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Review Paper

The effect of season and weather on physical activity: A systematic review

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Summary *Objectives:* This study reviewed previous studies to explore the effect of season, and consequently weather, on levels of physical activity.
Study design and methods: Thirty-seven primary studies (published 1980–2006) representing a total of 291 883 participants (140 482 male and 152 085 female) from eight different countries are described, and the effect of season on moderate levels of physical activity is considered.
Results: Upon review of the evidence, it appears that levels of physical activity vary with seasonality, and the ensuing effect of poor or extreme weather has been identified as a barrier to participation in physical activity among various populations. Therefore, previous studies that did not recognize the effect of weather and season on physical activity may, in fact, be poor representations of this behaviour.
Conclusions: Future physical activity interventions should consider how weather promotes or hinders such behaviour. Providing indoor opportunities during the cold and wet months may foster regular physical activity behaviours year round.

Introduction

A growing body of evidence indicates that levels of physical activity are influenced by environmental attributes, such as place of residence and accessibility of recreation facilities.[1,2] While a few studies have considered features of the natural environment, such as access to parks and playgrounds,[3] seasonality and weather conditions have been relatively overlooked as determinants of physical activity. Previous studies, and common logic, dictate that attributes such as amount of daylight, extreme temperatures and precipitation levels might influence physical activity behaviours, especially walking outdoors, the most common physical activity undertaken by all populations.[4,5] Weather conditions can strongly promote or deter physical activity behaviours.[6] Studies specific to children

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have suggested that being outdoors has been identified as a significant predicator of levels of physical activity.[7–11] Therefore, the aim of this review is to gain a better understanding of the effects of seasonal differences and variations in weather on levels of physical activity. As the amount of outdoor recreation time fluctuates according to season, and seasonality varies according to geographic location, this review will also consider regional variations among different countries.

Physical inactivity has been acknowledged as a causal factor to the current obesity epidemic.[12] Physical activity has numerous physiological and psychological health benefits, including reduced risk of coronary heart disease, hypertension, colon cancer, osteoporosis, diabetes mellitus, depression and anxiety, while allowing for controlled weight loss.[13–15] Despite the abundant health benefits, 56% of Canadians remain inactive.[16]

Currently in Canada, 56% of males and 39% of females are overweight or obese.[17] These rates have been echoed in the USA where a higher prevalence is evident in both males and females.[15] Obesity has been linked with major preventable diseases, including type 2 diabetes, cardiovascular disease, hypertension, stroke, gallbladder disease and some forms of cancer.[18–20] The healthcare costs associated with Canadians' obesity-related diseases are approximately 1.8 billion dollars/year.[21] Therefore, effective interventions that address and overcome current barriers to participation in physical activity are necessary in order to combat this disease.

Studies have provided conflicting results regarding levels of physical activity during the varying seasons; however, weather has been reported as a barrier to physical activity.[6,22,23] The resulting information is particularly valuable for determining how physical activity interventions must be modified during different seasons of the year, and for identifying the critical need for studies of physical activity prevalence among certain populations with respect to time of year. Therefore, the purpose of this study was to conduct a systematic review of the current literature pertaining to how season and weather affect levels of physical activity. For the purpose of this review, season will be defined as the natural periods in which the year is divided, which fluctuate by weather conditions, daylight hours and temperature. They will also be based upon the Northern hemisphere experience of spring and summer falling in April–August. Weather will be defined as meteorological conditions, such as temperature, wind, clouds and precipitation.

Methods

To obtain applicable literature for this systematic review, computerized searches of six databases were conducted in the English-language literature: Medline, CINHAL, PsychINFO, Physical Education Index, Geobase and PubMed. The search terms used to identify the chosen articles were: physical activity; season; weather; environmental influences; environmental predicators; climate; rain; snow; winter; and exercise. For thoroughness, the references incorporated within relevant articles, which revealed additional sources for analysis, were also reviewed. Based on this approach, 50 articles were recognized as potentially suitable. The abstracts, introductions and methodologies of each study were examined in order to evaluate the purpose, method and sample for potential inclusion in the systematic review. Studies were excluded from further consideration if they were entirely qualitative. Accordingly, a total of 37 studies, summarized in Table 1, were recognized as pertinent as they were primary studies, in which the prevalence of physical activity was considered under the season/weather context.

Results

From the 37 primary studies (published 1980–2006) representing a total of 291 883 participants (140 482 male and 152 085 female) from eight different countries (Canada, USA, Australia, Cyprus, Scotland, The Netherlands, France and Guatemala), it appears that season, and subsequently weather, have an integral effect on physical activity behaviours. Twenty-seven of 37 articles (73%) reported that weather has a significant impact on physical activity behaviours. For example, a study by Loucaides et al. (2004) revealed that weather accounts for as much as 42% of variance in measured physical activity.[24] Furthermore, four of the 37 articles acknowledged season or 'bad weather' as a perceived barrier to participation in physical activity, with one study's participants reporting a rate of 69%.[25] If weather is preventing people from participating in physical activity, measures must be taken to overcome this issue. The need for opportunities for indoor physical activity during the cold and wet months of the year is paramount.

Seasonal variations

A careful assessment of the results reported in Table 1 reveals that, in general, a seasonal effect is

Table 1 Seasonal/weather effect on physical activity behaviours.

Author	Study population	Test	Definition of weather/season	Weather/season effect
Baranowski et al.[8]	A tri-ethnic sample of 191, 3- and 4-year-old Texan children (90 males, 101 females)	The Children's Activity Rating Scale for up to 12 h was used four times per year		Activity was higher outside than inside. Outside activity levels were lower during summer, with the lowest activity level in July (which is the hottest month in Galveston)
Bergstralh et al.[26]	65 healthy postmenopausal females from Rochester, MN	Physical activity score was assessed with an ordinal scale (0–18) monthly for 2 years		A strong ($P<0.0001$) seasonal pattern in physical activity was present. August 3 was the average peak day, and the seasonal range in physical activity score was 2.0 units.
Bitar et al.[47]	83 adolescents aged 12–16 years attending two high schools in the suburbs of Clermont-Ferrand, France participated in spring and autumn (44 males, 39 females)	Energy expenditure was observed over a 24-h period using two whole-body calorimeters		Daily energy expenditure was higher in spring than in autumn ($P<0.10$). Energy expenditure was best explained by fat-free mass followed by season ($r^2=0.021$, $P<0.001$)
BRFSS Coordinators[48]	The 1994 BRFSS is a random-digit dialled telephone survey of the US population greater than 18 years of age. A total of 105 853 respondents from 50 different states participated	The BRFSS collected information on whether the respondent participated in exercise, recreation or physical activities other than their regular job duties during the past month		Prevalence of physical inactivity was highest in January (35.3%) and lowest in June (24.7%). Seasonal patterns (high prevalence during winter months and low prevalence during summer months) were consistent for all age groups, racial groups, regions of residence and for both sexes
Burdette et al.[10]	250 preschool-aged children (142 males, 108 females) from the Cincinnati metropolitan area	Parents of the preschoolers completed the outdoor playtime checklist on two weekdays and one weekend day		Average outdoor playtime (which has been highly correlated with physical activity in preschoolers) differed by season ($P<0.001$), with the highest levels of outdoor time occurring in summer and the lowest in winter

Table 1 (continued)

Author	Study population	Test	Definition of weather/season	Weather/season effect
Currie et al.[25]	450 females from Manly Warringah, Australia, with at least one child under 5 years of age	Telephone numbers were selected randomly in Manly Warringah, Australia and participants completed a structured questionnaire that asked for current physical activity and pram walking involvement		Participants reported that wet and windy weather prevented them from exercising with a pram group (69%)
Dannenberg et al.[4]	1598 males and 1762 females aged 20–69 years in the Framingham Offspring Cycle 2 study (Massachusetts)	Minnesota Leisure Time Physical Activity questionnaire with additional questions added and adapted from the Harvard Alumni Study questionnaire was used	Winter = January–March, spring = April–June, summer = July–September, autumn = October–December	Both males and females were more active in summer than in winter ($P<0.001$). Significantly lower leisure-time physical activity (712 kcal/week) occurred during winter compared with the other seasons (1156 kcal/week)
Dawson-Hughes et al.[49]	125 health postmenopausal females from Boston	Questionnaire was adapted from Kriska et al. to estimate the total energy expenditure per day walking and stair climbing plus energy expended on sports, housework and leisure activities		From June/July through December/January and December/January through June/July, there was a median decline of 35% in the level of physical activity
Fisher et al.[50]	209 children who attend nursery in Glasgow Scotland (101 boys, 108 girls)	A uniaxial accelerometer was used over 3–6 days to assess habitual physical activity and sedentary behaviour	Spring = February–April, summer = May–July, autumn = August–October, winter = November–January	Total physical activity was significantly lower in spring than summer, autumn and winter ($P<0.001$). A slight but significant seasonal variation in time spent in low-intensity and moderate-to-vigorous intensity activity was found
Goran et al.[51]	232 children (aged 4–10 years) from four different ethnic groups (white American children living in Burlington, VT and Birmingham AL; African American children living in Alabama; Guatemalan Mestizo children living in Guatemala City; and Native American Mohawk children living in Akwesasne, NY) (117 boys, 115 girls)	Total energy expenditure was measured over 14 days using the double- labelled water technique		Total energy expenditure was significantly influenced by season of study ($\approx$0.42 MJ/day higher in spring than in autumn). The impact that season has on total energy expenditure can be justified by differences in activity-related energy expenditure

Gordon-Larson et al.[22]	Nationally representative data from the 1996 National Longitudinal Study of Adolescent Health on 17 766 US adolescents enrolled in middle and high schools (8728 males, 9039 females)	Times per week of moderate-to-vigorous physical activity were collected by questionnaire. A standard 7-day recall questionnaire was used		No major effects of seasonality on physical activity were present. There was no relationship between physical activity and month during which activity patterns were measured, and therefore no evidence of a seasonality effect
Haggarty et al.[31]	10 adult men from Aberdeen Scotland, whose occupations required them to sit for the majority of the day	Subjects were measured using the double-labelled water method during summer and winter, and activities in 5-min blocks were recorded throughout the 10 days.		A large fall in energy expenditure was apparent in winter (even after accounting for shorter days and adverse weather conditions) – seasonal variation in expenditure is well illustrated
Huang and Volpe[52]	16 third- and fourth-grade students (10 boys, six girls) from low-income families in Massachusetts	Assessed using a self-administered questionnaire revised from the validated National Children and Youth Fitness Surveys I and II. It contains physical education and leisure-time related questions for 78 different physical activities		The average number of days per week that children participated in physical activity varied across all seasons. During winter, days spent in activity were significantly lower than in any other season ($P<0.05$)
Humpel et al.[53]	399 clients from a health insurance organization from Australian, aged 40 years or older (57% female)	Mail-out survey included questions on age, educational attainment, gender, walking behaviours, perceptions of the neighbourhood environment and participants' postal code	Defined weather as having a: (1) strong influence, (2) moderate influence, or (3) no influence on (1) neighbourhood walking, (2) exercise walking, (3) pleasure (social) walking, and (4) walking to get to and from places	The strongest association with walking for both males and females was weather. Although weather cannot be modified, individual perceptions about the influence of weather may be. Males and females who reported that weather did not inhibit their behaviour were six and seven times, respectively, more likely to walk for exercise
King et al.[32]	2912 American females, 40 years of age or olde	A modified version of the BRFSS was used. The questions focused on leisure-time physical activity, occupational activity and physical activity that occurred around the home		Ten percent of the population reported bad weather as a barrier to physical activity
Levin et al.[27]	Seventy-seven healthy adults (aged 21–59 years, 28 males, 49 females) enrolled in the Survey of Activity, Fitness and Exercise from the metropolitan area surrounding the University of Minnesota	Physical activity was measured by Caltrac accelerometers for 48 h every 26 days for 1 year.		Higher levels of physical activity were reported in the warmer months (April–September) compared with the colder months (October–March)

Table 1 (continued)

Author	Study population	Test	Definition of weather/season	Weather/season effect
Lindsey et al.[54]		Used infra-red monitors to measure traffic at 30 locations on five trails, measured neighbourhood characteristics using geographic information systems satellite imagery and US census	Weather variables measured: TempDev = deviation of daily average temperature from normal (°F), PrecipDev = deviation of daily precipitation accumulation from normal (inches),	
	SnowDev = deviation of daily snow accumulation from normal (inches),			
	SunDev = deviation of daily percentage sunshine from normal	Increased temperature above the daily mean and increases in daylight hours with sunshine increase trail traffic significantly. Increases in precipitation above average significantly decrease trail traffic. One inch of precipitation above average will reduce trail use by approximately 40%		
Loucaides et al.[55]	256 (129 males, 127 females) sixth-grade students from five schools located in different geographic regions of Cyprus	Self-report instrument was developed from two validated questionnaires, the Four by One-Day Recall and the Previous Day Physical Activity Questionnaire		Physical activity variation explained by weather ranged from 42% in winter to 51% in summer
Loucaides et al.[24]	256 Greek-Cypriot children (129 males, 127 females), aged 11–12 years, and their parents, from urban and rural areas	Physical activity levels were assessed using pedometers for four weekdays in winter and four weekdays in summer	Winter included January and February, summer included May and June	A significant main effect for season was present ($P<0.001$). Children in both rural and urban schools spend significantly more time playing outside during summer compared with winter
Lunt et al.[56]	153 West Australian adolescents (95 males, 58 females) aged 12–18 years with congenital heart disease	The New South Wales Schools Fitness and Physical Activity Survey was used		During winter, males were more active both vigorously and adequately. Also, considerably more females were insufficiently active in winter compared with summer

Ma et al.[57]	593 US adults aged 20–70 years, with the majority being white and employed full-time (277 females)	Adapted 7-day recall of physical activity (asked for activity in the last 24 h)		The lowest physical activity level was observed in winter (29.9) and the highest in spring (30.7)
Matthews et al.[58]	Residents of Worcester County, Massachusette, aged 20–70 years, who had telephone service and were free from extreme hypercholesterolaemia and not taking cholesterol-lowering medication ($n = 580$; 300 males, 280 females)	Three 24-h activity recalls per season	Environmental changes in ambient temperature, daylight and monthly precipitation. Measured average daily temperature, barometric pressure, humidity, total precipitation and average daylight cloud cover (%)	Females and males had seasonal changes in total activity of 1.4 MET-h/day and 1.0 MET-h/day, respectively, with peak amplitudes in July. Summertime increase in combined moderate intensity leisure and household activity of approx. 2.0–2.4 MET-h/day in females and males
Matthews et al.[59]	Cohort of healthy adults ($n = 580$; 300 males, 280 females) from Worcester, Massachusetts, aged 20–70 years, had telephone service, free from extreme hypercholesterolaemia and were not taking cholesterol-lowering medication	15, 24-h physical activity recalls of total, occupational and non-occupational activity obtained over 12 months		Six percent of the variance in physical activity over a 12-month period could be explained by seasonal effects
Merrill et al.[6]	110 544 data were considered from all states and territories of the USA, for people aged 18 years or older	2003 BRFSS was used	Data on weather conditions were taken from the Sheridan's revised spatial synoptic classification system (SSC2). Winter = December–February, spring = March–May, summer = June–August,	
	autumn = September–November	The percentage of participants meeting the physical activity guidelines varied significantly across seasons: winter = 44.6%, spring = 46.2%, summer 48.4%, autumn = 45.8% ($P < 0.001$). Season significantly influenced physical activity. The highest percentage of physical activity occurred during summer and the lowest in winter		

Table 1 (continued)

Author	Study population	Test	Definition of weather/season	Weather/season effect
Pivarnik et al.[60]	1996 Michigan BRFS – households were selected using random-digit dialling methods, eligible participants were 18 years or older. The total sample was 2843 individuals, of which reported leisure-time physical activity (1208 males, 1635 females) was included	The BRFS collected information on the two leisure-time physical activities that the respondents spent the most time doing during the last month when not at work. Fifty-five different activities to choose from when coding the respondents' specific activity	Winter = January–March, spring = April–June, summer = July– September, autumn = October–December	Number of participants reporting no leisure-time physical activity in the previous month was significantly higher ($P<0.0001$) in winter (32.5%) and autumn (28.7%) compared with spring (23.4%) and summer (17%). Weekly leisure-time physical activity energy expenditure was significantly higher during spring and summer compared with winter and autumn ($P<0.001$)
Plasqui and Westerterp[28]	25 healthy Dutch young adults (10 males, 15 females) aged 20–30 years, most worked at Maastricht University	Physical activity level = total energy expenditure/sleeping metabolic rate. Total energy expenditure was measured using double-labelled water. Sleeping metabolic rate was measured during an overnight stay in a respiratory chamber	Winter months result in substantially shorter days and worse weather conditions	No difference in total energy expenditure between seasons for males or females. Level of physical activity was higher in summer than winter (1.87 ± 0.22 versus 1.76 ± 0.18; $P<0.001$), with the difference being higher for males than females. Participation in moderate-intensity physical activity peaked in July, low-intensity in January and high-intensity in January and May for both males and females
Ross and Gilbert[35]	A national sample of children and young people in grades 5–12 participated	The National Children and Youth Fitness Survey was used. Participants were asked how physical activity varies between seasons		Maximum weekly activity minutes occurred in summer, with a rate of 42% and 41% higher than the annual average for boys and girls, respectively. Seasonal reports of weekly physical activity minutes for boys and girls were: summer = 1115; autumn = 639; winter = 521; spring = 765; year round = 760

Salmon et al.[61]	1332 participants (599 males, 733 females) from the Australian Electoral Commission Role, mean age of 45.4 years	One-week leisure-time physical activity recall measure		Participants reporting weather as a barrier to physical activity are more likely to engage in sedentary behaviour, television viewing and reading. Weather was associated with a 50% increased likelihood of participation in sedentary behaviours
Santos et al.[1]	Data from the HBSC survey for 6131 public school students (3004 males, 3127 females) aged 10–17 years. The Portuguese sample was representative of students attending sixth, eighth and tenth grades of the public school system	The HBSC questionnaire asked about both organized and non-organized physical activity participation		Participation in organized and non-organized physical activities was more frequent during spring and summer. Boys and girls from the active group reported significantly ($P<0.01$) more activities during spring and summer. However, no significant difference was present between seasons for the low-activity groups
Shephard et al.[62]	546 Quebec students aged 10–12 years who were given an additional 5 h/week of required physical education	24-h records were obtained for a typical Wednesday and Saturday. Additionally, students completed a diary sheet listing activities during each half-hour segment of the days investigated		Students spent significantly more time in light–moderate and vigorous activity on Wednesdays during autumn ($S<0.001$; $S<0.051$). However, students spent significantly more time in very light activity on Saturdays during spring ($S<0.003$)
Stephens et al.[40]	16 506 households from the 10 Canadian provinces participated. All people 10 years of age or older were asked to complete the questionnaires (8654 males, 8452 females)	The questionnaire was comprised of questions asking about the type, frequency, duration and intensity of leisure-time physical activities for the last year		Leisure-time physical inactivity was higher in winter than summer
Stetson et al.[63]	65 participants (28 males, 37 females), aged 22–71 years, were recruited from the YMCA in a large Midwestern city	Participants were asked to fill out a mailed survey, which asked them to describe a high-risk situation of recent personal experience		The most commonly cited attribute for exercise slips was bad weather (75% and 66.7% for males and females, respectively)
Tu et al.[23]	Class-attendance records ($n=21$ 538) from a cohort of 110 females aged 50 years or older (majority are inner-city African American)	Patient attendance for the exercise class sessions was recorded and detailed meteorological records were	Weather variables assessed: daylight hours, cloud cover, type of weather (rain, snow, hail, etc), intensity (light,	The daily attendance showed that adverse weather conditions in the hours before the class, including heat, wind chill,

Table 1 (continued)

Author	Study population	Test	Definition of weather/season	Weather/season effect
	who had frequented one of two community healthcare centres in Indianapolis, IN, in the last 12 months	sought. Sunlight hours and type of weather (rain, snow, fog, etc.) and intensity were established	moderate or heavy) and further attributes of weather such as freezing or blowing	snowfall and overcast skies, were associated with a lower likelihood of exercise class attendance ($P<0.05$)
Uitenbroek[30]	7202 males and 9284 females aged 18–60 years from the metropolitan areas of Glasgow and Edinburgh, Scotland	Daily interviews carried out by computer-assisted telephone interviewing with two questions focused on physical activity		The effect of season on physical activity was exceptional; physical activity peaked in early and mid July. The peak phase for seasonality in physical activity falls statistically later in the year for males than females, and the amplitude of seasonality is more prominent for females than males. Levels of physical activity were lower during cold, wet and winter months for both indoor and outdoor activity
Van Staveren et al.[64]	114 Dutch females aged 29–32 years from the municipality of Renkum, The Netherlands	Patterns of physical activity were assessed monthly 14 times with the 24-h recall method (by telephone). After 14 months, the same estimates were made with intervals of 2–3 months		During spring and summer, slightly more time was spent in walking and sports (additional 17 min/day). In summer, less time was spent sitting (15 min less)
Westerterp et al.[29]	52 healthy volunteers from Maastricht, The Netherlands, with a mean age of 29 years and mean body mass index of 21.8 participated (10 males, 42 females)	Physical activity level was observed as the ratio of total energy expenditure, as measured by double-labelled water, to resting energy expenditure as measured in a respiration chamber		Physical activity was higher in summer than in winter ($P<0.001$), and the difference was higher for males than females ($P<0.04$)
Wilcox et al.[33]	2912 American females, 40 years of age or older	A modified version of the BRFSS was used. The questions focused on leisure-time physical activity, occupational activity and physical activity that occurred around the home		Urban (8.9%) and rural (10.9%) females reported bad weather as a barrier to physical activity

BRFSS, Behavioural Risk Factor Surveillance System; BRFS, Behavioral Risk Factor Survey; HBSC, Health Behaviour in School-aged Children; MET, Metabolic Equivalent.

present as the levels of physical activity appear to be highest in spring and summer (April–August).[4,26–29] In most studies, levels of physical activity peaked in July–August and energy expenditure decreased in winter.[26,28,30] Researchers such as Haggarty et al. (1994) attributed the decline in activity to the shorter days and adverse weather conditions associated with winter.[31] The decline in activity during the colder season is particularly prominent in studies of children, as their time spent playing outdoors is highest in summer and decreases considerably during winter.[10] It should be recognized, however, that time available for play by children is highly dependent on the structure of the school year, which typically affords a 'summer holiday'.

Only one study included in Table 1 revealed a lower level of physical activity during summer than in winter.[8] It is important to note, however, that this study was conducted in Galveston, Texas where the average temperature for the month of July is 29 °C (84 °F), and extreme heat has been recognized as a deterrent to outdoor activities.[8] Conversely, precipitation and cold weather have also been acknowledged as barriers to engaging in physical activity in numerous accounts.[25,32,33]

Regional variation

From an international perspective, it is apparent that weather and season are common factors affecting participation in physical activity for all countries included in this review. Of course, weather varies by geographical region not political boundaries, but the research reviewed here seems to indicate that weather effects are similar within individual countries, if not entirely similar among different countries. In all countries represented, there appeared to be a systematic decrease in physical activity behaviours during the cold months. In the USA, however, the effect of weather was not straightforward, as some US studies also reported decreased physical activity in the hotter months.[8] These seemingly inconsistent findings appear to be a product of regional variations within the USA. This makes sense as the country covers an expansive territory, and there can be extreme regional variations in weather conditions within the continental USA (not to mention the differences exhibited by Hawaii and Alaska). Studies focusing entirely on populations in notoriously hot and humid states (e.g. Texas) may exhibit a decline in activity during summer compared with winter.[8] The USA, Canada and Australia are all expansive countries that encompass several climate zones. Scotland, Cyprus, The Netherlands, France and Guatemala do not have as much variation; however, issues still exist due to variations with respect to urban versus suburban, and mountain versus coastal settings. The fact that greater intranational variations were not identified in this review, particularly for other large and climatically diverse countries such as Canada or Australia, could be due to the fact that not enough studies have been conducted within these countries to account adequately for the broad range of climatic zones they encompass. This apparent void in the literature highlights the need for further research on the effect of weather on physical activity in these countries. It also seems possible that researchers located in countries with consistently warm and pleasant climates are not studying the influence of weather on physical activity because it is not a deterring factor.

Discussion and conclusions

The need to account for environmental variables, specifically weather, when developing physical activity interventions has become increasingly clear. This systematic review concurs with Tu et al. who noted the importance of considering environmental variables that may support or hinder physical activity behaviours throughout the year.[23] Poor weather has been identified as an environmental barrier to being physically active,[32,33] but to date, specific aspects of the weather/season have been highlighted as deterrents. In regions where sustained periods of uncomfortable weather and long seasons persist, it is necessary to offer indoor physical activity facilities so that participation can continue to take place.[23] Furthermore, levels of activity in winter may be lower than those in summer because winter activities may be less convenient and accessible (physically and financially) than summer activities.[6] Merrill et al.[6] argued that it is necessary for population-based interventions to provide information regarding 'choices for physical activity that are tailored by season and climate conditions and that address concerns related to convenience, safety, accessibility and aesthetics' (2005, p. 379).

Previous research has provided support that physical activity can be influenced by characteristics of the physical environment.[2,34] Although seasonal variation is not a set feature of the environment, numerous attributes such as daylight hours, temperature and precipitation might affect physical activity behaviours.[5] In some areas, temperature and humidity may have some effect on month-by-month differences.[8] In contrast, precipitation, cold weather and wind may be the deterring factor to physical activity (more likely the case in many parts of Canada and the northern USA). Important to note is that although it rains during all seasons of the year, it is the continuous poor weather that acts as an ongoing deterrent to participation in physical activity. One day of rain may prevent individuals from engaging in activity on that day; however, ongoing precipitation may decrease levels of physical activity for extended periods of time (e.g. months).

Preschoolers' physical activity behaviours have been highly correlated with outdoor playtime.[8,11] Of concern is the fact that season has been identified as having an intermediate effect on levels of physical activity in children,[34] and a strong relationship was revealed for children and young people by Ross and Gilbert.[35] To increase children's activity levels, researchers have suggested encouraging them to spend time outdoors;[36] however, children of this age typically need supervision and parents have identified that they are not interested in spending time outside in the cold.[37] Parents have identified that the warmer seasons were more conducive to physical activity for their preschoolers and the colder seasons posed greater challenges.[37] Therefore, parents identified the need for indoor facilities to provide the opportunity for year-round participation in physical activity.[38]

It has been reported that children are less active in winter than other seasons, particularly in regions that experience cold and long winters.[35,39,40] It is therefore imperative for additional efforts to be made to increase children's levels of physical activity during colder weather; innovative solutions are necessary to promote involvement in physical activities during winter.

Sallis et al. conducted a review of environmental and policy interventions to increase physical activity.[41] Weather was identified as a barrier to physical activity, so Sallis et al. suggested that people in areas with repeated and harsh rain or cold should be supplied with supplementary resources for indoor activity (e.g. swimming pools), in addition to providing resources for cold weather activities to take place outdoors (e.g. skating, cross-country skiing, etc.). A potential strategy to increase physical activity in winter is for local governments and organizations to provide facilities that support participation in the broad range of sports that are featured in the Winter Olympics, such as cross-country skiing, ice hockey and gymnastics to name a few. Recent Canadian research by Gilliland et al. suggested that even in cities with a long winter season such as London, Ontario, the number of publicly-provided spaces for outdoor recreation (e.g. baseball diamonds, football fields) outnumber indoor facilities (e.g. pools, gyms) by a ratio of 15 to 1.[42] Furthermore, the total number of visits to the city's indoor swimming pools are considerably higher in summer than in winter.

Sallis et al. confirmed the effect that weather can have on children, as they believed the strongest evidence of the weather effect came from observational studies of preschool-aged children.[34] In three different studies, children were found to be more active when outdoors;[7,8,43] being outdoors was the most powerful correlate of physical activity (with a maximum likelihood estimate correlation of 0.74 reported in one study).[43]

Obesity levels among children have been demonstrated to be highest when measured in autumn and winter (December–March), while a lower prevalence of obesity is present in summer (May–September).[44] The reduced prevalence of obesity in summer may result from higher levels of activity due to the increased availability of outdoor recreational facilities (i.e. parks), and weather that supports activity behaviours.[44] Given that obesity has reached epidemic proportions worldwide,[45] it seems imperative to acknowledge the effect of season and weather on physical activity. In order to combat obesity in both children and adults, it is necessary for physical activity interventions to be provided in a way that supports activity during all months of the year. The effect of season and weather has been highly overlooked in the creation of physical activity interventions and during the surveillance of levels of physical activity among different populations. It is clearly important to recognize bad or extreme weather as a deterrent; therefore, future researchers need to consider its importance and involvement in physical activity.

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