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The impact of children's exposure to greenspace on physical activity, cognitive development, emotional wellbeing, and ability to appraise risk

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ABSTRACT

Introduction: The current study utilised objective techniques to investigate the relationship between children's time spent in greenspace (open land covered in grass or other vegetation) with various physical and psychological variables. Potential relationships between physical activity and greenspace with body composition, emotional wellbeing, sensation seeking tendencies, ability to appraise risk, and cognitive development are investigated.
Methods: 108 participants aged 11–14 years from three intermediate schools in Auckland, New Zealand, were assessed. Moderate-to-vigorous physical activity (MVPA) and geolocational data were recorded using accelerometers and portable global positioning system (GPS) receivers (respectively) over a 7-day period in September-December 2014. Body mass index (BMI) and waist-to-height ratio (WHtR) were calculated from height, weight, and waist circumference. Participants also completed online cognitive testing, a computerised risk appraisal tool, and a questionnaire for assessing emotional wellbeing and sensation seeking characteristics. Data analysis took place during February to May 2015. Generalised linear mixed models were used to quantify the associations between MVPA, greenspace exposure, and secondary outcome variables.
Results: Findings confirmed that greenspace exposure is positively associated with MVPA in children ($B=0.94$; $p<0.05$). Furthermore, both greenspace exposure and MVPA were related to greater emotional wellbeing, with the former exhibiting a stronger relationship than the latter. Risk-taking and sensation seeking scores were positively associated with MVPA, but not with greenspace exposure. No associations were detected between BMI, WHtR, cognitive domains, and either MVPA or greenspace exposure.
Conclusions: Findings support the theory that for children, greenspaces are an important environmental influence on physical activity and emotional wellbeing.

1. Introduction

Physical inactivity in children has been identified as a significant and growing public health concern (W.H.O. Atlas, 2015). Regular moderate-to-vigorous physical activity (MVPA) in children is associated with numerous benefits, including improved cardiovascular health, reduced indicators of metabolic syndrome, improved musculoskeletal health, reduced risk of type 2 diabetes, and lesser symptoms of depression and anxiety (Janssen and LeBlanc, 2010). A growing body of research has investigated environmental influences on children's physical activity (Sallis et al., 2008; Cervero and Kockelman, 1997; Lovasi et al., 2011). In particular, this body of research has highlighted that greenspace provides an activity and health promoting environment (Wolch et al., 2010; Fjørtoft and Sageie, 2000; Ord et al., 2013). Greenspace is commonly defined as any open piece of land that is publically accessible and is partly or completely covered with grass, trees, or other vegetation (United States Environmental Protection Agency, 2014). Research on greenspace has generally found a positive correlation between time spent in greenspaces and children's physical activity (Lachowycz and Jones, 2011).

Recent technological improvements have enabled the collection of objective, high-resolution data on children's greenspace exposure. One such study used portable Global Positioning System (GPS) receivers and accelerometers to record positional and activity data from children during their free time (Almanza et al., 2011). This study found that children were 34–39% more likely to engage in MVPA when in greenspaces compared to non-

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greenspaces. A different research group, using the same technology found that children were 37% more likely to engage in MVPA when in a greenspace compared to non-greenspace (Wheeler et al., 2010). This particular study found that children only spent 2% of their after school time in greenspaces, however that this environment accounted for 9% of MVPA for boys and 6% of MVPA for girls.

A different body of research suggests that physical activity and greenspace exposure may be independently associated with other important aspects of childhood development, such as cognitive function, emotional wellbeing, and propensity towards risk-taking (Janssen and LeBlanc, 2010; Tomporowski et al., 2008; Wells, 2000; Faber-Taylor et al., 2002; Bonhauser et al., 2005; Nelson and Gordon-Larsen, 2006). The research linking children's greenspace exposure and cognitive development mostly consists of small, exploratory studies; however, this literature suggests positive associations exist between greenspace exposure and attentional capacity (Wells, 2000; Faber-Taylor et al., 2002). Furthermore, a literature review in 2008 concluded that there is a positive association between children's physical activity levels and their executive function (Tomporowski et al., 2008).

With regard to the relationship between physical activity and emotional health in children, observational studies have generally reported small to modest associations between physical activity and depressed mood (Janssen and LeBlanc, 2010). In contrast, experimental research has tended to report beneficial effects of exercise interventions on the symptoms of both anxiety and depression (Bonhauser et al., 2005; Norris et al., 1992; Annesi, 2005). Greenspace exposure has also been associated with greater emotional wellbeing in children, as indicated by lower self-rated measures of emotional distress found in children living in 'greener' neighbourhoods (Wells and Evans, 2003). However, conversely, a large survey of Canadian children found no consistent relationships between neighbourhood greenspace and emotional wellbeing (Huynh et al., 2013).

Theorists have also proposed an association between time spent in greenspace and the formation of healthy attitudes towards risk-taking (Louv, 2005). However, there has been no empirical research to test this hypothesis. Similarly, the associations between children's physical activity levels and their propensity to take risks has received very little research attention. A single study reported that children who participated in a wide range of sporting activities had lower self-reported levels of high-risk behaviours; however, this effect was highly mediated by parental involvement in sports activities (Nelson and Gordon-Larsen, 2006).

The current study seeks to address the aforementioned research gaps by combining accelerometry, GPS, and geographic information systems (GIS) to provide objective, high-resolution information on children's physical activity and location. Building on other studies that have used this methodology (Almanza et al., 2011; Wheeler et al., 2010), we add direct and validated measures of cognitive development, emotional wellbeing, and risk-taking behaviour. This methodology allows quantitative analysis of the relationship between greenspace exposure and physical activity, as well as enabling investigation into other important variables which contribute to healthy childhood development.

2. Methods

2.1. Participants

Recruitment for this study commenced with invitations to participate being made by the researchers to intermediate schools in Auckland, New Zealand. Schools were chosen to represent culturally, socioeconomically and geographically diverse neighbourhoods. Nine schools were approached and three agreed to participate. Although these schools cover geographically distinct and culturally diverse regions of Auckland, only middle to higher decile neighbourhoods were represented by the three participating schools. Intermediate schools cover the school years 7 and 8, which include children aged between 10 and 14. This age group was targeted by this study as previous research has shown that children in this age group exhibit a decrease in physical activity which continues into adolescence (Kimm et al., 2000; Troiano et al., 2008). Greater exposure to greenspace may provide a means of counteracting this trend. A total of 118 participants (46 boys, 66 girls) aged 11–14 years consented to participate in the study. Inclusion criteria included: 1) students enrolled in school years 7 or 8, 2) appropriate English language comprehension. Exclusion criteria included: 1) physical disability that impaired mobility, 2) cognitive impairment likely to affect the ability to complete testing. Written informed consent was obtained from the parents/guardians of all participants, and assent forms were signed by all participants. Ethical approval for this study was obtained by the Auckland University of Technology Ethics committee.

2.2. Measures

2.2.1. Greenspace exposure

Locational data were gathered using the Qstarz BT-Q1000XT GPS receiver (Qstarz International, http://www.qstarz.com, Taipai, Taiwan) which was worn on a waist belt during the monitoring period and configured to record data every 15 s. The accuracy and suitability of these devices has been established in previous research (Duncan et al., 2013; Schipperijn et al., 2014). Due to limited availability of these devices, 78 participants were fitted with a GPS receiver. Participants were given verbal and written instructions regarding use of the device and a diary to record non-wear time. They were instructed to wear the device as much as possible during waking hours but asked to remove the device for sleeping, bathing, and water based activities. They were given charging devices and instructed to recharge the devices every night while they slept, a routine that has been used successfully in similar research (Kerr et al., 2011). At the initial fitting of the device it was turned on and adhesive tape placed over the 'on/off' toggle to ensure that the device remained on and in recording mode throughout the duration of the seven-day monitoring period.

2.2.2. Physical activity

Physical activity frequency, duration, and intensity were measured using the Actigraph GT3X+ accelerometer (Actigraph, http://www.actigraphcorp.com, Pensacola, FL). These devices were configured to sample activity at 30 Hz that was aggregated into 15 s epochs. The accuracy and acceptability of these devices have previously been validated for use with children in physical activity research (Evenson et al., 2008; Trost et al., 2011). All 118 participants were fitted with accelerometer devices. These were also worn on the supplied belt above the right iliac crest and verbal and written instruction on correct use of the device was given similar to the GPS receiver. Activity intensity was classified as sedentary, light, moderate, or vigorous according to the Evenson cut-points (Evenson et al., 2008) which have been previously validated against both indirect calorimetry and other accelerometer devices (Trost et al., 2011).

2.2.3. Physical measures

The standing height of each participant was measured to the nearest millimetre with a portable stadiometer (Design No. 1013522, Surgical and Medical Products, Seven Hills, Australia), and weight was measured to the nearest 0.1 kg on a digital scale (Model Seca 770, Seca, Hamburg, Germany). BMI was then calculated as weight (kg) divided by squared height (m^2). In addition,