	33.6	16.84079	64.85	93	57
6195	fwaas4wf1	F	126.85	29.5	18.33332	59	91	68
6247	fphsa4maf1	F	132.6	31.8	18.0859	63.35	113	74

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6333	fkelo5wf1	F	134.65	33.7	18.58734	65.25	87	51
6367	mlija5nc1	M	141.9	34.3	17.0345	63.3	98	57
6543	mmita4bc1	M	135.1	28.7	15.7243	57.6	87	57
6565	femmi4bc1	F	131.65	29.05	16.76117	57.55	87	64
6572	fsuan5maf1	F	140.45	31.2	15.81653	64.1	111	71
6655	mshra4moc1	M	134.5	25.4	14.04071	52.1	97	58
6673	fchje4bc1	F	129.25	25.2	15.0848	51.9	116	97
6721	fduar5nc1	F	149.05	58	26.10742	82.95	84	66
6758	fhoch5maf1	F	134.05	26.5	14.74729	56.25	107	68
6760	fgoch5bc1	F	134.2	29.05	16.13025	62.1	94	69
6788	myary4wf1	M	135.35	30.9	16.86716	56.4	103	69
6834	fhehe5bc1	F	146.4	40.3	18.80282	69.05	86	56
6845	mhyra5moc1	M	157	53.5	21.70473	74.1	107	54
6998	mwaba5maf1	M	144.75	33.3	15.89304	58.05	103	57
7034	fkwkr5bc1	F	140.6	30.4	15.37811	57.85	85	56
7058	msoje5maf1	M	159.35	51	20.08473	72.5	110	60
7102	mneia4maf1	M	148.85	44	19.85889	75.9	99	58
7225	mclad4bc1	M	131.4	27.35	15.84042	58.35	84	54
7247	merim4bc1	M	137.4	29.9	15.8379	59.4	91	60
7376	fchro5moc1	F	139.1	38	19.63945	68.8	94	56
7386	mchch4maf1	M	151.45	48.95	21.34097	75.9	108	62
7533	mmore4maf1	M	147.4	37.5	17.25982	62.7	96	56
7558	mlavi5maf1	M	144.15	47	22.61875	74.55	96	65
7658	mheth4wf1	M	147.45	40.5	18.62797	65.95	94	63
7662	mgrde5maf1	M	135.65	28.6	15.5427	59.2	103	63
7664	fmaha4bc1	F	137.7	27.6	14.55597	57.25	80	52
7673	mchth4maf1	M	140.2	41.4	21.06223	71.1	102	59
7717	fnoem5wf1	F	147.15	52.6	24.29211	83.6	107	53
7864	mkobr5maf1	M	142.45	37.3	18.38163	67.25	108	81
7932	flaja5maf1	F	139.45	39.55	20.33806	72.25	105	73
7938	fluda5moc1	F	147.2	51.75	23.88332	84.85	107	69
7977	mwoke4maf1	M	139.4	33.8	17.39367	62.1	103	75
8021	fkwwi4moc1	F	151.1	30.5	13.35891	60.55	94	53
8035	fstmi4maf1	F	136.6	35.3	18.91792	66.9	112	65
8073	fgrsu5moc1	F	140.45	38.05	19.28906	64.05	99	67
8313	fluca5maf1	F	139.35	30.8	15.86123	60.05	86	60
8436	mloet5wf1	M	137.45	30.4	16.09104	59.05	88	53
8480	fmobr4maf1	F	131.05	27	15.72135	55	80	60
8508	ftase4maf1	F	135.85	31.25	16.93288	58.95	88	52
8538	fleyo5maf1	F	147.55	54.8	25.1711	76.95	109	57
8579	fhech4maf1	F	140.45	32.6	16.52624	58.65	86	67
8591	fbash5nc1	F	148.65	48.9	22.12988	76.2	103	61
8664	marju4nc1	M	133.1	28.1	15.86172	61.7	88	73
8703	mbhka4moc1	M	139.6	26.55	13.62366	54	102	62
8714	floem5wf1	F	155.25	43.45	18.02713	63.95	116	77
8728	fraha5moc1	F	139.85	30.65	15.67132	54.7	94	58
8867	mzike5wf1	M	139.05	38.05	19.67944	64.95	101	75
8910	mhush5nc1	M	138.5	47.1	24.55395	81.45	107	66
8915	mchhu4maf1	M	124.8	25.1	16.11553	55.85	95	60
8943	fphda4nc1	F	140.5	37.05	18.76876	63.55	95	59
8947	fwosa5bc1	F	138.05	25.9	13.59023	52.95	90	61

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8981	fdhpa5moc1	F	145.1	39.5	18.76127	72.5	91	55
9000	fbaly5maf1	F	154.55	49.4	20.68183	66.4	102	57
9032	fchch4maf1	F	140.2	36.1	18.36586	63.1	110	68
9038	mtrda5nc1	M	149.6	46.5	20.77733	70.7	107	75
9147	fyaka4maf1	F	145.55	40	18.88146	66.75	95	60
9170	mchda4maf1	M	133.65	28.2	15.78742	59	86	53
9546	fboda4wf1	F	143.05	33.6	16.41964	60.75	100	59
9584	fzava5maf1	F	147.6	41.5	19.04914	66.7	95	56
9585	mther5bc1	M	141.35	34.4	17.21737	62.95	104	70
9605	fmema5moc1	F	138.75	28.85	14.9858	52.25	84	55
9607	mmako4maf1	M	138.75	31.8	16.51814	60.25	109	60
9676	fjije4moc1	F	134.45	29.7	16.4299	55.9	93	59
9693	frojh4maf1	F	130.15	25.95	15.31966	57.95	107	61
9710	mvelo4wf1	F	138.7	32.9	17.10185	58.65	105	66
9733	mjuma5maf1	M	136.15	36.5	19.69054	68.05	95	72
9808	fsoan5maf1	F	132.45	29.9	17.04383	66.2	99	64
9869	mwomo4bc1	M	135.8	40.45	21.93406	72.3	95	71
9916	flash4moc1	F	134.65	27	14.89193	50.85	94	67
1017	mveda4maf1	M	145.15	43	20.40959	69.75	105	80
1176	mchjo4maf1	M	141.45	36	17.99271	61.1	#NULL!	#NULL!
1275	fhama4bbf1	F	128.1	24.3	14.8084	55.35	86	66
1464	mriia5bbf1	M	150	60.3	26.8	95.05	104	69
1700	fbrma4wf1	F	131.25	31.7	18.40181	62.45	86	50
1864	filan5maf1	F	143.9	38.8	18.73743	55.85	97	61
2053	mpapa4mf1	M	143.45	32.8	15.93943	60.85	100	71
2066	finke5bbf1	F	146	39.95	18.74179	71.4	93	59
2265	ffrka4mf1	F	138.6	29.55	15.38265	58.95	#NULL!	#NULL!
2273	mzhje5maf1	M	149.05	49.1	22.10129	75.35	113	70
2415	mswan5mf1	M	147.25	33.25	15.3349	60.05	100	61
2649	fsaje4nc1	F	137.1	37.2	19.79101	70.05	96	65
2701	fwage5wf1	F	134.15	26.9	14.94758	56.25	99	56
2709	fcala5bf1	F	135.35	24.3	13.26447	57.05	89	68
2714	fhash4mf1	F	134.7	30.1	16.58942	59	102	68
2879	mwaco4bc1	M	144.1	34.2	16.47017	62.5	84	50
2995	melli4maf1	M	138.15	41.85	21.92773	74.95	#NULL!	#NULL!
3050	mhora5maf1	M	136.75	30.5	16.30967	62.8	#NULL!	#NULL!
3054	floca4bbf1	M	142.5	38.1	18.7627	64.45	91	62
3437	mchto5ma1	M	143.7	37.2	18.0148	63.45	93	58
3651	mroro4nc1	M	136.35	42.55	22.88702	70.45	100	72
3682	mkijo5maf1	M	143.9	32.6	15.74331	58.1	105	68
3685	mbaru4maf1	M	146.45	34.5	16.08571	62.45	95	56
3692	fhaki4bbf1	F	134.6	35.1	19.3739	59.85	87	60
3770	faral5wf1	F	145.05	42.7	20.29516	71.6	80	60
3856	mfavi5nc1	M	138.85	49.9	25.88265	89.5	97	66
3991	mdebh4moc1	M	143.1	31.45	15.35824	56.8	95	80
4011	manbr5nc1	M	144.1	31.3	15.07358	62.7	87	49
4066	fmcme5wf1	F	140.35	35.9	18.22509	63.9	94	75
4233	fzhli4maf1	F	142.45	30.2	14.88271	56.35	99	64
4247	mlaro5bf1	M	134.5	32.15	17.772	61.5	92	55
4381	flesa5bf1	F	141.65	35.7	17.79242	61.75	95	69
4593	mahav4moc1	M	133.65	30.4	17.01906	62.8	88	69

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4625	mnipe4maf1	M	145.75	33.6	15.81693	64.45	96	63
4908	mstha5mf1	M	139.5	30.1	15.46743	57	93	55
5011	mdisu4moc1	M	136.9	26.55	14.16634	53.6	86	59
5160	mlira5maf1	M	144.95	40.7	19.37126	67.2	101	62
5180	mlhlo4wf1	F	130.7	24.85	14.54706	56.35	91	61
5187	fsije4maf1	F	144.85	34	16.20473	56.75	97	54
5264	myeto5maf1	M	163.55	74.9	28.00146	90.45	122	84
5400	fjokr4lf1	F	146.35	35.05	16.36449	61.85	85	59
5609	fhuda4bbf1	F	144.45	51.1	24.48983	80.85	103	67
5765	mzhal5maf1	M	145.65	42.6	20.08115	68.55	98	60
5932	fbash4bc1	F	135.75	45.05	24.44641	80.1	105	63
5961	morba4bf1	M	138.1	33.8	17.72268	60.8	70	46
5996	mshaa4bbf1	M	134.5	29.8	16.47296	60.55	93	59
6058	fbrsh5maf1	F	154.85	40.6	16.93182	61.95	#NULL!	#NULL!
6060	flesh5maf1	F	136.3	29.9	16.09457	55.6	103	67
6062	mmach4bbf1	M	133.35	25.8	14.50887	54.95	105	51
6109	fwija5moc1	F	140.45	42	21.29148	64.05	#NULL!	#NULL!
6152	fmcky5mf1	F	151.4	47.2	20.59161	72.15	106	64
6177	mhabo4maf1	M	132.45	32.5	18.52591	65.95	80	52
6208	fkran4wf1	F	132.2	27.1	15.50624	56.75	97	59
6251	fkoma5maf1	F	161.15	35.8	13.7855	62.25	135	120
6279	fnesh5mf1	F	148.45	37.2	16.88039	63.4	104	54
6301	fnosa4bc1	F	137.6	28.9	15.26374	56.6	98	58
6344	mmobr5maf1	M	143.15	36.9	18.0071	64.45	90	75
6529	mpajimaf1	M	150.85	41.2	18.10534	62.5	97	63
6631	mmemi5bbf1	M	#NULL!	#NULL!	#NULL!	#NULL!	106	73
6723	mczig5mf1	M	145.7	32.5	15.30961	57.1	101	68
6814	fruvi4bc1	F	141.35	#NULL!	#NULL!	65.95	84	48
6936	fgrme4bbf1	F	139.8	30.5	15.60578	55.8	92	58
7077	mquph5lf1	M	147.55	40	18.37306	65.45	93	56
7175	fdeta5maf1	F	140.75	33.1	16.70826	60.05	93	61
7204	mgash5lf1	M	140.5	28.7	14.53882	56.45	#NULL!	#NULL!
7264	fzhci4maf1	M	#NULL!	#NULL!	#NULL!	#NULL!	102	72
7293	flodi5maf1	F	151.55	42.7	18.59157	61.9	101	63
7465	floma4bc1	M	145.65	53.4	25.17215	80.55	93	54
7563	fraem4maf1	F	136.35	29.9	16.08277	54.6	#NULL!	#NULL!
7577	mwede4bc1	M	146.1	39.8	18.64587	63.9	92	56
7631	fkyme4maf1	F	134.4	28.7	15.88852	56.45	#NULL!	#NULL!
7880	fviha5nc1	F	149.9	39.7	17.66799	60.7	110	65
7911	mstda4bbf1	M	137.45	38.5	20.37845	73.9	96	60
7941	mfast5nc1	M	133.9	32.6	18.18262	63.8	96	59
8043	mgabe4bbf1	M	132.85	33.2	18.81113	59.45	91	61
8171	mtuda4mf1	M	148.25	37.2	16.92597	62.05	98	61
8308	mbrma4bbf1	M	144.2	46.1	22.17024	79.85	109	73
8409	fchsy4moc1	F	127.85	29.9	18.29236	58.9	101	65
8411	fwaan5bbf1	F	140.6	32.9	16.64276	61.7	85	54
8466	fholi4bbf1	F	142.1	42	20.79989	68.85	73	57
8520	mvake4bc1	M	122.25	21.4	14.31911	48.8	#NULL!	#NULL!
8524	figan5maf1	F	150.7	32.6	14.3546	55.8	88	57
8573	frani5maf1	F	140.15	44.1	22.45186	68.55	109	70
8583	mmefe4mf1		#NULL!	#NULL!	#NULL!	#NULL!	97	63

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8599	fhije4wf1	F	143.45	31.3	15.21049	55.7	96	60
8629	fbrar5maf1	F	152.55	51.4	22.0871	73.1	99	61
8894	fcaar4maf1	F	136.6	42.4	22.72294	73.4	#NULL!	#NULL!
8926	mlaja4bbf1	M	136.95	34.7	18.50143	58.85	#NULL!	#NULL!
8982	mlowe4bf1	M	133.45	28.7	16.11554	61.35	110	67
9099	mzech5bbf1	M	143.25	41.3	20.12615	68.6	93	55
9102	ftoda5maf1	F	147.25	43.3	19.96996	64.5	108	71
9139	mstky5wf1	M	139.45	29.9	15.37567	58.05	88	64
9388	mbayo5lf1	M	136.45	30.3	16.27405	59.85	100	75
9433	mfoma4bbf1	M	132.3	27.9	15.93986	62.85	75	59
9496	frecl4maf1	F	134.75	30.05	16.54958	57.6	95	59
9553	fguca4maf1	F	136.45	38	20.4097	63.05	113	82
9651	fobfr4bbf1	F	148.65	41.6	18.82624	61.45	83	60
9669	fsaev4maf1	F	135.8	31.4	17.02669	58.65	88	64
9934	mulma5mf1	M	139.45	41.3	21.23797	73.6	106	67
9996	mguan4mf1	M	154.6	59.3	24.81051	78.1	108	66

Raw Data

PR	SRMAX	Curlups	Pushups	GripTot	Lapsrun	DOB	Start Date	Age
98	23	37	3	37	45	3/29/1996	12/7/2005	9.69
87	23	4	5	22	28	8/22/1995	11/16/2005	10.24
99	17	9	14	32	51	1/24/1996	11/30/2005	9.85
84	28	9	3	27	41	10/25/1996	12/7/2005	9.12
103	15	23	2	25	24	3/1/1996	11/2/2005	9.67
74	36	16	8	33	44	10/4/1995	11/2/2005	10.08
90	27	8	0	42	14	7/6/1995	2/1/2006	10.58
104	25	22	2	19	14	5/20/1995	2/1/2006	10.70
99	25	12	2	30	19	11/28/1995	11/16/2005	9.97
83	34	23	21	29	31	8/2/1996	11/30/2005	9.33
84	31	28	2	43	43	8/26/1995	11/16/2005	10.23
86	38	8	3	33	30	4/20/1996	11/16/2005	9.57
86	25	20	28	30	61	6/25/1995	11/2/2005	10.36
93	29	0	0	25	4	7/12/1996	1/11/2006	9.50
92	28	32	10	44	36	10/12/1996	11/2/2005	9.06
#NULL!	27	7	5	29	26	12/2/1996	12/7/2005	9.01
91	32	9	6	34	35	4/29/1996	11/30/2005	9.59
86	19	8	15	38	22	10/6/1996	2/1/2006	9.32
94	24	0	1	41	10	7/25/1995	2/1/2006	10.52
93	26	14	12	40	54	4/22/1996	12/7/2005	9.63
89	28	27	2	50	18	3/19/1995	11/16/2005	10.66
94	21	0	0	41	13	10/3/1995	2/8/2006	10.35
63	21	8	7	39	44	5/6/1995	11/2/2005	10.49
85	14	0	0	30	16	7/14/1995	2/8/2006	10.57
76	31	5	10	31	44	11/9/1995	11/16/2005	10.02
103	16	11	0	30	20	9/10/1995	1/11/2006	10.34
83	21	8	1	38	18	2/16/1995	11/30/2005	10.79
67	24	21	10	33	31	5/2/1996	12/7/2005	9.60
91	16	0	0	37	28	4/13/1995	11/30/2005	10.63
106	29	2	0	24	17	4/6/1995	12/7/2005	10.67
112	34	0	0	19	9	8/12/1996	2/1/2006	9.47
82	22	15	8	43	17	1/24/1995	11/30/2005	10.85
73	6	15	0	33	19	7/17/1995	11/2/2005	10.30
85	33	4	0	42	8	5/5/1996	2/1/2006	9.74
95	25	11	6	26	21	5/31/1995	12/7/2005	10.52
94	37	9	10	37	10	7/4/1996	1/11/2006	9.52
79	28	14	0	42	31	10/19/1995	12/7/2005	10.14
84	28	0	0	36	10	10/20/1995	12/7/2005	10.13
86	25	7	0	40	28	2/10/1995	11/30/2005	10.80
97	28	4	0	31	15	7/8/1995	2/1/2006	10.57
85	15	22	2	46	17	11/29/1995	2/8/2006	10.20
80	22	3	0	30	12	10/28/1996	2/8/2006	9.28
67	20	16	5	25	34	4/28/1996	11/16/2005	9.55
86	25	0	3	26	14	7/1/1996	12/7/2005	9.43
77	27	0	1	32	26	11/15/1995	12/7/2005	10.06
116	30	20	0	46	26	4/21/1996	2/8/2006	9.80
96	16	10	4	41	25	2/27/1996	11/2/2005	9.68
92	28	18	0	41	16	2/18/1996	2/1/2006	9.95
84	39	9	13	45	28	6/4/1995	11/30/2005	10.49
101	32	5	0	42	8	12/18/1995	1/11/2006	10.07
98	29	94	14	27	30	7/1/1996	11/16/2005	9.38
97	29	0	0	22	28	12/12/1995	11/30/2005	9.97

Raw Data

78	20	7	7	30	26	1/6/1995	11/30/2005	10.90
109	31	4	0	33	17	10/18/1996	2/8/2006	9.31
92	35	0	0	25	22	8/23/1996	1/11/2006	9.39
72	26	15	1	53	36	9/19/1996	11/16/2005	9.16
95	13	4	15	36	26	5/26/1995	2/8/2006	10.71
108	22	0	0	29	11	1/11/1996	2/1/2006	10.06
92	16	29	2	37	27	2/15/1995	12/7/2005	10.81
91	28	5	3	37	41	1/22/1995	11/16/2005	10.82
71	22	5	1	31	43	4/28/1995	11/16/2005	10.55
74	26	10	7	39	49	2/18/1996	11/30/2005	9.78
81	14	4	0	27	7	8/18/1995	11/2/2005	10.21
67	48	94	42	42	38	8/4/1995	11/16/2005	10.29
66	15	14	0	40	12	2/22/1995	2/8/2006	10.96
101	23	0	0	47	10	7/17/1995	2/8/2006	10.57
66	18	11	12	44	43	2/6/1995	11/2/2005	10.74
91	26	23	9	42	29	11/10/1997	12/7/2005	8.07
111	29	1	0	42	7	8/23/1995	2/1/2006	10.44
81	8	0	0	35	8	2/6/1995	2/8/2006	11.01
86	18	8	5	30	8	10/31/1995	11/2/2005	10.01
92	38	29	0	25	22	11/19/1995	11/30/2005	10.03
77	31	12	3	25	15	10/27/1996	11/2/2005	9.02
65	49	10	2	51	14	9/29/1995	11/16/2005	10.13
80	33	15	8	42	44	2/18/1995	11/16/2005	10.74
88	35	0	2	44	28	4/25/1995	11/16/2005	10.56
69	21	3	1	34	17	7/18/1995	11/16/2005	10.33
88	33	18	0	31	12	1/23/1996	12/7/2005	9.87
87	23	2	0	23	23	9/15/1995	11/30/2005	10.21
83	31	20	0	25	23	11/21/1996	11/16/2005	8.99
87	33	0	0	25	8	9/18/1995	2/8/2006	10.39
75	34	11	2	44	20	1/4/1995	2/8/2006	11.10
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86	27	15	15	34	28	5/26/1996	11/2/2005	9.44
74	28	13	10	25	24	12/28/1996	11/30/2005	8.92
78	28	10	12	36	20	6/21/1996	11/2/2005	9.37
62	21	25	30	42	60	4/20/1995	11/2/2005	10.54
87	26	19	0	36	22	7/30/1995	12/7/2005	10.36
99	23	1	2	25	20	4/6/1996	2/8/2006	9.84
92	30	21	6	40	17	2/13/1995	11/30/2005	10.80
71	35	4	2	30	26	3/6/1995	12/7/2005	10.76
101	25	20	9	37	47	11/28/1995	11/30/2005	10.01
86	27	12	0	40	12	6/25/1996	1/11/2006	9.55
91	31	2	0	33	25	12/28/1995	11/16/2005	9.89
89	41	27	12	40	12	4/9/1996	11/16/2005	9.60
75	24	18	10	25	16	4/28/1995	11/16/2005	10.55
100	23	0	0	40	10	1/25/1995	2/1/2006	11.02
92	20	10	0	33	10	5/31/1996	11/16/2005	9.46
90	25	12	4	23	13	5/19/1996	11/2/2005	9.46
102	32	1	0	26	19	10/11/1996	12/7/2005	9.16
86	37	12	9	34	25	9/14/1995	11/2/2005	10.14
69	20	11	3	35	21	1/17/1995	1/11/2006	10.98
98	33	95	1	31	23	7/1/1996	11/16/2005	9.38
98	25	12	0	21	17	1/30/1996	11/16/2005	9.80
79	29	3	0	32	16	4/23/1995	12/7/2005	10.63

Raw Data

86	21	8	1	36	13	1/5/1996	2/1/2006	10.08
93	34	7	1	26	11	11/18/1996	11/16/2005	8.99
72	18	0	0	31	8	10/26/1995	1/11/2006	10.21
94	21	0	10	25	17	9/15/1995	11/30/2005	10.21
128	21	0	0	17	12	1/5/1995	11/16/2005	10.86
97	34	20	12	28	35	9/13/1996	11/2/2005	9.14
69	31	14	0	37	11	8/25/1995	11/16/2005	10.23
78	19	0	0	39	22	12/1/1995	2/8/2006	10.19
86	23	51	20	44	63	10/21/1995	12/7/2005	10.13
70	26	9	0	21	8	8/28/1995	11/16/2005	10.22
95	24	20	0	25	21	3/25/1995	11/30/2005	10.69
82	19	0	4	40	26	5/17/1996	12/7/2005	9.56
94	29	4	0	31	21	10/14/1996	11/16/2005	9.09
96	35	0	9	32	26	2/3/1996	11/16/2005	9.79
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88	18	0	0	28	12	1/7/1996	12/7/2005	9.92
69	28	17	16	48	81	4/17/1996	12/7/2005	9.64
89	25	8	9	42	13	11/17/1995	11/30/2005	10.04
98	16	17	2	34	11	5/26/1996	11/2/2005	9.44
78	24	7	16	35	40	8/8/1995	12/7/2005	10.33
82	30	2	0	21	17	8/5/1996	11/16/2005	9.28
72	18	6	0	41	12	11/25/1996	12/7/2005	9.03
98	5	0	0	27	5	11/11/1995	11/2/2005	9.98
89	35	17	0	36	19	12/5/1995	12/7/2005	10.01
93	31	10	1	29	28	12/22/1995	12/7/2005	9.96
70	29	20	0	48	12	4/19/1995	2/1/2006	10.79
94	19	0	0	39	12	11/6/1996	12/7/2005	9.08
89	22	18	0	23	26	4/12/1996	2/8/2006	9.83
90	27	6	8	35	36	6/26/1996	12/7/2005	9.45
82	30	32	2	39	14	3/5/1995	2/1/2006	10.91
90	37	3	1	27	14	9/23/1995	11/30/2005	10.19
80	11	3	0	26	16	7/21/1995	11/2/2005	10.29
93	38	4	6	35	33	9/9/1996	11/30/2005	9.22
103	23	19	5	32	24	3/2/1996	11/30/2005	9.75
79	36	9	2	32	19	11/23/1995	12/7/2005	10.04
93	23	11	6	40	33	2/8/1996	11/30/2005	9.81
94	31	0	0	30	10	8/10/1995	1/11/2006	10.42
87	21	0	2	25	22	6/21/1996	1/11/2006	9.56
112	23	7	4	27	26	8/30/1996	2/8/2006	9.44
114	16	25	5	38	20	1/24/1995	11/2/2005	10.77
119	16	0	0	26	8	1/8/1995	2/8/2006	11.09
97	23	36	3	39	38	4/29/1995	11/2/2005	10.51
85	16	2	0	24	6	10/29/1995	1/11/2006	10.20
91	27	0	11	21	48	7/9/1996	11/30/2005	9.39
91	36	2	0	37	16	10/10/1996	1/11/2006	9.25
84	40	7	0	30	15	3/16/1995	11/16/2005	10.67
73	30	9	0	37	12	3/5/1995	2/8/2006	10.93
90	31	5	2	41	20	3/8/1995	11/30/2005	10.73
92	26	11	4	35	26	8/11/1996	11/30/2005	9.30
80	21	12	0	39	10	1/19/1995	1/11/2006	10.98
92	27	12	1	37	15	4/5/1996	12/7/2005	9.67
79	33	12	14	33	32	8/22/1996	12/7/2005	9.29
80	18	19	8	31	40	2/7/1995	11/2/2005	10.74

Raw Data

81	29	75	10	47	27	6/1/1995	12/7/2005	10.52
78	23	5	0	30	15	12/6/1995	11/16/2005	9.95
92	39	9	16	28	12	7/5/1995	2/8/2006	10.60
#NULL!	23	11	13	40	14	7/18/1996	11/30/2005	9.37
109	37	30	0	25	8	11/17/1996	2/8/2006	9.23
79	29	26	19	30	53	7/3/1996	12/7/2005	9.43
74	27	25	37	41	46	11/21/1995	11/2/2005	9.95
67	41	11	14	36	42	4/14/1995	12/7/2005	10.65
83	42	18	0	29	17	8/16/1995	12/7/2005	10.31
88	20	0	0	20	11	9/2/1996	11/16/2005	9.20
92	32	0	0	25	16	3/22/1996	2/1/2006	9.86
88	25	19	0	38	21	1/16/1996	11/30/2005	9.87
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93	12	0	10	45	21	12/9/1995	1/20/2006	10.12
66	30	21	14	23	19	3/1/1996	11/2/2005	9.67
94	31	18	4	32	17		11/30/2005	#####
105	29	20	18	30	28	9/24/1996	11/23/2005	9.16
79	17	0	13	34	44	1/22/1995	1/20/2006	11.00
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79	19	13	14	40	41	2/22/1995	11/23/2005	10.75
95	28	0	0	26	7	3/22/1996	1/11/2006	9.81
62	22	4	13	26	12	6/21/1995	11/2/2005	10.37
84	29	28	5	23	12	10/25/1995	11/9/2005	10.04
85	21	11	8	22	12	11/7/1996	11/23/2005	9.04
80	22	4	1	37	10	7/27/1996	11/16/2005	9.31
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85	32	11	0	35	13	4/15/1995	11/30/2005	10.63
89	25	0	2	36	9	2/16/1996	1/11/2006	9.90
86	34	7	0	31	21	8/8/1995	11/30/2005	10.31
85	24	42	24	37	53	1/30/1996	12/7/2005	9.85
99	19	1	0	35	18	4/24/1996	1/20/2006	9.74
66	28	10	0	31	20	9/17/1995	11/2/2005	10.13
104	21	1	2	30	10	8/28/1995	1/11/2006	10.37
98	30	0	0	33	27	6/20/1996	2/1/2006	9.62
108	15	22	5	34	18	5/19/1995	1/11/2006	10.65
77	26	14	15	30	36	1/6/1995	11/2/2005	10.82
96	41	11	1	33	22	3/27/1997	12/7/2005	8.70
75	35	17	26	33	51	10/28/1995	11/9/2005	10.03
84	37	13	14	35	38 ?		11/9/2005	10.72
93	30	0	0	31	20	10/9/1996	2/1/2006	9.31
84	23	11	3	31	18	6/26/1996	12/7/2005	9.45
81	26	38	31	40	40	9/8/1995	11/23/2005	10.21
97	27	15	0	22	13	5/9/1996	2/8/2006	9.75
88	34	8	8	33	20	9/29/1995	11/30/2005	10.17
94	33	10	6	34	34	10/30/1996	11/2/2005	9.01
108	27	20	2	32	15	10/6/1996	12/7/2005	9.17
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109	25	4	0	40	11	8/19/1996	1/20/2006	9.42

Raw Data

75	26	16	0	36	16	12/13/1995	11/30/2005	9.97
83	32	0	0	24	16	6/3/1996	11/16/2005	9.45
96	31	10	9	40	32	2/16/1995	11/9/2005	10.73
80	17	7	4	35	33	5/30/1996	1/20/2006	9.64
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103	33	17	12	34	34	7/13/1995	1/20/2006	10.52
#NULL!	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!	9/8/1995	2/8/2006	10.42
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84	29	1	2	17	19	11/15/1996	12/7/2005	9.06
110	21	4	2	26	34	5/30/1996	11/2/2005	9.43
79	31	17	10	41	22	11/17/1995	11/30/2005	10.06
78	9	23	10	35	20	2/27/1995	11/23/2005	10.74
76	36	2	0	24	11	12/11/1996	11/16/2005	8.93
92	32	7	6	43	30	1/31/1995	11/30/2005	10.83
88	33	10	4	47	37	4/20/1995	11/30/2005	10.61
91	23	23	14	55	43	3/16/1995	1/20/2006	10.85
110	20	17	13	37	50	5/9/1995	11/23/2005	10.54
79	31	0	0	27	7	3/3/1996	11/16/2005	9.71
101	36	22	0	42	56	3/14/1995	1/20/2006	10.86
81	26	20	8	37	25	4/8/1995	11/9/2005	10.59
107	25	16	12	35	35 ?		11/30/2005	10.92
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86	41	21	1	31	31	3/29/1996	12/7/2005	9.69
91	29	9	4	40	40	5/4/1995	11/30/2005	10.58
60	17	3	0	41	13	6/17/1996	11/16/2005	9.42
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115	12	42	1	40	24	5/10/1996	11/16/2005	9.52
#NULL!	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!	8/27/1996	12/7/2005	9.28
79	24	13	8	41	15	9/14/1995	1/11/2006	10.33
90	22	10	5	37	16	4/15/1996	1/20/2006	9.77
83	13	6	0	26	10	8/28/1995	1/11/2006	10.37
91	25	0	20	39	33	7/2/1996	1/20/2006	9.55
102	21	83	25	42	47 ?		11/23/2005	#####
71	16	0	0	43	20	5/30/1996	1/20/2006	9.64
115	23	11	0	23	11	4/11/1996	2/8/2006	9.83
81	35	6	12	31	38	10/5/1995	1/20/2006	10.29
91	30	4	0	46	31	7/24/1996	1/20/2006	9.49
#NULL!	13	0	7	22	5	7/24/1996	11/16/2005	9.31
83	34	25	4	31	18	1/26/1995	11/30/2005	10.84
107	44	2	4	32	20	11/2/1995	11/30/2005	10.08
127	35	3	7	29	21	3/28/1996	11/23/2005	9.66
89	26	19	8	28	14	7/25/1996	11/2/2005	9.27
102	36	4	1	37	24	6/17/1995	12/7/2005	10.48
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#NULL!	28	18	8	39	31	1/21/1996	1/20/2006	10.00
75	16	0	0	21	16	9/14/1996	11/9/2005	9.15
97	24	8	11	36	22	4/25/1995	1/20/2006	10.74
88	31	16	10	43	17	9/19/1995	11/30/2005	10.20
82	23	17	20	38	61	8/2/1995	11/2/2005	10.25
83	19	5	6	30	17	10/18/1995	11/9/2005	10.06
75	32	26	9	36	54	7/10/1996	1/20/2006	9.53
106	21	10	0	28	9	5/31/1996	11/30/2005	9.50

Raw Data

97	40	6	5	28	18	1/12/1996	11/30/2005	9.88
91	31	30	0	46	35	1/26/1996	1/20/2006	9.98
100	25	8	7	25	43	12/19/1996	12/7/2005	8.97
107	19	9	4	28	22	6/19/1995	11/23/2005	10.43
81	18	0	1	37	27	4/4/1995	11/23/2005	10.64

Raw Data

Teacher ID	School ID	Ethnicity Code	Code Wear Days	Weather Code	Avg Wear Hours	Total Counts
235	13413	1	2	0.2	13.03038162	1844871
740	13441	1	1	0.4	14.20742638	2061594
653	13413	2	2	0.8	12.615788	1401196
235	13413	2	0	0.2	12.38531455	1418570
856	13755	1	0	1	14.19519746	1809042
521	13755	1	0	1	11.46798538	1144636
220	13394	2	0	0.8	14.87826159	1414068
220	13394	2	0	0.8	13.34169478	1560389
650	13441	1	0	0.4	13.82560032	1809262
653	13413	1	2	0.8	12.99116054	842437
740	13441	1	0	0.4	14.54383806	2673140
350	13441	2	0	0.4	14.52882417	1911797
546	13755	1	0	0.8	14.02849772	1970807
146	13392	2	2	0.8	14.67736167	2331735
856	13755	1	1	1	11.41135496	1475926
748	13413	1	0	0.2	12.14050407	1481188
653	13413	2	2	0.8	13.46826855	1475721
330	13394	2	0	0.8	13.19309387	1891861
730	13394	2	0	0.2	13.53792419	1017709
435	13413	2	0	0.8	11.5962859	1366065
650	13441	1	2	0.4	12.9605748	1814363
730	13394	2	2	0.8	11.38985161	1149876
521	13755	1	0	1	13.15086502	1150977
730	13394	2	2	0.2	12.58724001	749521
650	13441	1	0	0.4	11.5798037	1882124
140	13392	1	0	0.8	12.33339121	1756141
152	13413	1	2	0.8	12.75257199	1511791
235	13413	1	0	0.2	13.95453999	2102450
886	13413	1	2	0.8	12.40630538	1323842
426	13413	1	0	0.2	13.85650976	1117358
126	13394	2	0	0.6	15.29065291	1303903
168	13413	2	2	0.8	16.04234652	662495
521	13755	1	0	1	13.99456087	3054020
330	13394	2	0	0.8	15.50810676	1806882
426	13413	1	0	0.2	14.81843208	1386605
146	13392	2	0	0.8	14.82103592	1414668
426	13413	1	0	0.2	14.16380892	1831794
435	13413	0	2	0.2	11.49250565	1199520
152	13413	1	2	0.8	14.47436456	1927022
220	13394	2	0	0.8	14.50402596	1639927
710	13394	2	0	0.2	12.03054239	1388741
960	13394	2	2	0.2	13.05224088	1747523
350	13441	1	2	0.4	11.65384086	1112212
235	13413	2	2	0.2	13.06194194	1003620
435	13413	2	0	0.2	14.21710657	1496331
960	13394	2	0	0.2	13.31597539	1124231
856	13755	1	2	1	13.35473759	1754449
126	13394	2	0	0.8	14.24185304	1351248
658	13413	2	2	0.8	12.69418703	1116219

Raw Data

140	13392	2	0	0.8	14.26282993	1811441
350	13441	1	0	0.4	11.08035991	845824
886	13413	2	0	0.2	11.98981643	724647
886	13413	1	2	0.8	11.99502373	2041619
960	13394	2	0	0.2	14.63494352	2473362
451	13392	2	0	0.8	14.00944632	1170062
740	13441	1	0	0.4	13.70176622	1292298
710	13394	2	2	0.8	12.52115875	1349643
450	13394	2	0	0.2	12.4347326	1562084
426	13413	1	1	0.2	12.10382813	1277648
740	13441	1	0	0.4	13.36931931	2215439
740	13441	2	0	0.4	14.73149434	1408900
653	13413	1	2	0.8	12.33420855	1202207
521	13755	1	1	1	12.44261053	1409363
740	13441	1	0	0.4	13.55507045	2778271
710	13394	2	0	0.2	14.26568764	1042470
710	13394	2	0	0.2	10.78489554	611894
521	13755	2	0	1	13.72558047	1628605
748	13413	2	0	0.2	10.69961172	1807906
220	13394	2	0	0.8	14.68529459	1854896
710	13394	1	0	0.2	14.10089303	1724921
147	13755	1	0	1	13.18547331	3143363
658	13413	2	2	0.8	12.42113165	1379103
621	13755	1	0	1	12.69394721	1354067
650	13441	1	0	0.4	13.28454058	2127978
740	13441	1	0	0.4	13.5788847	2185348
740	13441	1	0	0.4	13.22929153	1558457
740	13441	1	0	0.4	11.85187537	1487769
435	13413	2	0	0.2	14.49245291	948589
658	13413	2	2	0.8	14.86404834	1063301
350	13441	2	2	0.4	13.90958203	1907709
710	13394	2	0	0.2	14.49772018	1681445
710	13394	2	0	0.8	14.29998015	1772971
856	13755	1	0	1	13.45981346	2251708
856	13755	1	2	1	12.83602138	1342373
653	13413	2	2	0.2	12.81245577	1324072
621	13755	1	2	1	13.2431574	1164362
521	13755	1	0	1	14.02849772	2476019
435	13413	2	0	0.8	14.21520143	1847328
730	13394	2	0	0.8	12.55010915	1816708
168	13413	2	0	0.8	13.23881723	789370
435	13413	2	0	0.2	14.27902362	1034613
168	13413	1	0	0.8	12.2113691	2181715
451	13392	2	0	0.8	13.15388311	2454646
740	13441	1	0	0.4	13.30454455	2304014
350	13441	1	2	0.4	14.03607601	2286340
740	13441	1	2	0.4	12.86064205	1552021
220	13394	2	2	0.6	13.48854211	1017313
130	13441	1	0	0.4	11.9352518	1168040
147	13755	1	0	1	13.95324469	1065839
748	13413	2	2	0.2	12.40154512	1106598

Raw Data

546	13755	1	0	1	11.19611808	1791455
657	13392	2	0	0.8	15.48108644	1986185
350	13441	1	1	0.4	11.61153798	1363879
350	13441	1	0	0.4	13.21500298	1812944
435	13413	2	0	0.2	13.88465965	1457031
126	13394	2	0	0.2	14.05231197	1174641
350	13441	2	0	0.4	14.05993253	1566947
140	13392	2	0	0.8	14.57547512	1478454
168	13413	2	2	0.8	14.59967963	965758
740	13441	1	0	0.4	14.32648164	671960
147	13755	2	0	1	15.14362405	1580825
650	13441	2	2	0.4	12.85270745	954170
710	13394	2	0	0.2	14.43048224	2673618
426	13413	1	0	0.2	14.12955854	2260111
650	13441	2	0	0.4	13.58460012	977491
658	13413	2	2	0.2	12.39833792	1133996
163	13413	1	0	0.2	11.27438371	1382195
350	13441	1	0	0.4	14.32818579	1418867
350	13441	1	0	0.4	14.31331613	1748974
710	13394	2	0	0.2	13.09783687	1006337
748	13413	2	0	0.2	13.43789353	1071120
163	13413	1	0	0.2	13.66556857	2167628
886	13413	2	2	0.8	14.08062001	1748628
147	13755	1	0	1	15.08455076	1656405
426	13413	1	0	0.2	13.54744989	1836389
350	13441	2	0	0.4	13.88084937	2069972
435	13413	2	0	0.2	13.04918898	1229318
546	13755	1	1	1	12.49693173	1269056
435	13413	2	0	0.2	14.24092082	1443942
426	13413	1	0	0.2	13.01591586	1312939
390	13394	2	0	0.8	14.69358211	1004801
235	13413	2	0	0.2	13.18452074	1706730
960	13394	2	0	0.2	14.55336376	987357
163	13413	2	2	0.8	14.86404834	1063301
220	13394	2	0	0.8	12.77491566	1346007
152	13413	2	2	0.8	13.5687453	1410105
521	13755	1	0	1	11.18949843	1014057
653	13413	1	2	0.8	12.271539	2187334
886	13413	2	2	0.8	13.82628399	1375395
426	13413	2	0	0.2	15.03562259	1250647
653	13413	1	2	0.8	11.73403161	1212354
140	13392	2	1	0.8	13.40339601	1389736
451	13392	2	0	0.8	14.68481842	2183768
960	13394	2	0	0.2	15.88206388	2358029
546	13755	1	0	1	12.08049216	1099830
710	13394	2	0	0.2	14.14566382	1261715
147	13755	1	2	1	13.34465195	1567407
140	13392	2	2	0.8	13.45259925	1806361
653	13413	2	2	0.8	13.02157665	1101429
146	13392	2	0	0.8	16.26608454	1569522
740	13441	2	0	0.4	14.74442045	2351298

Raw Data

730	13394	2	0	0.2	13.21405041	1304790
658	13413	2	2	0.8	13.74841316	1046612
886	13413	2	2	0.8	12.168028	1120395
657	13392	2	0	0.8	14.7638968	1215299
235	13413	2	0	0.2	13.87227625	1684341
748	13413	2	0	0.2	13.83417345	1496783
621	13755	1	2	1	12.81388013	1557653
426	13413	1	0	0.2	14.61692623	1334702
650	13441	1	0	0.4	12.24044292	1372835
710	13394	2	0	0.2	14.0978483	1192691
886	13413	1	2	0.8	13.6625753	1277321
960	13394	2	0	0.2	13.47029172	1454870
163	13413	2	0	0.2	15.06502215	1464842
147	13755	1	0	1	14.06194478	1501045
426	13413	2	0	0.2	14.48222985	1141499
435	13413	2	0	0.2	13.67890454	1108391
350	13441	2	1	0.4	14.0699226	1858506
330	13394	2	0	0.8	13.58174241	1669544
886	13413	1	#NULL!	#NULL!	#NULL!	#NULL!
653	13413	2	#NULL!	#NULL!	#NULL!	#NULL!
574	13443	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!
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621	13755	1	#NULL!	#NULL!	#NULL!	#NULL!
168	13413	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!
810	13753	2	#NULL!	#NULL!	#NULL!	#NULL!
145	13443	1	#NULL!	#NULL!	#NULL!	#NULL!
210	13753	1	#NULL!	#NULL!	#NULL!	#NULL!
658	13413	2	#NULL!	#NULL!	#NULL!	#NULL!
750	13753	1	#NULL!	#NULL!	#NULL!	#NULL!
451	13392	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!
521	13755	1	#NULL!	#NULL!	#NULL!	#NULL!
530	13411	1	#NULL!	#NULL!	#NULL!	#NULL!
810	13753	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!
350	13441	1	#NULL!	#NULL!	#NULL!	#NULL!
653	13413	2	#NULL!	#NULL!	#NULL!	#NULL!
426	13413	2	#NULL!	#NULL!	#NULL!	#NULL!
574	13443	1	#NULL!	#NULL!	#NULL!	#NULL!
658	13413	2	#NULL!	#NULL!	#NULL!	#NULL!
451	13392	2	#NULL!	#NULL!	#NULL!	#NULL!
168	13413	2	#NULL!	#NULL!	#NULL!	#NULL!
163	13413	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!
574	13443	1	#NULL!	#NULL!	#NULL!	#NULL!
546	13755	1	#NULL!	#NULL!	#NULL!	#NULL!
140	13392	2	#NULL!	#NULL!	#NULL!	#NULL!
126	13394	2	#NULL!	#NULL!	#NULL!	#NULL!
140	13392	1	#NULL!	#NULL!	#NULL!	#NULL!
546	13755	1	#NULL!	#NULL!	#NULL!	#NULL!
748	13413	2	#NULL!	#NULL!	#NULL!	#NULL!
530	13411	2	#NULL!	#NULL!	#NULL!	#NULL!
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126	13394	2	#NULL!	#NULL!	#NULL!	#NULL!

Raw Data

163	13413	1	#NULL!	#NULL!	#NULL!	#NULL!
210	13753	1	#NULL!	#NULL!	#NULL!	#NULL!
960	13394	2	#NULL!	#NULL!	#NULL!	#NULL!
152	13413	2	#NULL!	#NULL!	#NULL!	#NULL!
856	13755	1	#NULL!	#NULL!	#NULL!	#NULL!
235	13413	2	#NULL!	#NULL!	#NULL!	#NULL!
658	13413	2	#NULL!	#NULL!	#NULL!	#NULL!
630	13412	1	#NULL!	#NULL!	#NULL!	#NULL!
574	13443	1	#NULL!	#NULL!	#NULL!	#NULL!
168	13413	2	#NULL!	#NULL!	#NULL!	#NULL!
350	13441	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!
530	13411	1	#NULL!	#NULL!	#NULL!	#NULL!
574	13443	2	#NULL!	#NULL!	#NULL!	#NULL!
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435	13413	2	#NULL!	#NULL!	#NULL!	#NULL!
574	13443	1	#NULL!	#NULL!	#NULL!	#NULL!
710	13394	2	#NULL!	#NULL!	#NULL!	#NULL!
750	13753	1	#NULL!	#NULL!	#NULL!	#NULL!
235	13413	2	#NULL!	#NULL!	#NULL!	#NULL!
856	13755	1	#NULL!	#NULL!	#NULL!	#NULL!
168	13413	1	#NULL!	#NULL!	#NULL!	#NULL!
750	13753	1	#NULL!	#NULL!	#NULL!	#NULL!
130	13441	2	#NULL!	#NULL!	#NULL!	#NULL!
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127	13443	1	#NULL!	#NULL!	#NULL!	#NULL!
320	13412	2	#NULL!	#NULL!	#NULL!	#NULL!
886	13413	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!
320	13412	2	#NULL!	#NULL!	#NULL!	#NULL!
748	13413	2	#NULL!	#NULL!	#NULL!	#NULL!
168	13413	1	#NULL!	#NULL!	#NULL!	#NULL!
130	13441	1	#NULL!	#NULL!	#NULL!	#NULL!
235	13413	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!
350	13441	1	#NULL!	#NULL!	#NULL!	#NULL!
163	13413	2	#NULL!	#NULL!	#NULL!	#NULL!
657	13392	2	#NULL!	#NULL!	#NULL!	#NULL!
574	13443	1	#NULL!	#NULL!	#NULL!	#NULL!
657	13392	2	#NULL!	#NULL!	#NULL!	#NULL!
574	13443	1	#NULL!	#NULL!	#NULL!	#NULL!
370	13753	1	#NULL!	#NULL!	#NULL!	#NULL!
127	13443	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!
960	13394	2	#NULL!	#NULL!	#NULL!	#NULL!
145	13443	1	#NULL!	#NULL!	#NULL!	#NULL!
574	13443	1	#NULL!	#NULL!	#NULL!	#NULL!
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658	13413	1	#NULL!	#NULL!	#NULL!	#NULL!
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Raw Data

856	13755	1	#NULL!	#NULL!	#NULL!	#NULL!
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168	13413	1	#NULL!	#NULL!	#NULL!	#NULL!
521	13755	1	#NULL!	#NULL!	#NULL!	#NULL!
320	13412	2	#NULL!	#NULL!	#NULL!	#NULL!
574	13443	1	#NULL!	#NULL!	#NULL!	#NULL!
653	13413	1	#NULL!	#NULL!	#NULL!	#NULL!
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810	13753	#NULL!	#NULL!	#NULL!	#NULL!	#NULL!