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The Relationship between Educator Engagement & Interaction and Children's Physical Activity in Early Childhood Education and Care Services

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The Relationship between Educator Engagement & Interaction and Children's Physical Activity in Early Childhood Education and Care Services

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Abstract

Background: High levels of physical activity (PA) and low levels of sedentary behaviour (SB) are important for children's health and wellbeing. Many children attend early childhood education and care (ECEC), yet in these settings many children are not meeting recommended guidelines for PA and SB. ECEC settings are complex environments, with a number of potential factors influencing PA and SB of young children.

Aim: The aim of this thesis was to investigate the relationship between selected ECEC-related factors and children's PA and SB whilst in ECEC.

Methods: A systematic review on the correlates of children's PA and SB in ECEC was conducted. An observation study was then undertaken to examine the relationship between ECEC-related factors including routines, time spent in outdoor environments, size of outdoor environment, and educator behaviours and children's PA and SB. Children and educators in ECEC were recruited from the Illawarra region of NSW, Australia in 2015. The observation study used Actigraph accelerometers to objectively measure PA and SB, the Classroom Assessment and Scoring System (CLASS) to measure the quality of educator and child interactions, and surveys to collect descriptive data and information about the experiences of educators. The ECEC routine and the time spent in outdoor environments was collected through observation of centre programs and direct observation each day. Data were analysed using linear regression models examining the association between children's PA, SB and routine, time in outdoor environments, size of the outdoor environments and educator PA and SB.

Results: From 11 ECEC centres, 110 educators and 490 children aged 2-5years were recruited, and accelerometry data collected for each participant. A total of 131 observations were recorded, from which 87 met the CLASS criteria for this study. Centres with free routines reported better quality educator-child interactions when compared with centres that offered structured routines. Children in centres that offered free routines spent significantly less time in SB (p=0.001) and more time in total physical activity (TPA) (p=0.008). Increased time spent in outdoor environments had a significant relationship with the quality of educator and child interactions, and although not statistically significant, children in centres that offered >4hrs outdoor time each day spent less time in SB and more time in TPA. A significant association was reported between educator SB and children's SB (p=0.047).

Conclusion: This thesis provides an important contribution to the literature on the relationship between ECEC-related factors and children's PA and SB while in ECEC. The observation study demonstrated that free routines and increased time in outdoor environments promote children's PA and reduce children's SB, and has a positive relationship with the quality of educator and child interactions. It was also established that educator SB has an influence on children's SB. As routines, time in outdoor environments and the practices of educators are modifiable, they are potentially, with minimal changes, a highly effective way to enhance children's health and wellbeing through promoting PA and reducing SB.

Statement of the thesis style

In agreement with my supervisors, this thesis has been prepared in journal article compilation style format. This style format was chosen to be appropriate for this thesis because the outcomes of this work provide important information for researchers and practitioners to develop policies and procedures to promote children's physical activity and reduce children's sedentary behaviour in ECEC, and consequently contribute to enhancing the evidence-base for improving children's health.

List of publications from the thesis

Chapter 2

Tonge, K.L., Jones, R.A., Okely, A.D. (2016). Correlates of children's objectively measured physical activity and sedentary behavior in early childhood education and care services: A systematic review. *Preventive Medicine*, 89, 129-139.

(Appendix B) *Scopus citations = 36*

Chapter 3

Tonge, K. L., Jones, R. A., Hagenbuchner, M., Nguyen, T. V., & Okely, A. D. (2017). Educator engagement and interaction and children's physical activity in early childhood education and care settings: an observational study protocol. *BMJ Open*, *7*(2). doi:http://dx.doi.org/10.1136/bmjopen-2016-014423

(Appendix C) *Scopus citations = 3*

Chapter 4

Tonge, K. L., Jones, R. A., & Okely, A. D. (2019). Quality Interactions in Early Childhood Education and Care Center Outdoor Environments. *Early Childhood Education Journal*, 47(1), 31-41. doi: 10.1136/bmjopen-2016-014423

(Appendix D) *Scopus citations = 0*

Submitted for publication

Chapter 5

Tonge, K.L., Jones, R.A., & Okely, A.D. (2019). Environmental influences on children’s physical activity in early childhood education and care. *JPAH.* (minor revisions recommended, revised manuscript to be submitted).

Chapter 6

Tonge, K.L., Jones, R.A., & Okely, A.D. (2019). The relationship between educators’ and children’s physical activity and sedentary behaviour in early childhood education and care. *Health Education Research.* (under review).

The greater part of the work involved in this thesis is directly attributable to me, as the PhD candidate. Supervisors and co-authors have been involved in conceiving and designing the research instruments. All authors revised and approved the published, submitted and presented work. The observations, data collection and analyses, and reporting have been performed solely by me, in keeping with the requirements of my candidature. Documentation of the statement of contribution for each peer-reviewed article in this thesis can be found in Appendix A: Author contribution forms.

Conference presentations in support of this thesis

Tonge, K.L, Jones, R.A., & Okely, A.D. (2015). The use of Real Time Location Systems in Early Childhood Education and Care Settings. *International Society of Behavioral Nutrition and Physical Activity Annual Meeting*, South Africa 2015 (Oral symposium presentation)

Tonge, K.L, Jones, R.A., & Okely, A.D. (2015). Correlates of children's physical activity and sedentary behaviour in early childhood education & care: a systematic review. *HDR Conference*, Wollongong 2015 (Oral presentation).

Tonge, K.L, Jones, R.A., & Okely, A.D. (2016). The use of Radio Frequency Identification systems in Early Childhood Education and Care settings. *HDR Conference*, Wollongong 2016 (Oral presentation).

Tonge, K.L, Jones, R.A., & Okely, A.D. (2017). Improving children's physical activity in Early Childhood Education and Care Centres through quality interactions. *Early Start Conference*, Wollongong 2017 (Oral presentation).

Dedication

This thesis is dedicated to my family. We have a proud family tradition that values education and this has been passed through many generations - from my grandparents to my parents and to myself. As I complete this next step in my education journey, with my own children by my side, I proudly share these family values with the next generation.

Acknowledgements

After completing my undergraduate teaching degree and working for many years in ECEC, I always knew I would pursue further studies. It was a matter of finding the 'right time'. After completing my Masters, continuing to work, and with 3 young children, I knew that my Doctorate was something that was achievable. The time was right, and I am now very proud to say that I have finally achieved what I had always knew I would do!

Accomplishing my PhD would not have been possible without the expertise, support and encouragement of my supervisors. I feel extremely grateful to have been supervised by Senior Prof Tony Okely. Tony provided a wealth of knowledge and experience to my research, as well as support and guidance throughout my Doctorate. I admire Tony's patience, generosity and willingness to allow me to develop as an early researcher. I feel privileged to have you as my supervisor. I am also grateful for the support and encouragement of Dr Rachel Jones. Rachel had belief in me, and often reminded me that the time was right to start my PhD. Rachel's expertise and support throughout my Doctorate was something that I will always remember. The (gentle, but firm) reminders of the tasks and timelines ahead of me kept me motivated and helped me realise that every step was a step of progress. I have learnt so much about life as a researcher from both of my supervisors. Thank you!

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RTLS analysis. The team at Convergence (Hong Kong) were also integral in the collection of RTLS data. Your patience and willingness to help was appreciated.

When I commenced my PhD I entered into a realm of new opportunities, as well as challenges. Transitioning from an Early Childhood Teacher to a fulltime student presented an interesting change, and I could not have done it without my Early Start colleagues. I am grateful for my 'forever friends' that I have met along the way, and it is these people that have made the journey such a rich experience. Penny and Tamara, the entire research team, as well as Katharina (my RTLS buddy), Jenny (my Geera walking buddy), Ruth and all 'the Dutchies' have always brought a warmth to the office and an interest in my work. Through this experience I have met new people and made lifelong friends, who I will treasure forever. A very special mention to my 'Crazy Corner' buddies, the place where I started my PhD. Myrto, Sanne, Yvonne and Christel, I cannot thank each of you enough for the friendship and laughter you have brought not just to myself, but my family – we adore you! Yvonne you have been a steadfast PhD buddy, and I still recall the day we met. Little did I know how strong our friendship and support for each other would be become, it has been amazing sharing this journey with you! To my buddy CvL, your strength and resilience, as well as your wisdom has encouraged me, and I am forever grateful for our friendship. As you would say, 'time for the next adventure'! Thank you also to Jade (as well as Simon and Alfie) who provided support and a special friendship throughout my PhD, your encouragement and generosity I am forever grateful for. Thank you also to Karel and Laura, you have such a special place in our family.

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List of Abbreviations

BEACHES	Behaviours of Eating and Activity for Children's Health Evaluation System
CLASS	Classroom Assessment and Scoring System
ECEC	Early childhood education and care
EPAO	Environment and Policy Assessment and Observation
EYLF	Early Years Learning Framework
LPA	Light-intensity physical activity
MPA	Moderate-intensity physical activity
MVPA	Moderate- to- vigorous-intensity physical activity
NQS	National Quality Standards
OSRAC-P	Observational system for Recording Physical Activity in Children-preschool
OSRAP	Observation System for Recording Activity in Preschools
PA	Physical activity
RTLS	Real Time Location System
SB	Sedentary behaviour
SEF	Social Ecological Framework
SOFIT	System for Observing Fitness Instruction Time
TPA	Total physical activity
VPA	Vigorous-intensity physical activity

Chapter 1: Introduction

1.1 General Introduction

Early childhood (birth-5years) is a significant period for children’s growth, development and establishing patterns of behaviour (Carson et al., 2017; Daelmans et al., 2017). High levels of physical activity and low levels of sedentary behaviour are essential at this time for children’s health and wellbeing. Physical activity (of at least moderate- to vigorous- intensity) is consistently associated with a broad range of physiological, cognitive and psychosocial health outcomes (Carson et al., 2017; Timmons, Leblanc, & Carson, 2012), whereas children’s sedentary behaviour is adversely associated with health outcomes (Pereira, Cliff, Sousa-Sá, Zhang, & Santos, 2019). Promoting physical activity and reducing sedentary behaviour in early childhood is critical as physical activity and sedentary behaviour is known to track from early childhood into adulthood (Biddle, Pearson, Ross, & Braithwaite, 2010; Janz et al., 2014; Jones, Hinkley, Okely, & Salmon, 2013).

In Australia, many children attend early childhood education and care (ECEC). For example, 89% of children aged 4years attend an ECEC centre, and 92% of these children attend for more than 15hours a week (ABS, 2016). Consequently, these settings have an important influence on many children and the potential to promote children’s health and wellbeing. Children can attend ECEC from 6weeks of age until they enter formal schooling at approximately 5years of age. Long Day Care-funded centres enrol children from 6weeks of age, and Preschool-funded centres enrol children from 2years of age. Pattern and number of days attended are not mandated, however most children attend 2-3 days a week, and dependent on centre type, hours of attendance can range from 6-12hours a day. The National Quality Standards, governed by the Australian Children's Education & Care Quality Authority (ACECQA), ensure a focus on quality care and education across all ECEC (DEEWR, 2009). ECEC have the physical and social environments, including the affordance of time, space and resources that support children and provide valuable opportunities for promoting physical activity and reducing sedentary behaviour (Riethmuller, Jones, & Okely, 2009). However, many children are not meeting the recommended guidelines [≥15mins/hr MVPA; <30mins sedentary at a time (Institute of Medicine, 2011)] for physical activity and sedentary behaviour while in ECEC (Christian et al., 2018), and studies (Carson et al., 2016; Ellis et al., 2017) report that Australian children were sedentary for 48% of their time in ECEC. This is problematic, and it is essential that ECEC-related aspects that influence children's physical activity and sedentary behaviours within these settings are investigated and understood further.

Correlates of children's physical activity in ECEC have been well-studied, and just as important, although less frequently studied, are the correlates of children's sedentary behaviour in ECEC. ECEC are complex environments, and not surprisingly, studies have demonstrated that the correlates of physical activity and sedentary behaviour in ECEC are multi-dimensional, and when organised using a social-ecological framework, mostly occur in the child, educator, physical environmental and organisational domains. Collectively, the most frequently examined correlates of physical activity and sedentary behaviour include age (Mazzucca et al., 2018), sex (Olesen, Lund Kristensen, Korsholm, & Froberg, 2013; Vanderloo et al., 2014), outdoor environments (Schlechter, Rosenkranz, Fees, & Dzewaltowski, 2017; Tandon, Saelens, Zhou, & Christakis, 2018) and active opportunities, such as movement breaks (Barbosa, Coledam, Stabelini Neto, Elias, & Oliveira, 2016; Tucker, Vanderloo, Burke, Irwin, & Johnson, 2015). However, to date, there has been no review that has summarised the correlates of physical activity and sedentary behaviour in ECEC and subsequently identified remaining gaps in the literature. Investigating all potential correlates of children's physical activity and sedentary behaviour in ECEC is important as there is potential that modifiable, low-cost, accessible and scalable, factors that have a positive influence on children's physical activity and sedentary behaviour in ECEC have not been identified.

Educators have an important influence on the quality of children's experiences in ECEC, and further evidence indicates the quality of ECEC has a positive influence on children's outcomes. Although studies have assessed the quality of ECEC, and the quality of interactions in ECEC, there are no known studies that have specifically measured the quality of educator and child interactions in outdoor environments. Outdoor environments are important for promoting children's physical activity and reducing sedentary behaviour (Schlechter et al., 2017; Soini et al., 2016; Tandon et al., 2018), and so the quality of educator and child interactions in outdoor environments may have the potential to influence children's physical activity and sedentary behaviour. There are a number of assessment tools, such as the Early Childhood Environment Rating Scales (ECERS-R, ECERS-E, ITERS) (Sylva, Siraj-Blatchford, Taggart, & Ebscohost, 2010) and the Sustained Shared Thinking and Emotional Well-being Scale (SSTEW) (Siraj, Kingston & Melhuish, 2015) that measure the quality of ECEC (including environments, interactions and programs), however, the Classroom Assessment and Scoring System Pre-K (CLASS PreK) (Pianta, La Paro, & Hamre, 2008) specifically measures the quality of educator and child interactions in ECEC. To date, there have been no known studies that have used CLASS Pre-K to measure educator and child interactions in outdoor environments. Just as the quality of educator and child interactions specifically in outdoor environments has not been studied, there is also a gap in the evidence-base relating to aspects of the ECEC outdoor environment (such as routine and the amount of time spent in outdoor environments) that may have a relationship with the quality of educator and child interactions. These aspects have the potential to influence the quality of educator and child interactions, and consequently by improving the quality of educator and child interactions, the potential to influence children's physical activity and sedentary behaviour.

Many children are not meeting recommended guidelines for physical activity and sedentary behaviour while in ECEC. ECEC represents an ideal setting for promoting children's physical activity and reducing sedentary behaviour, however, there are several gaps in the evidence base. For example, the relationship between children's physical activity and sedentary behaviour and ECEC routines largely remains unknown. There is only one known study (Wolfenden et al., 2018) that specifically examined the relationship between children's physical activity and ECEC routine. No studies have investigated the relationship between children's sedentary behaviour and ECEC routine. Additionally, there are limited studies that explore the relationship between the amount of time spent in outdoor environments and children's physical activity and sedentary behaviour in ECEC. All ECEC centres follow a routine each day, either free-flowing (children can move freely between indoor and outdoor environments for all or part of the day), or a structured (children are either indoors or outdoors, and this is determined by educators), just as all ECEC centres have an outdoor environment, or one that replicates one. Further evidence is needed to determine the relationship between routine and time spent in outdoor environments, which are accessible, and modifiable aspects of ECEC, and potentially could be important in the promotion of optimal levels of physical activity and sedentary behaviour for children.

Despite educators being influential role models for children in ECEC, as well as the potential for ECEC to promote children's physical activity and reduce sedentary behaviour, there is only one known study (Fossdal, Kippe, Handegård, & Lagestad, 2018) that has examined the relationship between educators' physical activity and children's physical activity in ECEC. No studies have investigated the relationship between educator's sedentary behaviour and children's sedentary behaviour in ECEC. As children spend considerable time in ECEC environments, and educators' behaviours are known to impact the experiences and behaviours of children in their care (Bronfenbrenner, 2006; Pianta, Hamre, & Stuhlman, 2003), it is reasonable to suggest that educators' physical activity and sedentary behaviour may have an important influence on children's physical activity and sedentary behaviour. Given the importance of the ECEC environment in optimising physical activity and sedentary behaviour levels for children, the purpose of this thesis was to examine a variety of ECEC-related factors that could be important in furthering understanding the influences on children's physical activity and sedentary behaviour in ECEC.

1.2 Aim and research questions

The overall aim of this Doctorate was to investigate the relationship between ECEC-related factors and children's physical activity and sedentary behaviours while in ECEC. The ECEC-related factors were quality of educators' and children's interactions in outdoor environments, routines, time spent in outdoor environments, size of outdoor environment, and educators' physical activity and sedentary behaviour.

The Doctorate investigated the following research questions:

1. What are the correlates of children's physical activity and sedentary behaviour in ECEC settings?

2. What is the relationship between physical environmental aspects of ECEC centres and the quality of educator and child interactions in outdoor environments?

3. What is the relationship between ECEC routines, time spent in outdoor environments and the size of the outdoor environment, and children's physical activity and sedentary behaviour?

4. What is the relationship between educators' physical activity and sedentary behaviour and children's physical activity and sedentary behaviour?

1.3 Thesis outline

This thesis comprised a literature review, which included a systematic review published in a peer-reviewed journal (section 2.7.2), description of the methodology, three original research studies reported in separate chapters, a general discussion and conclusions. Chapters 3 and 4 have been accepted for publication in peer-reviewed journals, and Chapter 5 and Chapter 6 are under review in peer-reviewed journals.

The thesis commences with a systematic review and update of the correlates of children's physical activity and sedentary behaviour in ECEC (Chapter 2). This review addressed research question 1, and identified gaps in the literature based on social-ecological framework, including the domains of child, educator, physical environmental and organisational. The findings of this systematic review informed the subsequent chapters.

Chapter 3 outlines the methods used for this research, incorporating the study design, participant recruitment and eligibility criteria, outcome measures and the statistical analysis method. The chapter also describes the strengths, risks and limitations of the study design.

Research question 2 is answered in Chapter 4 by reporting on the relationship between the quality of educator and child interactions in the outdoor environment, and physical environmental aspects of ECEC - routines and the amount of time spent outdoors. Quality educator and child interactions are essential to quality ECEC environments (Howard et al., 2018), and quality ECEC environments influence children's outcomes (Melhuish et al., 2015). Chapter 4 examines the quality of educator and child interactions in the outdoor environment, an environment that is important for promoting children's physical activity (Schlechter et al., 2017; Soini et al., 2016; Tandon et al., 2018). The CLASS Pre-K assessment tool measured the quality of interactions. The chapter describes the relationship between educator and child interactions in the outdoor environment and ECEC routine and time spent in outdoor environments.

The focus of Chapter 5 is the relationship between children's physical activity and sedentary behaviour in ECEC centres and attributes of ECEC – routines and time spent in the outdoor environment, similar to those examined in Chapter 4, as well as the size of the outdoor environment. Multivariate analyses examined associations of the attributes with levels of children's physical activity and sedentary behaviour. This chapter answered research question 3.

Chapter 6 addresses research question 4, by investigating the relationship between educators' and children's physical activity and sedentary behaviour in ECEC settings. This chapter also provides insight into physical activity levels and sedentary behaviour of educators while in ECEC.

Chapter 7 summarises the results of this thesis in relation to the research aims. Strengths and limitations of the research are discussed and recommendations for future directions of research in this area, as well as an overall conclusion are provided.

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Chapter 2: Literature Review

This chapter is based on the initial phases of the Behavioural Epidemiology Framework as it relates to physical activity and sedentary behaviour (Sallis, Owen, & Fotheringham, 2000). It reviews the literature on children's physical activity and sedentary behaviour in early childhood and then discusses these behaviours in relation to children's health and wellbeing. The prevalence of children's physical activity and sedentary behaviour in early childhood education and care (ECEC) settings is then detailed. A systematic review, published in *Preventive Medicine* in May 2016, then presents the correlates of children's physical activity and sedentary behaviour in ECEC. This systematic review uses a socio-ecological model to examine the child, educator, physical environment and organisational factors related with children's physical activity and sedentary behaviours in ECEC. An update of this systematic review then summarises additional studies published since the original systematic review. Finally, physical environment and educator influences on children's physical activity and sedentary behaviours in ECEC are reviewed.

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2.1 Children's physical activity and health

There is considerable evidence that physical activity is important for children's health and wellbeing and is associated with a range of short- and long- term health outcomes. A recent systematic review by Carson et al. (2017), and an earlier systematic review by Timmons, Leblanc and Carson (2012) examined the relationships between physical activity and health indicators in the early years (0-4 years). Physical activity (of at least moderate- to vigorous-intensity) was consistently found to be positively associated with a broad range of physiological, cognitive and psychosocial health outcomes, although not consistently associated with adiposity outcomes.

Prior to starting school, children are spending increasingly more time in out-of-home care environments, such as ECEC (Hesketh, Griffin, & Sluijs, 2015). There has been a steady rise in ECEC attendance over the past decade (OECD, 2014). In Australia for example, 56% of children aged 4 years attended a preschool program in 2001 (ABS, 2004), whereas in 2018 86% children aged 4 years attend a preschool program (ABS, 2018). In 2018, the majority (95%) of children enrolled in a preschool program attended for 15 hours or more per week (ABS, 2018). Consequently, these ECEC environments present an increasing influence on many children, and have a critical role to promote children's healthy behaviours including physical activity and sedentary behaviour (Trost, Ward, & Senso, 2010; Ward, Vaughn, McWilliams, & Hales, 2010).

2.1.1 Children's physical activity, adiposity and motor development

A number of studies (Jones, Okely, Gregory, & Cliff, 2009; Reilly, 2008; Trost, Sirard, Dowda, Pfeiffer, & Pate, 2003) have reported an association between higher levels of physical activity and reduced obesity. However, in the systematic review by Carson et al. (2017), it was reported that physical activity was not consistently associated with adiposity (possible due to the 'low' to 'very low' quality of studies and in turn the risk of bias). Similarly, a systematic review by Timmons et al. (2012) reported that from four randomised controlled trials, three found no effect of a physical activity program on body mass index (BMI) (Jones et al., 2011; Reilly et al., 2006) or total body fat (Specker & Binkley, 2003). These findings indicate that further investigation is warranted, and in particular using higher quality studies.

Overall, a positive association between physical activity and gross motor skills was reported within the literature. In the review by Carson et al. (2017), physical activity was favourably associated with at least one measure of motor development in seven of the 10 studies reviewed (De Kegel et al., 2013; Dudek-Shriber & Zelazny, 2007; Fisher et al., 2005; Kuo, Liao, Chen, Hsieh, & Hwang, 2008; Lin, Cherng, & Chen, 2017; Pfeiffer, Dowda, McIver, & Pate, 2009; Williams et al., 2008). The Williams et al. (2008) study (n=198, 3-4 year old children) found significant positive associations between total motor performance and moderate- to vigorous-intensity physical activity (MVPA) and motor performance and vigorous-intensity physical activity (VPA). Fisher et al. (2005) reported a weak but significant positive correlation between total gross motor skill score and physical activity in 394 children aged three to five years. Another study examined the relationship between gross motor skills and physical activity in 46 children (aged three to five years) and specifically looked at gender differences (Cliff, Okely, Smith, & McKeen, 2009). A positive association was found between object control skills and physical activity among boys, while locomotor skills were associated with physical activity among girls.

2.1.2 Children’s physical activity and cognitive health

Tandon and colleagues’ (2016) recent systematic review examined the relationship between physical activity and cognitive development among children under five years of age. Twelve studies were identified (five cross-sectional, three longitudinal and four experimental), and the majority (n=11) of these studies reported evidence suggesting that physical activity or gross motor skills are related to cognition or learning. Both acute bouts and longer-term exposures to physical activity showed a positive relationship to executive function (particularly self-regulation, sustained attention, and working memory) and academic tasks in the four intervention studies (Draper, Achmat, Forbes, & Lambert, 2012; Kirk, Vizcarra, Looney, & Kirk, 2014; Mavilidi, Okely, Chandler, Cliff, & Paas, 2015; Mierau et al., 2014).

Mavilidi et al. (2015; 2016; 2018; 2019) published results from four randomised controlled trials which examined the relationship between physical activity and cognitive outcomes. In each study the intervention group had better cognitive outcomes than the control group immediately post intervention and at follow-up. Two earlier studies showed modest improvement in executive functions after an acute aerobic exercise bout (Hillman, Kamijo, & Scudder, 2011) or as a result of habitual aerobic exercise (Davis, Ford, Anderson, & Doyle, 2007).

In contrast, other studies assessing the relationship between physical activity and cognitive outcomes have shown null or inconclusive relationships. For example, Mierau et al. (2014) found no relationship between the exercise condition and cognitive performance in a random cross-over study. Two meta-analyses (Angevaren, Aufdemkampe, Verhaar, Aleman, & Vanhees, 2008; Smith et al., 2010), involving 11 and 29 studies, respectively, reported modest to no effect of aerobic activity on subsequent executive functioning.

2.1.3 Children's physical activity and psychosocial health

Although the evidence is relatively limited and many studies only include a narrow range of psychosocial outcomes (Hinkley et al., 2014), participation in physical activity has been shown to support psychosocial wellbeing (self-esteem, social interactions, behavioural regulation) in young children (Griffiths et al., 2016; LeBlanc et al., 2012; Lindsey, 2014; Lobo & Winsler, 2006; Timmons et al., 2012). Lobo & Winsler's (2006) study (n=40, four-year-old children) found significant positive associations between physical activity, social competence and internalising and externalising behaviour. Another study examined the relationship between personality traits and physical activity in 179 children (aged 3-5years) (Buss, Block, & Block., 1980). A positive association was found between physical activity and children being more outgoing and less socially withdrawn.

2.2 Children's sedentary behaviour and health

Evidence related to the associations between sedentary behaviour and health outcomes in young children is limited, whereas more evidence exists for school-aged children (Carson et al., 2016), youth (Carson et al., 2016), and adults (Trost, 2002). Most studies for young children focus on the relationship between screen-based sedentary behaviour (TV viewing, time spent engaged with electronic devices) and health outcomes (Downing, Hnatiuk, & Hesketh, 2015; Poitras et al., 2017). A systematic review by Downing and colleagues (2015) examined the prevalence of sedentary time in children under 2years of age (n=24 studies), and more recently, a systematic review by Poitras et al. (2017) examined the relationships between sedentary behaviour and health indicators, and the doses of sedentary behaviour that were associated with health indicators in children aged 0 to 4 years (n=96 studies). Findings consistent between these reviews were that there is limited understanding of children's sedentary behaviour, other than screen-based behaviours and additional research using valid and reliable measures is needed to further understand sedentary behaviour in the early years.

Despite limited high-quality studies examining sedentary behaviour in young children, results are consistent with those reported in older children (LeBlanc et al., 2010; Thorp, Owen, Neuhaus, & Dunstan, 2011; Tremblay et al., 2011). Studies demonstrate that there is growing evidence that spending excessive time in sedentary behaviours, independent of the amount of MVPA, may be adversely associated with adiposity and cardio metabolic health outcomes for children, particularly those who are overweight, or obese (Cliff et al., 2014; Saunders et al., 2013). The similarities in these studies across age groups is important to note. A systematic review by Biddle, Pearson, Ross, & Braithwaite (2010) tracked sedentary behaviours from childhood to adolescence, and found that sedentary behaviours track at moderate levels from childhood and that sedentary behaviours in preschool-aged children may form the foundation for such behaviours in the future. It was also noted that sedentary behaviours may track slightly better than physical activity, reinforcing the need for further investigation.

Assessing the impact of sedentary behaviour on child outcomes is difficult as it is important to consider the impact of what young children are doing while sedentary, as well as the time children are sedentary (Carson et al., 2015; 2019). For example, it is evident that screen time is unfavourably associated with health indicators across early childhood, however, the relationship between interactive non–screen based sedentary behaviours, such as reading and storytelling is positive (Carson et al., 2016; LeBlanc et al., 2012; Poitras et al., 2017). This reinforces the notion that not all types of sedentary behaviour may be equal when examining children's development (Carson et al., 2015). Additionally, although current literature is often limited to traditional screen use, such as TV viewing, it is also important to consider various and newer forms of screen viewing that may be present in ECEC such as Smartboards and tablets, and understand whether their influence is any different from traditional screen use.

2.2.1 Children's sedentary behaviour, adiposity and motor development

A systematic review on sedentary behaviour and health indicators (0-4years) (Le Blanc et al., 2012) identified 11 studies that reported an association between increased sedentary behaviour and unfavourable levels of adiposity (LeBlanc et al., 2012). Three of the 11 studies reported a dose–response relationship between hours of television viewing and increased BMI and percent body fat (i.e., the higher number of sedentary hours the higher BMI/percent body fat) (Blair et al., 2007; Pagani, Fitzpatrick, Barnett, & Dubow, 2010; Reilly et al., 2005). Similarly, a study by Harrison & Liechty (2012) examined media exposure and dietary habits (354 children, aged 2-5 years), and found unfavourable associations between sedentary behaviour and weight status among girls (Harrison & Liechty, 2012). A more recent systematic review by Poitras et al. (2017) examined sedentary behaviours and health indicators in the early years, and from 96 studies included in the review, 60 studies included a measurement of adiposity. The quality of studies ranged from very low to moderate, and findings indicate that associations between objectively measured total sedentary time and adiposity were predominantly null, as were associations between screen-based sedentary behaviours and adiposity (Poitras et al., 2017).

Few studies have reported on the relationship between sedentary behaviour and motor development in young children. In the Poitras et al. (2017) systematic review, which identified seven studies conducted with children (0-4years), sedentary behaviour (screen time) was unfavourably associated with motor skill development. Furthermore, a relationship was found between children with delayed motor skill development and increased time watching TV, compared to children with typical motor skill development (Poitras et al., 2017). A study by Johansson et al. (2015) examined the levels and patterns of sedentary behaviour, physical activity and motor skills in Swedish children aged two years, and the influence of environmental factors (such as parental obesity). The authors found no associations between sedentary behaviour and motor skills in these children, and that variation in motor skills may be due to endogenous factors, such as genetic variations in this age group (Johansson et al., 2015).

2.2.2 Children's sedentary behaviour and cognitive health

The systematic review by LeBlanc and colleagues (2012) examined the relationship between sedentary behaviour and health indicators of children aged birth to five years. From 21 studies identified, five studies examined the relationship between sedentary behaviour (TV viewing) and cognitive development of children aged 2-5 years. From these studies, two studies found no association, and three studies reported a dose–response relationship with each additional hour of television exposure related to decreased vocalisation, classroom engagement, and maths scores (LeBlanc et al., 2012). These findings were consistent with a subsequent review examining the relationship between sedentary behaviour and cognitive development by Carson and colleagues (2015). In this review the vast majority of evidence found that high levels of sedentary behaviour (screen time) had a detrimental effect on cognitive development during early childhood (Carson et al., 2015).

2.2.3 Children's sedentary behaviour and psychosocial health

Studies reporting on relationships between sedentary behaviour and psychosocial health have shown mixed results (Hinkley et al., 2014). Hinkley and colleagues' (2014) systematic review examined the relationship between physical activity, sedentary behaviour and psychosocial health among children under five years of age. From the 15 studies that reported sedentary behaviour, a total of 25 indicators of psychosocial well-being were investigated. The most commonly investigated were hyperactivity/inattention (n=7 studies) and aggressive behaviours (n=7 studies). Only one study (Griffiths, Dowda, Dezateux, & Pate, 2010) examined the association between sex, resulting in minimal differences, yet indicating more emotional and conduct problems in girls when sedentary behaviour was higher. In the Hinkley et al. (2014) review, some evidence showed a decrease in sedentary behaviour was associated with positive psychosocial health. Overall, the results were inconclusive. A study by Ebenegger et al. (2012) (n=450, 4-6 year old children) that examined children's hyperactivity/inattention and lifestyle characteristics found significant positive associations between hyperactivity/inattention and sedentary behaviours (measured by accelerometers and parent-reported TV viewing). Similarly, a study by Pagani et al. (2010) found that children's inattention and aggressive behaviours were associated with sedentary behaviour measured by TV viewing.

2.3 Tracking of physical activity and sedentary behaviour

There is evidence that physical activity behaviours track from early childhood to adulthood (Biddle et al., 2010; Janz, Burns, & Levy, 2005; Jones, Hinkley, Okely, & Salmon, 2013;

Strong et al., 2005). Similarly, it is known that the total time spent in sedentary behaviour tracks moderately from early childhood (aged 3-5 years) into childhood (aged 5-8 years) (Jones et al., 2013). A recent longitudinal study (Carson et al., 2019) examined physical activity and sedentary behaviour across three time-points in early childhood and the association with social skills. The study tracked 251 toddlers and their parents from 2014/2015 with follow-up at 1 and 2 years. Although this study did not find significant associations between children's physical activity, sedentary behaviours and social skills across early childhood, light-intensity physical activity (LPA) and MVPA did track at moderate levels across the three time-points, with a stronger association observed for the tracking of MVPA over time, compared to LPA. This is an important finding, as there have been no other known studies that have objectively-measured and tracked MVPA and LPA in toddlers. An earlier study by Kelly et al. (2007) assessed and tracked total physical activity (TPA) and MVPA, as well as sedentary behaviours of 42 children over a two-year period, with a mean age of 3.8 years at baseline. This study found low levels of tracking of TPA, MVPA and sedentary behaviour.

2.4 Guidelines for physical activity and sedentary behaviour in children

Considering evidence showing the health benefits of physical activity (Carson et al., 2017), and the potential for sedentary behaviour to have adverse effects on young children's health and development, government authorities and professional organisations have acknowledged the importance of promoting physical activity and limiting sedentary time in young children. Australian 24-hour movement guidelines for the early years released in November 2017 recommend that children aged 3-5 years should participate in at least 180 minutes of physical activity each day. This physical activity is to be spread throughout the day, can come from a variety of physical activities (structured and unstructured play), and for preschool-aged children, should include at least 60 minutes of energetic play, with more physical activity better. Additionally, these guidelines recommend that sedentary screen time should be less than 1 hour per day (with less being better) and young children should not be restrained in (e.g., in a stroller/buggy/pram) for extended periods (Okely et al., 2017). These recommendations align with guidelines from several other countries including Canada (Tremblay et al., 2017), United Kingdom (NHS, 2019), New Zealand (Ministry of Health, 2017), and the World Health Organisation (World Health Organization, 2019).

The National Academy of Medicine (Institute of Medicine, 2011), have developed specific physical activity and sedentary behaviour recommendations for children in ECEC. They suggest that children should spend at least 15 minutes per hour whilst attending ECEC in MVPA and the amount of time preschool-aged children spend in sedentary behaviour should be limited to less than 30 minutes at one time.

There has been a lack of evidence to support an optimum frequency, intensity, duration and type of physical activity required to promote healthy growth and development (Carson et al., 2017). Carson et al. (2017) reported that various frequencies (per day or per week) of physical activity were associated with positive health outcomes, such as motor development (Lin et al., 2017) and bone skeletal health (Jazar, Takruri, Khuri-Bulos, 2012). Similarly, the ideal physical activity intensity and duration remains inconclusive with positive health outcomes being reported for all different physical activity intensities (Carson et al., 2017). Higher-intensity physical activity, even in the early years seems to be most consistently associated with better health outcomes and increased duration of physical activity seems to be better (Ansari, Pettit, Gershoff, 2015; Jazar et al., 2012). The most recent update of guidelines by the World Health Organization for children's physical activity added a specific MVPA guideline (≥60mins/day) and a non-specific recommendation for toddlers (World Health Organization, 2019). A number of different types of physical activity have been found to have favourable associations with health outcomes (Carson et al., 2017). The type of sedentary behaviour seems to be more important with current evidence suggesting that screen time is more detrimental to cognitive development in the early years (Carson et al., 2016; Poitras et al., 2017). Despite the lack of consensus regarding frequency, intensity, duration and type, the international recommendations support the notion that more is better in relation to physical activity and less is better in relation to sedentary behaviour.

2.5 Prevalence of physical activity and sedentary behaviour in ECEC

Levels of physical activity and sedentary behaviour whilst attending ECEC centres is less than optimal, with many children not meeting current recommendations. A recent study by Christian and colleagues (2018) tracked the activity of 1596 children from 104 ECEC centres in Perth, Australia, over seven days. Results show that according to the Australian 24 Hour Movement Guidelines for the Early Years (Okely et al., 2017), on days when children attended ECEC for a standard 8-hour day, only 12% of children aged 2-5 years met guidelines for physical activity (recommended 180mins/day), and only 60% met guidelines for energetic play (recommended 60mins/day). This was compared to a typical day (i.e., not attending ECEC) where 34% children met guidelines for physical activity, and 87% met guidelines for energetic play. Children's TPA and MVPA are below recommended levels, but children are accumulating even less time in TPA and MVPA during a day that they attend ECEC. Several other studies also indicate that children's physical activity while in ECEC is low, and children are not meeting current guidelines for physical activity while in ECEC (15mins per hour) (Hinkley, Salmon, Crawford, Okely, & Hesketh, 2016; O'Dwyer et al., 2014; O'Neill, Pfeiffer, Dowda, & Pate, 2016; Pate et al., 2015). A study by Vanderloo and colleagues (2014) suggested that Canadian children accumulate only 1.54 min/hr in MVPA while in ECEC, and spend the majority of their time (up to 40.64 min/hr) being sedentary. A more recent study (Ellis et al., 2017) examined the sitting, standing and physical activity time of 300 children while in ECEC, finding that children spend over 50% of their day sitting while in ECEC. As participation in physical activity negatively correlates with age (Garriguet et al., 2016) and evidence shows that children are not meeting recommended levels of physical activity across the day while in ECEC, it is important that factors within the ECEC environment that influence children's physical activity and sedentary behaviour are examined to develop strategies that promote children's physical activity and reduce sedentary behavior while in these settings.

2.6 Measurement of children's physical activity and sedentary behaviour

Young children's physical activity patterns are often sporadic and short in duration which make accurate measurement difficult (Reilly, 2008). Instruments used to measure physical activity and sedentary behaviours vary and include both indirect (e.g., self-report; parent, teacher, or caregiver proxy) and direct measures (e.g., accelerometer, pedometers or direct observation) (Timmons, et al., 2012). Accelerometers are most commonly used to objectively measure young children's physical activity and sedentary behaviour (Bornstein, Beets, Byun, & McIver, 2011; Hnatiuk, Salmon, Hinkley, Okely, & Trost, 2014; Van Cauwenberghe, Labarque, Trost, de Bourdeaudhuij, & Cardon, 2011) and have been found to be the most valid and reliable measurement tool for this population (Cliff, Reilly, & Okely, 2009). To capture the short bursts of activity characteristic of children, 15 second epochs are frequently used (Cliff et al., 2009; Reilly, 2008). There are a number of cut-points used for sedentary behaviour and physical activity (Cliff et al., 2009; Hesketh & Sluijs, 2016; Hinkley et al., 2016; Pate, Almeida, McIver, Pfeiffer, & Dowda, 2006; Pate et al., 2015; Sirard, Trost, Pfeiffer, Dowda, & Pate, 2005; Van Cauwenberghe, Jones, Hinkley, Crawford, & Okely, 2012). The most valid cut-points for physical activity and sedentary behaviour are SB≤25 counts/15s; LPA 25-419counts/15s; and MVPA ≥420counts/15s (Janssen et al., 2013). These cut points will be used throughout this thesis.

2.7 Correlates and influences of children's physical activity and sedentary behaviour

The correlates of physical activity and sedentary behaviour for children are often reported using a socio-ecological framework (Hinkley, Crawford, Salmon, Okely, & Hesketh, 2008; Olesen, Kristensen, Korsholm, Koch, & Froberg, 2015; Sallis et al., 2000; Tonge, Jones, & Okely, 2016). This framework incorporates several layers of influence starting with personal and biological factors and gradually becoming broader to include social, cultural and physical environment influences.

The correlates of young children's physical activity and sedentary behaviour, detailed using the socio-ecological framework, have been well studied. In relation to habitual physical activity, boys are consistently more active than girls (Hinkley et al., 2008; Pate et al., 2015; Sallis et al., 2000; Trost et al., 2003). Higher levels of parent physical activity, better adult–child interactions, and positive encouragement is consistently associated with children's increased physical activity and reduced sedentary behaviour (Hesketh et al., 2014; Sallis et al., 1993; Trost & Loprinzi, 2011). More time spent in an outdoor play space (Boldemann, Blennow, & Dal, 2006; Sallis et al., 1993), as well as the type of preschool attended (Finn, Johannsen, & Specker, 2002; Pate, Pfeiffer, Trost, Ziegler, & Dowda, 2004) are consistently positively associated with children's physical activity and negatively associated with children's sedentary behaviour. Relationships between other variables such as age (Finn et al., 2002; Pate et al., 2004), socio-economic status (Kelly et al., 2006; Sallis et al., 2000) and BMI (Kelly et al., 2006; Sallis et al., 2000) have been less consistent.

2.7.1 Correlates and influences of children's physical activity and sedentary behaviour within ECEC

Given the increasing time that young children spend in ECEC settings and the influence of these settings on children's physical activity and sedentary behaviour, ECEC-related correlates are important to investigate and consider. Some studies have investigated ECEC-related factors, with varying results. For example, portable play equipment has been associated with high physical activity levels and low sedentary behaviour in some studies (Dowda et al., 2009), whilst in other studies no association, or mixed associations were reported (Bower et al., 2008; Gubbels, Van Kann, & Jansen, 2012; Nicaise, Kahan, & Sallis, 2011; Vanderloo et al., 2014; Van Cauwenberghe et al., 2012). Similarly, staff training has a positive association with children's LPA (van Cauwenberghe et al., 2012), whereas in other studies there was a negative association with children's physical activity (Nicaise et al., 2011; Sugiyama et al., 2011), or no association with sedentary behaviour (Bower et al., 2008; Dowda et al., 2009). The availability of adequate space has a positive association with increased physical activity in a number of studies (Dowda et al., 2009; Gubbels et al., 2011; Nicaise et al., 2011), and decreased sedentary behaviour (Dowda et al., 2009), however in another study there was no association (Olesen et al., 2013), and furthermore no association with MVPA in another study (Sugiyama, Okely, Masters, & Moore, 2011). The presence of outdoor environments has positive associations for higher levels of physical activity in many studies (Raustorp et al., 2012; Stephens et al., 2014; Vanderloo, Tucker, Johnson, & Holmes, 2013), as well as lower sedentary behaviour for boys (Vanderloo et al., 2014) whereas there was no association between outdoor environments and girls' MVPA (Vanderloo et al., 2013).

To date, there has been no known reviews that have comprehensively and systematically examined this literature. Given the complexity of the ECEC environment, there are a number of potential correlates such as the quality of educator interactions with children, the activity levels of educators, time spent in outdoor environments and the influence of the ECEC routine, that may have a relationship with children's physical activity and sedentary behaviour, and so warrant further investigation.

The following section reports on a published systematic review, with an update, that report the ECEC-related correlates in relation to physical activity and sedentary behaviours. Similar to other reviews, the socio-ecological framework was used to structure the reviews.

2.7.2 Published systematic review

This section has been published as: Tonge, K.L., Jones, R.A., & Okely, A.D. (2016). Correlates of children's objectively measured physical activity and sedentary behaviour in early childhood education and care services: A systematic review. *Preventive Medicine, 89,* 129-139.

2.7.2.1 Introduction

Children's health and well-being are paramount to ensure optimum learning and development (DEEWR, 2009). Physical well-being allows children to be physically active and active children have improved blood pressure, cholesterol and bone density, emotional and cognitive development, self-esteem, and social interaction skills compared with less active children (Copeland, Kendleigh, Saelens, Kalkwarf, & Sherman, 2012; Lewicka & Farrell, 2007; Timmons et al., 2012). Active experiences support children to become ‘physically literate’, which is the foundation of physical activity experiences for later years (Maude, 2008).

The period of early childhood (birth to 5 years) is critical for establishing health, well-being and healthy behaviours (Ward, Vaughn, McWilliams, Hales, & Derek, 2010). It is a time of rapid growth in young children, including significant brain development (Shonkoff, 2013), physical and social development, as well as the formation of behaviour patterns. It is a time of significant opportunity, yet one of considerable risk, and that quality experiences are crucial as an investment in children’s health and well-being (Shonkoff, 2013). Social and physical environments have an important influence (Brown et al., 2009), and quality experiences provide opportunities for children to learn from significant others, as well as practice skills that will lead to better immediate and long-term health and education outcomes (Melhuish, Belsky, Leyland, & Barnes, 2008; Shonkoff, 2013;).

The nature and scale of Early Childhood Education and Care (ECEC) services have changed dramatically in most developed countries in the last two decades according to the OECD (Organisation for Economic Co-operation and Development). In Western Europe for example there has been an increase in children attending ECEC from 20% to 90% over a 15-20 year period from 1994 to 2014 (OECD, 2014). With enrolment rates high, the ability of ECEC service programs to influence many children’s learning, development and behaviours in a way that will promote good health across their life spans (Ward et al., 2009) is significant. ECEC services can provide social and physical environments that support quality experiences, learning and development through offering structured and unstructured experiences (Ward et al., 2010), including physical activity experiences. A number of physical activity interventions that have focused on modifying the social and physical environment have been implemented in ECEC services (Gordon, Tucker, Shauna, & Carron, 2013) however results have been inconsistent. For example Cardon et al. (2008) reported no significant changes in physical activity levels following implementation of an intervention that focus on the physical environmental, while Hannon and Brown (2008) reported significant changes in light-, moderate- and vigorous-intensity physical activity following their intervention that also focused on modifications to the physical environment. Recommendations from recent reviews (Gordon et al., 2013) suggest that further understanding of the ECEC environment and factors in these services that influence physical activity and sedentary behaviour is required.

Reviews have addressed the correlates of children's physical activity (Hinkley et al., 2008) and sedentary behaviour (Hinkley et al., 2010), yet to the best of our knowledge, no reviews have specifically identified correlates within ECEC services. Identifying influences on physical activity and sedentary behaviour in ECEC services is particularly important for the development of evidence-guided programs and interventions (Hinkley et al., 2008). Therefore the aim of this systematic review was to identify these influences. Consistent with other reviews of correlates of physical activity in children and adults (Hinkley et al., 2010; Hinkley et al., 2008; Ridgers, Salmon, Parish, Stanley, & Okely, 2012; Sallis et al., 2000) a social-ecological framework was used to scaffold the variables identified in this review. An ecological model will allow for the investigation of multidimensional factors that influence physical activity and sedentary behaviour and the bidirectional relationships among these factors as well as the investigation of how factors at one level moderate the influence of factors from another level (Kearns, 2010).

2.7.2.2 Methods

The process and reporting of this review adhered to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement (Moher, Liberati, Tetzlaff, & Altman, 2009).

Search Strategy

A literature search of papers was conducted in eight electronic databases - ERIC, SPORT Discus, MEDLINE, Education Research Complete, Scopus, A+ Education, PsychINFO and PubMed. The databases were searched from their creation until April 2015. The search was conducted using the search terms physical activity OR movement AND preschool OR childcare OR daycare OR nursery OR pre-K AND correlate OR factor OR influence OR predictor. A similar search was conducted for sedentary behaviour and used the following terms sedentary behaviour OR sitting AND preschool OR childcare OR daycare OR nursery OR pre-K AND correlate OR factor OR influence OR predictor. Duplicates from these searches were then removed (KT). Titles were then screened (KT, RJ, AO) and following this abstracts and full articles were reviewed (KT, RJ) and checked if there was a discrepancy (AO). Manual searches of reference lists were also completed, and experts in the field were consulted (KT). Data were collected and analysed in 2014 and 2015. This extensive process of selection was similar to that described in a number of other systematic reviews (Hinkley et al., 2008; Ridgers et al., 2012; Sallis et al., 2000).

Inclusion and exclusion criteria

Papers were included if they: (1) were peer reviewed, written in English and available in full text, (2) included data from an ECEC service (birth-5years) setting, and (3) were a quantitative study that used an objective measure (such as accelerometers or OSRAP) of physical activity and/or sedentary behaviours. Pilot and mixed methodology studies were included if they met these criteria. Studies that measured habitual physical activity were included if physical activity and sedentary behaviour data during ECEC hours were reported separately. Intervention studies were excluded as the interventions did not report associations.

Data extraction and synthesis

Information extracted from each article included: the sample (age range of children, number of ECEC services, number of children), physical activity/sedentary behaviour assessment and outcome (method(s) of data collection, level of physical activity and/or sedentary behaviour assessed), and correlates of physical activity and sedentary behaviour (e.g., boys were more active than girls, older children more active than younger children). Researchers (KT, RJ, AO) then categorised these correlates into the associated social-ecological framework domains (Child, Educator, Physical Environmental and/or Organisational) (Table 2.2). A variety of techniques were used in the selected papers to report variables including univariate, bivariate and multilevel analyses. Similar to another review (Ridgers et al., 2012), for analyses focused on correlates where multiple analytic models were reported, findings from the most advanced, fully-adjusted model were extracted (Hinkley et al., 2010).

All variables were recorded in the tables. Those that were reported a statistically significant ($p<0.05$) association with physical activity and/or sedentary behaviour were coded as + or -, depending on the association (column 3, Table 2.3 and 2.4) and those that were not significant were recorded in column 4, Table 2.3 and 2.4. The number of studies reporting the same association was tallied and then this ‘tally’ was converted to a percentage. Some studies reported multiple variables (such as child age in relation to indoor as well as outdoor environments). In these instances, the reference was included multiple times in the association column (Table 2.3 & 2.4) and the specific variable measured indicated with a footnote (Ridgers et al., 2012). These codes were then analysed and given a summary code for association (Table 2.1) based upon the percentage of studies and the direction of the association. This method of coding has been used previously (Hinkley et al., 2010; Hinkley et al., 2008; Ridgers et al., 2012; Sallis et al., 2000).

Table 2.1: Rules for classifying variables regarding strength of association with children's physical activity and sedentary behaviour in ECEC centres

Studies supporting association (%)	Summary code	Explanation of code
0-33	0	No association
34-59	?	Indeterminate/inconclusive association
60-100	+	Positive association
60-100	-	Negative association

Note. When an outcome was studied four or more times, it was coded as:

00 (no association); ?? (indeterminate); ++ (positive association); or - - (negative association).

2.7.2.3 Results

Summarising the articles

A total of 3771 papers were retrieved with 27 studies meeting inclusion criteria (Figure 2.1 & Table 2.2). More than half the studies (56%) were conducted in the U.S. (n=15) (Bower et al., 2008; Byun et al., 2013; Dowda et al., 2009; Dowda et al., 2004; McKenzie et al., 1992; Nicaise et al., 2011; Pate et al., 2004; Pate et al., 2008; Pate et al., 2014; Raustorp et al., 2012; Robinson et al., 2012; Shen et al., 2013; Stephens et al., 2014; Trost et al., 2003; Williams et al., 2008), with the remaining conducted in Canada (n=3) (Gagne & Harnois, 2013; Vanderloo et al., 2013; Vanderloo et al., 2014), Sweden (n=3) (Boldemann et al., 2006; Pagels et al., 2011; Raustorp et al., 2012), Netherlands (n=2) (Gubbels et al., 2012; Gubbels et al., 2011), Belgium (n=2) (Cardon et al., 2008; Van Cauwenberghe et al., 2012), Denmark (n=2) (Grontved et al., 2009; Olesen et al., 2013), and Australia (n=1) (Sugiyama et al., 2011). One study collected data across countries - Sweden and the U.S. (Raustorp et al., 2012). Physical activity and sedentary behaviours were assessed using accelerometers (n=17) (Byun et al., 2013; Dowda et al., 2009; Gagne & Harnois, 2013; Grontved et al., 2009; Olesen et al., 2013; Pagels et al., 2011; Pate et al., 2004; Pate et al., 2014; Raustorp et al., 2012; Shen et al., 2013; Stephens et al., 2014; Sugiyama et al., 2011; Trost et al., 2003; Van Cauwenberghe et al., 2012; Vanderloo et al., 2013; Vanderloo et al., 2014; Williams et al., 2008), direct observation [OSRAP (n=8) (Bower et al., 2007; Dowda et al., 2004; Dowda et al., 2009; Gubbels et al., 2011; Gubbels et al., 2012; Nicaise et al., 2011; Pate et al., 2008; Trost et al., 2003), BEACHES (n=1) (McKenzie et al., 1992), SOFIT (n=1)(Van Cauwenberghe et al., 2012)] and pedometers (n=4) (Boldemann et al., 2006; Cardon et al., 2008; Pagels et al., 2011; Robinson et al., 2012). Five studies used multiple objective methods of measuring physical activity and sedentary behaviour (Van Cauwenberghe et al., 2012; Dowda et al., 2009; McKenzie et al., 1992; Pagels et al., 2011; Trost et al., 2003), for example OSRAP as well as accelerometers (Trost et al., 2003). Of the 27 studies included, most (74%) reported MVPA (Bower et al., 2008; Dowda et al., 2009; Dowda et al., 2004; Grontved et al., 2009; McKenzie et al., 1992; Nicaise et al., 2011; Olesen et al., 2013; Pagels et al., 2011; Pate et al., 2004; Pate et al., 2008; Pate et al., 2014; Raustorp et al., 2012; Shen et al., 2013; Stephens et al., 2014; Sugiyama et al., 2011; Trost et al., 2003; Van Cauwenberghe et al., 2012; Vanderloo et al., 2013; Vanderloo et al., 2014; Williams et al., 2008), and many (56%) reported TPA (Boldemann et al., 2006; Bower et al., 2008; Cardon et al., 2008; Gagne & Harnois, 2013; Gubbels et al., 2011; Gubbels et al., 2012; McKenzie et al., 1992; Pagels et al., 2011; Pate et al., 2008; Pate et al., 2014; Robinson et al., 2012; Trost et al., 2003; Vanderloo et al., 2013; Vanderloo et al., 2014). Sedentary behaviour was reported in thirteen studies (48%) (Bower et al., 2007; Byun et al., 2013; Dowda et al., 2004; Dowda et al., 2009; Nicaise et al., 2011; Pagels et al., 2011; Pate et al., 2004; Pate et al., 2008; Raustorp et al., 2012; Sugiyama et al., 2011; Vanderloo et al., 2013; Vanderloo et al., 2014; Williams et al., 2008) (Table 2.2).

Sixty-six physical activity and sedentary behaviour correlates were identified (Table 2.3 & 2.4), of which 13 were classified as child variables, 10 classified as educator variables, 21 classified as physical environmental and 22 classified as organisational variables. Associations identified (Table 2.3 & 2.4) reflect the relationship between the correlate and children's total physical activity (light, moderate and vigorous) and sedentary time while in the ECEC service, within a range of environments (indoor, outdoor, structured, unstructured), unless noted otherwise.

Figure 2.1: Flow diagram of search results

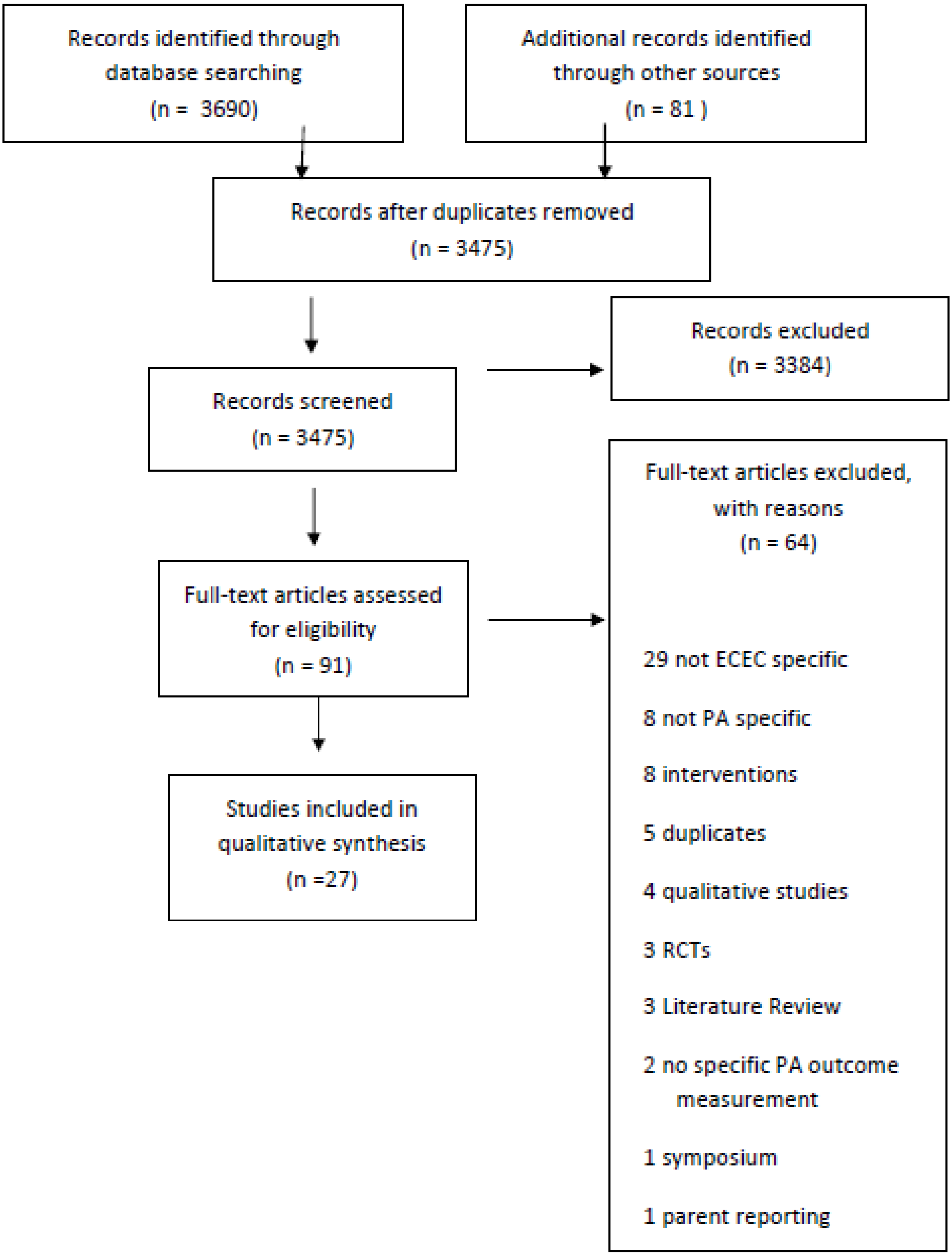

Table 2.2: Summary of included articles

Author, date, location	Sample	Physical activity / sedentary behaviour assessment and outcome	Correlates of physical activity / sedentary behaviour identified	Social Ecological Framework Domain Association
Boldemann, Blennow, Dal, Martensson, Raustorp, Yuen & Wester, 2006 **Sweden**	4-6 year olds 11 preschools 197 children	Pedometers (Yamax Digiwalker SW-200) Step count TPA	Environments with more natural features Boys more active than girls Older boys more active	Child Educator Physical Environmental Organisational
Bower, Hales, Tate, Rubin, Benjamin & Ward, 2008 **U.S.**	3-5 year olds 20 child care centres	OSRAP TPA, sedentary & MVPA	Supportive environments – higher EPAO scores	Educator Physical Environmental Organisational
Byun, Blair & Pate, 2013 **U.S**	4 year olds 17 preschools 331 children	Actigraph accelerometers Activity intensity Sedentary	Montessori preschools – less sedentary behaviour.	Child Organisational
Cardon, Van Cauwenberghe, Labarque, Haerens & De Bourdeauhuij, 2008 **Belgium**	4 & 5 year olds 39 preschools 783 children	Pedometers Step count TPA	Boys more active than girls Less children per m^2 Shorter recess Hard surface for boys Less teachers present for girls	Educator Physical Environmental Organisational
Dowda, Brown, McIver, Pfieffer, O'Neill, Addy & Pate, 2009 **U.S**	3-5 year old 20 preschools 299 children	OSRAP Accelerometry MVPA, sedentary	Higher quality Less fixed equipment More portable equipment Less use of IT Larger playgrounds	Educator Physical Environmental Organisational
Dowda, Pate, Trost, Almeida & Sirard, 2004	3-5 year old 9 preschools 266 children	OSRAP MVPA, sedentary	Field trips College educated teachers Quality of service	Educator Organisational

U.S				
Gagne & Harnois, 2013 **Canada**	20 centers 242 children	Accelerometer TPA	Educator intention Descriptive norm Democratic intervention Educator's age Resources available Age Sex	Child Educator Physical Environmental
Grontved, Pederson, Anderson, Kristensen, Moller & Froberg 2009 **Denmark**	3-6 year old 6 preschools 190 children	Actigraph Accelerometer TPA, MVPA	Boys more active than girls Older children more active Preschool attended	Child Organisational
Gubbels, Kremers, van Kann, Stafleu, Candel, Dagnelie, Thijs & de Vris, 2011 **Netherlands**	2 & 3 year old 9 centers 175 children	OSRAC-P TPA	Staff behaviour Group size Positive prompts by educators	Child Educator Physical Environmental Organisational
Gubbels, Van Kann & Jansen, 2012 **Netherlands**	2 & 3 year old 9 centers 175 children	OSRAC-P TPA	Outdoor environment Portable jumping equipment Structured track Older children more active Less PA with: Portable slides, fixed swinging equipment & sandboxes	Child Physical Environmental
McKenzie, Sallis, Nader, Broyles, & Nelson, 1992 **U.S**	4 year old 63 preschools 351 children	BEACHES direct observation UNIQ heart watch (for validation of observation) TPA, MVPA	Anglo compared to Mexican-American Boys more active than girls	Child Physical Environmental
Nicaise, Kahan & Sallis, 2011	4 & 5 year olds 51 children	OSRAC-P MVPA, sedentary	Boys more active Children with normal weight more active	Child Educator Physical Environmental

U.S				
Olesen, Kristensen, Korsholm & Froberg, 2013 **Denmark**	5 & 6 year olds 42 preschools 426 children	Actigraph accelerometers MVPA	Motor coordination Location of building Sex Afternoon play Size of indoor play area per child Less PA: Preterm birth, vegetation on playground, rain	Child Educator Physical Environmental Organisational
Pagels, Boldemann & Raustorp, 2011 **Sweden**	3-5 year olds 4 preschools 55 children	Actigraph Accelerometers Pedometers Sedentary, LPA, MPA, MVPA, TPA	Age Boys more active	Child
Pate, O'Neill, Byun, McIver, Dowda & Brown, 2014 **U.S**	4 year old 17 preschools 301 children	Actigraph Accelerometry LPA, MVPA, TPA	Preschool attended Boys more active than girls	Child Organisational
Pate, McIver, Dowda, Brown & Addy, 2008 **U.S**	3-5 year olds 24 preschools 493 children	OSRAC-P Sedentary, LPA, MVPA, TPA	Boys more active than girls 3 yr old boys more active than 4-5yr olds Preschool attended	Child
Pate, Pfieffer, Trost, Ziegler & Dowda, 2004 **U.S**	3-5 year old children 9 preschools 281 children	Actigraph accelerometer Sedentary, LPA, MVPA, VPA	Preschool attended Boys more active than girls Black children more VPA	Child
Raustorp, Pagels, Boldemann, Cosco, Soderstrom & Martensson, 2012 **U.S & Sweden**	3- 5 year olds 4 preschools 50 children	Actigraph Accelerometer LPA, MVPA, sedentary	Outdoors more active Sedentary greater indoors	Physical Environmental Organisational
Robinson, Wadsworth & Peoples, 2012	34 children	Pedometers	Locomotor skills	Child

U.S		TPA		
Shen, Alexander, Milberger & Jen, 2013 **U.S**	3-5 years 2 preschools 46 children	Actigraph accelerometer LPA, LMVPA, MPA, VPA	Season has no influence on PA	Physical Environmental
Stephens, Xu, Lesesne, Dunn, Kakietek, Jernigan & Khan, 2014 **U.S**	2yr, 10mth – 5yr, 11mth 110 centers 1352 children	Actigraph accelerometer MVPA	Boys more active than girls Outdoor play space Non-Hispanic black children more MVPA than Hispanic	Child Physical Environmental
Sugiyama, Okely, Masters & Moore, 2011 **Australia**	3-5 years old 10 child care centers	Actigraph accelerometer MVPA, sedentary	Lower staff: child ratios Indoors for PA increased MVPA and less sedentary Fixed play equipment more MVPA, less sedentary	Educator Physical Environmental Organisational
Trost, Sirard, Dowda, Pfieffer & Pate, 2003 **U.S**	3-5 year old children 9 preschools 245 children	OSRAP Accelerometer TPA, MVPA, VPA	Overweight boys less active	Child
Van Cauwenberghe, De Bourdeaudhuij, Maes & Cardon, 2012 **Belgium**	35 preschools 573 children	Actigraph accelerometers SOFIT MVPA	Less knowledge content Less promotion Less management Less preschoolers per space Obstruction material Not using throwing equipment	Child Educator Physical Environmental Organisational
Vanderloo, Tucker, Johnson, van Zandvoort, Burke & Irwin, 2014 **Canada**	5 preschools 31 children	Actical Accelerometers Sedentary, MVPA, TPA	Portable equipment Staff behaviour	Educator Physical Environmental Organisational
Vanderloo, Tucker, Johnson, & Holmes, 2013 **Canada**	13 preschools 31 children	Actical Accelerometers Sedentary, MVPA, TPA	Outdoors	Physical Environmental

Williams, Pfieffer, O'Neill, Dowda, McIver, Brown & Pate, 2008 **U.S**	3 & 4 year olds 22 preschools 198 children	Actigraph accelerometer Sedentary, LPA, MVPA, VPA	Locomotor skills	Child

Note. LPA – light-intensity physical activity; LMPA – light- to-moderate intensity physical activity; MPA – moderate-intensity physical activity; MVPA – moderate- to-vigorous intensity physical activity; TPA – total physical activity; OSRAP – Observation System for Recording Activity in Preschools; BEACHES - Behaviours of Eating and Activity for Children's Health Evaluation System ; SOFIT – System for Observing Fitness Instruction Time; OSRAC-P – Observational system for Recording Physical Activity in Children-preschool.

When a variable had no association with a SEF (Social Ecological Framework) domain, the SEF domain was not listed.

Summarising the outcome findings

Child variables

Twelve child correlates were identified (Table 2.3 & 2.4). The most frequent individual correlate reported was sex (n=18), with boys being more physically active than girls. Strong positive associations (four or more studies) with children's physical activity in ECEC services were found for age and motor coordination, older children were more active than younger children (six out of nine studies) (Boldemann et al., 2006; Gagne & Harnois, 2013; Grontved et al., 2009; Gubbels et al., 2011; Gubbels et al., 2012; Pagels et al., 2011) and better motor coordination was positively related to physical activity (three out of four studies) (Olesen et al., 2013; Robinson et al., 2012; Williams et al., 2008).

Educator variables

Educator variables included individual characteristics such as qualifications, training, attitudes and practices.

Of the 27 studies, educator variables were the least studied. Eight variables were reported from 13 references (Table 2.3 & 2.4). Of the variables identified, none reported a strong association, and only educator behaviours (i.e., prompts and feedback) (Bower et al., 2007; Boldemann et al., 2006; Dowda et al., 2009; Gagne & Harnois, 2013; Gubbels et al., 2011; Vanderloo et al., 2014; Van Cauwenberghe et al., 2012), educator qualification and training (Bower et al., 2008; Cardon et al., 2008; Dowda et al., 2004; Dowda et al., 2009; Nicaise et al., 2011; Sugiyama et al., 2011; Van Cauwenberghe et al., 2012) and educator presence (Cardon et al., 2008; Gubbels et al., 2011; Nicaise et al., 2011; Sugiyama et al., 2011) were reported four or more times, all with inconclusive results.

Physical environmental variables

Physical environmental variables were the most frequently reported domain of children's physical activity and sedentary behaviour in ECEC services, with 12 variables identified (Table 2.3 & 2.4). Strong positive associations were reported between physical activity and outdoor environments (e.g., the opportunities for children to play in these) and the size of the play space. Outdoor environments were associated with increased children's physical activity in six of the seven studies (Raustorp et al., 2012; Stephens et al., 2014; Vanderloo et al., 2013 (4 variables)), and reduced sedentary behaviour in three of the four studies (Pate et al., 2004; Vanderloo et al., 2013 (two variables)). It was only with girls' MVPA that there was no association for both physical activity and sedentary behaviour in outdoor environments (Vanderloo et al., 2013). The size of the play space was associated in four of the seven studies (Boldemann et al., 2006; Dowda et al., 2009; Gubbels et al., 2011; Nicaise et al., 2011) with larger play spaces (e.g., total area, m^2) related to higher levels of physical activity.

Organisational Variables

Eleven organisational variables were reported (Table 2.3 & 2.4). Active opportunities, service quality (e.g., as rated by the two scales: EPAO, ECERS-R), preschool location and group size were all identified five or more times, with only active opportunities showing strong positive associations with children's physical activity, which included a shorter recess (play time) (Cardon et al., 2008). Policy was discussed in two studies (Bower et al., 2008; Olesen et al., 2013) both no association with physical activity or sedentary behaviour was identified.

Table 2.3: Summary of reported correlates – physical activity

Correlate	Found association with children's physical activity in ECEC service (reference)	Association (±)	Found no association with children's physical activity in ECEC service (reference)	Summary coding for row (n/N for row; %)	Summary code for association (-/+)
CHILD VARIABLES					
Age of child	(Older) Gagne & Harnois, 2013, Gubbels et al., 2012, Pagels et al., 2011, Gubbels et al., 2011[e], Grontved et al., 2009, Boldemann et al., 2006 (Younger) Stephens et al., 2014[a], Shen et al., 2013	+	Olesen et al., 2013, Gubbels et al., 2011[d], Pate et al., 2004[u]	8 /11 (73)	++
BMI / Adiposity	Robinson et al., 2012, Nicaise et al., 2011, Trost et al., 2003[f]	-	Byun et al., 2013, Olesen et al., 2013, Trost et al., 2003[g]	3/6 (50)	??
Motor coordination	Olesen et al., 2013, Robinson et al., 2012, Williams et al., 2008	+	Williams et al., 2008[h]	3/ 4 (75)	++
Sex	Stephens et al., 2014[b], Pate et al., 2014, Byun et al., 2013, Gagne & Harnois, 2013, Olesen et al., 2013, Van Cauwenberghe et al., 2012[c], Nicaise et al., 2011, Pagels et al., 2011,	+	Robinson et al., 2012, Gubbels et al., 2011, Pate et al., 2008[a], Pate et al., 2004[a]	14/18 (78)	++

	Grontved et al., 2009, Pate et al., 2008, Pate et al., 2008[u], Boldemann et al., 2006, Pate et al., 2004[u], McKenzie et al., 1992				
Born pre term	Olesen et al., 2013	-		1/1 (100)	-
Ethnicity	Stephens et al., 2014[b] Byun et al., 2013, Pate et al., 2004[c], McKenzie et al.,1992	+	Olesen et al., 2013 Pate et al., 2008[v], Pate et al., 2004[v]	4/7 (57)	??
Parent Education	Olesen et al., 2013	+	Byun et al., 2013, Pate et al., 2008[w]	1/3 (33)	?
Attendance Rates	Boldemann et al., 2006	+		1/1 (100)	+
Peer prompts (response to)	Gubbels et al., 2011[e]	+	Gubbels et al., 2011[d]	1 /2 (50)	?
EDUCATOR VARIABLES					
Age of educator	Gagne & Harnois, 2013	+		1/1 (100)	+
Educator Influences					
Educator intention & belief	Gagne & Harnois, 2013	+		1/1 (100)	+
Educator confidence & enjoyment			Gagne & Harnois 2013, Olesen et al., 2013	0/2 (0)	0
Educator behaviours (prompts, feedback)	Gagne & Harnois, 2013, Gubbels et al., 2011, Boldemann et al., 2006	+	Vanderloo et al., 2014 Dowda et al., 2009[b] Bower et al., 2008	3/7 (43)	??
	Van Cauwenberghe et al., 2012	-			

Educator Qualifications & Training	Van Cauwenberghe et al., 2012[a], Nicaise et al., 2011, Sugiyama et al., 2011 Van Cauwenberghe et al., 2012[b]	+ -	Dowda et al., 2009[b] Bower et al., 2008, Cardon et al., 2008 Dowda et al., 2004[b]	3/8 (38)	??
Social Environment					
Solitary environment	Nicaise et al., 2011	+		1/1 (100)	+
Peers present	Nicaise et al., 2011[t], Gubbels et al., 2011	+	Nicaise et al., 2011 (>1 peer), Gubbels et al., 2011[t]	2/4 (50)	??
Educator present	Gubbels et al., 2011[d], Sugiyama et al., 2011[b] Cardon et al., 2008[g]	+ -	Nicaise et al., 2011, Gubbels et al., 2011[e], Cardon et al.,2008[f]	2/6 (33)	00
PHYSICAL ENVIRONMENTAL VARIABLES					
Environment					
Sedentary items			Bower et al., 2008, Bower et al., 2008[b]	0 /2 (0)	0
Indoor environments (relationship to physical activity)			Gagne et al., 2013, Vanderloo et al., 2013, Olesen et al., 2013	0/3 (0)	0
Outdoor environments (relationship to physical activity)	Raustorp et al., 2012[v], Stephens et al., 2014[b], Vanderloo et al., 2013, Vanderloo et al., 2013[b], Vanderloo et al., 2013[x], Vanderloo et al., 2013[g]	+	Vanderloo et al., 2013[y]	6/7 (86)	++
Size of play space (total area of the outdoor environment, m^2)	Dowda et al., 2009[b], Nicaise et al., 2011,	+	Olesen et al., 2013, Sugiyama et al., 2011[b]	4/6 (67)	++

	Boldemann et al., 2006, Gubbels et al., 2011				
Natural features / surface	Nicaise et al., 2011, Olesen et al., 2013,	+	Cardon et al., 2008, Sugiyama et al., 2011	2/5 (40)	??
	Sugiyama et al., 2011[b]	-			
Gradient	Olesen et al., 2013	+	Sugiyama et al., 2011	1/2 (50)	?
Shade			Sugiyama et al., 2011	0/1 (0)	0
Markings			Cardon et al., 2008	0/1 (0)	0
Equipment					
Portable equipment	Dowda et al., 2009, Nicaise et al., 2011[z], Vanderloo et al., 2014[b], Gubbels et al., 2012[m], Van Cauwenberghe et al., 2012[l],	+	Bower et al., 2008, Bower et al., 2008[b], McKenzie et al., 1992, Gagne et al., 2013, Vanderloo et al., 2014, Cardon et al., 2008, Olesen et al., 2013	5/13 (38)	??
	Van Cauwenberghe et al., 2012[j]	-			
Fixed equipment	Dowda et al., 2009[b], Nicaise et al., 2011, Gubbels et al., 2012[aa], Sugiyama et al., 2011[b]	+	Bower et al., 2008, Bower et al., 2008[b], Vanderloo et al., 2014, Cardon et al., 2008, Olesen et al., 2013	4/10 (40)	??
	Vanderloo et al., 2014[b]	-			
Height of equipment			Cardon et al., 2008	0/1 (0)	0
Weather	Olesen et al., 2013	+	Shen et al., 2013	1/ 2 (50)	?
ORGANISATIONAL VARIABLES					

Opportunities					
Active opportunities ***(e.g., recess, indoor space for PA)***	Bower et al., 2008 Bower et al., 2008[b], Cardon et al., 2008, Sugiyama et al., 2011[b]	+	Dowda et al., 2009[b]	4/5 (80)	++
Sedentary opportunities ***(e.g., sitting at group time)***			Bower et al., 2008, Bower et al., 2008[b], Vanderloo et al., 2014[b]	0/3 (0)	0
Physical Activity Policy			Bower et al., 2008, Bower et al., 2008[b], Olesen et al., 2013	0/3 (0)	0
Service Quality ***(e.g., EPAO, ECERS-R)***	Dowda et al., 2009[b], Boldemann et al., 2006, Gubbels et al., 2011	+	Bower et al., 2008, Bower et al., 2008[b], Dowda et al., 2004[b]	3/6 (50)	??
Preschool Location	Raustorp et al., 2012[bb]	+	Raustorp et al., 2012[cc], Raustorp et al., 2012[dd], Raustorp et al., 2012[ee], Raustorp et al., 2012[ff], Grontved et al., 2009	1/6 (17)	0
Program Type					
Preschool type	Byun et al., 2013 (Montessori), Pate et al., 2014 (Montessori)	+	Byun et al., 2013 (private), Dowda et al., 2004[b], Olesen et al., 2013	2/ 5 (40)	??
Group size	Cardon et al., 2008 (child: educator ratio), Dowda et al., 2009, Van Cauwenberghe et al., 2012 (child: educator ratio)	+	Dowda 2009[b], Dowda et al., 2004[b], Olesen et al., 2013, Sugiyama et al., 2011	3/7 (43)	??
Field trips	Dowda et al., 2004[b]	+	Dowda et al., 2009[b], Olesen et al., 2013	1/3 (33)	0
Time spent outside			Dowda et al., 2009[b],	0/3 (0)	0

			Dowda et al., 2004[b], Olesen et al., 2013		
Electronic media	Dowda et al., 2009[b]	-	Dowda et al., 2004, Olesen et al., 2013	1/3 (33)	0
Free time			**Dowda et al., 2004**	**0/1 (0)**	**0**

Note. a-Light-intensity activity (LPA); b- Moderate- to-vigorous intensity physical activity (MVPA); c- Vigorous-intensity physical activity (VPA); d- indoor; e- outdoor; f- boys; g- girls; h-3 year olds; j-throwing equipment ; k-equipment with wheels; l-obstruction equipment; m-riding toys; n-jumping; p-slides; q-structured track; r-sandbox; s-swinging equipment; t -1 peer; u–MVPA & VPA; v–Light activity & MVPA; w-Light, MVPA & VPA; x-MVPA & boys; y-MVPA & girls; z-MVPA, throwing equipment & equipment with wheels; aa-jumping, slides, structured track, sandbox & swinging equipment; bb-Light activity & indoor; cc-MVPA & indoor; dd-MVPA & outdoor; ee-Light activity & outdoor; ff-boys & girls

+positive association; ++positive association for four or more studies; -negative association; 0 no association; 00 no association for four or more studies; ?indeterminate/inconclusive; ?? indeterminate/inconclusive for four or more studies

When no note is used, this refers to total physical activity (light, moderate and vigorous intensity)

Some studies presented multiple variables within the results (such as child age in relation to indoor as well as outdoor environments). When this occurred the reference was counted multiple times in the association column and the specific variable(s) measured indicated with a footnote.

Table 2.4: Summary of reported correlates – sedentary behaviour

Correlate	Found association with children's sedentary behaviour in ECEC service (reference)	Association (±)	Found no association with children's sedentary behaviour in ECEC service (reference)	Summary coding for row (n/N for row; %)	Summary code for association (-/+)
CHILD VARIABLES					
Age	Byun et al., 2013	+		1/1 (100)	+
Sex	Byun et al., 2013	+	Pate et al., 2008, Pate et al., 2004	1/3 (33)	?
Ethnicity	Byun et al., 2013	+	Pate et al., 2008, Pate et al., 2004	1/3 (33)	?
Parent Education			Byun et al., 2013, Pate et al., 2004	0/2 (0)	0
EDUCATOR VARIABLES					
Educator Training & Qualifications			Bower et al., 2008, Dowda et al., 2009, Dowda et al., 2004, Sugiyama et al., 2011	0/4 (0)	0
Educator Behaviours			Bower et al., 2008, Dowda et al., 2009	0/2 (0)	0
PHYSICAL ENVIRONMENTAL VARIABLES					
Environment					
Sedentary items			Bower et al., 2008	0/1 (0)	0
Indoor environments			Vanderloo et al., 2013	0/1(0)	0
Outdoor environments	Pate et al., 2004, Vanderloo et al., 2013,	-	Vanderloo et al., 2014[g]	3/ 4 (75)	- -

	Vanderloo et al., 2014[f]				
Size of play space (total area of the outdoor environment, m^2)	Dowda et al., 2009	-	Sugiyama et al., 2011	1/ 2 (50)	?
Natural features / surface			Sugiyama et al., 2011	0/1 (0)	0
Gradient			Sugiyama et al., 2011	0/1 (0)	0
Shade			Sugiyama et al., 2011	0/1 (0)	0
Equipment					
Portable equipment	Dowda et al., 2009	-	Bower et al., 2008	1/ 2 (50)	?
Fixed equipment	Dowda et al., 2009 Sugiyama et al., 2011	+ -	Bower et al., 2008	1/3 (33)	0
ORGANISATIONAL / POLICY VARIABLES					
Opportunities					
Active opportunities ***(e.g., recess, indoor space for PA)***	Bower et al., 2008, Sugiyama et al., 2011	-	Dowda et al., 2009	2/3 (66)	-
Sedentary opportunities ***(e.g., sitting at group time)***			Bower et al., 2008	0/1 (0)	0
Physical Activity Policy			Bower et al., 2008	0/1 (0)	0
Service Quality ***(e.g., EPAO, ECERS-R)***	Dowda et al., 2009, Dowda et al., 2004	-	Bower et al., 2008	2/3 (66)	-
Preschool Location	Raustorp et al., 2012[d] (Sweden)	-	Raustorp et al., 2012[e]	1/ 2 (50)	?
Program Type					

Preschool type	Byun et al., 2013 (Montessori)	-		1/1 (100)	-
Group size			Dowda et al., 2009 (child: educator ratio), Dowda et al., 2004	0/2 (0)	0
Field trips			Dowda et al., 2009, Dowda et al., 2004	0/2 (0)	0
Time spent outside			Dowda et al., 2009, Dowda et al., 2004	0/2 (0)	0
Electronic media	Dowda et al., 2009	+	Dowda et al., 2004	1/ 2 (50)	?
Free time			Dowda et al., 2004	0/1 (0)	0

Note. d- Indoor; e- Outdoor; f- Boys; g- Girls; +positive association; -negative association; 0 no association; ?indeterminate/inconclusive; When no note is used, this refers to total sedentary behaviour.

Some studies presented multiple variables within the results (such as preschool location in relation to indoor as well as outdoor environments). When this occurred the reference was counted multiple times in the association column and the specific variable(s) measured indicated with a footnote.

2.7.2.4 Discussion

This is the first known review that reports the correlates of physical activity and sedentary behaviour in ECEC services. It is warranted given that the majority of children aged three to five years attend ECEC services (OECD, 2014) and ECEC services have a critical role in providing opportunities for children to be physically active and less sedentary. Similar to other reviews on children's physical activity and sedentary behaviour, this review showed that correlates of children's physical activity and sedentary behaviour with ECECs are multi-dimensional (Hinkley et al., 2008; Hinkley et al., 2010; Sallis et al., 2000). A greater number of physical activity correlates were identified compared with sedentary behaviour correlates, and consistent with a review on correlates of physical activity during school recess time (Ridgers et al., 2012), the majority of variables identified in this review were at the child and physical environmental levels of the social ecological framework. Even though many variables were identified at the child level, this review has primarily focused on the more modifiable influences of children's physical activity and sedentary behaviour within an ECEC service, such as routines and opportunities for physical activity experiences. Discussions of child characteristics are abbreviated as the child variables have been addressed in other reviews (Hinkley et al., 2008; Timmons et al., 2012) and this systematic review primarily focuses on factors associated within ECEC services.

The child domain provided evidence that boys were more active than girls, which is consistent with other reviews (Ridgers et al., 2012; Sallis et al., 2000), that older children were more active than younger children, as were children with better motor coordination. A reason for these results in an ECEC environment may be the programs and environments that are offered to children. Even though sex and age are not modifiable characteristics, it is important for programs and social and physical environments, which are modifiable aspects, to be designed to provide opportunities for all children to improve skills and increase physical activity. Given that educators within the ECEC environment are responsible for providing experiences for children, it is plausible to suggest that they may need to provide more intentional opportunities for children from the identified groups, such as for girls to engage in active play (Morgan et al., 2013), and programs and environments that engage younger children and children with less developed motor skills. These may increase children's motivation and involvement in physical activity, even at this young age.

Educators were included in this review as a specific domain as they are an important aspect of ECEC service pedagogy. Less than 50% (12 from 27) of the studies and only 12% (eight from 66) of the variables were in the educator domain and none of these reported strong associations with physical activity or sedentary behaviour. Although educator variables were the least represented in the 27 studies in this review, several correlates were identified, including: educators being present (Cardon et al., 2008; Gubbels et al., 2011; Nicaise et al., 2011; Sugiyama et al., 2011) and educator training and qualifications (Bower et al., 2008; Cardon et al., 2008; Dowda et al., 2004; Dowda et al., 2009; Nicaise et al., 2011; Sugiyama et al., 2011; Van Cauwenberghe et al., 2012). While educator involvement, creativity during physically active play, and modelling have been suggested as strategies to promote children's physical activity and reduce sedentary behaviours (Dwyer et al., 2008; Irwin et al., 2005; Tandon et al., 2015), no studies were found that assessed these associations in ECEC settings. Due to the few educator variables reported, it is difficult to draw conclusions in this domain and given the role of the educator within the ECEC environment, a greater number of studies investigating these variables are needed. Specifically, active involvement and engagement of educators are potentially important factors in increasing children's physical activity and reducing sedentary behaviours (Hodges, Smith, Tidwell, Berry, 2013; Tandon et al., 2015), as is evident in a study of home environments (Hesketh et al., 2014), which showed associations between the physical activity of mothers and their four year old children. In the absence of studies in this area in ECEC settings, this warrants further studies in the relationship between the physical activity and sedentary behaviours of educators and children.

In the physical environmental domain, this review presented two variables with strong positive associations - the presence of an outdoor environment and larger play spaces. Both were conducive to higher levels of physical activity and conversely outdoor environments were positively associated with reduced sedentary behaviours. Reasons for the presence of an outdoor environment influencing physical activity maybe that outdoor environments afford opportunities for children to engage in activities that may not be present within indoor settings, such as equipment more conducive to gross motor experiences, as well as varying surfaces and natural features that may promote more active play. This result is consistent with another study that indicated that the outdoor environment supports children's active play opportunities (Tandon et al., 2015) yet other studies conclude that the presence of outdoor environments for physical activity may not be as important as once thought, but rather it is the equipment available that had a more influential role (Alhassan et al., 2007; Dowda et al., 2009; Hannon and Brown, 2008). The reason that the size of the outdoor environment, such as larger play spaces has also reported a positive influence on increasing children's physical activity may be that access to spacious environments provide opportunities for children to move more freely and may result in the need for greater movement between experiences, an aspect of environmental design which is an area of ongoing research (Boldemann et al., 2006). Together, the presence of outdoor environments, and the influence of the size of these environments provides evidence of the significance of appropriately designed ECEC services and programs that offer sufficient opportunities for play in outdoor spaces (Sallis et al., 2000).

Interestingly, multiple aspects of the physical environmental domain presented either no association or an inconclusive result: sedentary items (e.g., the presence of TV, computers), natural features / surface (e.g., gardens, the type of surface), indoor environments, gradient (e.g., the presence of hills), shade, markings (e.g., bike tracks), portable equipment, fixed equipment, height of equipment and weather conditions. These inconclusive results may be due to the wide range of variables identified, and is in contrast to other reviews (Dyment, Bell & Lucas, 2009; Hodges et al., 2013) that have suggested that these factors are important.

The organisational domain primarily found little to no association with physical activity or sedentary behaviour. The only strong positive association with physical activity was the provision of active opportunities which included structured physical activity, the facilitation of a specific indoor space for physical activity and planned recess times (Bower et al., 2008; Cardon et al., 2008; Dowda et al., 2009; Shen et al., 2013). Reasons for this could be the range of variables presented in this domain, and the variability within each, such as specific aspects of the program including field trips, preschool type, group size, and the use of electronic media. As discussed, in the physical environmental domain the greatest physical activity occurs outside (Pate et al., 2004; Van Cauwenberghe et al., 2012) however the findings in the organisational domain show that the way an indoor environment is used is related to physical activity (such as having a specific space for physical activity) (Sugiyama et al., 2011). Therefore to maximise opportunities for increasing physical activity and reducing sedentary behaviour, it is important for educators also to consider how they can most effectively use the inside environment for physical activity and reducing sedentary behaviour. Reducing children's sitting time inside (Sugiyama et al., 2011) and incorporating more movement activities (Archer & Siraj, 2014) into learning experiences are modifiable aspects of ECEC services and may have positive benefits for children's physical activity.

It is interesting to note that in the organisational domain, the actual period of time spent outside has no association with children's physical activity and in particular with children's MVPA (Dowda et al., 2004; Dowda et al., 2009). This is important for the ECEC sector as it appears to be the quality, rather than the quantity of the play-time that is significant. This view is supported by another study that reports that additional outdoor playtime is inversely related to children's physical activity levels (Alhassan et al., 2007). Consistent with another study (Sallis et al., 2000), the findings related to opportunities for physical activity validate the need for well-designed, intentional environments and programs to support physical activity, and also align with a qualitative study (Tucker et al., 2011) which suggests educators felt that additional training and resources were key areas to increase children's physical activity and reduce sedentary behaviours. Providing these opportunities should be a goal of directors, educators and policy developers. Adopting written policies, in conjunction with existing programs that support frameworks and curriculum may increase children's daily physical activity and the attainment of daily recommendations.

Strengths & Limitations

This review has a number of strengths: (1) alignment with the PRISMA statement for reporting systematic reviews (Moher et al., 2009) thereby providing precision and structure; (2) reviews studies that used objective measures of physical activity and sedentary behaviour; (3) included correlates that have not been specifically studied before in ECEC settings; and (4) follows a social ecological framework, which provided a clear organisation of the reporting and analysis, relevant to an ECEC service.

However the results of this review should be considered in light of a number of limitations, including: (1) there were only a small number of studies for some variables. Of significance is that less than a third of the variables identified were investigated four or more times and less than 30% of the studies examined correlates across all levels of the model simultaneously, (2) most of the studies were from the U.S. and therefore may limit the generalisability of the results, (3) the search was limited to studies in the English language,

(4) the studies reviewed included varied in sample size (2-63 ECEC services and 34-783 children) and methodologies (although all used an objective measure of physical activity and /or sedentary behaviour), which may potentially impact the heterogeneity of the estimates, and the likelihood of biases in the overall conclusion. This variability seen in the papers reviewed is similar to previous reviews (Hodges et al., 2013; Ridgers et al., 2012) and is expected given the diversity within the ECEC sector. Furthermore, the range of methods of assessing physical activity and sedentary behaviour may have influenced the associations identified, which is consistent with other reviews (Hinkley et al., 2010; Hodges et al., 2013; Ridgers et al., 2012). It is crucial that future studies focus on consistently using the most objective measures of physical activity and sedentary behaviour to increase comparability of study results, (5) the social ecological framework is a complex framework and the potential interactions between the various domains may have consequences on the outcome measures (investigating such interactions was beyond the scope of this review), and (6) some variables explored have presented conflicting positive and negative associations (e.g., educator behaviours in Table 2.3), this is not factored into the coding approach adopted. An alternate approach to 'tallying' the scores maybe more appropriate in future reviews.

2.7.2.5 Conclusion

The early years are a significant time for children, and ECEC services are in a crucial position to promote and encourage learning and development, as well as healthy behaviours (Riethmuller, Jones, & Okely, 2010). This systematic review explored the correlates of physical activity and sedentary behaviour in ECEC services.

In summary, this review shows that the influences upon children's physical activity and sedentary behaviour in ECEC settings are multidimensional. Educators have a critical role in promoting physical activity and reducing sedentary time, and have opportunities to support children's activity levels across many of the domains in the social ecological framework. This review will inform ECEC practice as it highlights capacities for increasing physical activity, such as the effective use of space, time and intentional teaching opportunities. Professional development for educators that focuses on these aspects within an ECEC service, as well as an emphasis on their role as a facilitator/educator of quality experiences is warranted. Further research and intervention is needed to ensure children have access to rich environments, knowledgeable and involved educators, as well as quality interventions and programs that are most conducive to engaging children in levels of physical activity for health and well-being in early childhood and beyond.

2.7.3 Updated systematic review

Eighteen additional studies, which met the original eligibility criteria, have been published since the completion of the published systematic review (i.e., May 2015). These articles were systematically reviewed using the same methods that were used for the original systematic review.

Table 2.5: Summary of articles included in the update to published systematic review

Author, date, location	Sample	Physical activity / sedentary behaviour assessment and outcome	Correlates of physical activity / sedentary behaviour identified	Social Ecological Framework Domain Association
Barbosa, Coledam, Stabelini Neto, Elias, & Oliveira, 2016 **Brazil**	4-6yr olds 8 preschools 370 children	Accelerometers Educator questionnaire TPA, SB	Centres that offered recess more TPA Indoor PA area less SB	Organisational
Bell et al., 2015 **Australia**	3-5yrs 20 preschools 328 children	Pedometers EPAO	Greater steps in centres that had a written policy Greater steps where staff led structured physical activity sessions and joined in active play. 4 year olds were significantly more active than 5 year olds (age)	Child Educator Organisational
Copeland, Khoury, & Kalkwarf, 2016 **US**	30 preschools 388 children	Accelerometers MVPA	>60 minutes in the outdoors higher MVPA >60 minutes in active time (outdoors and indoors) had higher MVPA Boys more active than girls	Child Organisational
Erinosho, Hales, Vaughn, Mazzucca, & Ward, 2016 **US**	50 preschools 544 children	Accelerometers SB, MVPA	Written policies relating to time spent outdoors negatively associated with observed time outdoors Policies relating to staff supervision negatively associated with SB Policies relating to media negatively associated with SB	Organisational
Guo, Schenkelberg, O'Neill, Dowda, & Pate, 2018 **US**	3-5yr old children 22 preschools 227 children	Accelerometers LPA, MVPA	High BMI and high motor score more time in PA	Child
Henderson, Grode, O’Connell, & Schwartz, 2015 **US**	35 preschools 447 children	Accelerometers MVPA	Boys more MVPA than girls Older children more MVPA Heavier children more active >60mins outdoor play higher MVPA Indoor space for PA more MVPA	Child Organisational

			Staff encouraged more time indoors, more MVPA Centre location (mid SES) more MVPA	
Hesketh, Griffin, & Sluijs et al., 2015 **UK**	3-4 yr old children 30 preschools 202 children	Accelerometers SB MVPA	Full day of care, greater MVPA and less SB for boys and girls	Organisational
Hinkley, Salmon, Crawford, & Okely et al., 2016 **Australia**	136 centres 1002 children	Actigraph GT1M accelerometers HAPPY study TPA	Children more active out of care Boys more active in outdoor spaces with natural ground coverings Girls association with time spent inside before outside (more time inside, less active outside)	Physical Environmental
Iivonen et al., 2016 **Finland**	14 ECEC 53 children	OSRAC observations SB, LPA, MVPA	More time spent in SB in indoor environment compared to outdoor environment	Physical Environmental
Mazzucca et al., 2018 **US**	3-5yr old children 50 ECEC 559 children	Accelerometers EPAO-SR MVPA, SB	Outside children 3.2 yrs more MVPA Children more MVPA when educators >10yrs experience Greater EPAO centre quality rating , negative association with MVPA Weather (humidity, rain , higher temp) positive association with SB	Child Educator Physical Environmental Organisational
Olesen, Kristensen, Korsholm, Koch, & Froberg, 2015 **Denmark**	5-6yr old children 40 preschools 351 children	Actigraph accelerometers MVPA	Parent perceptions of chosen activities and motor coordination, positive association with MVPA. Rain – negative association with MVPA Boys – rural areas and size of preschool positive association with MVPA Girls – age and size of indoor areas positive association with MVPA	Child Physical Environmental Organisational
Schlechter, Rosenkranz, Fees, & Dzewaltowski, 2017 **US**	3-6yr old children 2 centres 73 children	Actigraph GT1M accelerometers Video observation SB, TPA	TPA greater outdoors Small groups greater TPA No association with morning / afternoon	Physical Environmental Organisational
Soini et al., 2016 **Netherlands**	3 yr old children 14 centres	OSRAC-P SB, LPA, MVPA	Boys less SB, more MVPA Outdoor more active Social context (prompts) more active	Child Physical Environmental Educator

Finland	187 children			
Tandon, Saelens, Zhou, & Christakis, 2018 **US**	3-5yr old children 5 centres 46 children	Actigraph GT3X+ Accelerometers GPS – Q Travel software SB, LPA, MVPA	More LPA & MVPA, less SB outdoors	Physical Environmental
Tucker, Maltby, Burke, Vanderloo, & Irwin, 2016 **Canada**	2-6 yr old children 28 ECEC 216 children	Actical Accelerometers SB, MVPA, TPA	Weight, sex, ECEC type, no associations.	Child Organisational
Tucker, Vanderloo, Burke, Irwin, & Johnson, 2015 **Canada**	2-5 yr old children 297 children	Accelerometers EPAO MVPA, TPA	Centre based care, greater SB than FDK (full day kindergarten) Centre based: SB - negative association with SB opportunities, fixed play equipment and staff behaviour. SB – positive association with SB environment, portable play equipment FDK: SB – negative association with SB opportunities, fixed play equipment SB – positive association with SB environment, portable play equipment, staff behaviour	Child Physical Environmental Educator
Vanderloo, Tucker, Johnson, Burke, & Irwin, 2015 **Canada**	2-5 yr old children 297 children	Actical Accelerometers EPAO MVPA, TPA	FDK (Full day kindergarten) greater MVPA Centre based: MVPA – negative association with active opportunities, SB environment, staff behaviour, PA training and education MVPA – positive association with SB opportunities, fixed play equipment, PA policy MVPA – no association with portable play equipment TPA – negative association with active opportunities, SB environment, staff behaviour, PA training and education, portable play equipment TPA – positive association with SB opportunities, fixed play equipment and PA policy FDK:	Organisational

			MVPA – negative association with SB environment, portable play equipment, staff behaviour, PA training and education MVPA – positive association with active opportunities, SB opportunities, fixed play equipment TPA – negative association with active opportunities, SB environment, portable play equipment, staff behaviour, PA training and education TPA – positive association with SB opportunities, fixed play equipment	
Ward et al., 2017 **Canada**	50 preschools 723 children	Actical Accelerometers TPA, MVPA, LPA, SB	Educator practices: Formal & informal PA promotion - no association with TPA, MVPA, LPA, SB Overall educator practices, no association with TPA, MVPA, LPA, SB	Child Educator

2.7.3.1 Results

Summarising the articles

The characteristics of the additional studies are outlined in Table 2.5. Over a third were conducted in the U.S. (n=7) (Copeland et al., 2016; Erinosho et al., 2016; Guo et al., 2018; Henderson et al., 2015; Mazzucca et al., 2018; Schlechter et al., 2017; Tandon et al., 2018), with the remaining conducted in Canada (n=4) (Tucker et al., 2016; Tucker et al., 2015; Vanderloo et al., 2015; Ward et al., 2017), Australia (n=2) (Bell et al., 2015; Hinkley et al., 2016), Finland (n=2) (Iivonen et al., 2016; Soini et al., 2016), Denmark (n=1) (Olesen et al., 2015), Brazil (n=1) (Barbosa et al., 2016), UK (n=1) (Hesketh et al., 2015) and Netherlands (n=1) (Soini et al., 2016). One study collected data across two countries – Netherlands and Finland (Soini et al., 2016). Physical activity and sedentary behaviour were assessed using accelerometers (n=15) (Barbosa et al., 2016; Copeland et al., 2016; Erinosho et al., 2016; Guo et al., 2018; Henderson et al., 2015; Hesketh et al., 2015; Hinkley et al., 2016; Mazzucca et al., 2018; Olesen et al., 2015; Schlechter et al., 2017; Tandon et al., 2018; Tucker et al., 2016; Tucker et al., 2015; Vanderloo et al., 2015; Ward et al., 2017), direct observation (OSRAC and OSRAC-P (n=2)) (Iivonen et al., 2016; Soini et al., 2016) and pedometers (n=1) (Bell et al., 2015). Most (78%) reported MVPA (Copeland et al., 2016; Erinosho et al., 2016; Guo et al., 2018; Henderson et al., 2015; Hesketh et al., 2015; Iivonen et al., 2016; Mazzucca et al., 2018; Olesen et al., 2015; Soini et al., 2016; Tandon et al., 2018; Tucker et al., 2016; Tucker et al., 2015; Vanderloo et al., 2015; Ward et al., 2017) and 38% reported TPA (Barbosa et al., 2016; Hinkley et al., 2016; Schlechter et al., 2017; Tucker et al., 2016; Tucker et al., 2015; Vanderloo et al., 2015; Ward et al., 2017). Sedentary behaviour was reported in over half of the studies (59%) (Barbosa et al., 2016; Erinosho et al., 2016; Hesketh et al., 2015; Iivonen et al., 2016; Mazzucca et al., 2018; Schlechter et al., 2017; Soini et al., 2016; Tandon et al., 2018; Tucker et al., 2016; Ward et al., 2017) (Table 2.5).

Summarising the outcome findings

Thirty-three physical activity and sedentary behaviour correlates were identified (Table 2.6 and 2.7), of which five were classified as child variables, four classified as educator variables, 10 classified as physical environmental variables and 14 classified as organisational variables.

Child variables

Five child correlates were identified (Tables 2.6 and 2.7). The most frequent individual correlate was sex (n=5) with boys being more active and less sedentary than girls. Strong positive associations (four or more studies) with children's physical activity in ECEC were found for age; older children were more active than younger children (three out of four studies) (Bell et al., 2015; Olesen et al., 2015; Mazzucca et al., 2018) and lower BMI (Guo et al., 2018; Henderson et al., 2015) and better motor coordination (Guo et al., 2018; Olesen et al., 2015) was positively related to physical activity (both two out of two studies).

Educator variables

Similar to the original review, the updated review reported educator variables such as the presence of educators, educator experience and educator behaviours (such as prompts), were the least studied. Of the 18 studies in the updated review, three educator variables were reported from five studies (Bell et al., 2015; Mazzucca et al., 2018; Soini et al., 2016; Tucker et al., 2015; Ward et al., 2017), and from these the most frequent educator correlate was educator behaviours (n=4 studies) (Bell et al., 2015; Soini et al., 2016; Tucker et al., 2015; Ward et al., 2017), with educator behaviours reporting positive associations with physical activity in two studies (Bell et al., 2015; Soini et al., 2016), no association with physical activity in one study (Ward et al., 2017), and a negative association with children' sedentary behaviour in one study (Tucker et al., 2015) (Tables 2.6 and 2.7). Of the variables identified, none reported strong associations, and only educator behaviours were reported more than once (n=5), with inconclusive results.

Physical environmental variables

Eight physical environmental variables were reported, from 10 individual studies (Tables 2.6 and 2.7). The availability of outdoor environments and weather were reported for both physical activity and sedentary behaviour. The availability of outdoor environments were reported in three of the five studies (Schlechter et al., 2017; Soini et al., 2016; Tandon et al., 2018), with positive associations for TPA (Schlechter et al., 2017), MVPA (Soini et al., 2016; Tandon et al., 2018) and LPA (Tandon et al., 2018). Weather (e.g., rain) had a negative association with physical activity (Olesen et al., 2015), yet had a positive association with sedentary behaviour (Mazzucca et al., 2018). Size of play space (Olesen et al., 2015), and natural features (Hinkley et al., 2016) were positively associated with physical activity for boys.

Organisational variables

Organisational variables were the most frequently reported domain of children's physical activity and sedentary behaviour in ECEC services, with 14 variables identified from 10 individual studies (Tables 2.6 and 2.7). Strong positive associations were reported between physical activity and active opportunities, with increased physical activity in four of the ten studies (Barbosa et al., 2016; Copeland et al., 2016; Henderson et al., 2015; Olesen et al., 2015), and reduced sedentary behaviour in two of the four studies (Barbosa et al., 2016; Tucker et al., 2015). Active opportunities included indoor space for physical activity (Barbosa et al., 2016; Henderson et al., 2015), greater time in outdoor play spaces (Copeland et al., 2016; Henderson et al., 2015) and size of indoor areas (Olesen et al., 2015). Positive associations were reported when children participated in a full day of care (rather than a part day) (Hesketh et al., 2015; Vanderloo et al., 2015) and when children spent more time in outdoor environments (Copeland et al., 2016; Henderson et al., 2015). The presence of a physical activity policy had a mixed association with physical activity (Bell et al., 2015; Erinosho et al., 2016), and service quality (e.g., as rated by EPAO) was negatively associated with physical activity (Mazzucca et al., 2018).

Table 2.6: Summary of reported correlates – physical activity

Correlate	Found association with children's physical activity in ECEC service (reference)	Association (±)	Found no association with children's physical activity in ECEC service (reference)	Summary coding for row (n/N for row; %)	Summary code for association (-/+)
CHILD VARIABLES					
Age of child	Bell et al., 2015[a], Olesen et al., 2015[d], Henderson et al., 2015[e], Mazzucca et al., 2018	+		4/4 (100)	++
BMI / Weight	Guo et al., 2018, Henderson et al., 2015	+	Tucker et al., 2016	2/3 (66)	+
Motor coordination	Olesen et al., 2015, Guo et al., 2018	+		2/2 (100)	+
Sex	Copeland et al., 2016[c], Henderson et al., 2015[c], Soini et al., 2016[c]	+	Tucker et al., 2016	3/4 (75)	++
EDUCATOR VARIABLES					
Educator behaviours	Bell et al., 2015, Soini et al., 2016	+	Ward et al., 2017	2/3 (66)	+
Educator experience	Mazzucca et al., 2018	+		1/1 (100)	+
Educator present	Bell et al., 2015	+		1/1 (100)	+
PHYSICAL ENVIRONMENTAL VARIABLES					
Time spent indoors before outdoors	Hinkley et al., 2016[d]	-		1/1 (100)	-
Outdoor environments	Schlechter et al., 2017, Soini et al., 2016, Tandon et al., 2018	+		3/3 (100)	+
Size of play space	Olesen et al., 2015[c]	+		1/1 (100)	+

Natural features / surface	Hinkley et al., 2016[c]	+		1/1 (100)	+
Weather	Olesen et al., 2015	-		1/1 (100)	-
ORGANISATIONAL / POLICY VARIABLES					
Active opportunities ***(e.g., recess, indoor space for PA)***	Barbosa et al., 2016, Copeland et al., 2016 , Olesen et al., 2015[d], Henderson et al., 2015	+		4/4 (100)	++
Physical Activity Policy	Bell et al., 2015 Erinosho et al., 2016	+ -		1/2 (50)	?
Service Quality ***(e.g., EPAO, ECERS-R)***	Mazzucca et al., 2018	-		1/1 (100)	-
Preschool Location	Olesen et al., 2015[c], Henderson et al., 2015	+		2/2 (100)	+
Full day of care	Hesketh et al., 2015, Vanderloo et al., 2015	+		2/2 (100)	+
Preschool type			Tucker et al., 2016	0/1 (0)	0
Group size	Schlechter et al., 2017	+		1/1 (100)	+
Time spent outside	Copeland et al., 2016[b], Henderson et al., 2015	+		2/2 (100)	+
Time of day		0	Schlechter et al., 2017	0/1 (0)	0

Note. a- younger children more active; b-more time outdoors; c-boys ; d-girls; e-older children more active

Table 2.7: Summary of reported correlates – sedentary behaviour

Correlate	Found association with children's sedentary behaviour in ECEC service (reference)	Association (±)	Found no association with children's sedentary behaviour in ECEC service (reference)	Summary coding for row (n/N for row; %)	Summary code for association (-/+)
CHILD VARIABLES					
Sex	Soini et al., 2016[c]	-		1/1 (100)	-
EDUCATOR VARIABLES					
Educator Behaviours	Tucker et al., 2015	-	Ward et al., 2017	1/2 (50)	?
PHYSICAL ENVIRONMENTAL VARIABLES					
Indoor environments	Iivonen et al., 2016	+		1/1 (100)	+
Outdoor environments	Tandon et al., 2018	-		1/1 (100)	-
Weather (rain)	Mazzucca et al., 2018	+		1/1 (100)	+
Portable equipment	Tucker et al., 2015	+		1/1 (100)	+
Fixed equipment	Tucker et al., 2015	-		1/1 (100)	-
ORGANISATIONAL / POLICY VARIABLES					
Active opportunities ***(e.g., recess, indoor space for PA)***	Barbosa et al., 2016, Tucker et al., 2015	-		2/2 (100)	-
Sedentary opportunities ***(e.g., sitting at group time)***	Tucker et al., 2015	+		1/1 (100)	+
Supervision Policy	Erinosho et al., 2016	-		1/1 (100)	-

Media Policy	Erinosho et al., 2016	-	1/1 (100)	-
Full day of care	Hesketh et al., 2015, Tucker et al., 2015	-	2/2 (100)	-

Note. a- younger children more active; b-more time outdoors; c-boys ; d-girls; e-older children more active

2.7.3.2 Discussion

The 18 additional studies published since the initial systematic review (Tonge et al., 2016) reported similar findings to the previous studies, and consistent evidence for children's physical activity and sedentary behaviour. Country of origin of the studies remained consistent: in both reviews the majority of studies were conducted in the U.S. and Canada. Accelerometers were consistently the most popular method for measuring physical activity and sedentary behaviour. MVPA was the reported in nearly three quarters of all studies in both reviews, and SB was reported in around half of all studies in each review, yet TPA was reported in considerably less studies in the follow-up review. In both reviews, physical environmental and organisational variables were the most frequently reported, however there was a greater percentage of studies that reported organisational variables in the second review. The consistent reporting of the physical environmental and organisational variables in both reviews maybe indicative of the importance of these domains in ECEC settings or the diversity of these domains (i.e., a number of different variables fall under these domains). It could also be due to the fact that the variables in these domains are most easily assessed and do not require measurement of children or involve educators. Data pertaining to these domains can be largely sourced from documents or policies. The increase in studies in the organisational domain seen in the updated review may reflect that changes seen at a regulatory level within the ECEC international sector over the past few years. A number of interventions (Jones et al., 2014; Wolfenden et al., 2016; Wolfenden et al., 2011) have focused on the importance of policies and being accountable for procedures, thus reflecting the number of variables in this domain.

In the child domain, a strong positive association between children's physical activity and sex (boys more active than girls) and children's age (older children more active) was reported in both reviews. For motor coordination (greater motor coordination related to increased physical activity) a strong positive association was reported in the initial review but not in the updated review. This difference is likely due to the limited number of studies (n=2, compared to n=4 in the initial review) reporting this variable in the updated review. In the updated review, child BMI was identified as having a positive association with children's physical activity (from three studies), whereas in the original review an inconclusive association was reported (from six studies). Similar to the motor coordination variable, these changes are most likely a result of the number of studies in the updated review that reported this variable.

Educator variables were the least reported in both reviews. In this domain, the variable educator behaviour (prompts and feedback) was the most frequently reported, yet results were inconclusive. From both reviews, 10 studies reported educator behaviour and physical activity, and findings were mixed (n=3 positive associations, n=3 negative associations and n=4 no association). Likewise, educator behaviour and sedentary behaviour indicated inconclusive results from four studies (n=1 negative association and n=3 no association). Educator presence was also reported in both reviews, and similar to educator behaviours, results were inconclusive for the relationship with physical activity (from seven studies, n=2 positive association, n=2 negative association and n=3 no association), however no studies reported the relationship between educator presence and sedentary behaviour. Interestingly, an inconclusive association (n=8 no association, from 12 studies) was reported between educator qualifications, physical activity and sedentary behaviour. Although the limited number of studies in this domain may have impacted these findings, the results provide justification for future research. All educators in ECEC, despite their qualifications are critical for decision-making, establishing and facilitating routines, modeling behaviours, and influencing daily practices and environments (Melhuish et al., 2015), and although qualified educators are essential for quality ECEC, the outcomes from these reviews support the significance of all educators present, not just those with specific qualifications. Additionally, rather than educators just being present, and providing feedback and prompts alone, there is a need for further examination of what educators are doing while with the children - information that was not reported in the included studies. Further examination of educators' practices, such as active participation and engagement is needed as they may have an important impact on children's physical activity and sedentary behaviour.

In the physical environmental domain, it was consistent across reviews that the availability and size of outdoor environments was positively associated with physical activity (strong association for physical activity in the original review, and a positive association in the updated review) and negatively associated with sedentary behaviour (both reviews negative association). Aspects of an ECEC physical environment, such as natural features, and surface types remain consistent with positive associations with physical activity. Yet, a notable difference between the original and updated review is the absence of studies that report equipment (such as sedentary items, portable and fixed equipment) in the updated review. Although findings were mixed in the original review only one study reported variables (two variables - portable and fixed equipment) in this domain in the updated review, and both these variables focused on the relationship between sedentary behaviour (positive association for portable equipment; negative association for fixed equipment). Reasons for this may be due to a large number of studies in this area previously, or the popularity of these variables as potential correlates of children's physical activity and sedentary behaviour at the time of the original review, or researchers prioritising the measurement of other variables in this domain in the updated review period.

In the organisational domain, active opportunities had a strong association with physical activity and a negative association with sedentary behaviour in both reviews. This finding reinforces the role and importance of an educator in allowing these opportunities, supporting the increased awareness required in the educator domain. Additionally, in the organisational domain, the variable 'physical activity policy' reported no consistent association in the original review (from three studies), yet in the updated review a mixed association was reported (from two studies). This change may have resulted as an increase of policy-related documents has occurred in the sector over the past 10 years although the number of studies is still very low in the updated review, suggesting that a greater number of studies are needed to confirm this association. A notable addition to the organisational domain in the updated review is the association between physical activity, sedentary behaviour and a full day of ECEC. This was not mentioned in the previous review, yet a positive association was found in the updated review. As children are now participating in a wider and more diverse array of ECEC settings, this is an important aspect to consider.

Although a number of differences were identified when the original and updated reviews were compared, the overall number of studies reporting the variables and the associations are still relatively small. The lack of studies has resulted in very few strong positive associations which is the highest evidence, suggesting that additional studies are needed which further support the current studies or investigate additional important ECEC-based correlates.

2.7.4 Additional ECEC-based correlates

Given the complexity of the ECEC environment, the number of variables that could be associated with physical activity and sedentary behaviour are numerous. Variables that warrant further investigation are: time spent outdoors and quality of educator and children interactions in the outdoors, ECEC routines and educators' physical activity and sedentary behaviour levels.

2.7.4.1 Time spent outdoors

The outdoor environment is perhaps the most effective environment to promote children's physical activity and reduce sedentary behaviour in ECEC. Several reviews and individual studies (albeit cross-sectional studies) have consistently shown positive relationships between outdoor environments and children's physical activity (Bower et al., 2008; Copeland et al, 2016; Ferreira et al., 2007; Henderson et al., 2015; Hinkley et al., 2008; Sallis et al., 2000; Timmons, Naylor, & Pfeiffer, 2007; Tucker, 2008). In the study by Copeland et al. (2016), objective measures of physical activity and sedentary behaviour reported that children (n= 388) who experienced at least 60 minutes of outdoor time while in ECEC were more active over 24 hours than children who spent less than 60 minutes of time outdoors. The study by Henderson et al. (2015) reported similar findings: children (n=447) attending centres which offered 60 minutes or longer outdoor time had significantly higher levels of MVPA compared to those that had less than 60 minutes of outdoor time.

In contrast a number of studies have found no association between times spent outdoors in ECEC settings and physical activity, however these are the minority rather than the majority. Dowda et al. (2004, 2009) reported no association between time spent outdoors and children's physical activity. The initial study by Dowda et al. (2004) measured physical activity using the OSRAP, reporting a lower percentage of time in MVPA when children spent more time outdoors and had more free time, than those with less free time and less time outdoors. A more recent study by Dowda et al. (2009) measured children's physical activity using accelerometers. In this latter study time spent in MVPA was associated with other variables (e.g., quality of the ECEC environment, the presence of less fixed and more portable playground equipment, lower use of electronic media, larger playgrounds, educator qualifications and resources) but not with time spent in outdoor environments.

A number of studies (again mainly cross-sectional studies) have shown that increasing the time outdoor is positively associated with reduced sedentary behaviour (Dolinsky et al., 2011; Gray et al., 2015; Raustorp et al., 2012; Vanderloo et al., 2015). A recent systematic review and meta-analysis by Pereira, Cliff, Sousa-Sá, Zhang, & Santos, (2019) showed that, compared to the indoor environment, sedentary behaviours are less frequent in the outdoor environment. Interestingly, the presence of policies promoting outdoor time has been reported to have no association with sedentary behaviours among preschool-aged children (Dowda et al., 2004). Gray et al. (2015) suggests that rather than concluding that time in the outdoor environment did not influence sedentary behaviour, it may be the implementation of outdoor environment policies, such as policies that hindered movement (such as sun-safety, risk-aversion, and increased supervision) (Wyver et al., 2010) or that the outdoor play spaces were not challenging enough (Copeland, Kendeigh, Saelens, Kalkwarf, & Sherman, 2012).

It is highly likely that physical activity is greater, and sedentary activity is reduced in an outdoor environment as this environment has affordances that cannot be captured or easily replicated elsewhere, such as the availability of open space, specific equipment (e.g., climbing equipment, bikes and balls), natural features and that this environment is often open-ended and self-directed (Wyver et al., 2010). Given the mixed results it is important to further investigate the relationship between time spent outdoors, and perhaps the allocation of time spent outdoors, and children's physical activity and sedentary behaviour.

2.7.4.2 Quality of educator and children interactions in the outdoors

High quality ECEC has a positive influence on children's learning and development outcomes (Melhuish et al., 2015) and quality experiences in early childhood lead to better health and education outcomes in early childhood and beyond (Campbell et al., 2012; Gertler et al., 2014; Melhuish, 2008; Shonkoff, 2014). Educators are central to ECEC settings and they have a key role and significant influence on the quality of program and pedagogy (Wang, Hatzigianni, Shahaeian, Murray, & Harrison, 2016). Research has found that the quality of the program, and therefore many young children's experiences and opportunities in ECEC, depends on the skills, dispositions and understandings of the educators (Melhuish et al., 2015).

Within an ECEC centre, relationships develop between children and educators and there is substantial evidence to support that meaningful interactions between educators and children in ECEC environments are key to children's learning and development. More specifically, the interactions of educators are crucial to promoting quality ECEC environments, and educators have an important role in promoting positive emotional, social and academic development (Hamre, Hatfield, Pianta, & Jamil, 2014). Educators are critically important in providing an appropriate program which meets the needs of the children and aligns with the curriculum. Educators must be responsive to developing a play-based program that is appropriate for both the indoor and outdoor environment that caters for all learning and developmental areas for all children (Ebbeck, Yim, & Warrier, 2019).

A number of studies have reported on the interactions between educators and children in the indoor environment. For example, Hamre and colleagues (2014) examined teacher-child interactions of 325 teachers and 1407 children from 10 Head Start programs in the U.S. When teachers offered more responsive interactions during classroom experiences, children demonstrated greater gains in cognitive, self-regulatory, and relational functioning. Another study (Curby, Grimm, & Pianta, 2010) examined the variations of teacher–child interactions over the first two hours of the day, and how certain types of interactions (e.g., organisational) set the stage for other types of interactions. A total of 693 pre-K classrooms were observed over two consecutive days, and the authors found that interactions were relatively stable during the first period of the day, and classroom organisation and emotional support had a positive interdependence on each other, resulting in better outcomes for teacher-child interactions. However, no studies to date have reported on the quality of interaction between educators and children in the outdoor environment. Given that the majority of physical activity occurs in the outdoor environment (Mazzucca et al., 2018; Raustorp et al., 2012; Vanderloo et al., 2013), and several studies have shown strong association between time spent outdoors in ECEC and increased physical activity and decreased sedentary behaviour (Gray et al., 2015; Schlechter et al., 2017; Soini et al., 2016; Tandon et al., 2018; Truelove et al., 2018), it is important to investigate the relationship between educator-child interactions and physical activity and sedentary behaviour in the outdoor environment.

2.7.4.3 ECEC Routines

Internationally, most ECEC settings adhere to a routine throughout the day. Specifically, in Australia, routines usually involve children spending part of the day indoors and part of the day outdoors. In some ECEC centres children spend an allocated time indoors and outdoors where in other ECEC settings children are able to move freely between the indoor and outdoor environment. To date, no known studies have investigated the influence of ECEC routines (such as the sequence of indoor – outdoor opportunities) on physical activity and sedentary behaviours and the influence of child-initiated compared to adult-initiated movement between areas. This may be important to consider as studies have shown that the amount of time spent in indoor environments has an impact on children's physical activity while in outdoor environments (Hinkley et al., 2016).

It has been suggested that increasing the frequency of periods of outdoor free-play in ECEC may represent an opportunity to increase children's physical activity and reduce sedentary behaviours. For example, in Razak et al.'s (2018) randomised controlled trial involving children aged three to six years, the intervention centres (n=5) scheduled three separate 15 minute periods of outdoor free-play, which equated to their usual daily duration of outdoor play. Control centres (n=5) scheduled the normal single outdoor free-play session. Children's physical activity was measured with accelerometers over a five-day period. This simple intervention found that scheduling multiple periods of outdoor free-play significantly increased the time children spent in MVPA while in ECEC (Razak et al., 2018). The findings from this study are consistent with another intervention (Tucker et al., 2017) that modified the scheduling of outdoor free playtime in ECEC. The intervention provided four opportunities for outdoor free-play (four 30 min blocks) (alongside staff training and provision of portable play equipment) and found that the intervention increased children's MVPA by 1.28 minutes per hour compared to control services. In addition, a Belgian study (Van Cauwenberghe et al., 2012) trialed scheduling extra recesses to reduce playground density. The project reduced the number of children playing at the same time and increased the frequency of play in the outdoor environment, resulting in small increases in MVPA. Although scheduling more frequent periods of outdoor play-time has been shown to be important for promoting children's physical activity and reducing sedentary behaviour, a study by Hinkley and colleagues (2016) found that the amount of time spent indoors before going outdoors has an association with physical activity (specifically girls). The study found more time spent indoors before going outdoors has an adverse effect on children's physical activity when they go outdoors (Hinkley et al., 2016). This is an important consideration for educators and policy makers alike, to ensure optimal scheduling and management of movement between indoor and outdoor environments.

It is evident that the current generation of children play outside less frequently and for shorter duration than previous generations (Bassett-Gunter, Rhodes, Sweet, Tristani, & Soltani, 2017). Although this observation relates to habitual physical activity, these trends may also be apparent in ECEC, with an increased focus on curricula experiences for school readiness, such as literacy and numeracy (Nicolopoulou, 2010). Studies have shown that some children indicate that they prefer to play outside when given the choice (Glenn, Knight, Holt, & Spence, 2013; Miller & Miller Kuhaneck, 2008), yet children may be drawn indoors by interest in sedentary activities such as screen time, listening to music, art, and reading which is likely motivated, in part, by the changing nature of children's social environments. As each ECEC centre has the opportunity to design their own routine, further investigation into the most effective scheduling of time and the flow between indoor and outdoor environments is warranted to ensure practices that promote children's health and wellbeing.

2.7.4.4 Educators' physical activity and sedentary behaviour levels

Despite the importance of educators in the ECEC environment, and the influence of educators on children's experiences, few studies (Fossdal, Kippe, Handegård, & Lagestad, 2018; Ward et al., 2017) have measured the relationship between children's physical activity and educators' physical activity. A number of qualitative studies have measured educator perceptions relating to children's physical activity (Lyn, Evers, Davis, Maalouf, & Griffin, 2014; Gehris, Gooze, & Whitaker, 2015), and there has been one study that involved educator self-reporting their motivation and intention to engage children in physical activity (Gagne & Harnois, 2014). The study by Fossdal et al. (2018) objectively measured children's (n=289, 4-6 years) and educators' (n=72) physical activity from 13 randomly selected preschools in Norway. All participants wore an Actigraph accelerometer for seven consecutive days. The study demonstrated an association between educators' and children's physical activity, however it is suggested that further examination, using a longitudinal study design, is required to determine whether the association is based on educator impact on children's physical activity or if it is the children that affect the educators' physical activity levels, or a combination thereof. Another study examined the association between educators' and children's physical activity (and dietary intake) (Ward et al., 2017), using accelerometers to objectively measure children's physical activity, whereas direct observation using items from the Nutrition and Physical Activity Self-Assessment for Child Care (NAP SACC) was used to observe educators' practices (including physical activity) over the course of the two data collection days. This study found an association between educators' and children's eating patterns, yet no association between educators' and children's physical activity. Possible explanations for this is that the presence of researchers may have influenced educators' behaviours, and the different tools used to measure physical activity (i.e., accelerometers for children, direct observation for educators). Due to the mixed results and the limited number of studies that have examined the relationship between an educators' and children's physical activity and sedentary behaviour, it is clear that more studies are warranted. Educator practices may be a critical element for promoting children's physical activity and reducing sedentary behaviour.

2.8 Conclusions

This chapter provided background information on children's physical activity and sedentary behaviours, including a review of the benefits of physical activity, correlates of physical activity and the importance of the ECEC setting for young children. This was followed by a published systematic review on the correlates of physical activity and sedentary behaviour in ECEC. Finally, a systematic review and synthesis was conducted on the literature published since the original searches of the correlates of children's physical activity and sedentary behaviour in ECEC were conducted.

Although a number of variables relating to children's physical activity and sedentary behaviour in ECEC have been reported, there are important gaps in the evidence base. Routine may be a potential factor that influences children's physical activity and sedentary behaviour in ECEC, as may be the quality of educator and child interactions in an outdoor environment, and the practices of educators. These warrant further investigation.

Therefore, the research conducted as part of this PhD aimed to answer the following questions:

1. What are the correlates of children's physical activity and sedentary behaviour in ECEC

settings?

2. What is the relationship between physical environmental aspects of ECEC centres and the quality of educator and child interactions in outdoor environments?
3. What is the relationship between ECEC routines, time spent in outdoor environments and the size of the outdoor environment, and children's physical activity and sedentary behaviour?
4. What is the relationship between educators' physical activity and sedentary behaviour and children's physical activity and sedentary behaviour?

The next chapter will present the published methods for the study and the research that addresses these research questions identified in this literature review.

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Chapter 3: Methods

Chapter 2 reviewed pertinent literature on the children's physical activity and sedentary behaviour in ECEC and identified gaps in the evidence base that formed the aims and research questions for this thesis. Chapter 3 will present the study design that addresses the aim of the study.

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Abstract

The benefits of regular physical activity and reduced sedentary time for children are significant. Previous research has addressed the quantity and quality of children's physical activity and sedentary behaviour while in ECEC, yet little research has investigated the social and physical environmental influences on physical activity and sedentary behaviour in these settings. This study aims to measure these social and physical environmental influences on children's physical activity and physical activity using a combination of a Real Time Location System (a closed system that tracks the location of movement of participants via readers and tags), accelerometry and direct observation.

This study is the first of its kind to combine Real Time Location Systems and accelerometer data in ECEC settings. It is a cross sectional study involving approximately 100 educators and 500 children from 11 ECEC settings in the Illawarra region of New South Wales, Australia. A Real Time Location System and Actigraph GT3X+ accelerometers will be concurrently used to measure the level and location of the children's and educators' physical activity and sedentary behaviour while in outdoor environments. Children and educators will wear accelerometers on their hip that record tri-axial acceleration data at 100Hz. Children and educators will also wear a tag watch on their wrist that transmits a signal to anchors of the Real Time Location System and the triangulation of signals will identify their specific location. In addition to these, up to three random periods (10-25 minutes in length) will be used to collect observational data each day and assessed with the Classroom Assessment and Scoring System to measure the quality of interactions. In conjunction with the Real Time Location System and accelerometers, these observations will measure the relationship between the quality of interactions between educators and children and children's physical activity and sedentary behaviour.

3.1 Introduction

The period of early childhood is critical for learning and development (Shonkoff, 2014). Children's health and wellbeing are paramount, and contribute to their ability to concentrate, cooperate and learn (DEEWR., 2009). More specifically, appropriate levels of physical health allow children to be physically active which in turn is associated with improved blood pressure, cholesterol and bone density, as well as a number of social and emotional benefits such as enhanced self-esteem and social interaction skills (Copeland, Kendeigh, Saelens, Kalkwarf, & Sherman, 2012; Lewicka, 2007; Vives-Rodriguez, 2005). Research also shows that physical activity and sedentary behaviour patterns in early childhood track into childhood, providing longer-term health benefits (Jones, Hinkley, Okely, & Salmon, 2013). Despite the known benefits of increasing physical activity and reducing sedentary behaviour for young children, compliance with recommended physical activity guidelines within ECEC settings (15 minutes per hour) (Institute of Medicine, 2011) for children aged 3-5years is low (Ellis et al., 2017; Pate et al., 2015), highlighting the need to identify the specific influences on children's physical activity and sedentary behaviour in these settings.

ECEC settings provide opportunities for children's learning and development and have the potential to offer quality physical activity experiences (Karila, 2012; Sandberg & Arlemalm-Hagser, 2011). Children's physical activity and sedentary behaviour in ECEC settings are influenced by a number of factors, including child characteristics and the physical environment of the ECEC setting (Coleman & Dyment, 2013; Tonge, Jones, & Okely, 2016). Evidence shows that physical environmental factors such as the availability of an outdoor environment, natural ground coverings and the size of the play space (larger spaces are associated with greater levels of physical activity) have a positive influence on children’s physical activity and sedentary behaviour levels in ECEC settings, as do the presence of natural features and portable equipment such as gardens and bikes (Hinkley, Salmon, Crawford, Okely, & Hesketh, 2016; Tonge et al., 2016). Furthermore, evidence also shows that the presence of fixed equipment, such as a sandpit has an adverse effect on levels of physical activity (Tonge et al., 2016). As the physical environment is a key indicator of children’s physical activity and sedentary behaviour in ECEC settings (Tonge et al., 2016), it is important that all potential influences from the physical environment are considered. Child and educator activity and movement around the physical environment may be influenced by social factors such as educator and peer presence and interaction, as well as physical factors, such as the amount and quality of the resources and equipment offered. To better understand these influences it is important to identify social and physical ‘hot spots’ (locations that are predominant areas for the selected activity), intensity, type, and duration of physical activity, as well as the movement of educators and children around the environment. Importantly, the location of children and educators physical activity in relation to social and physical environmental contexts is an aspect that has not been studied in ECEC settings before.

The adult role is critical in providing quality opportunities for a child’s learning (Siraj-Blatchford, 2009). Evidence shows that a quality relationship between children and educators enhances children’s motivation, engagement and performance in the learning experience (Sabol & Pianta, 2012) as well as their willingness to explore the environment (Hamre & Pianta, 2001; Pianta & Nimetz, 1991). The importance of significant educator relationships for children in ECEC settings is well documented (Adamson, Bakeman, Deckner, & Nelson, 2014; Siraj-Blatchford, 2009). For example, the positive outcomes of quality educator/child interactions for children at risk (Sabol & Pianta, 2012) and the significance of children's engagement with educators for the development of secure attachments (Ritchie & Howes, 2003). However, few studies have investigated the relationship between educators' and children's physical activity and sedentary behaviour, or the influence of the quality of educator-child interactions on physical activity and sedentary behaviour. Studies to date have been qualitative in nature with small sample sizes (Dyment & Coleman, 2012; Froehlich-Chow & Humbert, 2014) and no studies have used objective measures. Moreover, as very little is known about the physical activity and sedentary behaviour of educators, it is yet to be determined whether and how the physical activity and sedentary behaviour of an educator affects the physical activity and sedentary behaviour of children. This study will address these gaps using objective measurements of physical activity and sedentary behaviour alongside the identification of social and physical environmental location of physical activity and sedentary behaviour. In addition to these, the use of an observation tool (CLASS) will assess the quality of interactions between educators and children in the outdoor environment and will provide an opportunity to measure the relationship between the quality of interactions and levels of children's physical activity and sedentary behaviour.

In recent years, a number of commercial location identification systems (for example Global Positioning Systems (GPS) and radio frequency tracking devices) have been developed and used in studying the location and movements of participants around an area (Dunton, Almanza, Jerrett, Wolch, & Pentz, 2014; Lachowycz, Jones, Page, Wheeler, & Cooper, 2012; Quigg, Gray, Reeder, Holt, & Waters, 2010; Rodriguez, Brown, & Troped, 2005; Smith et al., 2013). To date, however, only a handful of studies have combined location identification systems and objective measures of physical activity and sedentary behaviour such as accelerometry. For example, GPS and accelerometers have been used together to measure location and physical activity levels of older children in neighbourhoods, parks and playgrounds (Dunton et al., 2014; Lachowycz et al., 2012; Quigg et al., 2010; Rodriguez et al., 2005). Among adults, the ‘Active Buildings’ study (Smith et al., 2013) used a combination of a radio frequency tracking device (OpenBeacon TagPRO) and accelerometers to investigate associations between office layout and physical activity. These studies have demonstrated that social and physical environmental factors have positive effect on the type and duration of physical activity. No studies have utilised a combination of such measures within ECEC settings. The innovative use of the tracking identification system in this study in combination with the objective measure of physical activity and sedentary behaviour will allow specific identification of the social and physical environmental influences that promote or hinder physical activity and sedentary behaviour levels for children and educators within ECEC settings.

3.1.1 Study Aim

The combination of a RTLS, accelerometry and direct observation will provide a study design that will address research questions that can only be resolved with the synchronised use of these measures. Thus, the aim of this study is to investigate the relationship between ECEC-related factors and children’s physical activity and sedentary behaviours whilst in ECEC settings.

The research questions are:

1. What are the correlates of children’s physical activity and sedentary behaviour in ECEC settings?

2 What is the relationship between physical environmental aspects of ECEC centres and the quality of educator and child interactions in outdoor environments?

3 What is the relationship between ECEC routines, time spent in outdoor environments and the size of the outdoor environment, and children's physical activity and sedentary behaviour?

4 What is the relationship between educators' physical activity and sedentary behaviour and children's physical activity and sedentary behaviour?

a) are there *social* 'hot spots' in an ECEC outdoor environment where children and educators participate in physical activity levels and sedentary behaviour, and where are they?

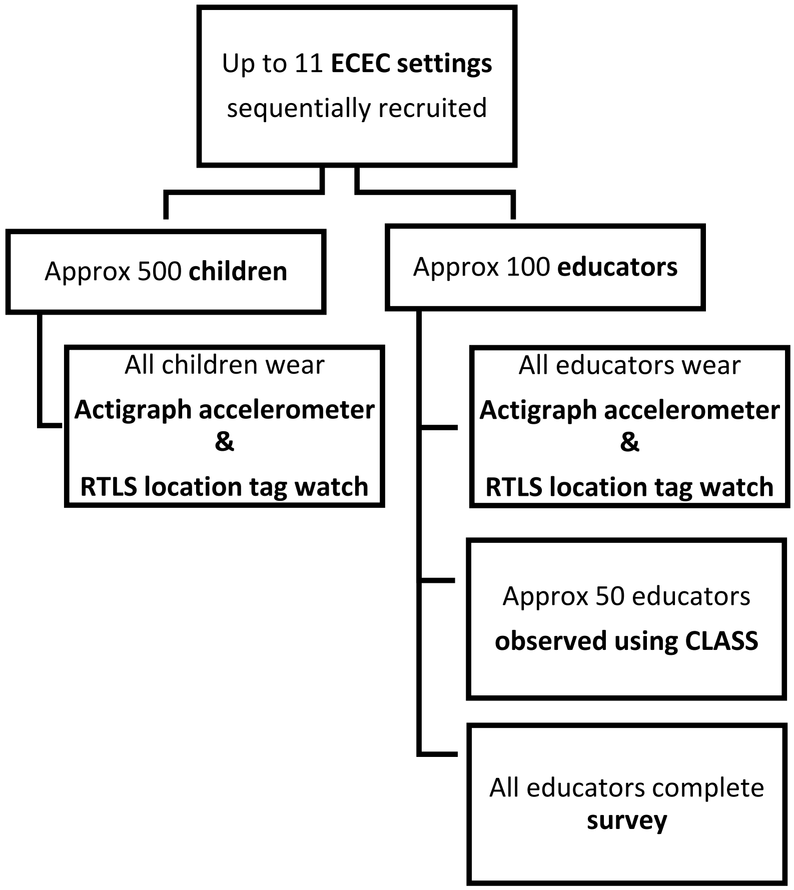
b) are there *physical environmental* 'hot spots' in an ECEC outdoor environment where children and educators participate in physical activity and sedentary behaviour, and where are they?

3.2 Methods and analysis

3.2.1 Study Design

This cross sectional study will combine a number of data collection methods (Figure 3.1). A cross sectional design was chosen as it will enable the researchers to capture descriptive data on a number of variables in a short time frame (one time point only) in ECEC settings. It will use the most objective methods available to measure the physical activity and sedentary behaviour and location of children and educators in ECEC outdoor environments.

Figure 3.1: Study design



3.2.1.1 Setting & Participants

During 2015/2016, ECEC services in the Illawarra region of New South Wales, Australia, within a 2 hour driving radius from the University of Wollongong will be recruited. Services invited to participate in the study will enrol children aged 2-5 years, and have access to outdoor play spaces which will be separate from other play spaces for younger children. All children aged 2-5 years enrolled in the service and their educators will be invited to participate in the study. Data will be collected over five consecutive days in each service. Each morning the project team members will fit the accelerometers and RTLS wrist tags on the children and educators, and they will be encouraged to wear them for the duration of the day. In the case of an unexpected event, and/or adverse weather that may lead to atypical practice or where children are not present in the outdoor environment, another data collection day will be scheduled.

ECEC settings in Australia provide care and education for young children prior to school. Attendance is not compulsory, and the number and sequence of days, as well as the time of attendance each day is not prescribed. A typical pattern of enrolment for children aged 2-5 years is two or three days per week, for 6-8 hours each day. Just as ECEC attendance may vary, so do the ECEC environments, routines and programs within each setting. For example, some settings provide free-flowing play for children between indoor and outdoor environments (i.e., children can move freely between the indoor and outdoor environment), whereas other settings provide distinct times for inside and outside play. This study will include a mix of settings to ensure that the data is representative of the ECEC sector. The diversity of settings will be taken into consideration when data are collected, and the time and timing of the data collection period specific to each setting.

Information about the study will be presented to educators and families at staff and parent meetings, and will also be available on the Participant Information Sheets. Consent will be gathered by the researcher prior to data collection, and parents and carers will be asked to provide child consent. Ethical approval was obtained through the University of Wollongong Human Research Ethics Committee (HE14/330).

3.2.1.2 Study Size

As the aim of the study is to examine the physical activity and sedentary behaviour and location of children as well as educators in an outdoor ECEC setting, it is important to recruit enough educators to investigate the relationships at a centre level. Much of the analysis will be descriptive however we would expect a moderate correlation of 0.3 between the physical activity and sedentary behaviour of educators and children. For this correlation to be significant (alpha=0.05 and power=0.80) 85 educators are needed. To allow for clustering at the ECEC level and based on an intra-class correlation of 0.01 and an average cluster size of 10, approximately 100 educators will be targeted. To recruit 100 educators, up to 11 services will be approached, on the basis of each ECEC service employing between 6 and 15 educators. The number of children at each service ranges between 20 and 90, and so 11 services will provide approximately 500 children which is a sufficient number of child participants for the study.

3.2.1.3 Measurement Instruments

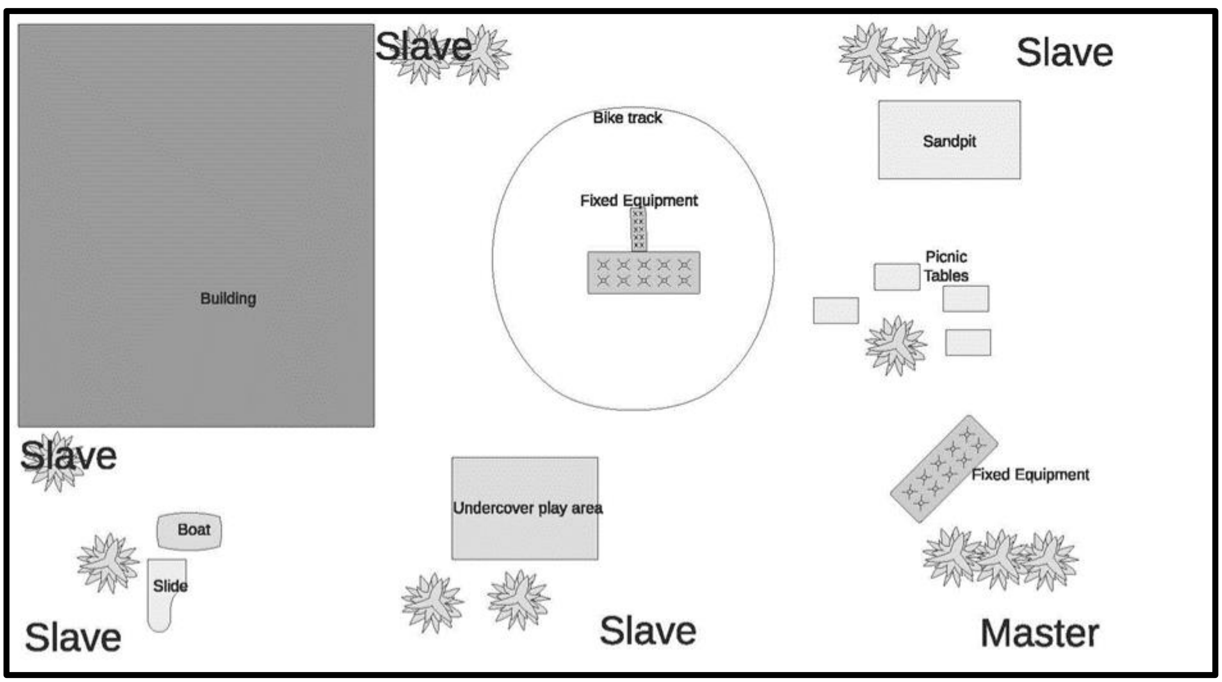
To investigate the children and educator's location and movements around the ECEC setting, a location tracking identification system (Real Time Location System – RTLS) will be used. Actigraph accelerometers will measure the amount and intensity of physical activity and sedentary behaviour of the children and educators. Each accelerometer will be paired with a RTLS wrist tag as a uniquely coded set. As a set, they will be stored in a coded bag, and fitted and removed simultaneously to ensure they are matched at all times. A Master sheet will record the unique code for each participant. The quality of the interaction between the children and educators will be assessed using the CLASS observation tool. Information about organisational policies, procedures and professional development related to children's physical activity and sedentary behaviour will be collected through surveys. These data methods will be combined to determine the social and physical environmental ‘hot spots’ for children’s and educators’ physical activity and sedentary behaviour, the quality of educator and child interactions and the influence on physical activity and sedentary behaviour, levels of educator physical activity and sedentary behaviour, the influence of ECEC setting characteristics on physical activity and sedentary behaviour, and the organisational processes that support educator practices and professional development in relation to children’s physical activity and sedentary behaviour.

3.2.1.3.1 Real Time Location System (RTLS)

Educators’ and children’s locations and movements within the ECEC outdoor environment will be measured using a RTLS (Convergence Systems Limited, Hong Kong) which collects data using radio frequency signals. Data are triangulated from the wrist watch tags (Figure 3.2a) that are worn by each participant to the anchor readers (Figure 3.2b) (which are distributed evenly around the perimeter of the outdoor ECEC environment). One of the anchor readers is the Master anchor which consolidates all the collected data on an attached laptop computer. The wrist watch tags are lightweight (52 mm diameter x 14 mm thick, 35 g), dust and water proof and have a frequency range of 902 – 928MHz. Anchor readers (29 cm x 21 cm x 8 cm, 1.5kg) will be positioned in all corners and recesses of the outdoor environment. To ensure that no anchor is more than 10m apart, the anchor readers will also be placed along the perimeter of the environment to ensure even spacing throughout, particularly in large outdoor spaces. The position of the anchors will be ECEC-specific and will be tailored to each ECEC setting’s outdoor environment (Figure 3.3). Anchor readers will be secured to a wall bracket, placed on a tripod or suspended from a secure location (2m from the ground). Children’s outdoor activities will not be hindered as a result of the positioning of the anchor readers.

Figure 3.2: RTLS Instruments. a) Wrist watch tag b) Slave anchor reader

Figure 3.3: Layout of RTLS Anchor readers in ECEC setting



All anchor readers will be set up prior to the children arriving at the ECEC setting. Each morning, children and educators will be fitted with a wrist watch and will be asked to wear it for the duration of their time at the ECEC setting for that day. Wearing of these wrist watches will be monitored throughout the day to ensure compliance, and all wrist watches will be collected at the end of the day.

The RTLS data are collected and measured as a ‘range’ from at least three anchor readers. This can be viewed live, or recorded as a ‘Data Pack’. One or more tags can be viewed at a time and can be viewed as a movement track over a period of time around the designated ‘cell’ area (which is the total outdoor environment) or can be isolated to observing the actual location of tags at any time (Figure 3.4). Once the ‘Data Pack’ is created, these options for replaying the data can be accessed.

Figure 3.4: RTLS program: Tag tracking – the movement of one or more tags can be tracked and recorded as a line around the space.

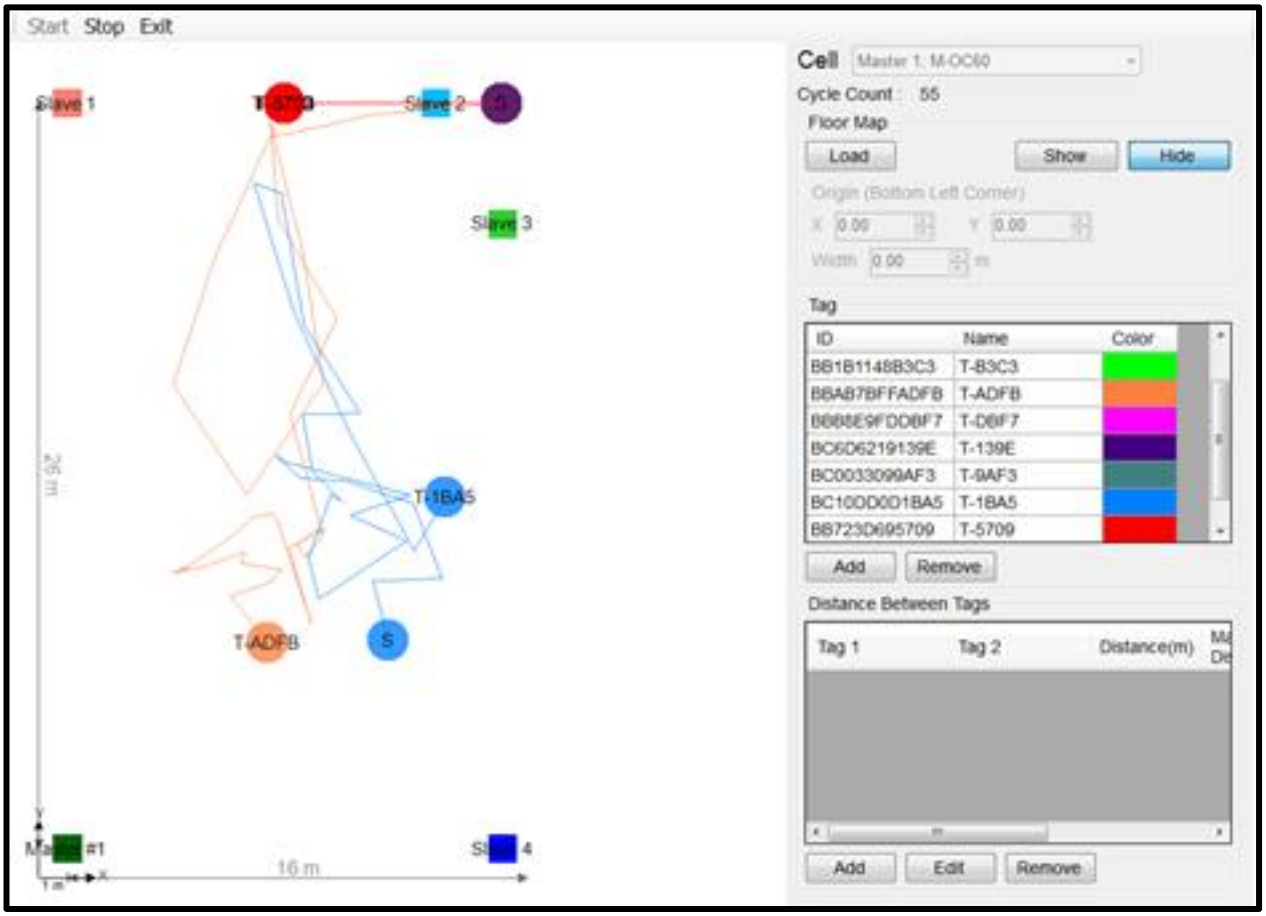
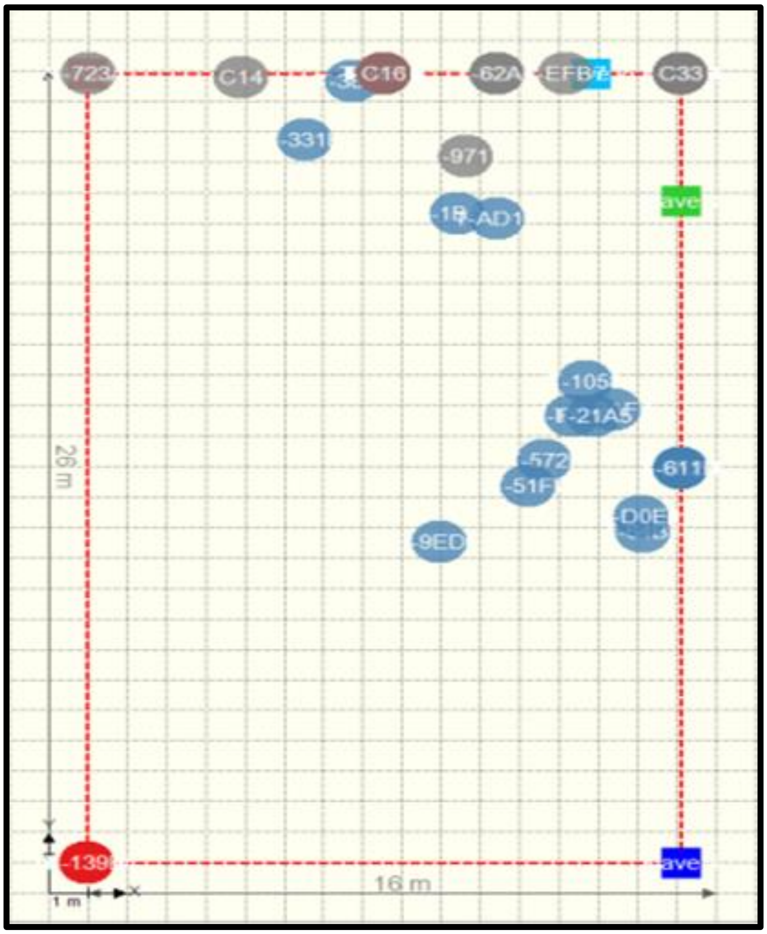


Figure 3.5: RTLS program: Tag location – each tag can be individually coded, and is represented as a circle that moves through the space



3.2.1.3.2 Actigraph Accelerometers

Children and educators will be asked to wear an Actigraph GT3X+ (Actigraph, Florida) accelerometer. These accelerometers (38 x 37 x 18mm, 27g) are light weight, unobtrusive devices worn on the right hip on an elastic belt. They will be fitted at the same time as the wrist watch tags. Accelerometers measure tri-axial g-forces from which the amount and intensity (sedentary, light, moderate, vigorous) of physical activity is determined. They are a water resistant accelerometer that can collect very high-frequency raw data or wave-form tri-axial accelerometer counts at 30 Hz epochs for >7 days. Previous versions have been the most widely used accelerometer in paediatric research to date, they are a valid and reliable measurement tool, and are the most widely used objective measure of physical activity and sedentary behaviour for young children (Lewicka, 2007) and adult populations (Gorman et al., 2014; Troiano, Berrigan, & Dodd, 2008).

3.2.1.3.3 Classroom Assessment Scoring System (CLASS), Pre-K

During data collection at each ECEC setting, observational data will be collected using the Classroom Assessment Scoring System (CLASS), Pre-K (Pianta, La Paro, & Hamre, 2008). Observations will be between 10 and 25 minutes in length and will be video-taped and then later scored to determine the quality of interactions. CLASS Pre-K is an observation system which assesses three domains of classroom quality – emotional support, classroom organisation and instructional support. Each domain is divided into specific dimensions such as positive climate, productivity and quality of feedback (Pianta et al., 2008) (Figure 3.5). CLASS has widely been used to assess classroom quality within the indoor environment (Pianta et al., 2008), yet the use of it in outdoor environments is limited. For this study, CLASS will provide an additional dimension to the data by measuring elements of interactions such as verbal communication and modelling, which alongside the accelerometer and location data will determine the relationship between the quality of interactions and children's physical activity. In total, up to 15 outdoor observational periods will be video recorded for each ECEC setting. During the observations, randomly chosen educators will also wear a small portable microphone attached on the upper body to enable conversations to be audio-recorded. To ensure reliability (Kervin et al., 2016) of the observations and scoring, a second observer will observe and score 10% of the recorded observations.

Figure 3.6: CLASS Domains & Dimensions

Emotional Support	Classroom Organisation	Instructional Support
Positive Climate Negative Climate Teacher Sensitivity Regards for Student Perspectives	Behaviour Management Productivity Instructional Learning Formats	Concept Development Quality of Feedback Language Modelling

3.2.1.3.4 Surveys and additional data collection

Child and educator descriptive data, information about the experiences of educators, and specific ECEC setting characteristics will be collected through surveys, observations and interviews. Child descriptive data, such as age, sex and days of enrolment will be provided by the parent/carer on the child's Consent Form. Educator descriptive information such as year of birth, sex, qualifications, days of work and position in the ECEC setting will be provided on their Consent Form. Each educator will be asked to complete a survey pertaining to organisational policies, procedures and professional development for each ECEC setting. For example, questions such as: 'Have you undertaken formal education or training in providing physical activity experiences to children? and 'In what ways does your centre promote children to be physically active'? will be asked. Additional environmental data will also be collected including daily floor plans of the outdoor environment, weather conditions at regular intervals during the day, a record of programmed and spontaneous activities, and portable equipment present in the environment. Photos and videos will be taken of significant activities, such as spontaneous group physical activity experiences and environment and equipment changes as they occur. General data such as the size of the physical environments, number of children enrolled, and the organisational structure of the ECEC setting will be collected through observation and informal interviews.

3.2.2 Analysis

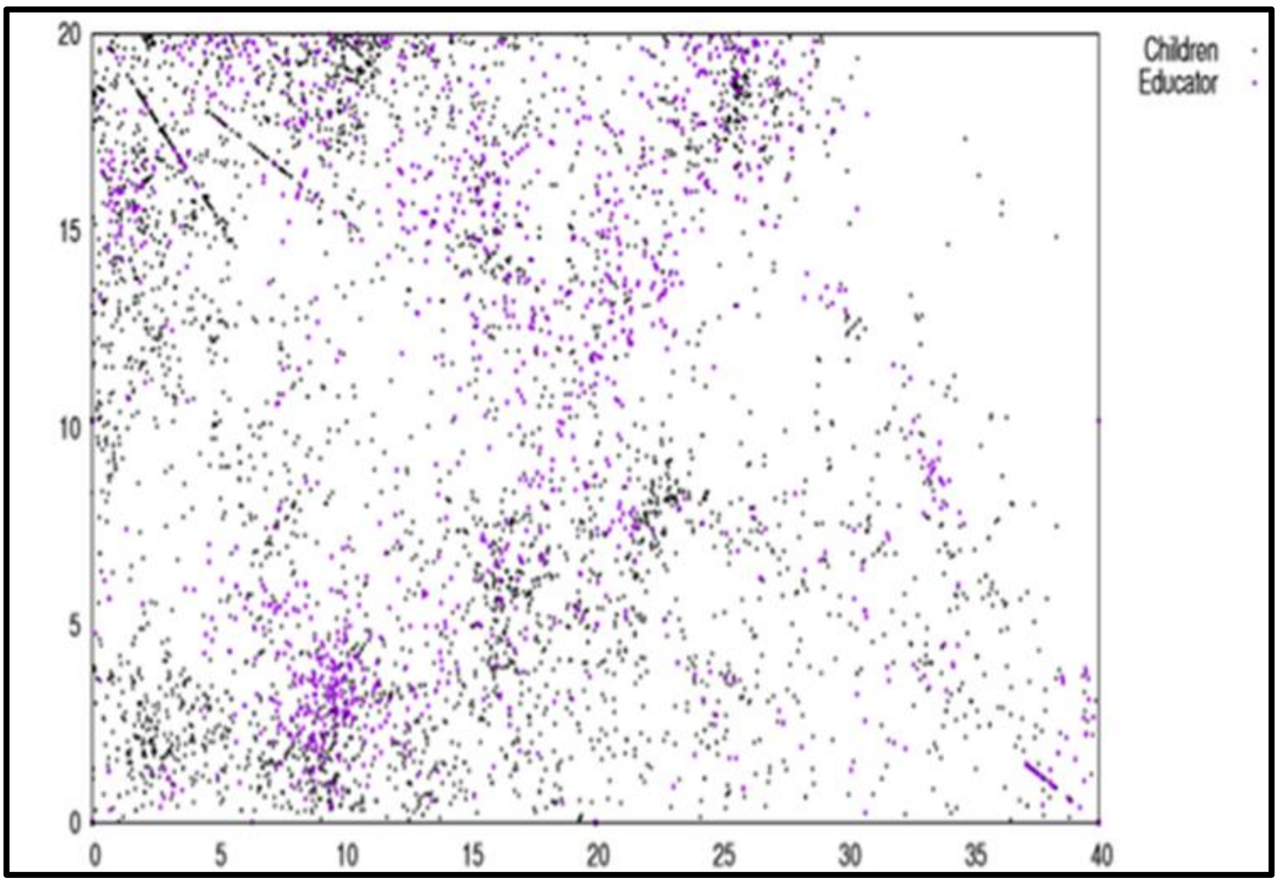
3.2.2.1 RTLS (Real Time Location System)

RTLS data are recorded in real-time, in intervals of one second. The recorded information consists of a data pack and log file for location data. There are a number of illustrations that can be produced from these files. The location of all children and educators during a particular period of time or across the whole day can be determined (Figure 3.6a), as well as the frequency, measured in 10 second bouts, of when a child or educator stays at particular locations during the given period of time (Figure 3.6b). Additionally, the RTLS data can determine when children and educators are inside or outside through the measurement of their location.

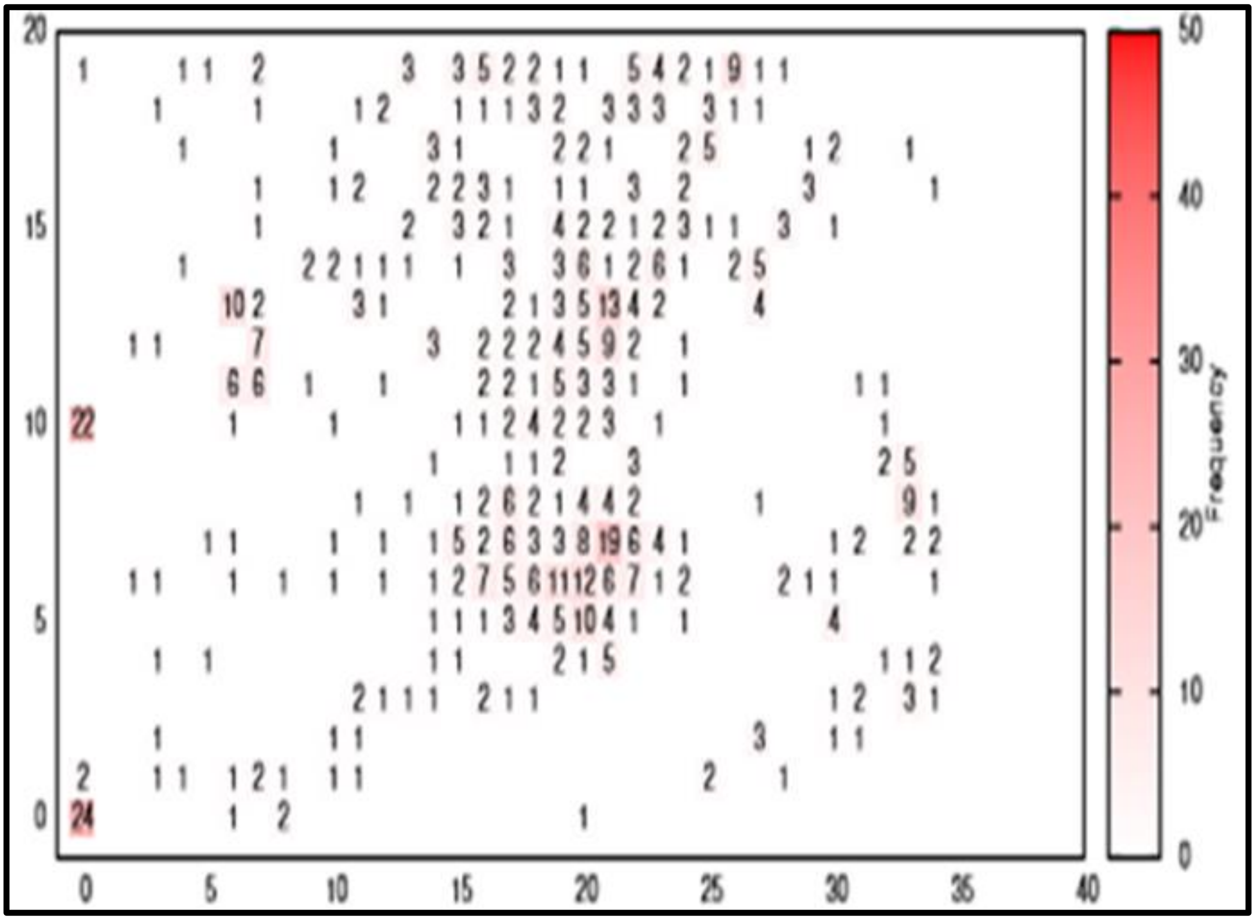
The initial analysis of the location data is completed with the RTLS site manager software package in which commands are created and entered to produce graphs such as in Figure 3.6 (a) & (b). The software also allows an export of log files containing all real-time location data. The software is run under a Linux/Fedora operation system. The code used is the C programming language, and the Linux shell. The extracted information is stored in text file (.txt) while the raw data files are in .csv extension. Gnuplot is used to create the illustrations for visual-support analysis.

Figure 3.7: RTLS graphs

a) RTLS Location - represents a 1 hour time frame, and the location of all tags within the space in 10 sec intervals. This measures 'hot spots' of location.



b) RTLS frequency – represents a single participant's presence in particular locations in the space, indicated as a proportion of the time.



3.2.2.2 Actigraph Accelerometers

For this study, the time spent in different intensities of physical activity and sedentary behaviour for children will be measured according to the cut-points: sedentary behaviour ≤ 37 counts/15sec; light-intensity physical activity 37-420 counts/15sec; moderate- to-vigorous intensity physical activity ≥420 counts/15sec (Pate, Almeida, McIver, Pfeiffer, & Dowda, 2006) which are well established and the best understood measurement for classifying physical activity intensity and sedentary behaviour among children aged 3-5years. For educators, the cut points: sedentary behaviour ≤ 25 counts/15sec; light physical activity 2-504 counts/15sec; moderate/vigorous physical activity ≥ 505 counts/15sec (Troiano et al., 2008) will be used for physical activity and sedentary behaviour measurement. For this study, non-wear time will be calculated at 20 minutes, with a minimum wear time of 180 minutes per day and at least 1 day of accelerometer data collected per participant for data to be valid. Accelerometer data will be analysed using ActiLife software.

3.2.2.3 CLASS (Classroom Assessment Scoring System), Pre-K

The video observations collected will be assessed using CLASS Pre-K. Standardised procedures and scoring sheets as detailed in the CLASS Pre-K manual (Pianta et al., 2008) will be followed. For each service the six longest video recordings, each no less than 10 minutes in length will be scored. Given the unique outdoor environment, all observations will be assessed retrospectively which will increase the accuracy of the scoring. Additionally, 10% of videos will be scored by a second observer for inter-reliability. For each observation, a rating from 1-7 (low to high range) is given for each dimension. The scores from the dimensions (within each domain) are added and then averaged to provide a domain score for each observation. Each ECEC setting will receive an average score (calculated from the six videos) for each of the domains.

3.2.2.4 Surveys and additional data collected

All information from the consent forms, surveys and additional data collected will be entered into an Excel spreadsheet.

3.3 Conclusion

The study is the first of its kind internationally. The design incorporates novel methods of objectively measuring the social and physical environmental influences on children's physical activity and sedentary behaviour in ECEC services, and the multi-level data collection supports a depth of analysis that is unique. Previous research addresses levels of children's physical activity and sedentary behaviour, yet the physical activity and sedentary behaviour of educators, the specific locations of physical activity and sedentary behaviour within an ECEC setting, organisational characteristics of ECEC settings that influence physical activity and sedentary behaviour, and the relationship between children's and educators' physical activity and sedentary behaviour has not been investigated. The experiences and relationships that occur for children at this age are significant, and include establishing foundations for health and well-being, learning and social experiences that will have positive long-term effects (Howes, 2000). Importantly, quality relationships and environments have the potential to promote children's confidence and competence in being physically active which will establish behaviours that promote health and wellbeing conducive to learning and development.

Given the study's specialised environment (i.e., the outside environment in ECEC settings) and the use of multiple instruments additional methodological consideration will need to be considered. For example, the position of the RTLS anchors will be unique to each ECEC outdoor environment due to the individual design of the settings, and their placement will need to consider safety and security aspects for the children in each centre. The RTLS watches are designed for adults, and so consideration of comfort and their secure fastening on children's wrists will need to be managed. Children will wear additional wrist bands to ensure that the wrist watch tags are secure. As the study relies on the synchronised use of accelerometers and location watches, it is crucial that each individual monitor is identified accurately for each participant to ensure information can be cross-checked. Additionally, as the study is carried out in an outdoor environment, at times the presence of the children and educators in the environment will be weather dependent. Weather conditions will also influence the preparation of the RTLS equipment as it is not suitable in wet or adverse conditions.

This project has several benefits for the research community, making an important contribution to the field's understanding of the correlates of children's physical activity and sedentary behaviour in ECEC services. The focus on social environments, as well as the physical environmental aspects of ECEC settings on children's physical activity and sedentary behaviour is innovative, as is the measurement of educator physical activity and sedentary behaviour and location. The outcomes of this study have the potential to inform and add to current knowledge, resulting in positive influences on policy and practice in ECEC settings that will provide quality experiences and opportunities to support children's physical activity and reduce sedentary behaviour, resulting in improved health and wellbeing.

3.4 Post-Script

A Real Time Location System (RTLS) was used to collect educator and children's locations and movements within the ECEC outdoor environment. As was described above, RTLS data was collected from over 100 educators and 400 children from 11 ECEC centres participating in the study.

Time-series engineers were involved in observing the RTLS data that was available, however due to the complexity of analysing the data, and the limited resources available to do so, the inclusion of data from the location system in this PhD was not possible.

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Chapter 4: Quality Interactions in Early Childhood Education and Care Outdoor Environments

Chapter 2 reviewed pertinent literature on the children's physical activity in ECEC and identified gaps in the evidence base that formed the aims and research questions for this thesis, and Chapter 3 presented the study design that addresses the aim of the study.

Chapter 4 will present the results of the study that address research question 2, an examination of the relationship between physical environmental aspects of ECEC centres and the quality of educator and child interactions in outdoor environments.

This chapter has been published as:

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Abstract

Quality interactions are crucial for children's learning and development. Early Childhood Education and Care (ECEC) centres have the opportunity to support children's learning and development, yet the quality of interactions and influences on the quality of interactions in outdoor environments is not known.

This study assessed the quality of educator interactions in outdoor environments using the CLASS Pre-K assessment tool. Eleven ECEC centres participated in the study, which included 110 educators and 490 children. Eighty-seven observations were collected to measure the CLASS Pre-K domains (1–lowest to 7-highest). Mean domain scores were 6.02 (Emotional Support), 5.23 (Classroom Organisation) and 4.46 (Instructional Support). Regression analyses show free routines had significant relationships with Teacher Sensitivity ($p=0.03$) and Instructional Learning Formats ($p=0.03$), and increased amounts of time spent outside had the most significant relationships with Teacher Sensitivity ($p=0.001$) and Behaviour Management ($p=0.001$).

Recommendations to improve the quality of interactions in outdoor environments include providing a free routine and increasing the amount of time spent in outdoor environments. As these recommendations are modifiable practices, they are potentially the easiest to alter and therefore with minimal change the quality of interactions between educators and children could be greatly enhanced.

4.1 Introduction

4.1.1 The Early Years

The early years (birth – 5 years) are a time of rapid growth, including significant physical, cognitive, social-emotional and brain development (Shonkoff, 2014). It is a time of opportunity where children's health and wellbeing, as well as quality experiences are an investment in learning and development (Shonkoff, 2014). During these early years, many children attend an ECEC centre. In Australia, for example, 89% of children aged 4 years attend an ECEC centre, and 92% of these children attend for more than 15 hours a week (ABS, 2016). Furthermore, in most developed countries over the last two decades there has been an increase in children's attendance in formal ECEC experiences (OECD, 2014). As such, ECEC centres play a critical role in the early life experiences for many children and are fundamental for children's learning and development, health and wellbeing.

4.1.2 Early Childhood Education and Care centres

ECEC centres support children's learning and development through the provision of quality physical and social environments. This includes ensuring the availability of adequate equipment and space, as well as opportunities for structured and unstructured experiences and interactions (Ward, 2010). Educators have a significant role in these ECEC environments as they facilitate experiences, and have opportunities to engage in interactions with children. Establishing quality interactions between children and educators is crucial (DEEWR, 2009; Ritchie & Howes, 2003; Wang, Hatzigianni, Shahaeian, Murray & Harrison, 2016) just as quality physical environments are for children's learning and development.

ECEC centres typically provide indoor and outdoor environments, and educators are encouraged to place equal value on these environments as places for children's learning and development (NQS, 2016). Both environments offer opportunities for children and provide experiences in all developmental areas. While there may be variation in the features and proportion of time spent in each environment, the quality of experiences and interactions that occur in these environments are equally significant (NQS, 2016). Despite the importance of both environments to a child's development, little is known about the influence of an educator's interactions with children in outdoor environments, and consequently the value of the outdoor environment for learning and development may be undervalued (Ulset, Vitaro, Brendgen, Bekkhus & Borge, 2017). The opportunities that outdoor environments provide, such as increased physical activity, space, natural playscapes and access to equipment such as bikes, climbing equipment and balls, also reinforces their unique role in children's learning, health, and development.

4.1.3 Outdoor environments in Early Childhood Education and Care centres

All ECEC centres worldwide offer an outdoor environment, or an environment that replicates one. For ECEC centres in Australia, the provision of an outdoor environment is a requirement of the National Quality Standards (NQS, 2016). Typically, outdoor environments in ECEC centres provide many opportunities for children, including experiences that are unique to the space, such as building gardens, playing with trees and sandpits and playing in large open areas. The actual use of the outdoor space is managed at a centre level, as is the proportion of the day that children have access to this environment. Some ECEC centres provide free flowing routines where children select the environment that they play in (i.e., children can choose to be the indoor environment or the outdoor environment at any point throughout the day), whereas other centres regulate the use of the particular environment at various times of the day, including what occurs within the environment at that time, such as a group experience. Educators utilise and prepare the space for various educational and recreational purposes that support children's learning and development, including the promotion of gross motor skills; experiences such as painting, reading and building that may also be present indoors; and activities that may not be possible or ideal indoors, such as bike riding and ball games. Research has shown that children's physical activity is greater in outdoor environments than in indoor environments (Tandon, Saelens & Christakis, 2015), reinforcing its importance in promoting active lifestyles.

Although it is clear that outdoor environments provide valuable opportunities for children's learning and development, much less is known about what happens in these environments compared with indoor environments. In particular, there are no known studies that have examined the quality of an educator's interactions with children in outdoor environments. This is important given that children will typically spend up to nine hours each day in these environments (Ulset, et al., 2017) and that these environments are mandated in Australia in the NQS (NQS, 2016).

4.1.4 Quality in Early Childhood Education and Care centres

Improved outcomes for children in ECEC centres is often associated with the quality of the learning environment (Howes, et al., 2008; Mashburn, et al., 2008; Sylva, Siraj-Blatchford & Taggart, 2006). Although perspectives of quality in ECEC vary, research on quality has typically focused on structural characteristics, such as teacher-child ratios, group sizes and level of teacher education (LaParo, Thomason, Lower, Kintenr-Duffy, & Cassidy, 2012). An alternative yet equally important focus, is the quality of processes, such as interactions and engagement between educators and children (Howes et al., 2008). The study of process quality has shown that children's interaction and engagement with educators is related to their achievements (Burchinal, et al., 2008; Cameron, McDonald-Connor, & Morrison, 2005), and that quality interactions are the foundation of educators being powerful role models for children (Goldfield, Harvey, Grattan, & Adamo, 2012). In light of the importance of quality interactions for children's achievements, it is crucial to measure process quality in all learning environments, including outdoor environments. Additionally, it is crucial to measure process quality in light of ECEC centre practices, such as routines and time spent in environments, as these may influence the quality of environments and interactions.

4.1.5 Assessment of quality in Early Childhood Education and Care centres

Many instruments measuring quality in ECEC centres have assessed multiple aspects, both structural and process (Bryant, 2010) and although many of these instruments measure relevant components of the learning environment, the focus is more on processes such as physical and organisational structure (LaParo, Pianta, & Stuhlman, 2004). Instruments such as the Classroom Assessment and Scoring System (CLASS) Pre-K (Pianta, LaParo & Hamre, 2008) offer a specific measure of the quality of interactions between educators and children. CLASS Pre-K is a real-time observational tool that assesses the quality of interactions between educators and children in ECEC environments based on specific and focused observations of individual educators. Central to CLASS Pre-K is the theoretical framework that educator and child interactions are crucial for academic and social-emotional success (Sandilos, DiPerna, & The Family Life Project Key Investigators, 2014). The assessment is based on three core domains of interactions: emotional support, classroom organisation and instructional support. Although predominantly used for assessment in U.S. classrooms, CLASS Pre-K has been validated across a range of classrooms, for example, in ECEC centres with diverse languages (Downer, Booren, Lima, Luckner & Pianta, 2010), in various countries (Tayler et al., 2016; Pakarinen et al., 2010) and in comparison to other assessments of quality such as ECERS (LaParo et al., 2004). Findings indicate that CLASS Pre-K operates consistently across centres, demonstrating that it could function as a tool for improving quality in ECEC centres (Pianta et al., 2008). Despite the validation of CLASS Pre-K in various ECEC centres, a limitation of these studies is that the specific ECEC environment (indoor and/or outdoor) has not been identified. The use of CLASS Pre-K solely in outdoor environments in this study extends our understanding of CLASS Pre-K. Being aware of specific aspects of the quality of educator and child interactions, as well as possible influences on these interactions has the potential to empower educators to facilitate practices that support learning and development, health (inclusive of physical activity and sedentary behaviour) and wellbeing outcomes for children.

4.1.6 The current study

As outdoor environments and quality interactions are important for children's learning and development, understanding factors such as how the indoor-outdoor routine and the time spent outdoors influence the quality of interactions in outdoor environments will make an important contribution to optimising children's learning and development in ECEC centres. Therefore the aims of this study were to:

1) Report on CLASS Pre-K scores in ECEC centre outdoor environments, and to
2) Examine how the indoor-outdoor routine and the amount of time spent outdoors are related to CLASS Pre-K scores in ECEC centre outdoor environments.

4.2 Material & Methods

4.2.1 Early Childhood Education and Care centres & participants

In 2015, 11 ECEC centres located within a radius of 100km from Wollongong, NSW, Australia, were recruited. ECEC centres were eligible to participate if they enrolled children aged 2-5 years, and these children had access to outdoor play spaces which were separate from other play spaces for younger children in the centre. All eligible children and educators were invited to participate in the study, irrespective of the number of days enrolled or employed, respectively. Information about the study was presented to educators and families at staff and parent meetings and all eligible educators and children were provided with Participant Information Sheets and Consent forms. The study included a range of centres with variations in: the routine of the day, size and features of the physical environment, the number of children enrolled, and the use of indoor and outdoor environments, including the time that children have access to these environments. The detailed methods for the study from which these data were drawn were described in a previous paper (Tonge, Jones & Okely, 2016).

4.2.2 Observation measure – CLASS Pre-K

Observational data were collected from educators and children in the centres. The CLASS Pre-K assessment scale was used to measure the quality of interactions between educators and children in the outdoor environment. CLASS Pre-K is an observation based assessment for use in ECEC environments and provides a contextualised assessment of interactions based on real-life observations (Pianta et al., 2008). It was selected as the most suitable assessment as it measures the quality of interactions with a specific focus on educators.

CLASS Pre-K consists of 10 dimensions measuring three domains (Emotional Support, Classroom Organisation and Instructional Support) of classroom quality. Each dimension was rated on a 7-point Likert-scale (LaParo et al., 2004): low (1, 2), moderate (3-5), or high (6, 7) according to the CLASS Dimensions Overview, Pre-K-3 document (Pianta et al., 2008). The dimensions in the Emotional Support domain focus on the interactions that support social and emotional functioning in the environment, such as positive communication and expectations; responsiveness; and providing children with responsibilities and freedom of movement. These social and emotional attributes support motivation and connectedness to the learning environment (Hamre & Pianta 2001; Silver, Measelle, Armstrong, & Essex, 2005), essential for children's learning and development. The Classroom Organisation domain includes dimensions that relate to environment processes, such as an educator's organisation and management of behaviour, time and attention (Emmer & Stough, 2001), as well as effective questioning, use of resources and clarity of objectives. When these situations are well managed, learning environments function effectively and provide optimal conditions for children to engage in experiences for learning. The dimensions in the Instructional Support domain are based on the processes of children's acquisition of knowledge and the implementation of experiences, such as problem solving; prediction and experimentation; real life application; teacher scaffolding; and effective conversations. In particular, this domain identifies cognitive and language development as key to child outcomes, and as with the other CLASS domains, quality interactions between children and educators as essential for children's learning and development in ECEC centres.

4.2.2.1 Observation protocol

Data were collected from outdoor environments in each ECEC centre across five consecutive days. Throughout the data collection period, educators who were present in the outdoor environment were observed. To ensure a range of educators from each ECEC centre were observed, when there was more than one educator in the outdoor environment, educators who had not been observed previously were selected.

The frequency and timing of observations varied between centres, and were dependent on the centre routine and presence of children in the outdoor environment. The CLASS system has been validated for use in coding video recordings (Mashburn et al., 2008) and thus all observations in the study were video recorded using a portable video recorder and scored retrospectively. To ensure the recording adequately captured all auditory information, the educator being observed wore a Bluetooth microphone which transmitted all sounds in proximity of the educator, including verbal interactions. To ensure accuracy in the visual information collected, the researcher remained close to the observation area, as discretely as possible.

Recording the observations allowed for greater measurement scrutiny and more accurate scoring between the two observers. This was especially important when there was uncertainty in the observations, allowing for cross-checking between observers. The process of recording observations was also important as outdoor environments in ECEC centres are typically larger than indoor environments and additional noise, obstacles and limited proximity to the ‘event’ may occur. Recording observations ensured all aspects of the interactions (verbal and nonverbal) were able to be observed and assessed, even if the researcher was recording from a distance.

Observations met the criteria for CLASS scoring if they were more than 10 minutes in duration (Pianta et al., 2008) and the visual and auditory quality was satisfactory. At times the educator being observed completed tasks other than interactions with the children, including administration, programming and/or interactions with other educators and parents. These observations were still eligible for scoring as they provided insight into various influences on educator and child engagement and interactions.

During the observation period prior to scoring, detailed notes about the CLASS Pre-K indicators were made. Immediately following the observation period, notes from each of the indicators were reviewed and based on these, scores from the CLASS Pre-K range (1 – lowest to 7 – highest) for each dimension were recorded on the CLASS Pre-K scoring sheet (Pianta et al., 2008). For each item the ratings were averaged across all cycles to produce the final score for the domain. For all domains, except the Negative Climate, the higher the score, the more positive the interaction. The Negative Climate dimension was reversed scored as per the CLASS Pre-K manual (Pianta et al., 2008).

4.2.2.2 Training

Prior to scoring the recorded observations, two researchers participated in preliminary training. An online training package 'Introduction to the CLASS Tool' (Teachstone Training LLC©) consisting of five modules, approximately 30 minutes each in duration, was completed. This online package consisted of an overview of the purpose and structure of the CLASS tool as well as guided practice observation tasks that included observing an interaction, followed by multiple-choice questions to reinforce key elements of the interaction.

The second stage of training involved face-to-face professional development and consultation with other researchers, academics and practitioners who had used the CLASS Pre-K in their study. This one-day intensive workshop delivered by a certified CLASS Pre-K assessor provided opportunities for sharing knowledge as well as the purpose and implementation of the CLASS Pre-K assessment tool in ECEC centres.

4.2.2.3 CLASS Pre-K interrater reliability

Twelve observations (14%) were double-scored by independent and trained observers. Reliability was 82% of dimension scores within a score of 1 on the 7-point CLASS scale. Previous studies have maintained at least 80% reliability (Jamison, Cabell, LoCasale-Crouch, Hamre & Pianta, 2014; Sandilos et al., 2014).

4.2.3 Study size

This study forms part of a larger study examining the physical activity and location of children and educators in an outdoor ECEC setting (Tonge et al., 2016). In this larger study it was important to recruit enough educators to investigate the relationships at a centre level, and to allow for clustering at the ECEC level based on an intraclass correlation of 0.01 and an average cluster size of 10. Accordingly, approximately 85 educators were needed to be recruited for the main study (Tonge et al., 2016). To recruit at least 85 educators, 11 ECEC centres participated, on the basis of each ECEC centre employing between 6 and 15 educators.

4.2.4 Early Childhood Education and Care centres – factors influencing quality

For this study, two modifiable factors were examined in relation to the CLASS: ECEC routine and the amount of time spent outdoors each day (Table 4.1). The routine group included centres that offered either an indoor-outdoor program or an aspect of the day that was indoor-outdoor (i.e., children were able to freely move from the indoor environment to the outdoor environment and vice versa) or a structured routine, where children had designated times for indoor and outdoor experiences and there was no opportunity for free movement between the environments during the day. These were termed 'free routine' and 'structured routine' respectively. The time spent outdoors each day was based on the total time children and educators spent outdoors, as was collected from ECEC centre directors and through direct observation.

Table 4.1: Early Childhood Education and Care centre descriptives

Centre	Number of CLASS Observations	Number of educators observed	ECEC routine	Time spent outdoors each day (avg hrs)
1	6	6	Free	5.5
2	8	8	Structured	2.5
3	7	4	Free	4
4	4	4	Structured	2
5	7	5	Structured	2
6	10	8	Free	5.5
7	11	7	Structured	3.5
8	13	8	Structured	4
9	7	4	Free	4
10	8	5	Structured	2.5
11	6	5	Structured	3

Note: Free – children can move freely between indoor and outdoor environments; Structured – children are either in the indoor or outdoor environment, as determined by the educators.

4.2.5 Statistical methods

CLASS scores for individual educators were entered into an Excel spreadsheet and the means, standard deviations and range of these scores were calculated. Using StataIC 13, adjustment was made for clustering of ECEC centres using the svyset command and linear regression analyses were performed to investigate the relationship between individual educator CLASS dimension scores (n=87) and the ECEC centre routine and time spent outside. Linear regression models were produced for each of the CLASS dimensions in each of the ECEC centre groups (n=2). Routine was classified as a categorical variable (free or structured) and adjustment was made for educator age and qualification in these linear regression analyses. Time spent outside was classified as a continuous variable, and similar to the routine analyses adjustment was made for educator age and qualification, but also for centre type (Long Day Care or Preschool) as the total length of the day offered to children enrolled differs between preschools and long day care centres. In Australia, Preschools are typically open between 9am and 3pm whereas Long Day Care centres can be open from 6am to 6pm.

4.3 Results

4.3.1 Descriptive statistics

From 11 ECEC centres, 110 educators and 490 children aged 2-5years were recruited. Four of the centres provided am free routine and seven of the centres provided a structured routine (Table 4.1). On one occasion the children did not have access to the outdoor environment due to adverse weather and so the same day of the following week was scheduled for data collection.

4.3.2 CLASS Pre-K

A total of 131 observations were recorded. Two thirds (n=87) of the observations recorded met the CLASS criteria for this study and included 64 educators. Videos that did not meet the criteria and the reasons for this were: 23 videos (18%) less than 10 minutes (these included educators leaving the environment due to commencing their lunch break, programming time, finishing their shift or all children moving inside), 14 videos (11%) did not have clear audio and/or visual and seven videos (5%) did not meet criteria for other reasons such as technical issues.

The average number of observations per centre was eight (range 4-13) (Table 4.1). One CLASS observation was scored for 72% (n=46) of educators, and 18 educators were observed on multiple occasions. Two CLASS observations were scored for 20% (n=13) of educators, and three observations were scored for 8% (n=5) of educators.

The educators were almost entirely female (97%, n=62) and the mean age was 35 years, with a range from 18 to 58 years of age. Educators reported a number of qualifications (16% degree qualified, 42% diploma qualified, 31% certificate III qualified, 11% student) and numerous primary positions/responsibilities were reported (9% Director, 2% Educational Leader, 3% second in charge, 6% teacher, 28% advanced child care worker, 25% support, 11% casual, 11% student, 5% trainee).

Scores for CLASS domains and dimensions are described in Table 4.2. Mean scores were greatest in the Emotional Support domain, and from this domain, the dimension Negative Climate scored the highest (mean = 6.91). The lowest mean scores were in the Instructional Support domain, and in this domain, the dimension Concept Development scored the lowest overall (mean = 4.08). Using threshold values suggested by the CLASS measure (Pianta et al., 2008) these results suggest that across the 11 centres, Emotional Support was typically of high quality and Classroom Organisation and Instructional Support were of medium quality.

Table 4.2: Mean scores for the CLASS Pre-K dimensions

CLASS Dimensions	**M (range, SD)**
Emotional Support	
Positive Climate	6.28 (2-7, 0.11)
Negative Climate*	6.91 (6 -7, 0.03)
Teacher Sensitivity	5.53 (2-7, 0.14)
Regard for Student Perspectives	5.34 (2-7, 0.13)
Classroom Organisation	
Behaviour Management	5.89 (3-7, 0.10)
Productivity	5.02 (1-7, 0.17)
Instructional Learning Formats	4.78 (1-7, 0.17)
Instructional Support	
Concept Development	4.08 (1-7, 0.18)
Quality of Feedback	4.79 (1-7, 0.17)
Language Modelling	4.51 (1-7,0.18)

Note. Negative Climate reserved scored; M=mean, SD = standard deviation

4.3.3 Linear regression analyses – CLASS Pre-K and Early Childhood Education and Care centre factors

A significant relationship was reported between free routines and Teacher Sensitivity (p=0.03) and Instructional Learning Formats (p=0.03) (Table 4.3). The relationship between free routine and Concept Development also approached statistical significance (p=0.06) (Table 4.3). In all of these cases, higher CLASS scores were reported when free routines were provided.

In the linear regression analysis for the time spent outdoors each day and CLASS dimensions (Table 4.4) significant relationships were reported for Regard for Student Perspectives and Teacher Sensitivity ($p=0.03$ and $p=0.001$ respectively); Instructional Learning Formats and Behaviour Management ($p=0.01$ and $p=0.001$, respectively); and Concept Development ($p=0.01$). For each item, higher CLASS scores were reported when more time was offered in the outside environment.

Table 4.3: Relationship between Early Childhood Education and Care centre routine and CLASS Pre-K dimensions

CLASS Dimensions	B coef	95% CI	P
Emotional Support			
Positive Climate	-0.35	-0.95, 0.26	0.23
Negative Climate*	0.10	-0.05, 0.25	0.17
Teacher Sensitivity	-0.93	-1.72, -0.14	**0.03**
Regard for Student Perspectives	-0.43	-1.20, 0.34	0.25
Classroom Organisation			
Behaviour Management	-0.56	-1.24, 0.13	0.10
Productivity	-0.67	-1.56, 0.21	0.12
Instructional Learning Formats	-0.92	-1.69, -0.14	**0.03**
Instructional Support			
Concept Development	-1.09	-2.22, 0.05	0.06
Quality of Feedback	-0.82	-1.86, 0.22	0.11
Language Modelling	-0.72	-1.72, 0.29	0.14

Note. $P<0.05$; bold – significant differences; CI - confidence interval; *Negative Climate was reverse-scored

Table 4.4: Relationship between time spent outdoors each day and CLASS Pre-K dimensions

CLASS Dimensions	B coef	95% CI	P
Emotional Support			
Positive Climate	0.15	-0.03, 0.34	0.10
Negative Climate*	-0.03	-0.07, 0.01	0.09
Teacher Sensitivity	0.39	0.19, 0.59	**0.001**
Regard for Student Perspectives	0.29	0.04, 0.54	**0.03**
Classroom Organisation			
Behaviour Management	0.35	0.19, 0.51	**0.001**
Productivity	0.35	-0.39, 0.74	0.07
Instructional Learning Formats	0.39	0.12, 0.66	**0.01**
Instructional Support			
Concept Development	0.49	0.18, 0.79	**0.01**
Quality of Feedback	0.36	-0.11, 0.84	0.12
Language Modelling	0.27	-0.10, 0.65	0.14

Note. P<0.05; bold – significant differences; CI - confidence interval; *Negative Climate was reverse-scored

4.4 Discussion

The purpose of this study was to report on CLASS Pre-K scores in ECEC centre outdoor environments, and to determine the influence of routines and the amount of time offered in outdoor environments on the quality of interactions between educators and children. Key findings indicate that providing a free routine that enables children to select either the indoor or outdoor environment; and greater amounts of time spent outside improves the quality of interactions between educators and children in ECEC centre outdoor environments.

The measurement of the quality of interactions between educators and children in ECEC outdoor environments is important because spending time in high-quality outdoor environments is critical for children's learning and development (Siraj-Blatchford, 2009). Most studies reporting results from CLASS Pre-K have been methodological. For example, validation studies (Downer et al., 2010; Pakarinen et al., 2010) or studies that have compared CLASS Pre-K with others instruments that assess quality (LaParo et al., 2004) or studies that assess the stability of interactions during the day (Curby, Grimm & Pianta, 2010). A few studies have focused on relationships between CLASS Pre-K and outcomes such as educational wellbeing and social development (Burchinal et al., 2008; Curby et al., 2009; Tayler et al., 2016) or assessed the relationship between CLASS Pre-K scores and service type (Tayler, Ishimine, Cloney, Cleveland & Thorpe, 2013). These studies consistently found that higher quality interactions resulted in improved outcomes for children. Although each of these studies has provided valuable information about quality interactions, there has been an absence of studies using CLASS Pre-K in the outdoor ECEC environment.

4.4.1 CLASS Pre-K in outdoor Early Childhood Education and Care centre environments

In this CLASS Pre-K study of the outdoor environment, the Emotional Support domain achieved the highest scores, and the Instructional Support domain achieved the lowest scores, a finding that is consistent with other CLASS Pre-K studies of indoor learning environments (Curby et al., 2010; LaParo et al., 2004; Sandilos & DiPerna, 2011; Tayler et al., 2013). This outcome may be a reflection of an ECEC environment where children's social and emotional wellbeing is paramount and valued as being more crucial for learning and development than academic achievement. Educators advocate that children's learning will be optimised when they feel that they belong, and are supported, safe and secure (DEEWR, 2009) - aspects assessed in the Emotional Support domain of CLASS Pre-K. Furthermore, in a study that measured the relationship between CLASS Pre-K Emotional Support domain scores and teacher efficacy, educators felt comfortable in a nurturing role, which aligns with indicators in the Emotional Support domain, such as sensitivity and creating a positive environment (Pakarinen et al., 2010).

Alongside the consideration that educators place high value on aspects in the Emotional Support domain, indicators in this domain, such as verbal and physical affection and providing comfort and assistance, may be more instinctive for educators compared with indicators in the Instructional Support domain, which scored the lowest. The Instructional Support domain relies on several skill-based concepts, such as advanced language, scaffolding, analysis and reasoning. Therefore, educators may require specific and intentional professional development to develop confidence in this domain. Accordingly, educators have indicated that they require further professional development to best support children's outcomes (Coleman & Dyment 2013; Tucker, van Zandvoort, Burke & Irwin, 2011), and it may be this provision of professional development that results in higher Instructional Support domain scores.

The overall scores from CLASS Pre-K in this study indicate that the Emotional Support and Classroom Organisation domains are in a high range of interaction quality, and that the Instructional Support domain is in the medium range. These ranges are higher than in other studies using CLASS Pre-K. For example, in other studies the mean scores for the Emotional

Support and Classroom Organisation domains were in the medium range, and the mean Instructional Support scores were in the low-medium range (Sandilos et al., 2011; Tayler et al., 2013). Conversely, a study in Finland using CLASS (Pakarinen et al., 2010) found similar patterns to the current study with higher ranges reported. Possible explanations for this include the interpretation and evaluation of the dimensions; the absence of literature on CLASS Pre-K specifically in outdoor environments which has resulted in comparisons with indoor and/or outdoor rather than outdoor environments specifically; and the suitability of the CLASS Pre-K assessment in its entirety for outdoor environments which may have resulted in misrepresented scores. Further studies specifically in ECEC outdoor environments are needed to provide a more accurate comparison and interpretation.

The highest scores in the Emotional and lowest in the Instructional Support domain may have been influenced by the assessment being in the outdoor environment. Indicators in the Instructional Support domain suggest that high-quality interactions are formed through defined exchanges, often requiring a high level of verbal interaction ('there are frequent conversations in the classroom' and 'the teacher often provides additional information to expand on students' understanding or actions'), whereas in the Emotional Support domain several indicators depend on non-verbal interactions ('there are frequent displays of positive affect by the teacher and/or students' and 'students have freedom of movement and placement during activities'). Affordances in outdoor environments differ from those in an indoor environment as the space is typically larger and opportunities for different experiences are available. For example, experiences that promote greater and faster movements such as climbing and bike riding are present, resulting in increased movement of and distances between educators and children. In these cases, measuring the quality of interactions by assessing verbal interactions may be compromised as the movement and location of educators and children may affect the level of verbal interactions that occur, as is linked to high-quality interactions in the Instructional Support domain. Interactions in outdoor environments may be more dependent on the educator's non-verbal involvement and interactions with children rather than verbal interactions. Subsequently this presents challenges in the assessment of the quality of interactions based on language modelling and conversations, as is indicated in the Instructional Support domain, more so than in the Emotional Support or Classroom Organisation domains.

In addition to the suitability of the indicators of Instructional Support, the actions of the educators in this outdoor environment may influence the Instructional Support scores. Due to the specific features and affordances of an outdoor environment, such as gardens, climbing equipment, bikes and typically more active play, educators may perceive that their main role during outdoor play is the supervision and safety of children (Coleman & Dyment, 2013). Consequently the outdoor environment may be underestimated as an intentional learning space. This perception may increase emotional support, to the detriment of instructional aspects such as concept development, effective feedback and language modelling (Pianta et al., 2008) as are indicators in the Instructional Support domain.

4.4.2 The relationship between quality of interactions and routines and time spent outdoors

ECEC centres are diverse and there are many factors, such as location, educator-child ratios, available space and resources (van Zandvoort, Tucker, Irwin & Burke, 2010), regulations and policies, as well as environmental factors such as the weather (Poest, Williams, Witt & Attwood, 1989; Tucker & Gilliland 2007) that influence practice and therefore children's experiences and outcomes. These may have a greater influence in outdoor environments. ECEC centres may not have the capacity to manage all potential influences, however it is evident in this study that there are factors, such as the type of routine and time spent outside, that educators can modify that may influence the quality of interactions between educators and children during time spent in outdoor environments.

When educators offered a free routine, such as children having access to indoor and outdoor environments at any time throughout the day, compared to a routine that was structured, for example children were indoors in the morning and outdoors in the afternoon, the quality of interactions between educators and children in an ECEC outdoor environment were consistently greater. Furthermore, other research has shown the benefits of a free routine that allows children to move freely between environments of choice on the amount of time children spend in experiences such as physical activity (Hesketh & van Slujis, 2016). When children spend increased periods of time in experiences, this allows their play to extend and develop, and opportunities for sustained shared thinking (Siraj–Blatchford, 2009) which are key aspects for learning and development are increased. Enabling children to move freely between environments also allows children to make choices for their play, and therefore may have an influence on the quality of their play and interactions. Additionally, allowing children to move freely between environments of choice has the potential to minimise the number of children in each space, therefore ensuring resources and equipment are accessible, avoiding waiting times and conflicts that may arise. Identifying such influences on the quality of educator and child interactions, and therefore children's experiences in ECEC centres is important to being able to design interventions that promote high quality environments and in turn potentially increase children's physical activity and decrease children's sedentary behaviour.

Teacher Sensitivity and Instructional Learning Formats were related to both free routines and increased time spent outside. Teacher Sensitivity focuses on awareness, responsiveness, addressing problems and student comfort (Pianta et al., 2008) whilst Instructional Learning Formats focuses on effective questioning, teacher involvement and hands on opportunities. In an ECEC centre when a free routine is provided, children have opportunities to move freely between environments, around peers, educators and experiences and potentially regulate their social and emotional experiences. In this emotional climate, children may be more comfortable and confident as they have a greater agency over their learning environment. Accordingly, the response of educators may reflect the disposition of the children within the environment, resulting in interactions that lead to more advanced motor skill development and opportunities for extended interactions. More time in an environment allows for these indicators to develop as transition times may be reduced, and children and educators have more opportunities to engage in sustained interactions (Siraj-Blatchford, 2009).

Consistent results were also found when greater amounts of time were spent outdoors. When ECEC centres provided children with more time in the outdoor environment across the day, higher quality interactions were reported. Increased time in an environment allows sustained periods of time engaged in experiences, as well as reducing the 'novelty' factor that may occur when children have shorter periods of time in an environment. Sustained periods of time in an outdoor environment provides opportunities free from interruption due to transitions, preparation and packing away of equipment. Accordingly, sustained opportunities in experiences have the potential for higher-level engagement, challenge and problem solving (Siraj-Blatchford, 2009) and subsequently environments that are stimulating (Melhuish, 2004). These factors may have influenced the quality of the interactions in this study, as greater time allowed better quality environments to develop. Interestingly, other studies indicate that it is the quality of the time, and what occurs within experiences that is important for children's outcomes, such as physical activity (Dowda et al., 2009; Dowda, Pate, Trost, Almeida & Sirard, 2004; Tonge et al., 2016). Recognising the influence of the quality as well as the quantity of the time spent outdoors is critical. The need for deliberate planning of time, experiences, interactions and intentional teaching in outdoor environments is essential and has the potential to influence the quality of interactions in the environment and subsequently children's experiences and outcomes.

4.4.3 Possibilities with CLASS Pre-K

This was an exploratory study measuring each domain and dimension from CLASS Pre-K. Using the scale solely in outdoor environments was unique and has presented some areas for further consideration. The assessment of the quality of interactions in outdoor environments with CLASS Pre-K needs to consider the assessment scales and aspects of the items being measured. For example, the dimension Productivity includes the criteria of maximising learning time and transitions. In an outdoor environment which is typically less structured, these aspects may not be as frequent. Additionally, due to outdoor environments in ECEC centres having a tendency to be more spontaneous, the clarity of learning objectives from the dimension Instructional Learning Formats, as well as indicators in the Classroom Organisation domain may not be as pronounced. Future studies measuring the quality of interactions in outdoor environments need to consider possible misrepresentations of dimension scores and report according to the observed environment. As was suggested in a study using the inCLASS measurement tool (Downer et al., 2010), it is apparent that CLASS Pre-K has the potential to provide a contextualised assessment of educator and child interactions, one that may compliment other ECEC centre assessments. In the absence of any other appropriate tools for the outdoor environment, this assessment tool is currently the best choice and hence the reason it was used in this study.

4.4.4 Strengths & limitations

This study has a number of strengths: (1) CLASS Pre-K assessed the quality of educator and child interactions in outdoor environments which has not been reported previously; and (2) identification of modifiable and achievable practices that support better quality interactions.

The focus on ECEC outdoor environments offers new information to what is already known about the quality of educator and child interactions in ECEC centres. The potential of outdoor environments as valuable learning spaces are often underestimated, therefore it is important to demonstrate the opportunities that they hold for children's learning and development. Further, it is important for educator and child interactions to be meaningful in ECEC centre outdoor environments as this has the potential to enhance children's physical activity, physical activity promotion and skill development for children's health and wellbeing.

Identifying modifiable aspects of practice that educators have the ability to manage is empowering for educators. There are some aspects of ECEC centres such as the size of the yard, geographic location and number of children enrolled that cannot be modified, yet reviewing and modifying the routine provided and the amount of time spent outside are somewhat more achievable. As this study shows, these changes can have significant effects on the quality of interactions between educators and children, and therefore child outcomes.

The results of the study should, however, be considered in light of a number of limitations, including the limited observation time in some ECEC centres, and the design and nature of CLASS Pre-K being perhaps better suited for indoor than outdoor environments.

Although the CLASS manual (Pianta et al., 2008) suggests that the results are reflective of typical practice, this may be a limitation of the present study. The total observation time which is measured with CLASS Pre-K may not be representative of the quality of educator and child interactions throughout the day. In this study the collection of observations only in outdoor environments meant that not all educators were observed, and the timing of the observations was set to a timeframe, for example only when the children and educators were in outdoor environments. In some ECEC centres that offered a free routine, it was only selected educators that engaged in the outdoor environment, and although the observations were random, there were limitations as to which educators were observed. Additionally, a small number of educators chose not to be involved in the observations and recordings. In these free-routine ECEC centres, as educators and children had the potential to move between environments at times this movement between environments would result in the observation ceasing. Further research comparing the quality of interactions between educators and children in outdoor and indoor environments is warranted.

ECEC centre environments are diverse and features of ECEC centre indoor and outdoor environments vary. Outdoor environments are typically larger and provide less structured experiences than indoor environments, and experiences may encourage more movement within and between areas, for example ball games, climbing equipment and portable equipment such as bikes and scooters. Consequently, children’s and educator’s movements may be different between these environments. It is apparent that the CLASS Pre-K tool has been designed for the indoor environment, and as such previous studies using this tool may have only investigated the indoor environment. This warrants consideration of its application in outdoor environments. Central to CLASS Pre-K assessments are verbal interaction and as indoor environments are generally smaller environments it is easier to capture conversations, whereas in outdoor environments which are generally larger and more open this may be difficult. As such, it is paramount that observers utilise the most effective methods of capturing all verbal interactions within any environment without influencing typical practice. Observations in this study were video recorded allowing the movement of educator and children while still recording vital information. To ensure accuracy in audio information, the educator selected for the observation also wore a wireless microphone. This further improved clarity of audio data collected, particularly from a distance or while the educators were moving. To reduce the effects of wearing the microphone on typical practice, such as reactivity which may result in participating in additional interactions, or perhaps not as many interactions, multiple observations were collected across the period of data collection in the ECEC centre.

4.5 Conclusion

High quality environments provide opportunities that support children’s learning and development, and it is crucial that value is placed on both indoor and outdoor environments as opportunities to develop quality interactions. Recommendations for future research include further investigations into the influence of quality interactions in ECEC outdoor environments that will support all areas of children’s learning, development, health and wellbeing. It is important that quality interactions are established to achieve positive outcomes and therefore it is important to understand potential factors that influence the quality of educator and child interactions in all environments. This study provides recommendations that educators have the capacity improve the quality of interactions by considering modifiable practices and opportunities that are available. Providing an aspect of a free flowing routine each day where children can select to be indoors or outdoors, as well as increasing the amount of time spent outdoor has shown a significant influence on quality educator and child interactions in outdoor environments. Consequently, establishing quality interactions throughout the ECEC environment has the potential to provide the best possible environments for children's learning, development, health and wellbeing.

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Chapter 5: Environmental Influences on Children's Physical Activity in Early Childhood Education and Care

Based on the systematic review results presented in Chapter 2, this chapter examined children's physical activity and sedentary behaviour in ECEC, and the relationship with routines, time spent in outdoor environments and the size of the outdoor environment. Findings are discussed and implications for ECEC practice presented.

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Abstract

Children's physical activity and sedentary behaviour in ECEC settings is influenced by a number of factors. The purpose of this study was to examine three less-studied environmental factors on children's physical activity and sedentary behaviour.

A cross-sectional study (n=490, aged 2-5years, 11 ECEC) was completed. ECEC routine, size of the outdoor environment and time spent in the outdoor environment were calculated for each centre. Children's physical activity and sedentary behaviour was measured using accelerometers. Linear regression models examined the association between children's physical activity and sedentary behaviour and daily routine, time in outdoor environments and size of the outdoor environments.

Children in centres that offered free routines spent significantly less time in sedentary behaviour (SB) (28.27mins/hr vs 33.15mins/hr; p=0.001) and more time in total physical activity (TPA) (7.99mins/hr vs 6.57mins/hr; p=0.008) and moderate- to vigorous-intensity physical activity (MVPA) (9.49mins/hr vs 7.31 mins/hr; p=0.008) than centres with structured routines. Children in centres with an outdoor environment greater than 400m^2 spent significantly less time in sedentary behaviour (28.94 min/hr vs 32.42 mins/hr; p=0.012). Although not significant, children in centres that offered more than 4 hours outdoor time each day spent less time in SB (29.12mins/hr vs 32.65mins/hr) and more time in TPA (16.79mins/hr vs 14.39mins/hr) than those that offered less outdoor time.

Modifiable practices such as offering a free routine, increasing the time spent in outdoor environments and managing the available space effectively could potentially offer an easy and sustainable way for ECEC to promote physical activity and reduce sedentary behaviour.

5.1 Introduction

High levels of physical activity and low levels of sedentary behaviour are associated with many psychosocial, cognitive and physical health benefits for children under 5 years of age (Timmons et al., 2012; Poitras et al., 2017). It is critical that positive physical activity behaviours develop in early childhood as these behaviours track into childhood and beyond, providing long-term health benefits (Jones, Hinkley, Okely, & Salmon, 2013).

In developed countries, such as Australia, a large proportion of young children attend some type of ECEC centre for extended periods (OECD, 2014) making these important environments to support children's physical activity (Tandon, Saelens, & Christakis, 2015). Young children are surprisingly inactive in these settings with several studies showing low compliance with recommended levels of physical activity and sedentary behaviour (Ellis et al., 2017; Pate et al., 2015) according to the National Academy of Medicine Recommendations (Institute of Medicine, 2011).

There is evidence that environmental factors, such as equipment and resources are important correlates of physical activity and sedentary behaviour in ECEC centres (Tonge, Jones, & Okely, 2016). Centre policies and practices such as daily routines -whether they are structured or free flowing indoor/outdoor (Hesketh & Sluijs, 2016); the amount of time spent in indoor and outdoor environments (Bento & Dias, 2017); the affordances in the physical environment (Vanderloo, Tucker, Johnson, & Holmes, 2013); and the engagement of educators (Gagne & Harnois, 2013) may also be influential (Wolfenden et al., 2011), yet further investigation is required to determine their level of influence on children's physical activity and sedentary behaviour.

Factors associated with the outdoor environment may be important, as children are typically more active in these environments (Raustorp et al., 2012). The outdoor environment provides opportunities for gross motor activities that are key to developing confidence and conducive to physical activity participation (Timmons et al., 2012). Although indoor environments are also influential on children's physical activity, the affordances of the outdoor environment and the potential for higher levels of physical activity and reduced sedentary behaviour in these environments can be difficult to replicate indoors (Bento & Dias, 2017) due to factors such as available space and design of the environment (Dowda, Pate, Trost, Almeida, & Sirard, 2004).

The aim of this study was to measure an aspect of ECEC centres that has not been previously examined - the influence of the centre indoor/outdoor routine on children's physical activity and sedentary behaviour. The facilitation of indoor and outdoor environments and the most effective implementation of them to promote children's physical activity and reduce sedentary behaviour is not well known. Routines in ECEC may be free-flowing or structured. A free-flowing routine allows the children to move freely between the indoor and outdoor environment for the entire day, or an aspect of the day, compared to a structured routine where children are in either the indoor or outdoor environment, as determined by educators. Understanding the influence of the style of the ECEC routine is important for children's physical activity and sedentary behaviour. Further, it provides a potentially modifiable approach to promoting children's physical activity and sedentary behaviour in this setting.

Examining time spent outdoors, a modifiable factor for ECEC centres, and the size of the space and their relationship with children's physical activity and sedentary behaviour were secondary aims of the study. Additionally, the study aims to measure children's physical activity and sedentary behaviour and determine whether current recommendations for physical activity in ECEC are being achieved.

5.2 Methods

A convenience sample of 11 ECEC centres located within a 100km radius of the city of Wollongong, New South Wales, Australia were recruited for the study. Data were collected between June and December 2015. ECEC centres were eligible to participate if they enrolled children aged 2-5 years, and these children had access to outdoor play spaces separate from other play spaces for younger children in the centre. All children aged 2-5 years enrolled in the centre, and their educators were invited to participate. The number and sequence of days, as well as the time of attendance each day was not mandated for children (although a typical pattern of enrolment for children aged 2–5 years is 2 or 3 days per week, for 6–8 hours each day). All eligible educators and parents of eligible children were provided with Participant Information sheets and Consent forms. Ethical approval was obtained through the University of Wollongong Human Research Ethics Committee (HE14/330).

The study included a blend of centres in order to capture a variety of features such as the centre indoor/outdoor routine; size and features of the physical environment; the number of children enrolled; and the use of indoor and outdoor environments, including the time that children had access to these environments.

Data for each centre were collected over five consecutive days. Children wore an Actigraph GT3X+ (ActiGraph, Fort Walton Beach, FL) accelerometer for each day of attendance. The accelerometers were placed on a belt that was attached around the child's waist with the time they were put on and removed recorded. Accelerometers are widely used to objectively measure young children's physical activity and sedentary behaviour and have been found to be a valid and reliable measurement tool for this population (Cliff, Okely, Smith, & Kim, 2009; Pate, Almeida, McIver, Pfeiffer, & Dowda, 2006; Sirard, Trost, Pfeiffer, Dowda, & Pate, 2005).

Accelerometer data were collected in 15second epochs. This enabled the short bursts of activity characteristic of young children to be captured (Cliff et al., 2009; Nilsson, Ekelund, Yngve, & Sjöström, 2002; Reilly, 2008; Ward, Evenson, Vaughn, Rodgers, & Troiano, 2005). The time spent in SB, TPA (light and, moderate- to vigorous-intensity physical activity) and MVPA were calculated using age-specific cut points (SB <25 counts/15s; TPA ≥ 200 counts/15s; MVPA >420 counts/15s) (Cliff et al., 2009; Janssen et al.,2013; Pate et al., 2006; Sirard et al., 2005). TPA was used to describe the combination of these levels of physical activity, other than SB. Using ActiLife software [(ActiGraph, Pensacola, FL; version ActiLife (v6.12.1)], accelerometer data was cleaned using a 20min non-wear time, a minimum wear time of 180mins/day, and a minimum of one day (Cliff et al., 2009).

The type of routine was collated from centre documentation, such as the weekly program, as well as researcher observations during the week of data collection. The routine type was either structured (distinct periods of inside or outside time), or free (an aspect of a free-flowing routine where the children could independently select to be indoors or outdoors). For example, a routine of free-indoor-outdoor meant that at the start of the day the children were able to access either indoor or outdoor play spaces, followed by all children playing indoors, and then all children playing outdoors. Given that such centres have aspects of a free routine these centres were classified as 'free routine' centres. Alternatively, centres that had a routine such as all children playing outdoors and then all children playing indoors were classified as 'structured' routine centres. Time spent outdoors was manually recorded by the researcher each day (i.e., when children were outdoors, the time was noted and when children returned inside, the time was also noted). The average minutes per day spent outdoors was then calculated for each centre. The size of the yard was measured using a steel tape measure and was recorded in m^2.

Data were analysed using STATA (Version 13 STATACorp LLC, College Station, Tx). Means and confidence intervals were calculated to describe the sample and show group differences. A multivariate linear regression analysis examined associations of the attributes of ECEC centres (routine, time outdoors, and size of outdoor environment) with the outcome variables, adjusting for the effects of centre clustering and gender. All the variables were categorical – routine (free or structured); time outdoors (<4 hours or ≥4hours); and size of the outdoor environment ($<400m^2$ or $\geq 400m^2$). Similar to a previous study (Sugiyama, Okely, Masters, & Moore, 2012) the size of the outdoor environment was dichotomized using a median split into smaller ($<400m^2$) and larger ($\geq 400m^2$). An alpha level of 0.05 was used to determine statistical significance. Children's compliance with meeting physical activity recommendations while at the centre was measured against the National Academy of Medicine Recommendations. This recommends that children accumulate an average of 15 minutes or more of TPA per hour (Institute of Medicine, 2011).

5.3 Results

Physical activity data were collected from 490 children across 11 centres, however only in eight centres were physical activity data collected all day. As such, only data from eight centres (316 children) were included in the analyses for this study. Table 5.1 shows the sample characteristics. Four centres were classified as having a free flowing routine, five centres spent four or more hours outside each day, and four centres had yard sizes that were greater than $400m^2$. Girls spent significantly more time in SB compared to boys (31.39 min/hr vs 29.01 min/hr, p=0.006), and boys were significantly more active than girls (TPA 17.22 mins/hr vs 14.89 min/hr, p=0.011; and MVPA 9.46 min/hr vs 7.79 mins/hr, p=0.002) (Table 5.2). A higher proportion of boys met the National Academy of Medicine Recommendations (62.03% vs 48.73% respectively) (Table 5.3) compared to girls.

Table 5.1: Characteristics of children and ECEC centres

Centre	Children consented (% boys)	Avg age	Routine	Time outdoors (hours)	Size of outdoor environment (m^2)
1	52 (50)	3y 11m	Free all day	5.5	1200
2	31 (65)	3y 10m	Free-Indoor-Outdoor	4	280
3	75 (47)	4yr 1m	Free all day	5.5	680
4	37 (49)	4yr 0m	Outdoor-Indoor-Outdoor	3.5	1050
5	28 (50)	4yr 0m	Outdoor-Indoor-Outdoor	4	320
6	33 (45)	4yr 2m	Free-Indoor	4	390
7	22 (41)	4yr 2m	Outdoor-Indoor-Outdoor	2.5	126
8	38 (55)	3yr 4m	Outdoor-Indoor-Outdoor	3	748

Note. Explanation of Routines: Free all day: children have access to indoor and outdoor environments all day; Free-Indoor-Outdoor: children have access to indoor and outdoor environments, followed by only indoors, and then only outdoors; Outdoor-Indoor-Outdoor: children are only outdoors, followed by only indoors, and then only outdoors; Free-Indoor: children have access to indoor and outdoor environments, followed by only indoors.

Girls spent significantly more time in SB compared to boys (31.39 min/hr vs 29.01 min/hr, p=0.006), and boys spent significantly more time in TPA and MVPA (17.22 min/hr vs 14.89 min/hr, p=0.011; 9.46 min/hr vs 7.79 min/hr, p=0.002, respectively) compared to girls (Table 5.2). Approximately 62% of boys, compared to 48% of girls met the National Academy of Medicine recommendations for physical activity while in ECEC (Table 5.3).

Children from ECEC centres that facilitated a free routine spent significantly less time in SB compared with children from centres which facilitated a structured routine (28.27 min/hr vs

33.15 min/hr, p=0.001). Children enrolled in free routine centres spent significantly more time in TPA and MVPA compared with children from structured routine centres (7.99min/hr vs 6.57min/hr, p=0.008; 9.49min/hr vs 7.31min/hr, p=0.008 respectively) (Table 5.2). More children enrolled in centres with free routines met the National Academy of Medicine recommendation compared with children from centres with a structured routine (66.49% vs 38.4%) (Table 5.3).

Table 5.2: Children's physical activity. Means, CI, adjusted difference, and P values.

		Mean mins/hr	Adjusted difference, 95% CI	P value
Sedentary Behaviour				
Sex	Boys	29.01 (27.83, 30.19)	2.377457	**0.006**
	Girls	31.39 (30.28, 32.50)	(0.93, 3.82)	
Routine	Free	28.27 (27.27, 29.27)	4.221823	**0.001**
	Structured	33.15 (31.96, 34.34)	(2.48, 5.96)	
Time outdoors	<4hrs	32.65 (31.16, 34.14)	-0.1467388	0.757
	≥4hrs	29.12 (28.17, 30.06)	(-1.23, 0.93)	
Size of outdoor environment	<400m²	32.42 (31.0, 33.86)	-0.0052063	**0.012**
	≥400m²	28.94 (28.0, 29.9)	(-0.01, -0.00)	
TPA				
Sex	Boys	17.22 (16.30, 18.13)	-0.6608422	**0.011**
	Girls	14.89 (14.08, 15.71)	(-1.12, -0.20)	
Routine	Free	7.99 (7.70, 8.29)	-1.167068	**0.008**
	Structured	6.57 (6.23, 6.91)	(-1.92, -0.41)	
Time outdoors	<4hrs	14.39 (13.33, 15.44)	0.0881758	0.684
	≥4hrs	16.79 (16.04, 17.54)	(-0.40, 0.58)	
Size of outdoor environment	<400m²	14.37 (13.35, 15.4)	0.001404	0.072
	≥400m²	17 (16.25, 17.76)	(-0.00, 0.00)	
MVPA				
Sex	Boys	9.46 (8.80, 10.12)	-1.662066	**0.002**
	Girls	7.79 (7.22, 8.36)	(-2.51, -0.81)	
Routine	Free	9.49 (8.89, 10.08)	-2.045559	**0.008**
	Structured	7.31 (6.72, 7.90)	(-3.36, -0.73)	
Time outdoors	<4hrs	7.64 (6.92, 8.36)	-0.396058	0.914
	≥4hrs	9.06 (8.51, 9.61)	(-0.87, 0.79)	
Size of outdoor environment	<400m²	7.61 (6.9, 8.33)	0.0025001	0.057
	≥400m²	9.19 (8.64, 9.75)	(-0.00, 0.01)	

Note. P<0.05; CI – confidence interval; bold – significant differences; TPA – total physical activity; MVPA – moderate- to vigorous-intensity physical activity

Table 5.3: Proportion of children meeting National Academy of Medicine Recommendation (≥15mins TPA/hr) (IOM, 2011)

Sex		**Routine**		**Time outdoors**		**Size of outdoor environment**	
Boys	**Girls**	**Free**	**Structured**	**<4hrs outdoors**	**≥4hrs outdoors**	**<400m^2**	**≥400m^2**
62.03%	48.73%	66.49%	38.4%	45.36%	59.82%	41.23%	63.37%

Note. Explanation of Routines: Free routine: children are able to independently choose whether they want to be indoors or outdoors; Structured routine: children are either all indoors or all outdoors

Children in ECEC centres with smaller outdoor environments (<400m^2) spent significantly more time in SB (32.42min/hr vs 28.94min/hr, p=0.012) compared to children in centres with larger outdoor environments (≥400m^2) (Table 5.2). In centres that had an outdoor environment that was more than ≥400m^2, the proportion of children meeting physical activity recommendations was over 22 percentage points greater (41.23% vs 63.37%) than when the outdoor environment was <400m^2 (Table 5.3).

No significant relationships between the time spent in ECEC centre outdoor environment and physical activity were reported. However, data showed that more time in outdoor environments (i.e., ≥4hrs) resulted in children spending less time in SB and more time in all intensities of physical activity (Table 5.2). Approximately 60% of children who spent ≥4 hours outdoors met the National Academy of Medicine recommendations, while only 45% of children who spent <4 hours outdoors met this recommendation (Table 5.3).

5.4 Discussion

This study found significant relationships between children's physical activity and sedentary behaviour and sex, and two environmental factors - routine and size of the outdoor environment. Boys were more active and more likely to meet physical activity recommendations compared with girls, all children were less sedentary and more active in centres that offered a free routine, and children were less sedentary in ECEC that had larger outdoor environments.

There was a consistent relationship between sedentary behaviour, all levels of physical activity and sex. Boys were less sedentary and had higher levels of TPA and MVPA compared to girls. This is consistent with many other studies that also report a difference between the sedentary behaviour and physical activity of girls and boys (Copeland, Khoury, & Kalkwarf, 2016; Henderson, Grode, O'Connell, & Schwartz, 2015; Soini et al., 2016). Studies have shown that girls prefer light intensity activities, such as social play with peers or dolls, or with art materials (Barbu, Cabanes, & Maner-Idrissi, 2011) and so creating physical and social environments – indoors and outdoors that reduce sedentary behaviour and promote physical activity for girls is therefore important. This may include educators becoming actively involved with girls, as it is known that often girls will remain with educators, and are influenced by their behaviours (Wang et al., 2016). Consideration of the experiences that are offered, such as dramatic play, or music and movement in both indoor and outdoor environments may also be strategies that will support higher levels of activity from girls. It has been reported that the amount of time girls spent indoors before going outdoors was inversely associated with their physical activity (Hinkley, Salmon, Crawford, Okely, & Hesketh, 2016), and so adjusting the routine and scheduling of time that children have access to the outdoor environment is a strategy that may have a positive influence on the activity patterns for girls. Tandon et al., (2015) suggest that more active play opportunities, and scheduling fewer sedentary expectations, such as mandated nap times, or even sedentary group times may be critical.

There are few known studies that have examined the association between type of routine (i.e., free vs structured) and children's physical activity in ECEC (Hesketh & Sluijs, 2016; Lecathelinais et al., 2018). Outcomes vary between these studies - one has shown no significant association between children's physical activity and free routine (Lecathelinais et al., 2018), and the other (Hesketh & Sluijs, 2016) showed an association between children having unrestricted access to outdoor areas and improvements in children's physical activity. The findings of the current study align with other studies that have shown scheduling regular periods of outdoor free-play has a positive influence on children's physical activity (Razak et al., 2018; Tucker et al., 2017). A free routine can replicate scheduling of play periods for children as the children freely move between indoor and outdoor environments.

Our findings may be explained by free routines offering choice and independence, elements that contribute to sustained engagement and uninterrupted time that afford quality experiences (Siraj-Blatchford, 2009). Quality active opportunities influence children's physical activity (Bower et al., 2008; Gubbels, Kremers, & Kann, 2011) and so offering a free routine to increase the quality of experiences is an important consideration. Furthermore, as routines are a modifiable aspect of centres, with small changes there is potential for optimal impact. Facilitating an intervention that involves a less structured day and provision of a free routine may be a strategy for educators to increase children's physical activity and reduce children's sedentary behaviour, and could be piloted relatively easily.

Free routines typically provide children with more opportunities to play in outdoor environments. In this study, three centres had less than 4 hours outdoors, and a common feature of these centres was a structured routine in which only one period of outdoor time was scheduled during the day (i.e., the routine was indoor-outdoor-indoor). In all but one of the remaining centres (four or more hours outdoors), there was a free aspect to the day.

A significant relationship was found between the size of the outdoor environment and children's sedentary behaviour. This is congruent to other studies reporting that playground size is an important characteristic of children's physical activity in ECEC (Boldemann, Blennow, & Dal, 2006; Cardon, Van Cauwenberghe, Labarque, Haerens, & De Bourdeaudhuij, 2008). Strategies that may counteract the effect of smaller outdoor environments on children's sedentary behaviour and physical activity include increasing the amount of space afforded to each child. For example, scheduling play periods so that fewer children are in the environment at one time (Dowda, et al., 2009), offering a free routine which has the potential to distribute children between the indoor and outdoor environment, or accessing public spaces if available.

Although the relationships between sedentary behaviour and physical activity and time spent in outdoor environments were non-significant, there was a positive trend for all intensities of physical activity. This is consistent with other studies (Bower et al., 2008; Tandon et al., 2015). An explanation for this may be that outdoor environments are important for children's physical activity (Raustorp et al., 2012), so therefore it is feasible to suggest that more time in these environments will promote an increase in physical activity across the day. Furthermore, the opportunity to have more time in outdoor environments may also result in children engaging in sustained experiences, such as a game of soccer knowing that the affordance of time will allow for uninterrupted play. Contrary to these findings, other studies (Dowda, et al., 2009; Olesen, 2013) have reported no relationship between time in outdoor environments and children's physical activity. These differences between studies may be due to the scheduling of time in outdoor environments. While the emphasis should be on adequate amounts of time in outdoor environments, the scheduling of time (e.g., regular periods rather than large blocks of time) in the outdoor environment may also be significant (Razak et al., 2018).

According to current National Academy of Medicine recommendations (IOM, 2011), children should spend at least 60-90 minutes each day in outdoor environments (Copeland, 2012), however, there are barriers to accessing these environments and the time spent in them in ECEC settings. These barriers include the weather (Edwards et al., 2015; Olesen, 2013); educator perceptions of the environment such as supervision being paramount (Coleman, 2013; Temple & O'Connor, 2005); and/or the element of risk due to the unpredictable nature of the outdoor environment (Little & Wyver, 2008). To ensure that children meet the current recommendations for physical activity and sedentary behaviour while in ECEC, educators should reflect on current practices and promote quality time in outdoor environments. Outdoor environments have the potential to be a valuable space for learning, just as much as indoor environments are, and so intentionality is crucial. As time spent in an environment is a modifiable aspect of centre practice that does not require additional skills, training or expensive resources to implement (Pagnini, 2006), promoting children's physical activity through increasing the time spent outdoors is highly feasible.

The present study found that just over half of the children met the National Academy of Medicine recommendations for physical activity while at ECEC (15mins of TPA/hr). This finding is similar to other studies in the US (Brown et al., 2009), UK (Reilly et al., 2006) and Belgium (Cardon & Bourdeaudhuij, 2008). The highest proportion of children meeting the recommendations were in centres that offered a free routine, compared with centres that offered a structured routine. The reasons for this may be that outdoor play opportunities are greater in centres that offer a free routine, and as a result children's physical activity increases. Consistent with other studies (Nicaise, Kahan, & Sallis, 2011; Olesen, 2013; Pate, McIver, Dowda, Brown, & Addy, 2008; Stephens et al., 2014), the proportion of boys meeting the National Academy of Medicine recommendations was greater than girls. This may be due to girls engaging in more sedentary contexts and experiences, such manipulative, dramatic, and fine motor play compared with boys (Miller, 2008). Free routines may result in girls engaging in indoor environments more frequently than outdoor environments.

There were several limitations of the study. The inclusion of only eight ECEC services limited variability in the size of the outdoor environment, and may have impacted the results. The small sample size may mean that the results may not be able to be generalised to the wider ECEC sector. The amount of time that physical activity data were collected varied between ECEC centres as did the duration of each child's day, particularly as ECEC centre types and hours of operation varied. To overcome potential limitations due to this, researchers collected data the entire time that children were in the centre. Additionally, children's physical activity and sedentary behaviour were calculated as a proportion of time per hour. An important consideration for future studies will be an analysis of the influencing factors of educator behaviour, such as the environmental features of ECEC.

5.5 Conclusion

Children's physical activity and sedentary behaviour in ECEC has the potential to have a positive influence on daily levels of activity. Developing effective practices and policies within these settings are crucial. This study illustrates the positive influence of modifiable factors in ECEC centres – routine and time spent in outdoor environments on children's physical activity and sedentary behaviour. These findings are significant, as physical activity interventions are costly, time consuming and at times interruptive, and policies that support children's physical activity and sedentary behaviour in these settings are limited. Modifying environmental factors such as routine and the amount of time spent in outdoor environments may be a preferable choice.

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Chapter 6: The Relationship between Educators' and Children's Physical Activity and Sedentary Behaviour in Early Childhood Education and Care

Based on the systematic review results presented in Chapter 2, this chapter examined the relationship between educators' and children's physical activity and sedentary behaviour in ECEC. Findings are discussed and implications for ECEC practice presented.

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Abstract

Early childhood education and care (ECEC) has a significant role to play in the promotion of physical activity and reduction of sedentary behaviour in young children. In ECEC, educators' physical activity and sedentary behaviour may be an important factor influencing children's physical activity and sedentary behaviour. However limited evidence exists for this relationship. The aim of this study was to examine the relationship between educators' and children's physical activity and sedentary behaviour within ECEC settings.

The cross-sectional study included 11 ECEC centres from NSW, Australia. Objectively measured physical activity and sedentary behaviour were collected from educators and children using Actigraph accelerometers over five consecutive days. Data were analysed using STATA 13c. Linear regression models were used to examine the relationship between educators' and children's physical activity and sedentary behaviour, adjusted for centre clustering.

Data were collected from 110 educators and 490 children. Educators spent 61% of their work day in sedentary behaviour and only 4% in moderate- to vigorous-intensity physical activity. A significant association was reported between educators' sedentary behaviour and children's sedentary behaviour ($\beta=0.66$; 95% Confidence Interval = 0.01, 1.31; $p=0.047$). An explanation for a non-significant relationship between educators' and children's physical activity may be the perception from educators that their role is primarily as supervisors in the outdoor environment.

The positive relationship identified between educators' and children's sedentary behaviour in this study highlights a novel area to target in future interventions. Improving physical activity of educators will likely improve children's physical activity and thus health and wellbeing outcomes.

6.1 Introduction

Optimal levels of physical activity and sedentary behaviour from a young age are critical for short- and long-term health and well-being (inclusive of psychosocial, cognitive and physical health) (Carson, Barnes, LeBlanc, Moreau, & Tremblay, 2017; Jones, Hinkley, Okely, & Salmon, 2013). Early childhood education and care (ECEC) environments and educators have a fundamental role to play in physical activity and sedentary behaviours for young children. This is particularly pertinent given the steady rise in ECEC attendance over the past decade (OECD, 2014) and well-established benefits of quality educator-child relationships (Melhuish et al., 2015; Wang, Hatzigianni, Shahaeian, Murray, & Harrison, 2016). Despite this, children are surprisingly inactive in ECEC settings. A number of recent studies report that while in ECEC, children spend more than 50% of their time being sedentary (Ellis et al., 2017; Pate et al., 2015; Tonge, Jones, & Okely et al., 2019, under review). Furthermore, while in ECEC less than half of children meet the National Academy of Medicine (Institute of Medicine, 2011) recommended levels of physical activity (15mins physical activity/hour) (Hinkley, Salmon, Crawford, Okely, & Hesketh, 2016; O'Dwyer et al., 2014; O'Neill, Pfeiffer, Dowda, & Pate, 2016; Pate et al., 2015) nor are most children meeting recommendations for sedentary behaviour (sitting or standing still should be limited to 30 minutes at one time) (Ellis et al., 2017).

Several physical, environmental and social factors are known to influence children's physical activity and sedentary behaviour in ECEC environments (Bower et al., 2008; Tonge, Jones, & Okely, 2016). A systematic review identified that educator behaviour, size and presence of outdoor environments, as well as natural features are associated with children's physical activity (Tonge et al., 2016 and Chapter 2). Active opportunities are associated with promoting children's physical activity and reducing sedentary behaviour (Barbosa, Coledam, Stabelini Neto, Elias, & Oliveira, 2016; Bower et al., 2008; Cardon & Bourdeaudhuij, 2008; Copeland, Khoury, & Kalkwarf, 2016; Henderson, Grode, O'Connell, & Schwartz, 2015; Olesen, Kristensen, Korsholm, Boye Koch, & Froberg, 2015; Sugiyama, Okely, Masters, & Moore, 2012), and recently, associations have been identified between ECEC daily routines and children's physical activity (Tonge et al., 2019, under review). The study by Tonge et al. reported that children engage in less sedentary behaviour, and more light intensity physical activity, and more moderate- to vigorous- physical activity (MVPA) when a free flowing routine is offered (i.e., when children have the choice of moving between the inside and outside environment).

Given the profound influence of educators on children's behaviours (Sabol & Pianta, 2012), it is reasonable to suggest that educators' physical activity and sedentary behaviours may influence children's physical activity and sedentary behaviours. To date, only one study has reported on educators' physical activity levels in ECEC and their relationship with children's physical activity (Fossdal, Kippe, Handegard, & Lagestad, 2018), although a few studies have examined the relationship between educator practices and children's physical activity (Ward, Belanger, Donovan, & Carrier, 2015; Ward et al., 2017). No known studies have reported on the relationship between educator's sedentary behaviour and children's sedentary behaviour. Gubbels, Kremers, & Kann (2011) investigated the association between ECEC and the physical activity of 2-3 year olds (n=175). The study found that prompts by educators (and peers) had a significant positive relationship with children's physical activity intensity. More recently, a systematic review examined the relationship between educators' practices and children's physical activity and eating behaviours (Ward, et al., 2015). From 15 studies that met criteria for the review, 10 studies measured children's physical activity levels, and although it was reported that educators may have a positive role in promoting children's healthy behaviours, specific aspects of educator behaviours that promote children's physical activity are less known (Ward et al., 2015). The only known study (Fossdal et al., 2018) examined the relationship between objectively measured educator physical activity, educator attitudes and initiative (measured by questionnaire), and children's physical activity. Accelerometers were used to measure children's (n=289) and educators' (n=72) physical activity in 13 ECEC, over seven consecutive days. The study found a significant association between educator's average activity levels and children's corresponding activity levels while in ECEC. The primary aim of this study was to examine the relationship between objectively measured educator physical activity and sedentary behaviour and children's physical activity and sedentary behaviour in a larger sample of children and educators.

6.2 Methods

The study involved a convenience sample of 11 ECEC centres located within a 100 km radius of Wollongong, New South Wales, Australia. Data were collected between June and December 2015. All children aged 2-5 years enrolled in the centre and their educators were invited to participate in the study. As the days and hours of attendance for children, and days and hours of work for educators are not mandated, children and educators attending the centre for any length of time on any day were eligible to participate. Information about the study was presented to educators and families at staff and parent meetings and all eligible educators and children were provided with participant information sheets and consent forms. Ethical approval was obtained through the University of Wollongong Human Research Ethics Committee (HE14/330).

Data for each centre were collected over five consecutive days. In an event which resulted in the typical day being altered by poor weather, data were collected on the next available day. Children and educators wore an Actigraph GT3X+ (ActiGraph, Fort Walton Beach, FL) accelerometer for each day of attendance, for the duration of their time at the centre. The accelerometers were placed on a belt that was attached around the children's and educators' waist (placed on the right hip) by the researcher, with the time they were put on and removed recorded. Accelerometers are widely used to objectively measure young children's physical activity and sedentary behaviour and have been found to be a valid and reliable measurement tool for this population (Cliff, Reilly, & Okely, 2009). Accelerometers are also used widely to measure adult physical activity and sedentary behaviour (Troiano et al., 2008).

Accelerometer data were collected in 15 second epochs for children to account for the short bursts of activity characteristic of young children (Cliff et al., 2009). The time spent in sedentary behaviour (SB), light(low) physical activity (LLPA), light(high) physical activity (HLPA), moderate- to vigorous-intensity physical activity (MVPA) and total physical activity (HLPA and MVPA; TPA) and were calculated using age-specific cut points for children [SB <25 counts/15s; LPA(low) 25-200 counts/15s; LPA(high) 201-420 counts/15s; MVPA >420 counts/15s; TPA >201 counts/15s] (Cliff et al., 2009; Pate, Almeida, McIver, Pfeiffer, & Dowda, 2006; Sirard, Trost, Pfeiffer, Dowda, & Pate, 2005). Using ActiLife software [(ActiGraph, Pensacola, FL; version ActiLife (v6.12.1)], accelerometer data was cleaned using a 20min non-wear time for children (Cliff et al., 2009). A minimum wear time of 180mins/day, and a minimum of one days wear was used for analysis (Stanley et al., 2016). During wear time no children napped, and so did not need to be considered in the analyses.

Accelerometer data for educators were analysed using widely used cut points for adults (SB<25 counts/15s; LPA 25-504 counts/15s; MVPA >504 counts /15s; TPA ≥ 25 counts/15s;) (Troiano et al., 2008). Using ActiLife software [(ActiGraph, Pensacola, FL; version ActiLife (v6.12.1)], accelerometer data was cleaned using a 60min non-wear time (Troiano et al., 2008). For analysis, one day of wear time was used (at least 180min/day) and LPA remained as a whole unit [i.e. no division between LPA(low) and LPA(high)].

Demographic data pertaining to each centre were noted and used to describe the sample. These data included age and sex of educators, number of days each educators worked, educator qualifications, number of children enrolled at the centre, daily routines, time spent outside and size of the outdoor environment.

Data were analysed using STATA 13c. A linear regression analysis examined the relationship between children and educators, adjusting for the effects of centre clustering. Average physical activity levels were calculated for educators and children. An alpha level of 0.05 was used to determine statistical significance.

6.3 Results

Physical activity data were collected from 110 educators (97% female, average age 36 years) and 490 children from 11 ECEC centres. Centres spent an average of 3.5 hours outdoors each day (range 2.0 - 5.5 hours), with six centres spending less than four hours outdoors each day. The average size of the outdoor environment was 626m^2 (range 126m^2 – 1080m^2), and four centres had an outside environment less than 400m^2. On average, the educators worked 3.5 days per week, and reported a range of qualifications (20% degree qualified).

Time spent in sedentary behaviour and different intensities of physical activity for educators and children in each centre are described in Table 6.1. Educators spent nearly two-thirds of their day in SB (61%), 39% in TPA and 4% in MVPA. In comparison, children spent just under half of their day in SB (48%), 36% in LPA and 16% of their day in MVPA. In total, children spent just under one third of their day at ECEC in TPA (29%) of their day at ECEC. Results for LPA were similar for educators and children (21.1mins/hr and 21.8mins/hr, respectively), however MVPA had a notable difference between educators and children (2.6mins/hr vs 9.5mins/hr, respectively). Educator MVPA ranged from 1.2mins/hr to 4.4mins/hr and children MVPA ranged from 5.8mins/hr to 15.1mins/hr.

Table 6.1: Average educators' and children's physical activity and sedentary behaviour in ECEC

	SB (mins/hr)	**LPA Low (mins/hr)**	**LPA High (mins/hr)**	**LPA (mins/hr)**	**MVPA (mins/hr)**	**TPA (mins/hr)*** **
Children (n=490)	28.7	13.9	7.8	n/a	9.5	17.4
Educators (n=110)	36.4	n/a	n/a	21.1	2.6	23.7

Note. mins/hr – minutes per hour. SB–sedentary behaviour, LPA–light-intensity physical activity, MVPA–moderate- to vigorous-intensity physical activity, TPA–total physical activity, * Children's cut points (Pate et al., 2006), ** Adult cut points (Troiano et al., 2008) ***Educator TPA includes LPA and MVPA; children's TPA includes LPA(high) and MVPA

Table 6.2 shows a significant association between educator SB and children SB (p=0.047). Although the associations between educator and children LPA (p=0.080), MVPA (p=0.120) and TPA (p=0.146) showed positive trends, none were statistically significant (Table 6.2).

Table 6.2: Associations between educators' and children's sedentary behaviour and physical activity

	Beta coefficient (95% CI)	**P value**
SB	0.66 (0.01, 1.31)	0.047
LPA	0.22 (-0.03, 0.47)	0.080
MVPA	1.26 (-0.39, 2.91)	0.120
TPA	0.39 (-0.16, 0.93)	0.146

Note. SB – sedentary behaviour, LPA – light-intensity physical activity (High light for children), MVPA – moderate- to vigorous-intensity physical activity, TPA – total physical activity, CI – 95% confidence interval, *p*=0.05

6.4 Discussion

The main aim of this study was to examine the relationship between educator's physical activity and sedentary behaviour and children's physical activity and sedentary behaviour in ECEC settings. This is the first paper to report on a positive relationship between educators' sedentary behaviour and children's sedentary behaviour (Table 6.2). Although these are initial findings from one study, they may influence the focus of future interventions. It is reasonable to suggest targeting educators' sedentary behaviour in future ECEC-based interventions might be beneficial. ECEC-based interventions specifically targeting children's sedentary behaviour have been reported (De Craemer et al., 2016; Ellis, Cliff , Howard, & Okely, 2019).

For example, a recent study investigated the potential efficacy of a standing preschool intervention on sitting, standing and stepping, using a number of unique and innovative methods to improve the sedentary environment of ECEC centres (Ellis et al., 2019). In this study vertical LEGO boards and standing tables were introduced into centres. Additionally, a number of extra easels were introduced to the ECEC environment, which encouraged children to paint and draw in a standing position rather than in a sitting position. Rubbish bins were placed away from tables (specifically at meal times) to encourage children to get up from their seats to dispose of their rubbish. The intervention encouraged children to spend the majority of their day standing or stepping rather than sitting. The intervention was shown to be highly feasible and acceptable (Ellis et al., 2019). To date there have been no studies that have tested the efficacy of modifying educators' sedentary behaviour levels. Given that sedentary behaviour levels of educators are possibly influenced significantly by their own beliefs and habits and ECEC-based philosophies, future interventions would need to consider these aspects in intervention design and implementation. Future interventions could consider professional development focusing on perceptions and role of educators within the ECEC outdoor environment, as well the importance of educator engagement and interaction. The introduction of 'Bush Preschool' or 'Beach Friends' approaches where the children's and educators' experiences are beyond the centre boundaries, and the key underlying feature of are that children and educators spend long and regular periods of time in unstructured play in natural forest or beach environments (Elliott &

Chancellor, 2014), may also decrease the sedentary behaviour of educators. Such programs encourage educators and children to explore their natural environment and consequently involve additional physical activity and reduced options for sedentary activities. External motivators such as the provision of Fitbits™ or pedometers or centre-wide initiatives may also be avenues to explore, although the cost associated with these incentives would need to be considered. It is reasonable to suggest that if educators are less sedentary and more active, their interactions with children, especially in the outdoor environment may be increased. Importantly, this has the potential to have a positive influence on children's outcomes.

In this study, educators spent the majority of their day in sedentary behaviour. Low levels of LPA and MVPA were reported (Table 6.1). Only one other known study (Fossdal et al., 2018) has objectively measured educator's physical activity. In the Fossdal et al. (2018) study, comprising 64 educators, educators spent 2.3 min/hr in MVPA while in ECEC which was consistent with the results of this study (2.6mins/hr, Table 6.1). Sedentary behaviour, LPA and TPA were not reported and thus cannot be compared. A number of factors may explain the sedentary behaviour and physical activity levels reported (Table 6.1). The perceived role of educators in the outdoor environment may be a factor. The outdoor environment is an important environment for children's health and development (Bento & Dias, 2017) and where most physical activity occurs in ECEC settings (Tandon, Saelens, Zhou, & Christakis, 2018). Despite both the indoor and outdoor environments being critical in children education and care (DEEWR, 2009), educator's perceived role often differs from the indoor environment to the outdoor environment. Studies have shown that educators subconsciously transition from an 'educator' to a 'supervisor' as they move from the indoor environment to the outdoor environment (Leggett & Ford, 2013; Leggett & Newman, 2017; Little, Wyver, & Gibson, 2011).

Educators suggest that their role in the outdoor environment is primarily to ensure the safety of children as they participate in free play activities (Bento & Dias, 2017; Munroe & McLellan-Mansell, 2013). Such perceptions often result in educators standing close to portable and fixed equipment or scanning the outdoor space to ensure safety of children and eliminate any risk adverse situations. This supervisory role in the outdoor environment might result in educators being more sedentary, and less time spent physical activity. Consequently, this may provide a reasonable explanation for the lack of statistically significant relationships between educators' and children's physical activity. If the environment where most physical activity can occur is the outdoor environment, and if educators' perceive their role in outdoor environments as a 'supervisor', rather than an active and important participant in children's experiences, quality interactions between educators and children may be limited, and educators less inclined to engage in physical activity with the children.

Leggett and Newman (2017) suggest that educators often believe that the outdoor environment is a time of freedom for the children, where play should be self-directed and not interrupted or guided by educators. Such perceptions result in educators feeling that role modelling and intentional teaching/intentional interactions is not required in the outdoor environment. It is well established that children in ECEC environments mimic the actions of educators and often congregate close to educators (Larson, Ward, Neelon, & Story, 2011). Thus, if educators spend most of their time outside minimising risk and supervising, rather than being engaged in intentional teaching opportunities, it makes sense that their and the children's physical activity levels are less than desired. Redefining the key role of educators in the ECEC outdoor environment, where most physical activity occurs, maybe a first step in increasing the physical activity levels of educators and inturn improving the levels of physical activity of children in ECEC environments (Larson et al., 2011).

Educators' confidence and competence relating to physical activity with the children, as well as their motivation levels may also be contributing factors to the high sedentary behaviour levels and low physical activity levels reported. Copeland, Kendeigh, Saelens, Kalkwarf, and Sherman (2012) suggest that educators often feel self-conscious about their own physical activity abilities, thus tend to not be actively involved in such learning experiences with the children. Other studies have reported low motivation levels of educators in relation to physical activity learning experiences (Gagne & Harnois, 2013) or educators choosing to use the time in the outside environment to simply socialise with other educators and take a break (Copeland et al., 2012). Perhaps up-skilling educators on the utmost importance of meaningful and engaging physical activity learning experiences maybe a first step in modifying feelings and motivation levels which may in-turn result in higher levels of physical activity and lower levels of sedentary behaviour in ECEC environments.

The non-significant relationship between educators' TPA and MVPA and children's TPA and MVPA needs further investigation. Given that sedentary behaviour is simply not the opposite of physical activity (van der Ploeg & Hillsdon, 2017), it cannot be assumed that a relationship between sedentary behaviour would result in a relationship between TPA and MVPA. Physical inactivity is perhaps closer to the opposite of physical activity, thus investigating levels of LPA maybe helpful. In this study, the relationship between educator's LPA and children's LPA showed a positive trend, thus perhaps future studies should also focus on the important of LPA for both educators and children. The inclusion of active energy breaks (Stanley et al., 2016), structured physical activity sessions (Stanley et al., 2016), or integrating physical activity into indoor intentional learning experiences (Mavilidi, Okely, Chandler, & Paas, 2016, 2017; Mavilidi, Okely, Chandler, Cliff , & Paas, 2015; Trost, Fees, & Dzewaltowski, 2008) might be viable options to investigate in future interventions.

This is the first known study to investigate the relationship between educators' and children's physical activity and sedentary behaviour whilst in ECEC environments. The objective measurement of physical activity and sedentary behaviour of both educators and children was a strength of this study. Physical activity and sedentary behaviour data were collected from a large number of educators (n=110) and children (n=490) and ECEC were diverse in nature. The sample of educators was nearly double that of the only other study that has reported educator physical activity data (Fossdal et al., 2018). However, the following limitations should also be acknowledged. The amount of time that physical activity and sedentary behaviour data were collected varied between ECEC centres. The strength of the relationships between educators' and children's sedentary behaviour and physical activity may have been diluted given that the educator data were based on a centre average. Direct comparison was not possible given the ratio of educators and children. Similar analyses (i.e., using the average per centre) were conducted by Fossdal et al. (2018), the only other study that has reported educator physical activity levels. Finally, as the study was a cross sectional design, no specific conclusions on causality can be drawn.

6.5 Conclusion

The ECEC environment has a significant role to play in the promotion of optimal levels of physical activity and sedentary behaviour in young children. Given the profound influence of educators on children's behaviours, a critical social factor influencing children's physical activity and sedentary behaviour may be the physical activity and sedentary behaviours of educators. Addressing some of the perceived barriers that educators face in the outdoor ECEC environment, where physical activity is most pronounced, may be an important first step increasing the educator's physical activity levels and reducing sedentary behaviour and those of the children in the care. The positive relationship between educators' sedentary behaviour and children's sedentary behaviour may provide a focus for future programs and interventions. To date, no studies have directly targeted educators' sedentary behaviour levels. Improving educator's and children's physical activity and reducing educator's and children's sedentary behaviour levels needs to be a priority. Optimising physical activity levels and time spent sedentary of children and educators will have significant immediate and long-term health and educational benefits.

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Chapter 7: General Discussion

7.1 Overview

The aim of this research was to investigate the relationship between ECEC-related factors and children's physical activity and sedentary behaviours in ECEC settings. The ECEC-related factors included routines, time spent outdoors, size of yard, quality of educators' and children's interactions, and educators' physical activity and sedentary behaviour. Chapter 2 detailed the relationship between children's physical activity and sedentary behaviour, health and well-being. Tracking of physical activity and sedentary behaviour were reviewed, as well as national and international physical activity and sedentary behaviour guidelines. Chapter 2 also examined the correlates of children's physical activity and sedentary behaviour in ECEC, highlighting key gaps in the literature. Chapter 3 outlined the methods for the study. Chapter 4 examined the relationship between environmental factors, including ECEC routines and time spent outdoors, and the quality of educator/child interactions in outdoor environments. Chapter 5 investigated the relationship between environmental factors, such as ECEC routines, time spent outdoors and size of the outdoor environment and children's physical activity and sedentary behaviour in ECEC. Chapter 6 examined the relationship between educators' physical activity and sedentary behaviour and children's physical activity and sedentary behaviour.

This chapter will present an overall discussion of the research. The key results will be considered in relation to the research questions and will be compared with the most recent body of literature.

Strengths and limitations will then be discussed and recommendations for future research will be proposed, followed by an overall conclusion.

7.2 Introduction

The Literature Review (Chapter 2), highlighted a number of key gaps in the correlates research, including the relationship between educators' physical activity and sedentary behaviour and children's physical activity and sedentary behaviour; the relationship between children's physical activity and ECEC routines and time spent in outdoor environments. This research sought to fill these gaps.

7.3 Key Findings and Comparison with other Studies

Research questions:

1. What are the correlates of children's physical activity and sedentary behaviour in ECEC settings?

ECEC contexts are important for promoting children's health and wellbeing, including physical activity and sedentary behaviour, and as such it is important to thoroughly understand the ECEC-related correlates in relation to children's physical activity and sedentary behaviour. The relationship between ECEC-related factors and children's physical activity and sedentary behaviours has been reported in a number of studies (Ellis, Cliff, Howard, & Okely, 2019; Gubbels, Kremers, & Kann, 2011; Gubbels, Van Kann, & Jansen, 2012; Hinkley, Salmon, Crawford, Okely, & Hesketh, 2016; Tandon, Saelens, & Christakis, 2015; Tandon, Saelens, Zhou, & Christakis, 2018; Trost, Ward, & Senso, 2010; Truelove et al., 2018; Van Cauwenberghe, De Bourdeaudhuij, Maes, & Cardon, 2012; Ward, Belanger, Donovan, Horsman, & Carrier, 2015; Ward et al., 2017), however given the complexity and dynamic nature of ECEC, it is important to review these correlates regularly and further investigate under-reported ECEC-related factors.

Chapter 2 presented the first comprehensive review (published and updated review) of ECEC-related correlates of children's physical activity and sedentary behaviour in ECEC. Cumulatively, the review spanned studies from 1992 to 2019 (published review 1992- 2014 and updated review 2015- 2019). Eight databases were searched, resulting in 45 studies which met the inclusion criteria (see Chapter 2). In total 99 different ECEC-related variables were identified; 61 variables associated with physical activity and 38 associated with sedentary behaviour. The lower number of sedentary behaviour related variables is most likely due to the previously limited recognition of the impact of sedentary behaviour on health and wellbeing of young children. Physical activity has internationally been recognised as a key factor in children's health and wellbeing, however it has only been in the last decade that sedentary behaviours has been recognised to be of equal importance (Carson, Kuzik, et al., 2015; Ellis et al., 2017). Additionally, studies were only included if an objective measure of sedentary behaviour was reported. Until relatively recently, subjective measures, for example, parent-proxy reported sedentary behaviour were commonly used and accepted (Downing, Hnatiuk, & Hesketh, 2015), however there are significant limitations associated with such reporting methods (e.g., over reporting), thus objective measures are far more accurate and are becoming more widely accepted (Carson, Hunter, & Kuzik, 2015; Downing et al., 2015; Hinkley et al., 2014; Pereira, Cliff, Sousa-Sá, Zhang, & Santos, 2019; Poitras et al., 2017). Current evidence suggests that both optimal levels of physical activity and sedentary behaviour are critical for health and wellbeing and this should be included simultaneously in future studies investigating ECEC-related correlates.

Approximately 70% of the identified variables were categorised as either physical environmental variables or organisational variables (31 and 36, respectively), the remainder were categorised as either child or educator variables (18 and 14, respectively). When all of the studies were analysed collectively, strong positive associations between age, motor coordination and sex and children's physical activity were evident. Older children are more active than younger children, children with better motor proficiency are more active than those who were less proficient and boys are more active and less sedentary than girls. Collectively no strong positive associations between child variables and sedentary behaviour were identified, thus further evidence is needed to enable definitive conclusions. The evidence pertaining to physical activity is strong enough to suggest that it may be important to target young girls with poor motor skills. Very few interventions have been implemented which young children (i.e., less than 3years of age). This may be simply the result of the large number of 3-5year old children that attend ECEC, the large variations in motor skill development in children under 3years, or may be that educators and researchers feel that physical activity learning experiences are more relevant for older children as these children have increased movement and cognitive abilities. Despite this, it is critically important to provide intentional physical activity opportunities for children in younger age groups and that a tailored, perhaps even individual approach is needed for physical activity interventions. To date, no interventions targeting 3-5 year old girls specifically have been evaluated. Single sex interventions/programs have been implemented for older children attending formal school. Such studies have shown mixed results (Biddle, Braithwaite, & Pearson, 2014; Bugge et al., 2012; Ridgers, Stratton, Fairclough, & Twisk, 2007; Salmon, Ball, Hume, Booth, & Crawford, 2008; Wright, Giger, Norris, & Suro, 2013). Given that the ECEC environment is substantially different from the school environment, and are often underpinned by child-initiated philosophies, it may not be possible to implement single sex programs, rather it may be more appropriate for educators to work within age, room or primary-carer groupings that are common to ECEC that ensure that such children have the opportunities and are encouraged to participate in experiences that promote physical activity.

Collectively, less than 15% of studies reported educator variables. The low proportion of studies may be due to the complexity of objectively assessing such variables. Despite the low number of studies, a strong positive association between educators' behaviours and children's physical activity was identified. Similar to the child variables, no relationships were identified for sedentary behaviour. Educators' behaviour is a broad term that was inclusive of educators leading structured physical activity, prompting children to increase physical activity or participating in active play (Bell et al., 2015); educators prompting or initiating physical activity (Soini et al., 2016); or educators leading planned lessons or talking with the children about physical activity (Ward et al., 2017). Educators have profound influence on children's choices and experiences within ECEC settings, and it is important that they model good practices and healthy behaviours. Often participation, or enthusiasm for an experience from educators will motivate children to participate. Therefore it is important for educators to understand and value the relationship between their behaviours and the children's physical activity and sedentary behaviour levels, particularly in outdoor environments which are known to be important for children's physical activity. Additional professional development in this area might be valuable, and furthermore, educator health and wellbeing may have be an unintended benefit of increased participation in physical activity.

Overall, strong positive associations between the outdoor environment (physical environmental domain) and children's physical activity and sedentary behaviour were identified. Strong positive associations between the natural environment and size of the play space and children's physical activity were also identified when the studies were collectively reviewed. All ECEC centres provide an indoor and outdoor (or an environment that replicates this) environment with the outdoor environment being critical for the promotion children's physical activity and reducing sedentary behaviours (Schlechter, Rosenkranz, Fees, & Dzewaltowski, 2017; Soini et al., 2016; Tandon et al., 2018). Outdoor environments are generally a larger space than the indoor environment, often have more unencumbered space, and in these environments there is typically less structured time. A feature of many outdoor environments is natural surroundings. These natural surroundings afford a sense of curiosity and exploration, inquiry-based thinking and sensory integration as children experience and navigate different terrains and objects, such as trees, dirt paths, puddles, grass, mud, slopes and other features found in natural environments, experiences that promote children's physical activity (Nicaise, Kahan, & Sallis, 2011; Olesen, Lund Kristensen, Korsholm, & Froberg, 2013). Consequently, not only do outdoor environments have the potential to promote children's physical activity and reduce sedentary behaviours, but they also have the capacity to increase children's learning in development in many areas (Ebbeck, Yim, & Warrier, 2019). The outdoor environment is often overlooked for what it can offer children's learning and development (Bento & Dias, 2017; Ebbeck et al., 2019). An outdoor environment invites risky play which can promote self-confidence and a sense of achievement (Little, Wyver, & Gibson, 2011), and children may be exposed to opportunities for real-life problem solving. An example of the potential of outdoor environments is seen in Forest Schools, (also known as Bush Preschools in Australia) which are gaining international popularity. In these ECEC settings, children spend all, or part of the day outside, and participate in rich experiences, across all developmental areas (Elliott & Chancellor, 2014). It is understandable that this curriculum-style is not possible for all centres but either offering an outdoor environment or an environment that replicates an outdoor environment is important.

The organisational domain presented the highest proportion of variables (36 from 99 variables) and a third of studies (22 from 66 studies) compared to the other domains. Collectively, strong positive associations between the provision of active opportunities (e.g., movement breaks and using the indoor space for physical activity) and children's physical activity and sedentary behaviour were identified. These findings are encouraging for all ECEC centres as it demonstrates that regardless of what resources, environments or training may be available, there are strategies that can be implemented that will provide opportunities to promote children's physical activity and reduce sedentary behaviour. Professional development to build the capacity of educators and create an understanding of the potential within their environments may be beneficial.

The research presented in Chapter 2, is the first body of research to collectively review the correlates of children's physical activity and sedentary behaviour in ECEC settings. Seven variables were strongly associated with children's physical activity (i.e., age, motor competency, sex, educators' behaviour, presence of outdoor environment, size of play space, presence of natural features and opportunities for activity opportunities). One variable (i.e., active opportunities) was strongly associated with children's sedentary behaviour. Although the ECEC setting is undoubtedly important in the promotion of physical activity and sedentary behaviour, the vast number and diversity of variables identified highlight the complexity of ECEC settings. Furthermore, there are a number of potential variables that have not been investigated and warrant further investigation. For example, the relationship between children's physical activity and sedentary behaviour and ECEC routine and time spent outdoors, as well as the relationship between educators' physical activity and sedentary behaviour and children's physical activity and sedentary behaviour remains unknown.

2. What physical environmental aspects of ECEC centres influence the quality of educator and child interactions in outdoor environments?

The broad aim of this thesis was to examine the relationship between potential ECEC-based correlates previously not investigated (such as ECEC routines, time spent in outdoor environments and educators' physical activity and sedentary behaviour) and children's physical activity and sedentary behaviour. Chapter 4 reported on the relationship between the quality of educators and children's interactions and ECEC routines and time spent in the outdoor environment. This study did not directly investigate the relationship between the quality of educator/children interactions and children's physical activity and sedentary behaviour. Originally, these data were to be used in conjunction with the Real Time Location System (RTLS) data, which would have enabled the relationship between educators' and children's physical activity and sedentary behaviours to be explored in greater detail (see Chapter 3). However the RTLS data were not able to be analysed as originally planned, thus these relationships were not able to be investigated.

Although the original analyses were not able to be conducted, the relationship between the quality of educator/child interactions in the outdoor environment, and ECEC routines and time spent in outdoor environments was important to report. ECEC routines and the time spent in the outdoor environment are important for children's physical activity and sedentary behaviour (Chapter 5), and similarly, Chapter 3 has shown that routines and time spent in outdoor environments have a relationship with the quality of interactions in outdoor environments. Quality is critical for children's learning and development, and so it is reasonable to suggest that it is also important for children's physical activity and sedentary behaviour. Therefore, facilitating ECEC environments that improve the quality of educator/child interactions may be a strategy to promote children's physical activity and reduce sedentary behaviour.

ECEC quality is a broad term that is inclusive of pedagogical practices, interactions and relationships between educators and children, child developmental assessments, resources and engagement with parents and communities (Hamre, Hatfield, Pianta, & Jamil, 2014; Mashburn et al., 2008; Melhuish et al., 2015; Sabol & Pianta, 2012; Sylva, Siraj-Blatchford, Taggart, & Ebscohost, 2010; Tayler et al., 2016). In recent years, studies have shown that children attending high-quality ECEC centres have better outcomes in many key developmental domains, compared to children attending low quality ECEC environments, particularly in disadvantaged communities (Biersteker, Dawes, Hendricks, & Tredoux, 2016; Eadie, Stark, & Niklas, 2019; Melhuish et al., 2015).

Positive relationships and meaningful interactions between educators and children have a profound influence on children's behaviours. A recent study by Wang, Hatzigianni, Shahaeian, Murray, & Harrison, (2016) showed that children often model their own behaviours from those of educators, and children who feel a strong connection to their educators are more likely to be motivated to relate, explore and have a greater sense of self-worth. Furthermore, the impact of the quality of educator/child interactions has been well documented, with a number of studies showing that strong and more meaningful interactions create a culturally, socially and emotionally respectful environment, and quality interactions contribute to many areas of children's learning, development and wellbeing (Eadie et al., 2019; Mashburn et al., 2008; Papadopoulou & Gregoriadis, 2017; Sabol et al., 2012; Wang et al., 2016). Although the impact of the quality of educator/child interactions has been well documented, subjective measures have often been used (Gagne & Harnois, 2014) and interactions have largely been examined within the indoor environment (Tayler et al., 2016). Given that ECEC the outdoor environment is regarded as the main learning space for physical activity, it is important to understand factors that might influence the quality of educator/child interactions in the outdoor environment and in turn, potentially influence children's physical activity and sedentary behaviour.

The relationship between the quality of educator/child interactions in the outdoor environment and routines and time spent in the outdoor environment were investigated in Chapter 4. This was the first study to use the CLASS Pre-K assessment tool exclusively in the outdoor environment. Higher CLASS Pre-K scores were reported for all domains and dimensions when free routines were provided, as well as when children spent more than four hours outdoors across the day (see section 4.3.3). In particular, significant relationships between the Teacher Sensitivity domain (Emotional Support dimension) and the Concept Development domain (Instructional Support dimension) and routines and time outdoors were found (see section 4.3.3). Additionally, significant positive relationships between the Student Perspectives domain (Emotional Support dimension), the Behaviour Management domain (Classroom Organisation dimension) and the

Instructional Learning Formats domain (Classroom Organisation dimension) were reported (see section 4.3.3).

As discussed in Chapter 5, offering free flowing routines, where children move freely between and within both indoor and outdoor environments has a number of potential advantages inclusive of, but not limited to, increased periods of time spent in specific learning experiences and thus opportunities for sustained shared thinking (Siraj-Blatchford, 2009), reduced waiting times and increased use of resources. Furthermore, a free-flowing routine may provide opportunities for children to regulate their own social experiences as they have the opportunity to choose who to interact with, and where to play. In addition to these advantages, the interactions between educators and children seem to be heightened when free flowing routines are offered. Generally, many ECEC settings provide opportunities in the day for children's free-choice. A study in the U.S. by Fuligni, Howes, Huang, Hong, & Lara-Cinisomo, (2012) found that on average, children spent 40% of their ECEC day in the free choice activities, and 28% in small or whole group experiences. However, this free choice is often within the one environment, and not across both indoor and outdoor environments. Free flowing routines that allow children to move between indoor and outdoor environments are not common in ECEC settings. Traditional structured routines involve all children within a particular age group transitioning from one learning environment to another in a structured format. This type of routine is perhaps favoured as it is deemed easier to manage mandated child/educator ratios and is perceived by educators that children are better supervised in structured routines. Although structured routines may be perceived as easier, it would seem that free flowing routines may be advantageous for improving the quality of educator/child interactions (and perhaps increasing children's physical activity and decreasing children's sedentary behaviour). Modifying ECEC routines from structured to free flowing may not require additional skills, training or expensive resources, which are frequently reported as barriers to change in ECEC environments (Pagnini, Wilkenfeld, King, Booth, & Booth, 2007); however change would require educators to embrace a cultural shift and an understanding of the intention and an expectation of their behaviour (Bartholomew, 2011; Kok, Peters, & Ruiter, 2017).

In Chapter 5, a positive relationship between free flowing routines and children's physical activity and sedentary behaviours was identified (i.e., children attending centres that offered free flowing routines, for the whole day or part of the day, participated in more physical activity and less sedentary behaviour than children attending centres that offered structured routines). Given that this is the first known study to report this relationship, additional studies are needed to confirm these results, however there is initial evidence to suggest that free flowing routines – either all day or for an aspect of the day – result in better quality educator/child interactions and higher levels of children's physical activity.

The relationship between higher quality educator/child interactions and the time spent in the outdoor environment may have resulted from the sustained periods of time engaged in experiences in the outdoor environment, Longer periods of outdoor time result in greater time without interruptions, and potential for sustained opportunities in experiences resulting in higher engagement, providing opportunities to extend exploration and inquiry-based learning (Siraj-Blatchford, 2009). This is important as greater time in the outdoor environment has been shown to have positive relationship with children's physical activity and sedentary behaviours both in this thesis (Chapter 2) as well as in other studies (Copeland, Khoury, & Kalkwarf, 2016; Henderson, Grode, O'Connell, & Schwartz, 2015).

Although these results are interesting and warrant further investigation, it should be noted that the cross-sectional nature of the data means that causality cannot be inferred. CLASS Pre-K also has a number of limitations when used in the outdoor environment. CLASS Pre-K is characterised by an assessment of supportive and enriching instruction across all content areas, positive interactions, and proactive classroom organisation. It is traditionally used for the indoor environment and thus assesses quality in terms of specific instruction, productivity and behaviour management (Pianta, La Paro, & Hamre, 2008). Although the outdoor environment is a valuable environment for learning, the characteristics of the outdoor environment are different to that of an indoor environment, and consequently the notion of quality may also look different. Outdoor environments are often larger than indoor environments, typically with more open space, and are often dynamic and at times unpredictable. A combination of assessment tools may provide a more comprehensive assessment of the quality of educator/child interactions in outdoor environments. The simultaneous use of the assessment scale known as the Movement Environment Rating Scale (MOVERS) (Archer & Siraj, 2017), and the CLASS Pre-K may be beneficial. MOVERS assesses product- and process-quality specifically in relation to children physical activity and children's physical development as well as the quality of interactions between educators and children. MOVERS is designed to be used for sustained periods across the day and is suitable for assessment in outdoor environments.

The CLASS scores in this study were higher than those reported in other studies (Anderson & Phillips, 2017; Curby et al., 2009). Reasons for this may be that previous studies have been predominantly based in the U.S. (Anderson et al., 2017; Curby et al., 2009; La Paro, Pianta, & Stuhlman, 2004) and there may be cross-cultural variations in ECEC that influenced the results, such as educator to child ratios, group sizes and curriculum. The higher scores may also be due to the observations being collected in the outdoor environment, whereas in other studies these observations would typically be conducted in the indoor ‘classroom’ environment. Observations were collected at random intervals throughout the day, rather than consistently across the whole day, and due to the nature of the outdoor environment - for example the open spaces and larger sizes compared to indoor environments - the educators wore small microphones. Educators were aware that they were being observed and may have reacted to this by changing their behaviours, and so typical practices may not have been observed. Further studies in the outdoor environment, over the entire day are needed to compensate for these factors that may have influenced the quality of educator/child interactions.

Altering the schedule of the day to allow for a free flowing routine, for all or part of the day, as well as offering additional time outdoor environments are modifiable aspects of ECEC. They are inexpensive, do not require additional educator training and are relatively accessible options to increase the quality of educator/child interactions, as well as potentially promoting children’s physical activity and reducing children’s sedentary behaviour. They are perhaps unrealised opportunities that will have a positive influence on children’s health and wellbeing.

3. What is the relationship between ECEC routines, time spent in outdoor environments and the size of the outdoor environment, and children’s physical activity and sedentary behaviour?

Chapter 5 investigated the relationship between children’s physical activity and sedentary behaviour and the ECEC routine, the amount of time spent in outdoor environments and the size of the outdoor environment. A significant relationship between ECEC routine and children’s physical activity and sedentary behaviour was reported in Chapter 5. Children attending ECEC settings that offered free-flowing routines spent significantly more time in TPA and MVPA and significantly less time in sedentary behaviour compared to those children attending ECEC settings with structured routines (Chapter 5). A significant relationship between the size of the outdoor environment and children's sedentary behaviour was also found. Children attending ECEC settings with larger outdoor environments spent significantly less time in sedentary behaviour compared to children attending ECEC settings that had smaller outdoor environments.

A recently published study, also in Australia, investigated the relationship between ECEC routines and children's physical activity and sedentary behaviour. Interestingly, the results presented in Chapter 5 are in contrast to this study. Wolfenden and colleagues (2018) conducted an intervention study, involving over 200 children from six ECEC centres, and found that offering a free-flowing routine had no significant effect on children's objectively measured physical activity. The intervention centres provided children with free flowing access to outdoor environments, while the control centres provided their usual scheduled periods of outdoor play (Wolfenden et al., 2018). The implementation of this intervention over a three-month period may have been a novelty to the children participating, and so may have contributed to the null findings. This is in contrast to the current study, in which the ECEC centres were already implementing this style of routine prior to data collection, and although the period of time that the free routine had been offered for was unknown, it was a familiar concept to the children. Another explanation for the different findings between free-flowing routines and children's physical activity in these studies, may be that a change in outdoor environment opportunities may have modified educator behaviours. The study by Wolfenden (et al., 2018) reported that there were reductions in educator prompts and positive statements about children's physical activity in the intervention group at follow-up compared with baseline, while such educator actions appeared relatively stable in the control group. Educator awareness, confidence, motivation and intention to use a variety of opportunities for spontaneous and intentional teaching is crucial in all environments (Gagne & Harnois, 2014). In free–flowing routines where structured teaching is not typical practice, spontaneous and intentional learning experiences are important, and it is necessary for educators to be aware of, and motivated to, respond to these opportunities for learning. This may have impacted intentional teaching opportunities that promoted children's physical activity in the intervention (Wolfenden et al., 2018). Furthermore, the study by Wolfenden et al. (2018) only measured children's MVPA, however the current study measured all intensities of physical activity as well as sedentary behaviour. In the current study (Chapter 5) a significant relationship was found with sedentary behaviour. With the evaluation of only two studies and the reporting of mixed findings, the evidence in this area is limited, thus it is reasonable to suggest that further examination is needed.

Modifying ECEC routines from a structured routine to a free-flowing routine is potentially a novel way of increasing children's physical activity and reducing sedentary behaviour. There are a number of advantages to free-flowing routines. For example, children's autonomy is increased with children having the opportunity to select their own activities, both indoors and outdoors (Hesketh & Sluijs, 2016). Moreover, a free-flowing routine provides access to increased space and resources as there is potential for children to spread across both environments rather than just one (Van Cauwenberghe et al., 2012). However, modifying ECEC routines may not be appropriate for all centres and/or children and perhaps needs to be considered carefully. The ECEC routine is dependent on the pedagogical and philosophical values of each centre. Some children may thrive in structured routines that provide set indoor or outdoor times, and in contrast, the ability to make the choice in a free-flowing routine may be overwhelming. However, although a structured routine restricts the children's ability to independently choose between indoor and outdoor environments, these routines may still incorporate an element of free play within the single environment (Raustorp et al., 2012).

Modifying routines in other ways, for example, increasing the number of sessions children spend outdoors has shown positive results in terms of increasing children's physical activity. Based on the premise that preschool-aged children participate the most amount physical activity during the first 10 minutes in an outdoor environment (McKenzie et al., 1997; Pate, Dowda, Brown, Mitchell, & Addy, 2013), and that physical activity is most intense during this time (Greever, Sirard, & Alhassan, 2015), Razak and colleagues (2018) conducted a randomised controlled trial, scheduling multiple periods of outdoor free-play to increase MVPA in children attending ECEC. Ten ECEC centres, and 316 children aged 3-6years participated over a 3month period. Children in the intervention group spent significantly more time in MVPA compared to children in the control group. Sedentary behaviour was not measured. A similar study by Tucker et al. (2017) trialled modifying the time spent in outdoor environments by offering shorter, more frequent opportunities. The intervention did not impact LPA, however positive relationships were reported with sedentary behaviour, MVPA and TPA short term (6 months), but not long term (12months). Tucker et al. (2017) suggest that given the lack of long-term impact, it is possible that the modified scheduling of periods in the outdoor environment influenced changes, but there may be other variables, such as educator training and educator practices that will promote longer-term, sustainable changes. Given the intermittent nature of young children's activity behaviours (Benham-Deal, 2005) offering more frequent, but shorter periods in the outdoor environment, may be a viable approach for promoting physical activity and reducing sedentary behaviour.

Chapter 5 reported a significant relationship between the size of the outdoor environment and children's sedentary behaviour (i.e., larger outdoor environments are associated with reduced sedentary behaviour). Studies investigating the association between the size of the outdoor environment and children's physical activity are not new, and findings from Chapter 2 report strong significant associations with physical activity (from 7 studies). However, there are fewer studies that examine the relationship between the size of the environment and children's sedentary behaviour, with only two studies identified in the systematic review (Chapter 2), with an inconclusive association. A recent systematic review and meta-analysis (Pereira et al, 2019) has shown that reducing children's sedentary behaviour may be just as important as promoting children's physical activity. Thus the current study is a valuable contribution to a gap in the literature, and further examination of strategies to reduce children's sedentary behaviour in all outdoor environments is recommended.

The null finding for the relationship between physical activity and the size of the outdoor environment in this study may be due to the lack of variance in the upper end of the size of the outdoor environment. The size of the outdoor environment ranged from 126m^2-1200m^2 (median 600m2), however only four centres had above the median size, i.e. greater than 600m^2. A study by Olesen et al. (2013) included 426 children aged 5-6 years, from 42 ECEC centres in Denmark. MVPA was measured using accelerometers across the ECEC day. A significant association with children's MVPA and the size of the indoor environment was found, however consistent with the current study there was no relationship with the size of the outdoor environment. A lack of variability in the lower end of the outdoor environment size (median

2700m^2; range 567–5175 m^2) was reported as a possible explanation. The variation of outdoor environment size must be a consideration when comparing the results internationally and between ECEC. In Australia, regulations (NSW Government, 2018) state that for each child in the ECEC centre, the amount of unencumbered outdoor space per child should be at least 7m^2. Although the size of outdoor environments cannot be modified, educators can modify how outdoor environments are used, and more space per child can be created. For example, free-flowing routines have the potential for less children to be in the environment at any time, and so may be a strategy for recreating an environment that has more space per child. Alternatively, if a structured routine is offered, educators may be able to schedule time for different groups to access the outdoor environment at different times so that not all children are in the space at the same time.

The examination of children's physical activity and sedentary behaviour and the relationship between ECEC routines, time spent in outdoor environments and the size of the outdoor environment in Chapter 5 has provided important insight into children's physical activity and sedentary behaviour. It has also presented strategies that are accessible to all ECEC centres that will promote children's physical activity and reduce children's sedentary behaviour. The affordance of movement between indoor environments through offering free routines, increased time in outdoor environments and well-managed use of space are modifiable aspects of all ECEC setting, and provide potentially cost-effective strategies to promote children's activity and healthy behaviours.

Since publication of this study, an application for a national competitive grant has been submitted to test the free routine verses structured routine hypothesis. The aim of the proposed study is to test if a free-flowing routine will increase physical activity and reduce sedentary behaviours levels of children in ECEC compared to those with a structured routine. The intervention would have a larger sample size compared to the current observational study. As evidence about the relationship between routines and children's physical activity and sedentary behaviour in ECEC is still in its infancy, larger studies like this are needed.

4. What is the relationship between educators' physical activity and sedentary behaviour and children's physical activity and sedentary behaviour?

Chapter 6 described the relationship between educators' and children's physical activity and sedentary behaviour in ECEC. A significant relationship between educator's and children's sedentary behaviour was reported, and although not significant, positive trends for LPA, MVPA and TPA were found.

Only one other known study has reported on the relationship between educators' and children's objectively measured physical activity in ECEC (Fossdal, Kippe, Handegård, & Lagestad, 2018). Fossdal et al. (2018) reported a significant association between educators' MVPA and children's MVPA. Although positive trends were reported for all intensities of physical activity (LPA, MVPA, TPA) in the present study, no significant associations were found, except for sedentary behaviour. The differences in sample size of the studies may have influenced the findings. The study presented in Chapter 6 involved significantly more educators than Fossdal et al.'s (2018) study (n=72). Sedentary behaviour was not reported in Fossdal et al., (2018), nor were the lower levels of physical activity, such as LPA.

The relationship between educators' objectively measured sedentary behaviour and children's objectively measured sedentary behaviour has not been reported previously, thus these current findings may have important implications for policy and practice, and potentially a new approach to time spent in sedentary behaviours. While in ECEC, educators spend nearly two-thirds (61%) of their day in sedentary behaviour (Chapter 6). The details of the sedentary behaviours that educators engaged in were not recorded (such as in the presence of children, or away from the children), however, as the main responsibility of educators is to be with the children, it was likely that most of the sedentary time measured would have been in the presence of children. Another study by Ward and colleagues (2018) objectively measured the physical activity of ECEC staff (n=553) over a seven day period. Although the measurement of physical activity was not limited to time in ECEC, consistent with the current study, many ECEC staff participated in low levels of physical activity, and high levels of sedentary behaviour (Ward et al., 2018). It is reasonable to suggest that these behaviours were also representative of their day in ECEC, and therefore while in the presence of the children.

Educators are important role models for children in ECEC, with children often congregating around educators and often mimicking educators' behaviours (Wang et al., 2016). Modifying educators' sedentary behaviour may therefore influence children's physical activity and sedentary behaviour. In turn, this may also have unintended benefits for educators' own health. Just as interventions to reduce the sedentary behaviours of children have been developed (Ellis et al., 2019), similar strategies may also be effective and important for educators. An intervention for ECEC educators - Caring and Reaching for Health (CARE) Healthy Lifestyles (Ward et al., 2018) - uses a multi-level approach to improve the physical activity and health behaviours of educators in ECEC. The program consists of workshops, magazines, goal setting, behaviour self-monitoring, feedback, email and text prompts, centre displays, and coaching for centre directors. Baseline results showed that educators are displaying several serious health risks such as obesity and low levels of physical activity. Likewise, a quasi-experimental study (Gosliner et al., 2010) targeted the health and wellbeing of educators in ECEC (n=13). Similar to the study by Ward et al. (2018) the intervention included initial training and newsletters, as well as a walking program. The intervention had no effect on educators' physical activity, however there was a significant but very modest decrease in sweetened beverage intake.

Educator health and wellbeing is important, and educators are important role models for children in ECEC, therefore a comprehensive approach is required to promote educators' physical activity. Short term strategies that have the potential to influence educator behaviours may involve standing desks or less chairs in the indoor and outdoor environments, strategies that encourage less sitting and more active standing. Policies that promote educator movement breaks, such as sharing tasks like music and movement experiences, routine times (e.g. nappy changes, serving meals) and involvement in outdoor environments, or incentives to engage educators in physical activity, such as wearing of FitBits™ and other step-tracking devices may also reduce their sedentary behaviours. It is important, however to acknowledge that there is are times during the day in ECEC that educators may need to be sedentary, such as when reading to children, sitting at meal times or sitting on the floor to be at the child's level. Recognising opportunities that typically would be sedentary and increasing active movement and educators' involvement during these times may be beneficial, such as story telling with movement and actions, digging in the sand while sitting with the children in the sandpit, participating in dramatic play with the children, or engaging in a ball game or game of tag with the children.

There is a clear gap in the literature relating to the influence of educators' physical activity and sedentary behaviour on children's physical activity and sedentary behaviour in ECEC. As educators are crucial to children's experiences in ECEC, educators' physical activity may hold a key to improving the health and wellbeing of children.

7.4 Significance of Research

This study has contributed to the literature pertaining to ECEC-based correlates of children's physical activity and sedentary behaviour. Given the profound importance of optimal physical activity levels and sedentary behaviour levels from a young age and the fact that children are not meeting current recommendations for physical activity and sedentary behaviour while in ECEC, understanding the influence of previously under-studied ECEC-base correlates is important. The research is also timely in light of the recent release of the global guidelines for physical activity, sedentary behaviour and sleep for children under 5years of age (WHO, 2019). The research also supports diverse curriculum styles, such as the emerging Bush Preschools movement in Australia, but also provides accessible and cost-effective strategies for all ECEC that will have a positive impact on children's health and wellbeing.

7.5 Contribution to Knowledge

The studies in this PhD build the evidence base by: 1) comprehensively summarising the correlates of children's objectively measured physical activity and sedentary behaviour in ECEC; 2) measuring the quality of educator/child interactions in an outdoor environment using CLASS PreK and assessing the relationship between the quality of educator/child interactions in the outdoor environment and ECEC routines and time spent in the outdoors; 3) examining the relationship between ECEC routines (free-flowing and structured), time spent in outdoor environments and the size of outdoor environments and children's physical activity and sedentary behaviour; and 4) examining the relationship between educators' and children's physical activity and sedentary behaviour. As one of the first studies of this kind, its contribution to the current literature, and addressing of a number of the current gaps within the field, provides evidence to inform future interventions.

7.6 Strength and Limitations

The systematic review was of high methodological quality – it was conducted using a registered study protocol, inclusive of a pre-determined search strategy, adhered to the PRISMA statement and was updated to include studies up to March 2019. This review was the first to comprehensively summarise the correlates of children's objectively measured physical activity and sedentary behaviour in ECEC. The sample size of educators and children was relatively large compared to other studies (Fossdal et al., 2018) and thus was a strength of the research. Furthermore, it was one of the first studies to report on educators' objectively measured sedentary behaviour. Another study had reported on educator's physical activity but not sedentary behaviour. The use of the CLASS Pre-K assessment tool to measure the quality of educator and child interactions in the outdoor environments was a novel approach and had not been reported previously.

However, the study did have limitations. Accelerometer data was not collected across the entire day in some ECEC centres. This restricted some analyses (Chapter 5) as it was not valid to compare all-day data with outdoor-only data. Although this was the case, there was still sufficient data to power the study. Additionally, analysis of individual educator and individual child accelerometer data was not possible, rather educator data was calculated as an average for each centre. Some information about child-educator associations may have been lost due to aggregating educator activity levels within the ECEC, and possibly weakened the associations. It would have been beneficial if this individual analysis were able to be conducted to determine individual relationships between educators and children, rather than educators as a group. RTLS data were collected, however could not be analysed. RTLS data would have enabled the investigation of the quality of educator/child interactions and children's physical activity and sedentary behaviour to be directly assessed. Additionally, these data would also have allowed for the examination of physical activity and sedentary behaviour 'hot spots' (i.e., where the majority of physical activity and sedentary behaviour would have taken place and the engagement of educators and children at these 'hot spots'). RTLS analysis would have involved complex analysis that could only be completed by time-series engineers. This was not communicated until after the data had been collected. Such data will be examined in the future. The CLASS Pre-K scale has been primarily used indoors in studies facilitated in the U.S., thus it was difficult to compare the results of this study with others.

7.7 Recommendations for Future Research

This study provides a number of opportunities for further research. An examination of outcomes that may be present between different types of ECEC, such as comparisons between family day care, long day care, preschools and occasional care centres, as well as community-based and privately-owned centres. These are important considerations as there may be variations in enrolment and attendance patterns (e.g., attendance may replicate school terms compared to all year, days and patterns of weekly enrolment may differ; and hours of attendance may be half-day, full-day or restricted to hours that replicate school hours); funding (e.g., in Australia preschools are State-funded, compared to long day care which is Federal-funded); educator qualifications and ratios (e.g., state by state in Australia these requirements differ, and centre-based requirements are different to family day care requirements); and possibly environmental factors (e.g., a family day care environment is often home-based, and numbers of children and educators fewer than in centre-based care). While an examination of these variables was not within the scope of this current research, the review did identify a number of specific ECEC centre types and curriculum styles, including that physical activity among boys was greater than among girls in rural preschools (Olesen et al., 2015); children in Montessori programs had higher levels of physical activity (Byun, Liu, & Pate, 2013) and reduced levels of sedentary behaviour (Byun et al., 2013; Pate et al., 2014) compared to traditional preschools; children were less active when the educator to child ratio was greater (i.e., more educators present) (Cardon & Bourdeaudhuij, 2008); and a full day of care resulted in higher levels of physical activity compared with children who attended part-day preschools (Hesketh, Griffin, & Sluijs, 2015; Vanderloo, Tucker, Johnson, Burke, & Irwin, 2015). The study only collected information on children 3 years and older. Further investigation of the physical activity and sedentary behaviour of younger children, such as 2-to 3-year-olds and even younger may provide insight into key opportunities for intervention, particularly as children attend ECEC from an early age. This research has provided strong evidence from which interventions can be designed to test some of these identified variables and factors, such as how to increase educators physical activity and reduce sedentary behaviour, changing from a structured to a free routine, increasing the number of hours spent in outdoor environments, and improving interaction and engagement between educators and children in the outdoor environment.

7.8 Conclusion

The aim of this Doctorate was to add to the evidence-base in the area of children’s physical activity and sedentary behaviour in ECEC. ECEC is increasingly significant in the lives of many children, and so further examination of this context was warranted. As such, this Doctorate has contributed evidence and provided a number of strategies for ECEC to promote children’s physical activity and reduce sedentary behaviour. The four papers (systematic review of the correlates of children’s physical activity and sedentary behaviour in ECEC; quality of educator and child interactions in ECEC outdoor environments; physical environmental influences on children’s physical activity and sedentary behaviour in ECEC; and the relationship between educators’ and children’s physical activity and sedentary behaviour in ECEC) have provided key findings on the correlates, prevalence, influencing factors and potential strategies for promoting children’s physical activity and reducing sedentary behaviour in ECEC. It was found that many children were not meeting recommended guidelines for physical activity or sedentary behaviour in ECEC, and that free routines have the potential to increase the quality of educator and child interactions in outdoor environments, as well as increase children’s physical activity and reduce sedentary behaviours. The findings also provided insight into the impact of increasing the time spent in outdoor environments. Finally, the findings suggested a new approach to promoting children’s physical activity and reducing sedentary behaviour in ECEC and present evidence to demonstrate the important relationship between educator practices and children’s physical activity and sedentary behaviours. These research findings will hopefully provide guidance for the development of new and innovative strategies and ECEC policies to promote children's physical activity and reduce children's sedentary behaviour in ECEC, to optimise children's health and well-being.

7.9 References

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Chapter 8: Appendix

8.1 Appendix A

8.1.1 Statement of contribution of others

Karen Tonge collaborated with her supervisors, Dr Rachel Jones and Senior Professor Tony Okely to design and conduct this doctoral research on The Relationship between Educator Engagement & Interaction and Children's Physical Activity in Early Childhood Education and Care Services. The candidate conducted the literature review and designed the study with the assistance of both supervisors. The candidate approached organisations and individuals to assist with recruitment (such as preschools and educators), fielded enquiries from potential participants, collected all data, cleaned, analysed and interpreted data (with the assistance of supervisors and a statistical consultant), and drafted and revised this thesis.

Karen L Tonge

Rachel A Jones

Anthony D Okely

8.1.2 Author contributions

Published article from Chapter 2:

Tonge, K.L., Jones, R.A & Okely, A.D. (2016). Correlates of children's objectively measured physical activity and sedentary behavior in early childhood education and care services: A systematic review. *Preventive medicine 89*: 129-139.

I attest that Karen Louise Tonge contributed to the above paper. KLT contributed to designing the review, conducted the review, analysed data and wrote the paper. RAJ and ADO contributed to designing the review, analysed data and edited the manuscript. All authors read and approved the final manuscript.

Rachel A Jones

Anthony D Okely

Published article from Chapter 3:

Tonge, K.L., Jones, R.A., Hagenbuchner, M., Nguyen, T.V. & Okely, A.D. (2017). Educator engagement and interaction and children's physical activity in early childhood education and care settings: an observational study protocol. *BMJ Open 7*(2). doi:10.1136/bmjopen-2016-014423

I attest that Karen Louise Tonge contributed to the above paper. KLT, RAJ and ADO designed the study and contributed to the study protocol. KLT drafted the manuscript and RAJ, MH, TVN and ADO assisted in drafting. All authors read and approved the final manuscript.

Rachel A Jones

Markus Hagenbuchner

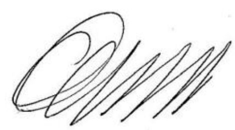
Tuc V Nguyen

Anthony D Okely

Published article from Chapter 4:

Tonge, K.L., Jones, R.A & Okely, A.D. (2019). Quality Interactions in Early Childhood Education and Care Center Outdoor Environments. *Early Childhood Education Journal. 47*(1): 31-41.

I attest that Karen Louise Tonge contributed to the above paper. KLT contributed to designing the research, conducted the research, analysed data and wrote the paper. RAJ contributed to designing the research, analysed data and edited the manuscript. ADO contributed to designing the research and edited the manuscript. All authors read and approved the final manuscript.



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Rachel A Jones

Anthony D Okely

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Rachel A Jones

Anthony D Okely

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Rachel A Jones

Anthony D Okely

8.2 Appendix B. Published article: Correlates of children's objectively measured physical activity and sedentary behavior in early childhood education and care services: A systematic review.

Tonge, K.L., Jones, R.A & Okely, A.D. (2016). Correlates of children's objectively measured physical activity and sedentary behavior in early childhood education and care services: A systematic review. *Preventive medicine 89*: 129-139.

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Correlates of children's objectively measured physical activity and sedentary behavior in early childhood education and care services: A systematic review

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ABSTRACT

Objective. To systematically review the correlates of physical activity and sedentary behavior among children in Early Childhood Education and Care (ECEC) services. Appropriate levels of physical activity and sedentary behavior are important to promote in ECEC services.

Methods. A systematic search of 8 databases identified 27 studies published between 1992 and 2015 that met the inclusion criteria. The data were collected and analyzed in 2014 and 2015, and variables were categorized using a Social Ecological Framework.

Results. Sixty-six variables were identified. The domains of child characteristics (18 studies) and physical environmental factors (17 studies) were most consistently studied, and, for physical activity had the most positive associations. The strongest associations of physical activity were: child's sex and age, children's gross motor co-ordination, provision of active opportunities for physical activity, and features of outdoor environments (size, use of and presence). The only strong association for sedentary behavior was the presence of outdoor environments.

Conclusion. The correlates of physical activity and sedentary behavior in ECEC services vary. It appears that the most significant influence from within these settings is the physical environments for both physical activity and sedentary behavior. There was an absence of consistent evidence at the educator and organizational levels. Further research in this area should focus on effective use of space, intentional teaching opportunities and well as professional development for educators with an emphasis on their role as a facilitator of quality experiences. This review has been registered with Prospero, #CRD42014013660.

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1. Introduction

Children's health and well-being are paramount to ensure optimum learning and development (DEEWR, 2009). Physical well-being allows children to be physically active and active children have improved blood pressure, cholesterol and bone density, emotional and cognitive development, self-esteem, and social interaction skills compared with less active children (Copeland et al., 2012; Timmons et al., 2012; Lewicka and Farrell, 2007). Active experiences support children to become 'physically literate', which is the foundation of physical activity experiences for later years (Maude, 2008).

The period of early childhood (birth to 5 years) is critical for establishing health, well-being and healthy behaviors (Ward et al., 2010). It is a time of rapid growth in young children, including significant brain development (Shonkoff, 2014), physical and social development, as well as the formation of behavior patterns. It is a time of significant opportunity, yet one of considerable risks, and that quality experiences are crucial as an investment in children's health and well-being (Shonkoff, 2014). Social and physical environments have an important influence (Brown et al., 2009), and quality experiences provide opportunities for children to learn from significant others, as well as practice skills that will lead to better immediate and long term health and education outcomes (Shonkoff, 2014; Melhuish et al., 2008).

The nature and scale of Early Childhood Education and Care (ECEC) services have changed dramatically in most developed countries in the last two decades according to the OECD (Organization for Economic Co-operation and Development). In western Europe for example there has been an increase in children attending ECEC from 20% to 90% over a 15–20 year period from 1994 to 2014 (OECD, 2014). With enrollment rates high, the ability of ECEC service programs to influence many children's learning, development and behaviors in a way that will promote good health across their life spans (Ward et al., 2009) is significant. ECEC services can provide social and physical environments that support quality experiences, learning and development through offering structured and unstructured experiences (Ward et al., 2010), including physical activity experiences. A number of physical activity interventions that have focused on modifying the social and physical environment have been implemented in ECEC services (Gordon et al., 2013), however, results have been inconsistent. For example Cardon et al. (2008) reported no significant changes in physical activity levels following implementation of an intervention that focus on the physical environment, while Hannon and Brown (2008) reported significant changes in light-, moderate- and vigorous-intensity physical activity following their intervention that also focused on modifications to the physical environment. Recommendations from recent reviews (Gordon et al., 2013) suggest that further understanding of the ECEC environment and factors in these services that influence physical activity and sedentary behavior is required.

Reviews have addressed the correlates of children's physical activity (Hinkley et al., 2008) and sedentary behavior (Hinkley et al., 2010), yet to the best of our knowledge, no reviews have specifically identified correlates within ECEC services. Identifying influences on physical activity and sedentary behavior in ECEC services is particularly important for the development of evidence-guided programs and interventions (Hinkley et al., 2008). Therefore the aim of this systematic review was to identify these influences. Consistent with other reviews of correlates of physical activity in children and adults (Ridgers et al., 2012; Hinkley et al., 2010; Hinkley et al., 2008; Sallis et al., 2000) a social ecological framework was used to scaffold the variables identified in this review. An ecological model will allow for the investigation of multidimensional factors that influence physical activity and sedentary behavior and the bidirectional relationships among these factors as well as the investigation of how factors at one level moderate the influence of factors from another level (Kearns, 2010).

2. Methods

The process and reporting of this review adhered to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement (Moher et al., 2009).

2.1. Search strategy

A literature search of papers was conducted in eight electronic databases - ERIC, SPORT Discus, MEDLINE, Education Research Complete, Scopus, A+ Education, PsychINFO and PubMed. The databases were searched from their creation until April 2015. The search was conducted using the search terms physical activity OR movement AND preschool OR childcare OR daycare OR nursery OR pre-K AND correlate OR factor OR influence OR predictor. A similar search was conducted for sedentary behavior and used the following terms sedentary behavior OR sitting AND preschool OR childcare OR daycare OR nursery OR pre-K AND correlate OR factor OR influence OR predictor. Duplicates from these searches were then removed (KT). Titles were then screened (KT, RJ, AO) and following this abstracts and full articles were reviewed (KT, RJ) and checked if there was a discrepancy (AO). Manual searches of reference lists were also completed, and experts in the field were consulted (KT). Data were collected and analyzed in 2014 and 2015. This extensive process of selection was similar to that described in a number of other systematic reviews (Ridgers et al., 2012; Hinkley et al., 2008; Sallis et al., 2000).

2.2. Inclusion and exclusion criteria

Papers were included if they: (1) were peer reviewed, written in English and available in full text, (2) included data from an ECEC service (birth-5 years) setting, and (3) were a quantitative study that used an objective measure (such as accelerometers or OSRAP) of physical activity and/or sedentary behaviors. Pilot and mixed methodology studies were included if they met these criteria. Studies that measured habitual physical activity were included if physical activity and sedentary behavior data during ECEC hours were reported separately. Intervention studies were excluded as the interventions did not report associations.

2.3. Data extraction and synthesis

Information extracted from each article included: the sample (age range of children, number of ECEC services, number of children), physical activity/sedentary behavior assessment and outcome (method(s) of data collection, level of physical activity and/or sedentary behavior assessed), and correlates of physical activity and sedentary behavior (e.g. boys were more active than girls, older children more active). Researchers (KT, RJ, AO) then categorized these correlates into the associated social ecological framework (Kearns, 2010) domain (Child, Educator, Physical Environmental and/or Organizational) (see Table 2). A variety of techniques were used in the selected papers to report variables including univariate, bivariate and multilevel analyses. Similar to another review (Ridgers et al., 2012), for analyses focused on correlates where multiple analytic models were reported, findings from the most advanced, fully-adjusted model were extracted (Hinkley et al., 2010).

All variables were recorded in the tables. Those that were reported a statistically significant ($p < 0.05$) association with physical activity and/or sedentary behavior were coded as + or −, depending on the association (column 3, Tables 3 and 4) and those that were not significant were recorded in column 4 Tables 3 and 4. The number of studies reporting the same association was tallied and then this 'tally' was converted to a percentage. Some studies reported multiple variables (such as child age in relation to indoor as well as outdoor environments). In these instances, the reference was included multiple times in the association column (Tables 3 & 4) and the specific variable measured indicated with a footnote (Ridgers et al., 2012). These codes were then analyzed and given a summary code for association (see Table 1) based upon the percentage of studies and the direction of the association. This method of coding has been used previously (Ridgers et al., 2012; Hinkley et al., 2008, 2010; Sallis et al., 2000).

3. Results

3.1. Summarizing the articles

A total of 3771 papers were retrieved with 27 studies meeting inclusion criteria (Fig. 1 & Table 2). More than half the studies (56%) were conducted in the U.S. (n = 15) (Pate et al., 2014; Stephens et al., 2014; Byun et al., 2013; Shen et al., 2013; Raustorp et al., 2012; Robinson et al., 2012; Nicaise et al., 2011; Dowda et al., 2009; Williams et al., 2008; Pate et al., 2008; Bower et al., 2008; Dowda et al., 2004; Pate et al., 2004; Trost et al., 2003; McKenzie et al., 1992), with the remaining conducted in Canada (n = 3) (Vanderloo et al., 2014; Vanderloo et al., 2013; Gagne and Harnois, 2013), Sweden (n = 3) (Raustorp et al., 2012; Pagels et al., 2011; Boldemann et al., 2006), Netherlands (n = 2) (Gubbels et al., 2012; Gubbels et al., 2011), Belgium (n = 2) (Van Cauwenberghe et al., 2012; Cardon et al., 2008), Denmark (n = 2) (Olesen et al., 2013; Grontved et al., 2009), and Australia (n = 1) (Sugiyama et al., 2011). One study collected data across countries – Sweden and the U.S (Raustorp et al., 2012). Physical activity and sedentary behaviors were assessed using accelerometers (n = 17) (Pate et al., 2014; Stephens et al., 2014; Vanderloo et al., 2014; Byun et al., 2013; Gagne and Harnois, 2013; Olesen et al., 2013; Shen et al., 2013; Vanderloo et al., 2013; Raustorp et al., 2012; Van Cauwenberghe et al., 2012; Pagels et al., 2011; Sugiyama et al., 2011; Dowda et al., 2009; Grontved et al., 2009; Williams et al., 2008; Pate et al., 2004; Trost et al., 2003), direct observation (OSRAP (n = 8) (Gubbels et al., 2012; Gubbels et al., 2011; Nicaise et al., 2011; Dowda et al., 2009; Pate et al., 2008; Bower et al., 2008; Dowda et al., 2004; Trost et al., 2003), BEACHES (n = 1) (McKenzie et al., 1992), SOFIT (n = 1) (Van Cauwenberghe et al., 2012)) and pedometers (n = 4) (Robinson et al., 2012; Pagels et al., 2011; Cardon et al., 2008; Boldemann et al., 2006). Five studies used multiple objective methods of measuring physical activity and sedentary behavior (Van Cauwenberghe et al., 2012; Pagels et al., 2011; Dowda et al., 2009; Trost et al., 2003; McKenzie et al., 1992), for example OSRAP as well as accelerometers (Trost et al., 2003). Of the 27 studies included, most (74%) reported moderate- to vigorous-intensity physical activity (MVPA) (Pate et al., 2014; Stephens et al., 2014; Vanderloo et al., 2014; Olesen et al., 2013; Shen et al., 2013; Vanderloo et al., 2013; Raustorp et al., 2012; Van Cauwenberghe et al., 2012; Nicaise et al., 2011; Pagels et al., 2011; Sugiyama et al., 2011; Dowda et al., 2009; Grontved et al., 2009; Bower et al., 2008; Pate et al., 2008; Williams et al., 2008; Dowda et al., 2004; Pate et al., 2004; Trost et al., 2003; McKenzie et al., 1992), and many (56%) reported total physical activity (TPA) (Pate et al., 2014; Vanderloo et al., 2014; Gagne and Harnois, 2013; Vanderloo et al., 2013; Gubbels et al., 2012; Robinson et al., 2012; Gubbels et al., 2011; Pagels et al., 2011; Bower et al., 2008; Cardon et al., 2008; Pate et al., 2008; Boldemann et al., 2006; Trost et al., 2003; McKenzie et al., 1992). Sedentary behavior was reported in thirteen studies (48%) (Vanderloo et al., 2014; Byun et al., 2013; Vanderloo et al., 2013; Raustorp et al., 2012; Nicaise et al., 2011; Pagels et al., 2011; Sugiyama et al., 2011; Dowda et al., 2009; Pate et al., 2008; Williams et al., 2008; Bower et al., 2008; Dowda et al., 2004; Pate et al., 2004 (Table 2).

Sixty-six physical activity and sedentary behavior correlates were identified (Tables 3 & 4), of which 13 were classified as child variables, ten classified as educator variables, 21 classified as physical environmental and 22 classified as organizational variables. Associations identified (Tables 3 & 4) reflect the relationship between the correlate and children's total physical activity (light, moderate and vigorous) and sedentary time while in the ECEC service, within a range of environments (indoor, outdoor, structured, unstructured), unless noted otherwise.

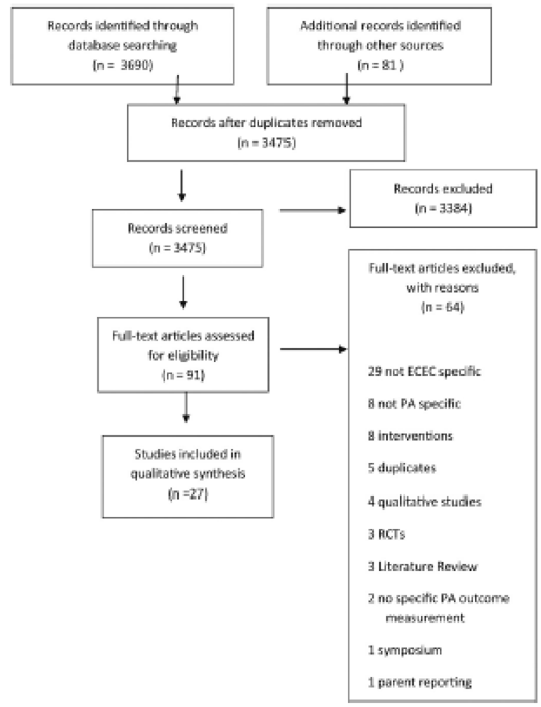

Fig. 1. Flow diagram of search results.

Table 1
Rules for classifying variables regarding strength of association with children's physical activity and sedentary behavior in ECEC services.

Studies supporting association (%)	Summary code	Explanation of code
0–33	0	No association
34–59	?	Indeterminate/inconclusive association
60–100	+	Positive association
60–100	−	Negative association

Note: When an outcome was studied four or more times, it was coded as: 00 (no association); ?? (indeterminate); ++ (positive association); or −− (negative association).

Table 2
Summary of included articles.

Author, date, location	Sample	Physical activity/sedentary behavior assessment and outcome	Correlates of physical activity identified	Social Ecological Framework Domain Association
Boldemann, Blennow, Dal, Martensson, Raustorp, Yuen & Wester, 2006 Sweden	4–6 year olds 11 preschools 197 children	Pedometers (Yamax Digiwalker SW-200) Step count TPA	Environments with more natural features Boys more active than girls Older boys more active	Child Educator Physical Environmental Organizational
Bower, Hales, Tate, Rubin, Benjamin & Ward, 2008 U.S.	3–5 year olds 20 child care centres	OSRAP TPA, sedentary & MVPA	Supportive environments – higher EPAO scores	Educator Physical Environmental Organizational
Byun, Blair & Pate, 2013 US	4 year olds 17 preschools 331 children	Actigraph accelerometers Activity intensity Sedentary	Montessori preschools – less sedentary behavior.	Child Organizational
Cardon, Van Cauwenberghe, Labarque, Haerens & De Bourdeaudhuij, 2008 Belgium	4 & 5 year olds 39 preschools 783 children	Pedometers Step count TPA	Boys more active than girls Less children per m^2 Shorter recess Hard surface for boys Less teachers present for girls	Educator Physical Environmental Organizational
Dowda, Brown, McIver, Pfieffer, O'Neill, Addy & Pate, 2009 US	3–5 year old 20 preschools 299 children	OSRAP Accelerometry MVPA, sedentary	Higher quality Less fixed equipment More portable equipment Less use of IT Larger playgrounds	Educator Physical Environmental Organizational
Dowda, Pate, Trost, Almeida & Sirard, 2004 US	3–5 year old 9 preschools 266 children	OSRAP MVPA, sedentary	Field trips College educated teachers Quality of service	Educator Organizational
Gagne & Harnois, 2013 Canada	20 centers 242 children	Accelerometer TPA	Educator intention Descriptive norm Democratic intervention Educator's age Resources available Age Sex	Child Educator Physical Environmental
Grontved, Pederson, Anderson, Kristensen, Moller & Froberg 2009 Denmark	3–6 year old 6 preschools 190 children	Actigraph Accelerometer TPA, MVPA	Boys more active than girls Older children more active Preschool attended	Child Organizational
Gubbels, Kremers, van Kann, Stafleu, Candel, Dagnelie, Thijs & de Vris, 2011 Netherlands	2 & 3 year old 9 centers 175 children	OSRAC-P TPA	Staff behavior Group size Positive prompts by educators	Child Educator Physical Environmental Organizational
Gubbels, Van Kann & Jansen, 2012 Netherlands	2 & 3 year old 9 centers 175 children	OSRAC-P TPA	Outdoor environment Portable jumping equipment Structured track Older chn more active Less PA with: Portable slides, fixed swinging equipment & sandboxes	Child Physical Environmental
McKenzie, Sallis, Nader, Broyles, & Nelson, 1992 US	4 year old 63 preschools 351 children	BEACHES direct observation UNIQ heart watch (for validation of observation) TPA, MVPA	Anglo compared to Mexican-American Boys more active than girls	Child Physical Environmental
Nicaise, Kahan & Sallis, 2011 US	4 & 5 year olds 51 children	OSRAC-P MVPA, sedentary	Boys more active Children with normal weight more active	Child Educator Physical Environmental
Olesen, Kristensen, Korsholm & Froberg, 2013 Denmark	5 & 6 year olds 42 preschools 426 children	Actigraph accelerometers MVPA	Motor coordination Location of building Sex Afternoon play Size of indoor play area per child Less PA: Preterm birth, vegetation on playground, rain	Child Educator Physical Environmental Organizational
Pagels, Boldemann & Raustorp, 2011 Sweden	3–5 year olds 4 preschools 55 children	Actigraph Accelerometers Pedometers Sedentary, LPA, MPA, MVPA, TPA	Age Boys more active	Child
Pate, O'Neill, Byun, McIver, Dowda & Brown, 2014 US	4 year old 17 preschools 301 children	Actigraph Accelerometry LPA, MVPA, TPA	Preschool attended Boys more active than girls	Child Organizational
Pate, McIver, Dowda, Brown & Addy, 2008	3–5 year olds 24 preschools	OSRAC-P	Boys more active than girls 3 yr old boys more active than	Child

Table 2 (continued)

Author, date, location	Sample	Physical activity/sedentary behavior assessment and outcome	Correlates of physical activity identified	Social Ecological Framework Domain Association
US	493 children	Sedentary, LPA, MVPA, TPA	4–5yr olds Preschool attended	
Pate, Pfieffer, Trost, Ziegler & Dowda, 2004 US	3–5 year old children 9 preschools 281 children	Actigraph accelerometer Sedentary, LPA, MVPA, VPA	Preschool attended Boys more active than girls Black chn more VPA	Child
Raustorp, Pagels, Boldemann, Cosco, Soderstrom & Martensson, 2012 US & Sweden	3–5 year olds 4 preschools 50 children	Actigraph Accelerometer LPA, MVPA, sedentary	Outdoors more active Sedentary greater indoors	Physical Environmental Organizational
Robinson, Wadsworth & Peoples, 2012 US	34 children	Pedometers TPA	Locomotor skills	Child
Shen, Alexander, Milberger & Jen, 2013 US	3–5 years 2 preschools 46 children	Actigraph accelerometer LPA, LMVPA, MPA, VPA	Season has no influence on PA	Physical Environmental
Stephens, Xu, Lesesne, Dunn, Kakietek, Jernigan & Khan, 2014 US	2yr, 10mth – 5yr, 11mth 110 centers 1352 children	Actigraph accelerometer MVPA	Boys more active than girls Outdoor play space Non-Hispanic black children more MVPA than Hispanic	Child Physical Environmental
Sugiyama, Okely, Masters & Moore, 2011 Australia	3–5 years old 10 child care centers	Actigraph accelerometer MVPA, sedentary	Lower staff: child ratios Indoors for PA increased MVPA and less sedentary Fixed play equipment more MVPA, less sedentary	Educator Physical Environmental Organizational
Trost, Sirard, Dowda, Pfieffer & Pate, 2003 US	3–5 year old children 9 preschools 245 children	OSRAP Accelerometer TPA, MVPA, VPA	Overweight boys less active	Child
Van Cauwenberghe, De Bourdeaudhuij, Maes & Cardon, 2012 Belgium	35 preschools 573 children	Actigraph accelerometers SOFIT MVPA	Less knowledge content Less promotion Less management Less preschoolers per space Obstruction material Not using throwing equipment	Child Educator Physical Environmental Organizational
Vanderloo, Tucker, Johnson, van Zandvoort, Burke & Irwin, 2014 Canada	5 preschools 31 children	Actical Accelerometers Sedentary, MVPA, TPA	Portable equipment Staff behavior	Educator Physical Environmental Organizational
Vanderloo, Tucker, Johnson, & Holmes, 2013 Canada	13 preschools 31 children	Actical Accelerometers Sedentary, MVPA, TPA	Outdoors	Physical Environmental
Williams, Pfieffer, O'Neill, Dowda, McIver, Brown & Pate, 2008 US	3 & 4 year olds 22 preschools 198 children	Actigraph accelerometer Sedentary, LPA, MVPA, VPA	Locomotor skills	Child

LPA – light physical activity; LMPA – light to moderate physical activity; MPA – moderate physical activity; MVPA – moderate to vigorous physical activity; TPA – total physical activity; OSRAP – Observation system for recording activity in preschools; BEACHES – Behaviors of Eating and Activity for Children's Health Evaluation System ; SOFIT – System for observing fitness instruction time; OSRAC-P – Observational system for recording physical activity in children-preschool.
Note: When a Variable had no association with a SEF domain, the SEF domain was not listed.

3.2. Summarizing the outcome findings

3.2.1. Child variables

Nine child correlates were identified (Tables 3 & 4). The most frequent individual correlate reported was sex (n = 18), with boys being more physically active than girls. Strong positive associations (4 or more studies) with children's physical activity in ECEC services were found for age and motor coordination, older children were more active than younger children (6 out of 9 studies) (Gagne and Harnois, 2013; Gubbels et al., 2012; Gubbels et al., 2011; Pagels et al., 2011; Grontved et al., 2009; Boldemann et al., 2006 and better motor coordination was positively related to physical activity (3 out of 4 studies) (Olesen et al., 2013; Robinson et al., 2012; Williams et al., 2008).

3.2.2. Educator variables

Educator variables included individual characteristics such as qualifications, training, attitudes and practices.

Of the 27 studies, educator variables were the least studied. Eight variables were reported from 13 references (Tables 3 & 4). Of the variables identified, none reported a strong association, and only educator behaviors (i.e., prompts and feedback (Vanderloo et al., 2014; Gagne and Harnois, 2013; Van Cauwenberghe et al., 2012; Gubbels et al., 2011; Dowda et al., 2009; Bower et al., 2008; Boldemann et al., 2006)), educator qualification and training (Van Cauwenberghe et al., 2012; Nicaise et al., 2011; Sugiyama et al., 2011; Dowda et al., 2009; Bower et al., 2008; Cardon et al., 2008; Dowda et al., 2004) and educator presence (Gubbels et al., 2011; Nicaise et al., 2011; Sugiyama et al., 2011; Cardon et al., 2008) were reported four or more times, all with inconclusive results.

3.2.3. Physical environmental variables

Physical environmental variables were the most frequently reported domain of children's physical activity and sedentary behavior in ECEC services, with 12 variables identified (Tables 3 & 4). Strong positive associations were reported between physical activity and outdoor environments (e.g., the opportunities for children to play in these) and the size of the play space. Outdoor environments were associated with increased children's physical activity in six of the seven studies (Stephens et al., 2014; Vanderloo et al., 2013(4 variables); Raustorp et al., 2012), and reduced sedentary behavior in three of the four studies

Table 3
Summary of reported correlates – physical activity.

Correlate	Found association with children's physical activity in ECEC service (reference)	Association (±)	Found no association with children's physical activity in ECEC service (reference)	Summary coding for row (n/N for row; %)	Summary code for association (−/+)
CHILD VARIABLES					
Age of child	(Older) Gagne & Harnois, 2013, Gubbels et al., 2012, Pagels et al., 2011, Gubbels et al., 2011[a], Grontved et al., 2009, Boldemann et al., 2006 (Younger) Stephens et al., 2014[a], Shen et al., 2013	+	Olesen et al., 2013, Gubbels et al., 2011[d], Pate et al., 2004[u]	8/11 (73)	++
BMI/adiposity	Robinson et al., 2012, Nicaise et al., 2011, Trost et al., 2003[f]	−	Byun et al., 2013, Olesen et al., 2013, Trost et al., 2003[g]	3/6 (50)	??
Motor coordination	Olesen et al., 2013, Robinson et al., 2012, Williams et al., 2008	+	Williams et al., 2008[h]	3/4 (75)	++
Sex	Stephens et al., 2014[b], Pate et al., 2014, Byun et al., 2013, Gagne & Harnois, 2013, Olesen et al., 2013, Van Cauwenberghe et al., 2012[c], Nicaise et al., 2011, Pagels et al., 2011, Grontved et al., 2009, Pate et al., 2008, Pate et al., 2008[u], Boldemann et al., 2006, Pate et al., 2004[u], McKenzie et al., 1992	+	Robinson et al., 2012, Gubbels et al., 2011, Pate et al., 2008[a], Pate et al., 2004[a]	14/18 (78)	++
Born pre term	Olesen et al., 2013	−		1/1 (100)	−
Ethnicity	Stephens et al., 2014[b] Byun et al., 2013, Pate et al., 2004[c], McKenzie et al., 1992	+	Olesen et al., 2013 Pate et al., 2008[v], Pate et al., 2004[v]	4/7 (57)	??
Parent education	Olesen et al., 2013	+	Byun et al., 2013, Pate et al., 2008[w]	1/3 (33)	?
Attendance rates	Boldemann et al., 2006	+		1/1 (100)	+
Peer prompts (response to)	Gubbels et al., 2011[a]	+	Gubbels et al., 2011[d]	1/2 (50)	?
EDUCATOR VARIABLES					
Age of educator	Gagne & Harnois, 2013	+		1/1 (100)	+
Educator Influences					
Educator intention & belief	Gagne & Harnois, 2013	+		1/1 (100)	+
Educator confidence & enjoyment			Gagne & Harnois 2013, Olesen et al., 2013	0/2 (0)	0
Educator behaviors (prompts, feedback)	Gagne & Harnois, 2013, Gubbels et al., 2011, Boldemann et al., 2006 Van Cauwenberghwe et al., 2012	+ −	Vanderloo et al., 2014 Dowda et al., 2009[b] Bower et al., 2008	3/7 (43)	??
Educator qualifications & training	Van Cauwenberghe et al., 2012[a], Nicaise et al., 2011, Sugiyama et al., 2011 Van Cauwenberghe et al., 2012[b]	+ −	Dowda et al., 2009[b] Bower et al., 2008, Cardon et al., 2008 Dowda et al., 2004[b]	3/8 (38)	??
Social Environment					
Solitary environment	Nicaise et al., 2011	+		1/1 (100)	+
Peers present	Nicaise et al., 2011[c], Gubbels et al., 2011	+	Nicaise et al., 2011 (>1 peer), Gubbels et al., 2011[c]	2/4 (50)	??
Educator present	Gubbels et al., 2011[d], Sugiyama et al., 2011[b] Cardon et al., 2008[g]	+ −	Nicaise et al., 2011, Gubbels et al., 2011[a], Cardon et al., 2008[f]	2/6 (33)	00
PHYSICAL ENVIRONMENTAL VARIABLES					
Environment					
Sedentary items			Bower et al., 2008, Bower et al., 2008[b]	0/2 (0)	0
Indoor environments (relationship to physical activity)			Gagne et al., 2013, Vanderloo et al., 2013, Olesen et al., 2013	0/3 (0)	0
Outdoor environments (relationship to physical activity)	Raustorp et al., 2012[v], Stephens et al., 2014[b], Vanderloo et al., 2013, Vanderloo et al., 2013[b], Vanderloo et al., 2013[x], Vanderloo et al., 2013[g]	+	Vanderloo et al., 2013[y]	6/7 (86)	++
Size of play space (total area of the outdoor environment, m^2)	Dowda et al., 2009[b], Nicaise et al., 2011, Boldemann et al., 2006, Gubbels et al., 2011	+	Olesen et al., 2013, Sugiyama et al., 2011[b]	4/6 (67)	++
Natural features/surface	Nicaise et al., 2011, Olesen et al., 2013, Sugiyama et al., 2011[b]	+ −	Cardon et al., 2008, Sugiyama et al., 2011	2/5 (40)	??
Gradient	Olesen et al., 2013	+	Sugiyama et al., 2011	1/2 (50)	?
Shade			Sugiyama et al., 2011	0/1 (0)	0
Markings			Cardon et al., 2008	0/1 (0)	0
Equipment					
Portable equipment	Dowda et al., 2009, Nicaise et al., 2011[z], Vanderloo et al., 2014[b], Gubbels et al., 2012[m], Van Cauwenberghe et al., 2012[i], Van Cauwenberghe et al., 2012[j]	+ −	Bower et al., 2008, Bower et al., 2008[b], McKenzie et al., 1992, Gagne et al., 2013, Vanderloo et al., 2014, Cardon et al., 2008, Olesen et al., 2013	5/13 (38)	??

Table 3 (*continued*)

Correlate	Found association with children's physical activity in ECEC service (reference)	Association (±)	Found no association with children's physical activity in ECEC service (reference)	Summary coding for row (n/N for row; %)	Summary code for association (−/+)
Fixed equipment	Dowda et al., 2009[b], Nicaise et al., 2011, Gubbels et al., 2012[aa], Sugiyama et al., 2011[b] Vanderloo et al., 2014[b]	+ −	Bower et al., 2008, Bower et al., 2008[b], Vanderloo et al., 2014, Cardon et al., 2008, Olesen et al., 2013	4/10 (40)	??
Height of equipment			Cardon et al., 2008	0/1 (0)	0
Weather	Olesen et al., 2013	+	Shen et al., 2013	1/2 (50)	?
ORGANIZATIONAL VARIABLES					
Opportunities					
Active opportunities *(eg. recess, indoor space for PA)*	Bower et al., 2008 Bower et al., 2008[b], Cardon et al., 2008, Sugiyama et al., 2011[b]	+	Dowda et al., 2009[b]	4/5 (80)	++
Sedentary opportunities *(eg. sitting at group time)*			Bower et al., 2008, Bower et al., 2008[b], Vanderloo et al., 2014[b]	0/3 (0)	0
Physical activity policy			Bower et al., 2008, Bower et al., 2008[b], Olesen et al., 2013	0/3 (0)	0
Service Quality *(eg. EPAO, ECERS-R)*	Dowda et al., 2009[b], Bolemann et al., 2006, Gubbels et al., 2011	+	Bower et al., 2008, Bower et al., 2008[b], Dowda et al., 2004[b]	3/6 (50)	??
Preschool location	Raustorp et al., 2012[bb]	+	Raustorp et al., 2012[cc], Raustorp et al., 2012[dd], Raustorp et al., 2012[ee], Raustorp et al., 2012[ff], Grontved et al., 2009	1/6 (17)	0
Program Type					
Preschool type	Byun et al., 2013 (Montessori), Pate et al., 2014 (Montessori)	+	Byun et al., 2013 (private), Dowda et al., 2004[b], Olesen et al., 2013	2/5 (40)	??
Group size	Cardon et al., 2008 (child: educator ratio), Dowda et al., 2009, Van Cauwenberghe et al., 2012 (child: educator ratio)	+	Dowda 2009[b], Dowda et al., 2004[b], Olesen et al., 2013, Sugiyama et al., 2011	3/7 (43)	??
Field trips	Dowda et al., 2004[b]	+	Dowda et al., 2009[b], Olesen et al., 2013	1/3 (33)	0
Time spent outside			Dowda et al., 2009[b], Dowda et al., 2004[b], Olesen et al., 2013	0/3 (0)	0
Electronic media	Dowda et al., 2009[b]	−	Dowda et al., 2004, Olesen et al., 2013	1/3 (33)	0
Free time			Dowda et al., 2004	0/1 (0)	0

a-Light activity; b- MVPA; c- VPA; d- indoor; e- outdoor; f- boys; g- girls; h-3 yr olds; j-throwing equipment; k-equipment with wheels; l-obstruction equipment; m-riding toys; n-jumping; p-slides; q-structured track; r-sandbox; s-swinging equipment; t − 1 peer; u- MVPA & VPA; v-Light activity & MVPA; w-Light, MVPA & VPA; x-MVPA & boys; y-MVPA & girls; z-MVPA, throwing equipment & equipment with wheels; aa-jumping, slides, structured track, sandbox & swinging equipment; bb-Light activity & indoor; cc-MVPA & indoor; dd-MVPA & outdoor; ee-Light activity & outdoor; ff-boys & girls.

+ positive ass; ++ positive ass for 4 or more studies; − negative ass; 0 no ass; 00 no ass for 4 or more studies; ? indeterminate/inconclusive; ?? indeterminate/inconclusive for 4 or more studies.

Note: When no note is used, this refers to total Physical Activity (light, moderate and vigorous intensity).

Note: Some studies presented multiple variables within the results (such as child age in relation to indoor as well as outdoor environments). When this occurred the reference was counted multiple times in the association column and the specific variable(s) measured indicated with a footnote.

(Vanderloo et al., 2013 (2 variables); Pate et al., 2004). It was only with girls' MVPA that there was no association for both physical activity and sedentary behavior in outdoor environments (Vanderloo et al., 2013). The size of the play space was associated in four of the seven studies (Gubbels et al., 2011; Nicaise et al., 2011; Dowda et al., 2009; Boldemann et al., 2006) with larger play spaces (e.g., total area, m^2) related to higher levels of physical activity.

3.2.4. Organizational variables

Ten organizational variables were reported (Tables 3 & 4). Active opportunities, service quality (e.g., as rated by the EPAO, ECERS-R), preschool location and group size were all identified five or more times, with only active opportunities showing strong positive associations with children's physical activity, which included a shorter recess (play time) (Cardon et al., 2008). Policy was discussed in two studies (Olesen et al., 2013; Bower et al., 2008) both no association with physical activity or sedentary behavior was identified.

4. Discussion

This is the first known review that reports the correlates of physical activity and sedentary behavior in ECEC services. It is warranted given that the majority of children aged 3–5 years attend ECEC services (OECD, 2014) and ECEC services have a critical role in providing opportunities for children to be physically active. Similar to other reviews on children's physical activity and sedentary behavior, this review showed that correlates of children's physical activity and sedentary behavior with ECECs are multi-dimensional (Hinkley et al., 2010; Hinkley et al., 2008; Sallis et al., 2000). A greater number of physical activity correlates were identified compared with sedentary behavior correlates, and consistent with a review on correlates of physical activity during school recess time (Ridgers et al., 2012), the majority of variables identified in this review were at the child and physical environmental levels of the social ecological framework. Even though many variables were identified at the child level, this review has primarily focused on the more

Table 4
Summary of reported correlates – sedentary behavior.

Correlate	Found association with children's sedentary behavior in ECEC service (reference)	Association (±)	Found no association with children's sedentary behavior in ECEC service (reference)	Summary coding for row (n/N for row; %)	Summary code for association (−/+)
Child variables					
Age	Byun et al. (2013)	+		1/1 (100)	+
Sex	Byun et al. (2013)	+	Pate et al. (2008), Pate et al. (2004)	1/3 (33)	?
Ethnicity	Byun et al. (2013)	+	Pate et al. (2008), Pate et al. (2004)	1/3 (33)	?
Parent education			Byun et al. (2013), Pate et al. (2004)	0/2 (0)	0
Educator variables					
Educator training & qualifications			Bower et al. (2008), Dowda et al. (2009), Dowda et al. (2004), Sugiyama et al. (2011)	0/4 (0)	0
Educator behaviors			Bower et al. (2008), Dowda et al. (2009)	0/2 (0)	0
Physical environmental variables					
Environment					
Sedentary items			Bower et al. (2008)	0/1 (0)	0
Indoor environments			Vanderloo et al. (2013)	0/1(0)	0
Outdoor environments	Pate et al. (2004), Vanderloo et al. (2013), Vanderloo et al. (2014)[f]	−	Vanderloo et al. (2014)[g]	3/4 (75)	−
Size of play space (total area of the outdoor environment, m^2)	Dowda et al. (2009)	−	Sugiyama et al. (2011)	1/2 (50)	?
Natural features/surface			Sugiyama et al. (2011)	0/1 (0)	0
Gradient			Sugiyama et al. (2011)	0/1 (0)	0
Shade			Sugiyama et al. (2011)	0/1 (0)	0
Equipment					
Portable equipment	Dowda et al. (2009)	−	Bower et al. (2008)	1/2 (50)	?
Fixed equipment	Dowda et al. (2009) Sugiyama et al. (2011)	+ −	Bower et al. (2008)	1/3 (33)	0
Organizational/policy variables					
Opportunities					
Active opportunities (*e.g., recess, indoor space for PA*)	Bower et al. (2008), Sugiyama et al. (2011)	−	Dowda et al. (2009)	2/3 (66)	−
Sedentary opportunities (*e.g., sitting at group time*)			Bower et al. (2008)	0/1 (0)	0
Physical activity policy			Bower et al. (2008)	0/1 (0)	0
Service quality (*e.g., EPAO, ECERS-R*)	Dowda et al. (2009), Dowda et al. (2004)	−	Bower et al. (2008)	2/3 (66)	−
Preschool location	Raustorp et al. (2012)[d] (Sweden)	−	Raustorp et al. (2012)[e]	1/2 (50)	?
Program type					
Preschool type	Byun et al. (2013) (Montessori)	−		1/1 (100)	−
Group size			Dowda et al. (2009) (child: educator ratio), Dowda et al. (2004)	0/2 (0)	0
Field trips			Dowda et al. (2009), Dowda et al. (2004)	0/2 (0)	0
Time spent outside			Dowda et al. (2009), Dowda et al. (2004)	0/2 (0)	0
Electronic media	Dowda et al. (2009)	+	Dowda et al. (2004)	1/2 (50)	?
Free time			Dowda et al. (2004)	0/1 (0)	0

d- Indoor; e- Outdoor; f- Boys; g- Girls; + positive ass; − negative ass; 0 no ass; ? indeterminate/inconclusive.
When no note is used, this refers to total sedentary behavior.
Note: some studies presented multiple variables within the results (such as preschool location in relation to indoor as well as outdoor environments). When this occurred the reference was counted multiple times in the association column and the specific variable(s) measured indicated with a footnote.

modifiable influences of children's physical activity and sedentary behavior within an ECEC service, such as routines and opportunities for physical activity experiences. Discussions of child characteristics are abbreviated as the child variables have been addressed in other reviews (Timmons et al., 2012; Hinkley et al., 2008) and this systematic review primarily focuses on factors associated within ECEC services.

The child domain provided evidence that boys were active than girls, which is consistent with other reviews (Ridgers et al., 2012; Sallis et al., 2000), that older children were more active than younger children, as were children with better motor coordination. A reason for these results in an ECEC environment may be the programs and environments that are offered to children. Even though sex and age are not modifiable characteristics, it is important for programs and social and physical environments, which are modifiable aspects, to be designed to provide opportunities for all children to improve skills and increase physical activity. Given that educators within the ECEC environment are responsible for providing experiences for children, it is plausible to suggest that they may need to provide more intentional opportunities for children from the identified groups, such as for girls to engage in active play (Morgan et al., 2013), and programs and environments that engage younger children and children with less developed motor skills. These may increase children's motivation and involvement in physical activity, even at this young age.

Educators were included in this review as a specific domain as they are an important aspect of ECEC service pedagogy. Less than 50% (12 from 27) of the studies and only 12% (8 from 66) of the variables were in the educator domain and none of these reported strong associations with physical activity or sedentary behavior. Although educator variables were the least represented in the 27 studies in this review, several correlates were identified, including: educators being present (Gubbels et al., 2011; Nicaise et al., 2011; Sugiyama et al., 2011; Cardon et al., 2008) and educator training and qualifications (Van Cauwenberghe et al., 2012; Nicaise et al., 2011; Sugiyama et al., 2011; Dowda et al., 2009; Bower et al., 2008; Cardon et al., 2008; Dowda et al., 2004). While educator involvement, creativity during physically active play, and modeling have been suggested as strategies to promote children's physical activity and reduce sedentary behaviors (Tandon et al., 2015; Irwin et al., 2005), we found no studies in ECEC settings that assess these associations. Due to the few educator variables reported, it is difficult to draw conclusions in this domain and given the role of the educator within the ECEC environment, a greater number of studies investigating these variables are needed. Specifically, active involvement and engagement of educators are potentially important factors in increasing children's physical activity and reducing sedentary behaviors (Tandon et al., 2015; Hodges et al., 2013), as is evident in a study of home environments (Hesketh et al., 2014), which showed associations between the physical activity of mothers and their 4 year old children. In the absence of studies in this area in ECEC settings, this warrants further studies in the relationship between the physical activity and sedentary behaviors of educators and children.

In the physical environmental domain, this review presented two variables with strong positive associations - the presence of an outdoor environment and larger play spaces. Both were conducive to higher levels of physical activity and conversely outdoor environments were positively associated with reduced sedentary behaviors. Reasons for the presence of an outdoor environment influencing physical activity maybe that outdoor environments afford opportunities for children to engage in activities that may not be present within indoor settings, such as equipment more conducive to gross motor experiences, as well as varying surfaces and natural features that may promote more active play. This result is consistent with another study that indicated that the outdoor environment supports children's active play opportunities (Tandon et al., 2015) yet other studies conclude that the presence of outdoor environments for physical activity may not be as important as once thought, but rather it is the equipment available that had a more influential role (Dowda et al., 2009; Hannon and Brown, 2008; Alhassan et al., 2007). The reason that the size of the outdoor environment, such as larger play spaces has also reported a positive influence on increasing children's physical activity may be that access to spacious environments provide opportunities for children to move more freely and may result in the need for greater movement between experiences, an aspect of environmental design which is an area of ongoing research (Boldemann et al., 2006). Together, the presence of outdoor environments, and the influence of the size of these environments provide evidence of the significance of appropriately designed ECEC services and programs that offer sufficient opportunities for play in outdoor spaces (Sallis et al., 2000).

Interestingly, multiple aspects of the physical environmental domain presented either no association or an inconclusive result: sedentary items (e.g., the presence of TV, computers), natural features/surface (e.g., gardens, the type of surface), indoor environments, gradient (e.g., the presence of hills), shade, markings (e.g., bike tracks), portable equipment, fixed equipment, height of equipment and weather conditions. These inconclusive results may be due to the wide range of variables identified, and is in contrast to other reviews (Hodges et al., 2013; Dyment et al., 2009) that have suggested that these factors are important.

The organizational domain primarily found little to no association with physical activity or sedentary behavior. The only strong positive association with physical activity was the provision of active opportunities which included structured physical activity, the facilitation of a specific indoor space for physical activity and planned recess times (Shen et al., 2013; Dowda et al., 2009; Bower et al., 2008; Cardon et al., 2008). Reasons for this could be the range of variables presented in this domain, and the variability within each, such as specific aspects of the program including field trips, preschool type, group size, and the use of electronic media. As discussed, in the physical environmental domain the greatest physical activity occurs outside (Van Cauwenberghe et al., 2012; Pate et al., 2004) however the findings in the organizational domain show that the way an indoor environment is used has been shown to be related to physical activity (such as having a specific space for physical activity) (Sugiyama et al., 2011). Therefore to maximize opportunities for increasing physical activity and reducing sedentary behavior, it is important for educators also to consider how they can most effectively use the inside environment for physical activity and reducing sedentary behavior. Reducing children's sitting time inside (Sugiyama et al., 2011) and incorporating more movement activities (Archer and Siraj, 2014) into learning experiences are modifiable aspects of ECEC services and may have positive benefits for children's physical activity.

It is interesting to note that in the organizational domain, the actual period of time spent outside has no association with children's physical activity and in particular with children's MVPA (Dowda et al., 2004, 2009).This is important for the ECEC sector as it appears to be the quality, rather than the quantity of the play time that is significant. This view is supported by another study that reports that additional outdoor playtime is inversely related to children's physical activity levels (Alhassan et al., 2007). Consistent with another study (Sallis et al., 2000), the findings related to opportunities for physical activity validate the need for well-designed, intentional environments and programs to support physical activity, and also align with a qualitative study (Tucker et al., 2011) which suggests educators felt that additional training and resources were key areas to increase children's physical activity and reduce sedentary behaviors. Providing these opportunities should be a goal of directors, educators and policy developers. Adopting written policies, in conjunction with existing programs that support frameworks and curriculum may increase children's daily physical activity and the attainment of daily recommendations.

4.1. Strengths & limitations

This review has a number of strengths: (1) alignment with the PRISMA statement for reporting systematic reviews (Moher et al., 2009) thereby providing precision and structure; (2) reviews studies that used objective measures of physical activity and sedentary behavior; (3) included correlates that have not been specifically studied before in ECEC settings; and (4) follows a social ecological framework, which provided a clear organization of the reporting and analysis, relevant to an ECEC service.

However the results of this review should be considered in light of a number of limitations, including: (1) there were only a small number of studies for some variables. Of significance is that less than a third of the variables identified were investigated four or more times and less than 30% of the studies examined correlates across all levels of the model simultaneously, (2) most of the studies were from the U.S and therefore may limit the generalizability of the results, (3) the search was limited to studies in the English language, (4) the studies reviewed included varied in sample size (2–63 ECEC services and 34–783 children) and methodologies (although all used an objective measure of physical activity and/or sedentary behavior), which may potentially impact the heterogeneity of the estimates, and the likelihood of biases in the overall conclusion. This variability seen in the papers reviewed is similar to previous reviews (Hodges et al., 2013; Ridgers et al., 2012) and is expected given the diversity within the ECEC sector. Furthermore, the range of methods of assessing physical activity and sedentary behavior may have influenced the associations identified, which is consistent with other reviews (Hodges et al., 2013; Ridgers et al., 2012; Hinkley et al., 2010). It is crucial that future studies focus on consistently using the most objective measures of physical activity and sedentary behavior to increase comparability of study results, (5) the social ecological framework is a complex framework and the potential interactions between the various domains may have consequences on the outcome measures (investigating such interactions was beyond the scope of this review), and (6) some variables explored have presented conflicting positive and negative associations (for example Educator Behaviors in Table 3), this is not factored into the coding approach adopted. An alternate approach to 'tallying' the scores may be more appropriate in future reviews.

5. Conclusion

The early years are a significant time for children, and ECEC services are in a crucial position to promote and encourage learning and development, as well as healthy behaviors (Riethmuller et al., 2010). This systematic review explored the correlates of physical activity and sedentary behavior in ECEC services.

In summary, this review shows that the influences upon children's physical activity and sedentary behavior in ECEC settings are multidimensional. Educators have a critical role in promoting physical activity and reducing sedentary time, and have opportunities to support children's activity levels across many of the domains in the social ecological framework. This review will inform ECEC practice as it highlights capacities for increasing physical activity, such as the effective use of space, time and intentional teaching opportunities. Professional development for educators that focuses on these aspects within an ECEC service, as well as an emphasis on their role as a facilitator/educator of quality experiences is warranted. Further research and intervention is needed to ensure children have access to rich environments, knowledgeable and involved educators, as well as quality interventions and programs that are most conducive to engaging children in levels of physical activity for health and well-being in early childhood and beyond.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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Transparency document

The Transparency document associated with this article can be found, in online version.

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8.3 Appendix C. Published article: Educator engagement and interaction and children's physical activity in early childhood education and care settings: an observational study protocol.

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BMJ Open

Educator engagement and interaction and children's physical activity in early childhood education and care settings: an observational study protocol

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ABSTRACT

Introduction: The benefits of regular physical activity for children are significant. Previous research has addressed the quantity and quality of children's physical activity while in early childhood education and care (ECEC) settings, yet little research has investigated the social and physical environmental influences on physical activity in these settings. The outcomes of this study will be to measure these social and physical environmental influences on children's physical activity using a combination of a real-time location system (RTLS) (a closed system that tracks the location of movement of participants via readers and tags), accelerometry and direct observation.

Methods and analysis: This study is the first of its kind to combine RTLSs and accelerometer data in ECEC settings. It is a cross-sectional study involving ~100 educators and 500 children from 11 ECEC settings in the Illawarra region of New South Wales, Australia. A RTLS and Actigraph GT3X+ accelerometers will be concurrently used to measure the level and location of the children's and educators' physical activity while in outside environments. Children and educators will wear accelerometers on their hip that record triaxial acceleration data at 100 Hz. Children and educators will also wear a tag watch on their wrist that transmits a signal to anchors of the RTLS and the triangulation of signals will identify their specific location. In addition to these, up to three random periods (10–25 min in length) will be used to collect observational data each day and assessed with the classroom assessment and scoring system to measure the quality of interactions. In conjunction with the real-time location system (RTLS) and accelerometers, these observations will measure the relationship between the quality of interactions and children's physical activity.

Ethics and dissemination: The results of this study will be disseminated through peer-reviewed publications and presentations. Ethical approval was obtained through the University of Wollongong Human Research Ethics Committee (HE14/330).

Strengths and limitations of this study

- The combined use of a Real Time Location System and accelerometry is an innovative and novel approach to measuring the child, educator and physical environmental influences on children's physical activity in Early Childhood Education and Care settings.
- The use of the Classroom Assessment and Scoring System solely in outdoor environments of Early Childhood Education and Care settings is unique to this study.
- The design will collect data from a large sample size and from multiple sources, which will allow for a comprehensive analysis of social and physical environmental variables that influence children's physical activity in Early Childhood Education and Care settings.
- The study is in a specialized environment and each setting has an individual design, so consideration for establishing the best possible placement of the Real Time Location System anchor readers is essential in each setting.
- As the study relies on the synchronised use of accelerometers and location watches, it is crucial that each individual monitor is identified accurately for each participant to ensure information can be cross-checked.

INTRODUCTION

The period of early childhood is critical for learning and development.[1] Children's health and well-being are paramount and contribute to their ability to concentrate, cooperate and learn.[2] More specifically, appropriate levels of physical health allow children to be physically active, which in turn is associated with improved blood pressure, cholesterol and bone density, as well as a number of social and emotional benefits such as enhanced self-esteem and social interaction skills.[3–5] Research also shows that physical activity patterns in early childhood track into childhood, providing longer term health benefits.[6] Despite the known benefits of physical activity for young children, compliance with recommended physical activity guidelines within early childhood education and care (ECEC) settings (15 min per hour[7]) for children aged 3–5 years is low,[8 9] highlighting the need to identify the specific influences on children's physical activity in these settings.

ECEC settings provide opportunities for children's learning and development and have the potential to offer quality physical activity experiences.[10 11] Children's physical activity and sedentary behaviour in ECEC settings are influenced by a number of factors, including child characteristics and the physical environment of the ECEC setting.[12 13] Evidence shows that physical environmental factors such as the availability of an outdoor environment, natural ground coverings and the size of the playspace (larger spaces related to greater levels of physical activity) have a positive influence on children's physical activity in ECEC settings, as do the presence of natural features and portable equipment such as gardens and bikes.[12 14] Furthermore, evidence also shows that the presence of fixed equipment, such as a sandpit, has an adverse effect on levels of physical activity.[12] As the physical environment is a key indicator of children's physical activity in ECEC settings,[12] it is important that all potential influences from the physical environment are considered. Child and educator activity and movement around the physical environment may be influenced by social factors such as educator and peer presence and interaction, as well as physical factors, such as the amount and quality of the resources and equipment offered. To better understand these influences, it is important to identify social and physical 'hot spots' (locations that are predominant areas for the selected activity), intensity, type and duration of physical activity, as well as the movement of educators and children around the environment. Importantly, the location of children and educators' physical activity in relation to social and physical environmental contexts is an aspect that has not been studied in ECEC settings before.

The adult role is critical in providing quality opportunities for a child's learning.[15] Evidence shows that a quality relationship between children and educators enhances children's motivation, engagement and performance in the learning experience,[16] as well as their willingness to explore the environment.[17 18] The importance of significant educator relationships for children in ECEC settings is well documented.[15 19] For example, the positive outcomes of quality educator/child interactions for children at risk[16] and the significance of children's engagement with educators for the development of secure attachments.[20] However, few studies have investigated the relationship between educator's physical activity and children's physical activity, as well as the influence of interactions on physical activity. Studies until now have been qualitative in nature with small sample sizes,[21 22] and no studies have used objective measures. Moreover, as very little is known about the physical activity of educators, it is yet to be determined whether and how the physical activity of an educator affects the physical activity of children. This study will address these gaps using objective measurements of physical activity levels alongside the identification of social and physical environmental location of physical activity. In addition to these, the use of an observation tool (classroom assessment scoring system, CLASS) will assess the quality of interactions between educators and children and also provide an opportunity to measure the relationship between the quality of interactions and levels of children's physical activity.

In recent years, a number of commercial location identification systems (eg, Global Positioning Systems (GPS) and radio frequency tracking devices) have been developed and used in studying the location and movements of participants around an area.[23–27] Until now, however, only a handful of studies have combined location identification systems and objective measures of physical activity such as accelerometry. For example, GPS and accelerometers have been used together to measure location and physical activity levels of older children in neighbourhoods, parks and playgrounds.[23–26] Among adults, the 'Active Buildings' study[27] used a combination of a radio frequency tracking device (OpenBeacon TagPRO) and accelerometers to investigate associations between office layout and physical activity. These studies have demonstrated that social and physical environmental factors have a positive effect on the type and duration of physical activity. No studies have used a combination of such measures within ECEC settings. The innovative use of the tracking identification system in this study, in combination with the objective measure of physical activity, will allow specific identification of the social and physical environmental influences that promote or hinder physical activity levels for children and educators within ECEC settings.

Study aim

The combination of a real-time location system (RTLS), accelerometry and direct observation will provide a study design that will address research questions that can only be resolved with the synchronised use of these measures. Thus, the aim of this study of children's and educator's physical activity in an ECEC outdoor environment is twofold: (1) to examine the engagement and interaction between educators and children and how the quality of these interactions may influence physical activity; (2) to determine whether there are physical activity 'hot spots' in the social and physical environmental outdoor environment within ECEC settings, and where they are.

This study will aim to address the following research questions:

- What are the levels of educator physical activity in ECEC settings and how does this influence the activity in children?
- How does the quality of the educator's interactions influence children's physical activity?
- How do ECEC setting characteristics influence the educator and children's physical activity?
- Are there social 'hot spots' in an ECEC outdoor environment where children and educators participate in physical activity levels, and where are they?
- Are there physical environmental 'hot spots' in an ECEC outdoor environment where children and educators participate in physical activity levels, and where are they?

METHODS AND ANALYSIS

Study design

This cross-sectional study will combine a number of data collection methods (figure 1). A cross-sectional design was chosen as it will enable the researchers to capture descriptive data on a number of variables in a short time frame (one time point only) in ECEC settings. It will use the most objective methods available to measure the physical activity and location of children and educators in ECEC outdoor environments.

Setting and participants

During 2015/2016, ECEC services in the Illawarra region of New South Wales, Australia, within a 2 hour driving radius from the University of Wollongong will be recruited. Services invited to participate in the study will enrol children aged 2–5 years and have access to outdoor play spaces which will be separate from other play spaces for younger children. All children aged 2–5 years enrolled in the service and their educators will be invited to participate in the study. Data will be collected over five consecutive days in each service. Each morning, the project team members will fit the accelerometers and RTLS wrist tags on the children and educators, and they will be encouraged to wear them for the duration of the day. In the case of an unexpected event, and/or adverse weather that may lead to atypical practice or where children are not present in the outdoor environment, another data collection day will be scheduled.

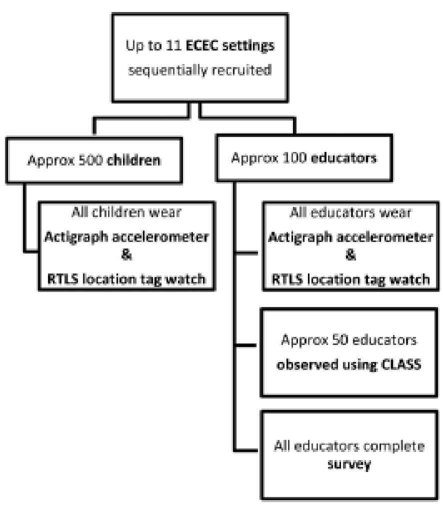

Figure 1 Study design. CLASS, classroom assessment scoring system; ECEC, early childhood education and care; RTLS, real-time location system.

ECEC settings in Australia provide care and education for young children prior to school. Attendance is not compulsory, and the number and sequence of days, as well as the time of attendance each day, is not prescribed. A typical pattern of enrolment for children aged 2–5 years is 2 or 3 days per week, for 6–8 hours each day. Just as ECEC attendance may vary, so do the ECEC environments, routines and programmes within each setting. For example, some settings provide free-flowing play for children between indoor and outdoor environments, whereas other settings provide distinct times for inside and outside play. This study will include a mix of settings to ensure that the data are representative of the ECEC sector. The diversity of settings will be taken into consideration when data are collected, with the time and timing of the data collection period specific to each setting.

Information about the study will be presented to educators and families at staff and parent meetings and will also be available on the participant information sheets. Consent will be gathered by the researcher prior to data collection, and parents and carers will be asked to provide child consent. Ethical approval was obtained through the University of Wollongong Human Research Ethics Committee (HE14/330).

Study size

As the aim of the study is to examine the physical activity and location of children as well as educators in an outdoor ECEC setting, it is important to recruit enough educators to investigate the relationships at a centre level. Much of the analysis will be descriptive; however, we would expect a moderate correlation of 0.3 between the physical activity levels of educators and children. For this correlation to be significant (α=0.05 and power=0.80), 85 educators are needed. To allow for clustering at the ECEC level and based on an intraclass correlation of 0.01 and an average cluster size of 10, ~100 educators will be targeted. To recruit 100 educators, up to 11 services will be approached, on the basis of each ECEC service employing between 6 and 15 educators. The number of children at each service ranges between 20 and 90, and so 11 services will provide ~500 children, which is a sufficient number of child participants for the study.

Measurement instruments

To investigate the children and educator's location and movements around the ECEC setting, a location tracking identification system (RTLS) will be used. Actigraph accelerometers will measure the amount and intensity of physical activity of the children and educators. Each accelerometer will be paired with an RTLS wrist tag as a uniquely coded set. As a set, they will be stored in a coded bag and fitted and removed simultaneously to ensure that they are matched at all times. A master sheet will record the unique code for each participant. The quality of the interaction between the children and educators will be assessed using the CLASS observation tool. Information about organisational policies, procedures and professional development related to children's physical activity will be collected through surveys. These data methods will be combined to determine the social and physical environmental 'hot spots' for children and educators' physical activity, the quality of educator and child interactions and the influence on physical activity, levels of educator physical activity, the influence of ECEC setting characteristics on physical activity and the organisational processes that support educator practices and professional development in relation to children's physical activity.

Real-time location system

Educators' and children's locations and movements within the ECEC outdoor environment will be measured using an RTLS (Convergence Systems Limited, Hong Kong), which collects data using radio frequency signals. Data are triangulated from the wristwatch tags (figure 2A) that are worn by each participant to the anchor readers (figure 2B) (which are distributed evenly around the perimeter of the outdoor ECEC environment). One of the anchor readers is the master anchor which consolidates all the collected data on an attached laptop computer. The wristwatch tags are lightweight (52 mm diameter×14 mm thick, 35 g), dust and water proof and have a frequency range of 902—928 MHz. Anchor readers (29 cm×21 cm×8 cm, 1.5 kg) will be positioned in all corners and recesses of the outdoor environment. To ensure that no anchor is more than 10 m apart, the anchor readers will also be placed along the perimeter of the environment to ensure even spacing throughout, particularly in large outdoor spaces. The position of the anchors will be ECEC-specific and will be tailored to each ECEC setting's outdoor environment (figure 3). Anchor readers will be secured to a wall bracket, placed on a tripod or suspended from a secure location (2 m from the ground). Children's outdoor activities will not be hindered as a result of the positioning of the anchor readers.

All anchor readers will be set up prior to the children arriving at the ECEC setting. Each morning, children and educators will be fitted with a wristwatch and will be asked to wear it for the duration of their time at the ECEC setting for that day. Wearing of these wristwatches will be monitored throughout the day to ensure compliance, and all wristwatches will be collected at the end of the day.

The RTLS data are collected and measured as a 'range' from at least three anchor readers. This can be viewed live or recorded as a 'Data Pack'. One or more tags can be viewed at a time and can be viewed as a movement track over a period of time around the designated 'cell' area (which is the total outdoor environment) or can be isolated to observe the actual location of tags at any time (figure 4). Once the 'data pack' is created, these options for replaying the data can be accessed.

Actigraph accelerometers

Children and educators will be asked to wear an Actigraph GT3X+ (Actigraph, Florida) accelerometer. These accelerometers (38×37×18 mm, 27 g) are lightweight, unobtrusive devices worn on the right hip on an elastic belt. They will be fitted at the same time as the wristwatch tags. Accelerometers measure triaxial g-forces from which the amount and intensity (sedentary, light, moderate, vigorous) of physical activity is determined. They are a water-resistant accelerometer that can collect very high-frequency raw data or wave-form triaxial accelerometer counts at 30 Hz epochs for >7 days. Previous versions have been the most widely used accelerometer in paediatric research to date, are a valid and reliable measurement tool and are the most widely used objective measure of physical activity for young children[4] and adult populations.[28 29]

Classroom assessment scoring system, Pre-K

During data collection at each ECEC setting, observational data will be collected using the classroom assessment scoring system (CLASS), Pre-K.[30] Observations will

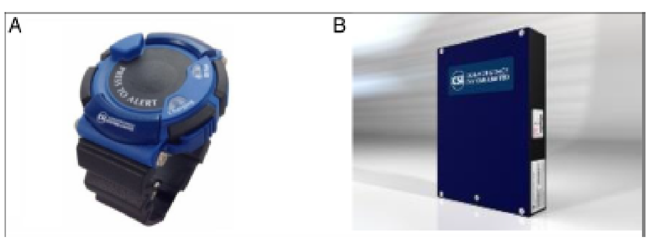

Figure 2 RTLS instruments. (A) Wristwatch tag. (B) Slave anchor reader. RTLS, real-time location system.

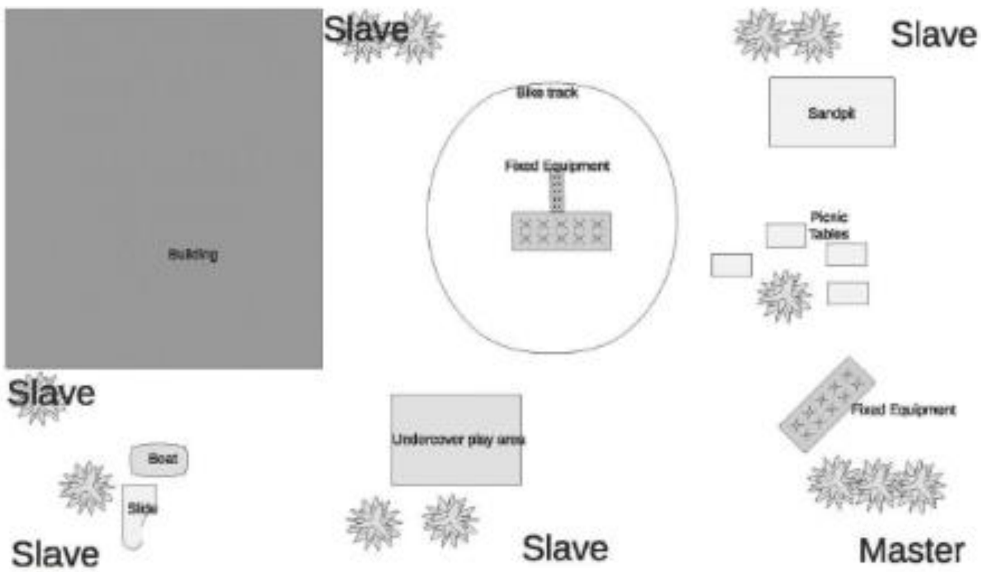

Figure 3 Layout of RTLS anchor readers in ECEC setting. ECEC, early childhood education and care; RTLS, real-time location system.

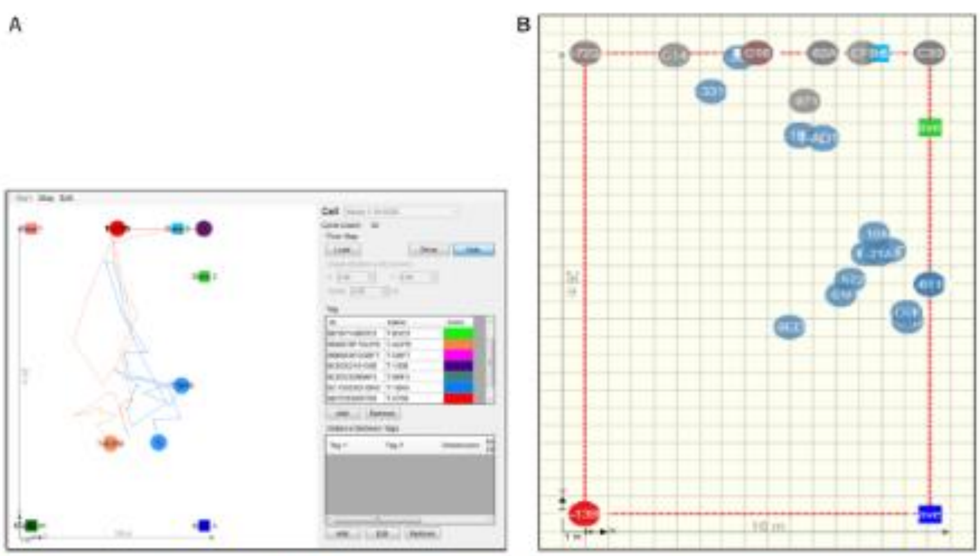

Figure 4 RTLS programme. (A) Tag tracking: the movement of one or more tags can be tracked and recorded as a line around the space. (B) Tag location: each tag can be individually coded and is represented as a circle that moves through the space. RTLS, real-time location system.

be between 10 and 25 min in length and will be videotaped and then later scored for quality of interactions. CLASS Pre-K is an observation system which assesses three domains of classroom quality—emotional support, classroom organisation and instructional support. Each domain is divided into specific dimensions such as positive climate, productivity and quality of feedback[30] (figure 5). CLASS has widely been used to assess

Figure 5 CLASS domains and dimensions. CLASS, classroom assessment scoring system.

classroom quality within the indoor environment,[30] yet the use of it in outdoor environments is limited. For this study, CLASS will provide an additional dimension to the data by measuring elements of interactions such as verbal communication and modelling, which, alongside the accelerometer and location data, will determine the relationship between the quality of interactions and children's physical activity. In total, up to 15 outdoor observational periods will be video recorded for each ECEC setting. During the observations, randomly chosen educators will also wear a small portable microphone attached on the upper body to enable conversations to be audio-recorded. To ensure reliability[31] of the observations and scoring, a second observer will observe and score 10% of the recorded observations.

Surveys and additional data collection

Child and educator descriptive data, information about the experiences of educators and specific ECEC setting characteristics will be collected through surveys, observations and interviews. Child descriptive data, such as age, sex and days of enrolment, will be provided by the parent/carer on the child's consent form. Educator descriptive information such as year of birth, sex, qualifications, days of work and position in the ECEC setting will be provided on their consent form. Each educator will be asked to complete a survey pertaining to organisational policies, procedures and professional development for each ECEC setting. For example, questions such as 'Have you undertaken formal education or training in providing physical activity experiences to children?, and 'In what ways does your centre promote children to be physically active'? will be asked. Additional environmental data will also be collected including daily floor plans of the outdoor environment, weather conditions at regular intervals during the day, a record of programmed and spontaneous activities and portable equipment present in the environment. Photos and videos will be taken of significant activities such as spontaneous group physical activity experiences and environment and equipment changes as they occur. General data such as the size of the physical environments, number of children enrolled and the organisational structure of the ECEC setting will be collected through observation and informal interviews.

Analysis

Real-time location system

RTLS data are recorded in real time, in intervals of 1 s. The recorded information consists of a data pack and log file for location data. There are a number of illustrations that can be produced from these files. The location of all children and educators during a particular period of time or across the whole day can be determined (figure 6A), as well as the frequency, measured in 10 s bouts, of when a child or educator stays at particular locations during the given period of time (figure 6B). Additionally, the RTLS data can determine when children and educators are inside or outside through the measurement of their location.

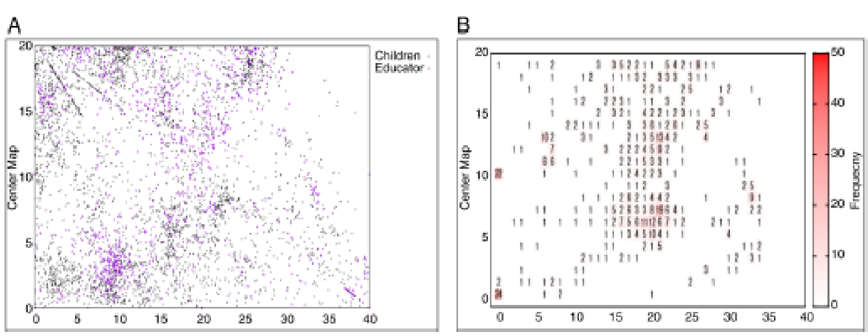

Figure 6 RTLS graphs. (A) RTLS location—represents a 1 hour time frame and the location of all tags within the space in 10 s intervals. This measures 'hot spots' of location. (B) RTLS frequency—represents a single participant's presence in particular locations in the space, indicated as a proportion of the time. RTLS, real-time location system.

The initial analysis of the location data is completed with the RTLS site manager software package in which commands are created and entered to produce graphs such as in figure 6A and B. The software also allows an export of log files containing all real-time location data. The software is run under a Linux/Fedora operation system. The code used is the C programming language and the Linux shell. The extracted information is stored in text file (.txt) while the raw data files are in .csv extension. Gnuplot is used to create the illustrations for visual-support analysis.

Actigraph accelerometers

For this study, the time spent in different intensities of physical activity for children will be measured according to the cut points: sedentary behaviour ≤37 counts/15 s; light physical activity 37–420 counts/15 s; moderate/vigorous physical activity ≥420 counts/15 s,[32] which are well established and the best understood measurement for classifying physical activity intensity and sedentary behaviour among children aged 3–5 years. For educators, the cut points: sedentary behaviour ≤25 counts/15 s; light physical activity 2–504 counts/15 s; moderate/vigorous physical activity ≥505 counts/15 s[29] will be used for physical activity and sedentary behaviour measurement. For this study, non-wear time will be calculated at 20 min, with a minimum wear time of 180 min per day and at least 1 day of accelerometer data collected per participant for data to be valid. Accelerometer data will be analysed using ActiLife software.

Classroom assessment scoring system, Pre-K

The video observations collected will be assessed using CLASS Pre-K. Standardised procedures and scoring sheets as detailed in the CLASS Pre-K manual[30] will be followed. For each service, the six longest video recordings, each no less than 10 min in length, will be scored. Given the unique outdoor environment, all observations will be assessed retrospectively, which will increase the accuracy of the scoring. Additionally, 10% of videos will be scored by a second observer for inter-reliability. For each observation, a rating from 1 to 7 (low to high range) is given for each dimension. The scores from the dimensions (within each domain) are added and then averaged to provide a domain score for each observation. Each ECEC setting will receive an average score (calculated from the six videos) for each of the domains.

Surveys and additional data collected

All information from the consent forms, surveys and additional data collected will be entered into an excel spreadsheet.

CONCLUSIONS

The study is the first of its kind internationally. The design incorporates novel methods of objectively measuring the social and physical environmental influences on children's physical activity in ECEC services, and the multilevel data collection supports a depth of analysis that is unique. Previous research addresses levels of children's physical activity, yet the activity levels of educators, the specific locations of physical activity in an ECEC setting, organisational characteristics of ECEC settings that influence physical activity and the relationship between children's and educator's physical activity have not been investigated. The experiences and relationships that occur for children at this age are significant and include establishing foundations for health and well-being, learning and social experiences that will have positive long-term effects.[33] Importantly, quality relationships and environments have the potential to promote children's confidence and competence in being physically active which will establish behaviours that promote health and well-being conducive to learning and development.

Given the study's specialised environment (ie, the outside environment in ECEC settings) and the use of multiple instruments, additional methodological consideration will need to be considered. For example, the position of the RTLS anchors will be unique to each ECEC outdoor environment due to the individual design of the settings, and their placement will need to consider safety and security aspects for the children in each centre. The RTLS watches are designed for adults, and so consideration of comfort and their secure fastening on children's wrists will need to be managed. Children will wear additional wristbands to ensure that the wristwatch tags are secure. As the study relies on the synchronised use of accelerometers and location watches, it is crucial that each individual monitor is identified accurately for each participant to ensure that information can be cross-checked. Additionally, as the study is carried out in an outdoor environment, at times the presence of the children and educators in the environment will be weather dependent. Weather conditions will also influence the preparation of the RTLS equipment as it is not suitable in wet or adverse conditions.

This project has several benefits for the research community, making an important contribution to the field's understanding of the correlates of children's physical activity in ECEC services. The focus on social environments, as well as the physical environmental aspects of ECEC settings on children's physical activity, is innovative, as is the measurement of educator physical activity and location. The outcomes of this study have the potential to inform and add to current knowledge, resulting in positive influences on policy and practice in ECEC settings that will provide quality experiences and opportunities to support children's physical activity, resulting in improved health and well-being.

DISSEMINATION

Written informed consent will be sought from all educators. All educators will receive detailed participant information and be informed that they have the right to withdraw from the study at any point.

Additionally, an information sheet will be provided to the parents of the children. Parents will provide written consent for their children to participate in the study, and children will provide assent. Parents and children will be informed that participation is not compulsory. The researchers will be present at all times in the case that a child chooses not to wear or to remove the monitors.

The results of the study will be disseminated to academic audiences through presentations and through peer-reviewed publications in relevant journals. Results will be disseminated to participants, the public, policymakers and the early childhood profession through seminars and press releases.

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8.4 Appendix D. Published article: Quality Interactions in Early Childhood Education and Care Center Outdoor Environments.

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Quality Interactions in Early Childhood Education and Care Center Outdoor Environments

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Abstract
Quality interactions are crucial for children's learning and development. Early Childhood Education and Care (ECEC) centers have the opportunity to support children's learning and development, yet the quality of interactions and influences on the quality of interactions in outdoor environments is not known. Research findings: this study assessed the quality of educator interactions in outdoor environments using the CLASS Pre-K assessment tool. 11 ECEC centres participated in the study, which included 110 educators and 490 children. 87 observations were collected to measure the CLASS Pre-K domains (1-lowest to 7-highest). Mean domain scores were 6.02 (emotional support), 5.23 (Classroom Organization) and 4.46 (Instructional Support). Regression analyses show free routines had significant relationships with Teacher Sensitivity ($p=0.03$) and Instructional Learning Formats ($p=0.03$), and increased amounts of time spent outside had the most significant relationships with Teacher Sensitivity ($p=0.001$) and Behavior Management ($p=0.001$). Practice or Policy: The major recommendations that would serve to improve the quality of interactions in outdoor environments include providing a free routine and increasing the amount of time spent in outdoor environments. As these recommendations are modifiable practices, they are potentially the easiest to alter and therefore, with minimal change, could enhance the quality of interactions between educators and children.

Keywords Preschool · Interactions · CLASS Pre-K · Educators · Quality · Outdoor environments

Introduction

The Early Years

The early years (birth—5 years) are a time of rapid growth, including significant physical, cognitive, social-emotional and brain development (Shonkoff 2014). It is a time of opportunity where children's health and wellbeing, as well as quality experiences are an investment in learning and development (Shonkoff 2014). During these early years, many children attend an Early Childhood Education and Care (ECEC) center. In Australia, for example, 89% of children aged 4 years attend an ECEC center, and 92% of these children attend for more than 15 h a week (ABS 2016). Furthermore, in most developed countries over the last two decades there has been an increase in children's attendance in formal ECEC experiences (OECD 2014). As such, ECEC centers play a critical role in the early life experiences for many children and are fundamental for children's learning and development, health and wellbeing.

Early Childhood Education and Care Centers

ECEC centers support children's learning and development through the provision of quality physical and social environments. This includes ensuring the availability of adequate equipment and space, as well as opportunities for structured and unstructured experiences and interactions (Ward 2010). Educators have a significant role in these ECEC environments as they facilitate experiences, and provide opportunities to engage in interactions with children. Establishing quality interactions between children and educators is crucial (DEEWR 2009; Ritchie and Howes 2003; Wang et al.

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2016) just as quality physical environments are for children's learning and development.

ECEC centers typically provide indoor and outdoor environments, and educators are encouraged to place equal value on these environments as places for children's learning and development (NQS 2016). Both environments offer opportunities for children and provide experiences in all developmental areas. While there may be variation in the features and proportion of time spent in each environment, the quality of experiences and interactions that occur in these environments are equally significant (NQS 2016). Despite the importance of both environments to a child's development, little is known about the influence of an educator's interactions with children in outdoor environments; consequently, the value of the outdoor environment for learning and development may be undervalued (Ulset et al. 2017). The opportunities that outdoor environments provide—such as space, natural playscapes and access to equipment (e.g., bikes, climbing equipment and balls) also reinforces their unique role in children's learning, health, and development.

Outdoor Environments in ECEC Centers

All ECEC centers worldwide offer an outdoor environment, or an environment that replicates one. For ECEC centers in Australia, the provision of an outdoor environment is a requirement of the National Quality Standards (NQS 2016). Typically, outdoor environments in ECEC centers provide many opportunities for children, including experiences that are unique to the space, such as building gardens, playing with trees and sandpits and playing in large open areas. The actual use of the outdoor space is managed at a center level, as is the proportion of the day that children have access to this environment. Some ECEC centers provide free flowing routines where children select the environment that they play in (i.e., children can choose to be the indoor environment or the outdoor environment at any point throughout the day), whereas other centers regulate the use of the particular environment at various times of the day, including what occurs within the environment at that time, such as a group experience. Educators utilize and prepare the space for various educational and recreational purposes that support children's learning and development, including the promotion of gross motor skills; experiences such as painting, reading and building that may also be present indoors; and activities that may not be possible or ideal indoors, such as bike riding and ball games. Research has shown that children's physical activity is greater in outdoor environments than in indoor environments (Tandon et al. 2015), reinforcing its importance in promoting active lifestyles.

Although it is clear that outdoor environments provide valuable opportunities for children's learning and development, much less is known about what happens in these environments compared with indoor environments. In particular, there are no known studies that have examined the quality of an educator's interactions with children in outdoor environments. This is important given that children will typically spend up to 9 h each day in these environments (Ulset et al. 2017) and that these environments are mandated in Australia in the NQS (2016).

Quality in Early Childhood Education and Care Centers

Improved outcomes for children in ECEC centers often are associated with the quality of the learning environment (Howes et al. 2008; Mashburn et al. 2008; Sylva et al. 2006). Although perspectives of quality in ECEC vary, research on quality has typically focused on structural characteristics, such as teacher-child ratios, group sizes and level of teacher education (LaParo et al. 2012). An alternative, yet equally important focus, is the quality of processes, such as interactions and engagement between educators and children (Howes et al. 2008). The study of process quality has shown that children's interaction and engagement with educators is related to their achievements (Burchinal et al. 2008; Cameron et al. 2005), and that quality interactions are the foundation of educators being powerful role models for children (Goldfield et al. 2012). In light of the importance of quality interactions for children's achievements, it is crucial to measure process quality in all learning environments, including outdoor environments. Additionally, it is crucial to measure process quality in light of ECEC center practices, such as routines and time spent in environments, as these may influence the quality of environments and interactions.

Assessment of Quality in Early Childhood Education and Care Centers

Many instruments measuring quality in ECEC centers have assessed multiple aspects, both structural and process (Byrant 2010) and although many of these instruments measure relevant components of the learning environment, the focus is more on processes such as physical and organizational structure (LaParo et al. 2004). Instruments such as the Classroom Assessment and Scoring System (CLASS) Pre-K (Pianta et al. 2008) offer a specific measure of the quality of interactions between educators and children. CLASS Pre-K is a real-time observational tool that assesses the quality of interactions between educators and children in ECEC environments based on specific and focused observations of individual educators. Central to CLASS Pre-K is the theoretical framework that educator and child interactions are crucial for academic and social-emotional success (Sandilos et al. 2014). The assessment is based on three core domains of interactions: emotional support, classroom organization and instructional support. Although predominantly used for assessment in US classrooms, CLASS Pre-K has been validated across a range of classrooms, for example, in ECEC centers with diverse languages (Downer et al. 2010), in various countries (Pakarinen et al. 2010; Tayler et al. 2016) and in comparison to other assessments of quality such as ECERS (LaParo et al. 2004). Findings indicate that CLASS Pre-K operates consistently across centers, demonstrating that it could function as a tool for improving quality in ECEC centers (Pianta et al. 2008). Despite the validation of CLASS Pre-K in various ECEC centers, a limitation of these studies is that the specific ECEC environment (indoor and/or outdoor) has not been identified. The use of CLASS Pre-K solely in outdoor environments in this study extends our understanding of CLASS Pre-K. Being aware of specific aspects of the quality of educator and child interactions, as well as possible influences on these interactions has the potential to empower educators to facilitate practices that support learning and development, health and wellbeing outcomes for children.

The Current Study

As outdoor environments and quality interactions are important for children's learning and development, understanding factors such as how the indoor-outdoor routine and the time spent outdoors influence the quality of interactions in outdoor environments will make an important contribution to optimising children's learning and development in ECEC centres. Therefore the aims of this study were to:

1. Report on CLASS Pre-K scores in ECEC centre outdoor environments, and to
2. Examine how the indoor-outdoor routine and the amount of time spent outdoors are related to CLASS Pre-K scores in ECEC center outdoor environments.

Materials and Methods

Early Childhood Education and Care Centers and Participants

In 2015, 11 ECEC centers located within a radius of 100 km from Wollongong, NSW, Australia, were recruited. ECEC centers were eligible to participate if they enrolled children aged 2–5 years, and these children had access to outdoor play spaces which were separate from other play spaces for younger children in the center. All eligible children and educators were invited to participate in the study, irrespective of the number of days enrolled or employed, respectively. Information about the study was presented to educators and families at staff and parent meetings and all eligible educators and children were provided with Participant Information Sheets and Consent forms. The study included a range of centers with variations in: the routine of the day, size and features of the physical environment, the number of children enrolled, and the use of indoor and outdoor environments, including the time that children have access to these environments. The detailed methods for the study from which these data were drawn were described in a previous paper (Tonge et al. 2016).

Observation Measure—CLASS Pre-K

Observational data were collected from educators and children in the centers. The CLASS Pre-K assessment scale was used to measure the quality of interactions between educators and children in the outdoor environment. CLASS Pre-K is an observation based assessment for use in ECEC environments and provides a contextualised assessment of interactions based on real-life observations (Pianta et al. 2008). It was selected as the most suitable assessment as it measures the quality of interactions with a specific focus on educators.

CLASS Pre-K consists of 10 dimensions measuring three domains (emotional support, classroom organization and Instructional Support) of classroom quality. Each dimension was rated on a 7-point Likert-scale (LaParo et al. 2004): low (1, 2), moderate (3–5), or high (6, 7) according to the CLASS Dimensions Overview, Pre-K-3 document (Pianta et al. 2008). The dimensions in the emotional support domain focus on the interactions that support social and emotional functioning in the environment, such as positive communication and expectations; responsiveness; and providing children with responsibilities and freedom of movement. These social and emotional attributes support motivation and connectedness to the learning environment (Hamre and Pianta 2001; Silver et al. 2005), essential for children's learning and development. The classroom organization domain includes dimensions that relate to environment processes, such as an educator's organization and management of behavior, time and attention (Emmer and Stough 2001), as well as effective questioning, use of resources and clarity of objectives. When these situations are well managed, learning environments function effectively and provide optimal conditions for children to engage in experiences for learning. The dimensions in the instructional support domain are based on the processes of children's acquisition of knowledge and the implementation of experiences, such as problem solving; prediction and experimentation; real life application; teacher scaffolding; and effective conversations. In particular, this domain identifies cognitive and language development as key to child outcomes, and as with the other CLASS domains, quality interactions between children and educators as essential for children's learning and development in ECEC centers.

Observation Protocol

Data were collected from outdoor environments in each ECEC center across five consecutive days. Throughout the data collection period, educators who were present in the outdoor environment were selected to be observed. To ensure a range of educators from each ECEC center were observed, when there was more than one educator in the outdoor environment, educators who had not been observed previously were selected.

The frequency and timing of observations varied between centers, and were dependent on the center routine and presence of children in the outdoor environment. The CLASS system has been validated for use in coding video recordings (Mashburn et al. 2008) and thus all observations in the study were video recorded using a portable video recorder and scored retrospectively. To ensure the recording adequately captured all auditory information, the educator being observed wore a bluetooth microphone which transmitted all sounds in proximity of the educator, including verbal interactions. To ensure accuracy in the visual information collected, the researcher remained close to the observation area, as discretely as possible.

Recording the observations allowed for greater measurement scrutiny and more accurate scoring between the two observers. This was especially important when there was uncertainty in the observations, allowing for cross-checking between observers. The process of recording observations was also important as outdoor environments in ECEC centers are typically larger than indoor environments and additional noise, obstacles and limited proximity to the event may occur. Recording observations ensured all aspects of the interactions (verbal and nonverbal) were able to be observed and assessed, even if the researcher was recording from a distance.

Observations met the criteria for CLASS scoring if they were more than 10 min in duration (Pianta et al. 2008) and the visual and auditory quality was satisfactory. At times the educator being observed completed tasks other than interactions with the children, including administration, programming and/or interactions with other educators and parents. These observations were still eligible for scoring as they provided insight into various influences on educator and child engagement and interactions.

During the observation period prior to scoring, observers made detailed notes about the CLASS Pre-K indicators. Immediately following the observation period, notes from each of the indicators were reviewed and based on these, scores from the CLASS Pre-K range (1 – lowest to 7 – highest) for each dimension were recorded on the CLASS Pre-K scoring sheet (Pianta et al. 2008). For each item the ratings were averaged across all cycles to produce the final score for the domain. For all domains, except the negative climate, the higher the score, the more positive the interaction. The dimension negative climate was reversed scored as per the CLASS Pre-K manual (Pianta et al. 2008).

Training

Prior to scoring the recorded observations, two researchers participated in preliminary training. An online training package 'Introduction to the CLASS Tool' (Teachstone Training LLC ©) consisting of five modules, approximately 30 min each in duration, was completed. This online package consisted of an overview of the purpose and structure of the CLASS tool as well as guided practice observation tasks that included observing an interaction, followed by multiple-choice questions to reinforce key elements of the interaction.

The second stage of training involved face-to-face professional development and consultation with other researchers, academics and practitioners who had used the CLASS Pre-K in their study. This one-day intensive workshop delivered by a certified CLASS Pre-K assessor provided opportunities for sharing knowledge as well as the purpose and implementation of the CLASS Pre-K assessment tool in ECEC centers.

CLASS Pre-K Interrater Reliability

Twelve observations (14%) were double-scored by independent and trained observers. Reliability was 82% of dimension scores within a score of 1 on the 7-point CLASS scale. Previous studies have maintained at least 80% reliability (Jamison et al. 2014; Sandilos et al. 2014).

Study Size

This study forms part of a larger study examining the physical activity and location of children and educators in an outdoor ECEC setting (Tonge et al. 2016). In this larger study it was important to recruit enough educators to investigate the relationships at a centre level, and to allow for clustering at the ECEC level based on an intraclass correlation of 0.01 and an average cluster size of 10. Accordingly, approximately 85 educators were needed to be recruited for the main study (Tonge et al. 2016). To recruit at least 85 educators, 11 ECEC centers participated, on the basis of each ECEC center employing between 6 and 15 educators.

Early Childhood Education and Care Centers—Factors Influencing Quality

For this study, two modifiable factors were examined in relation to the CLASS: center routine and the amount of time spent outdoors each day (Table 1). The routine group included centers that offered either an indoor-outdoor program or an aspect of the day that was indoor-outdoor (ie, children were

Table 1 Early Childhood Education and Care center descriptives

Centre code	Number of CLASS observations	Number of educators observed	ECEC routine	Time spent outdoors each day (avg hrs)
1	6	6	Free	5.5
2	8	8	Structured	2.5
3	7	4	Free	4
4	4	4	Structured	2
5	7	5	Structured	2
6	10	8	Free	5.5
7	11	7	Structured	3.5
8	13	8	Structured	4
9	7	4	Free	4
10	8	5	Structured	2.5
11	6	5	Structured	3

able to freely move from the indoor environment to the outdoor environment and vice versa) or a structured routine, where children had designated times for indoor and outdoor experiences and there was no opportunity for free movement between the environments during the day. These were termed 'free routine' and 'structured routine' respectively. The time spent outdoors each day was based on the total time children and educators spent outdoors, as was collected from ECEC center directors and through direct observation.

Statistical Methods

CLASS scores for individual educators were entered into an Excel spreadsheet and the means, standard deviations and range of these scores were calculated. Using StataIC 13, adjustment was made for clustering of ECEC centers using the svyset command and linear regression analyses were performed to investigate the relationship between individual educator CLASS dimension scores (n = 87) and the ECEC center routine and time spent outside. Linear regression models were produced for each of the CLASS dimensions in each of the ECEC center groups (n = 2). Routine was classified as a categorical variable (free or structured) and adjustment was made for educator age and qualification in these linear regression analyses. Time spent outside was classified as a continuous variable, and similar to the routine analyses adjustment was made for educator age and qualification, but also for centre type (long day care or preschool) as the total length of the day offered to children enrolled differs between preschools and long day care centers.

Results

Descriptive Statistics

From 11 ECEC centers, 110 educators and 490 children aged 2–5 years were recruited. Four of the centers provided an indoor-outdoor program and seven of the centers provided a structured program (Table 1). On one occasion the children were not present in the outdoor environment due to adverse weather and so the same day of the following week was scheduled for data collection.

CLASS Pre-K

A total of 131 observations were recorded. Two-thirds (n = 87) of the observations recorded met the CLASS criteria for this study and included 64 educators. Videos that did not meet the criteria and the reasons for this were: 23 videos (18%) less than 10 min (these included educators leaving the environment due to commencing their lunch break, programming time, finishing their shift or all children moving inside), 14 videos (11%) did not have clear audio and/or visual and seven videos (5%) did not meet criteria for other reasons such as technical issues, a planned experience used for field notes or observation testing.

The average number of observations per center was eight (range 4–13) (Table 1). One CLASS observation was scored for 72% (n = 46) of educators, and 18 educators were observed on multiple occasions. Two CLASS observations were scored for 20% (n = 13) of educators, and three observations were scored for 8% (n = 5) of educators.

The educators were almost entirely female (97%, n = 62) and the mean age was 35 years, with a range from 18 to 58 years of age. Educators reported a number of qualifications (16% degree qualified, 42% diploma qualified, 31% certificate III qualified, 11% student) and numerous primary positions/responsibilities were reported (9% Director, 2% Educational Leader, 3% second in charge, 6% teacher, 28% advanced child care worker, 25% support, 11% casual, 11% student, 5% trainee).

Scores for CLASS domains and dimensions are described in Table 2. Mean scores were greatest in the emotional support domain and, from this domain, the dimension negative climate scored the highest (mean = 6.91). The lowest mean scores were in the instructional support domain, and in this domain, the dimension concept development scored the lowest overall (mean = 4.08). Using threshold values suggested by the CLASS measure (Pianta et al. 2008) these results suggest that across the 11 centers, emotional support was typically of high quality and classroom organization and Instructional Support were of medium quality.

Linear Regression Analyses—CLASS Pre-K and Early Childhood Education and Care Center Factors

A significant relationship was reported between free routines and teacher sensitivity (p = 0.03) and instructional learning formats (p = 0.03) (Table 3). The relationship between free routine and concept development also approached statistical significance (p = 0.06) (Table 3). In all of these cases, higher CLASS scores were reported when free routines were provided.

In the linear regression analysis for the time spent outdoors each day and CLASS dimensions (Table 4) significant relationships were reported for regard for student perspectives and teacher sensitivity (p = 0.03 and p = 0.001 respectively); instructional learning formats and behavior management (p = 0.01 and p = 0.001, respectively); and concept development (p = 0.01). For each Item, higher CLASS scores were reported when more time was offered in the outside environment.

Table 3 Relationship between Early Childhood Education and Care center routine and CLASS Pre-K dimensions

	B coef.	95% CI	p
Emotional support			
Positive climate	−0.35	−0.95, 0.26	0.23
Negative climate	0.10	−0.05, 0.25	0.17
Teacher sensitivity	−0.93	−1.72, −0.14	0.03
Regard for student perspectives	−0.43	−1.20, 0.34	0.25
Classroom organization			
Behavior management	−0.56	−1.24, 0.13	0.10
Productivity	−0.67	−1.56, 0.21	0.12
Instructional learning formats	−0.92	−1.69, −0.14	0.03
Instructional support			
Concept development	−1.09	−2.22, 0.05	0.06
Quality of feedback	−0.82	−1.86, 0.22	0.11
Language modelling	−0.72	−1.72, 0.29	0.14

Free is both indoor and outdoor environments available to children for all or some of the day. Structured is only selected environments (indoor or outdoor) are available to children

Table 2 Mean scores for the CLASS Pre-K dimensions

CLASS dimensions	M (range, SD)
Emotional support domain	
Positive climate	6.28 (2–7, 0.11)
Negative climate[a]	6.91 (6–7, 0.03)
Teacher sensitivity	5.53 (2–7, 0.14)
Regards for student perspectives	5.34 (2–7, 0.13)
Classroom organization domain	
Behavior management	5.89 (3–7, 0.10)
Productivity	5.02 (1–7, 0.17)
Instructional learning formats	4.78 (1–7, 0.17)
Instructional support domain	
Concept development	4.08 (1–7, 0.18)
Quality of feedback	4.79 (1–7, 0.17)
Language modelling	4.51 (1–7,0.18)

[a]Negative climate reserved scored

Table 4 Relationship between time spent outdoors each day and CLASS Pre-K dimensions

	B coef.	95% CI	p
Emotional support			
Positive climate	0.15	−0.03, 0.34	0.10
Negative climate	−0.03	−0.07, 0.01	0.09
Teacher sensitivity	0.39	0.19, 0.59	0.001
Regard for student perspectives	0.29	0.04, 0.54	0.03
Classroom organization			
Behavior management	0.35	0.19, 0.51	0.001
Productivity	0.35	−0.39, 0.74	0.07
Instructional learning formats	0.39	0.12, 0.66	0.01
Instructional support			
Concept development	0.49	0.18, 0.79	0.01
Quality of feedback	0.36	−0.11, 0.84	0.12
Language modelling	0.27	−0.10, 0.65	0.14

Discussion

The purpose of this study was to report on CLASS Pre-K scores in ECEC centre outdoor environments, and to determine the influence of routines and the amount of time offered in outdoor environments on the quality of interactions between educators and children. Key findings indicate that providing a free routine that enables children to select either the indoor or outdoor environment; and greater amounts of time spent outside improves the quality of interactions between educators and children in ECEC centre outdoor environments.

The measurement of the quality of interactions between educators and children in ECEC outdoor environments is important because spending time in high-quality outdoor environments is critical for children's learning and development (Siraj-Blatchford 2009). Most studies reporting results from CLASS Pre-K have been methodological. For example, validation studies (Downer et al. 2010; Pakarinen et al. 2010) or studies that have compared CLASS Pre-K with others instruments that assess quality (LaParo et al. 2004) or studies that assess the stability of interactions during the day (Curby et al. 2010). A few studies have focused on relationships between CLASS Pre-K and outcomes such as educational wellbeing and social development (Burchinal et al. 2008; Curby et al. 2009; Tayler et al. 2016) or assessed the relationship between CLASS Pre-K scores and service type (Tayler et al. 2013). These studies consistently found that higher quality interactions resulted in improved outcomes for children. Although each of these studies has provided valuable information about quality interactions, there has been an absence of studies using CLASS Pre-K in the outdoor ECEC environment.

CLASS Pre-K in Outdoor Early Childhood Education and Care Center Environments

In this CLASS Pre-K study of the outdoor environment, the emotional support domain achieved the highest scores, and the instructional support domain achieved the lowest scores, a finding that is consistent with other CLASS Pre-K studies of indoor learning environments (Curby et al. 2010; LaParo et al. 2004; Sandilos and DiPerna 2011; Tayler et al. 2013). This outcome may be a reflection of an ECEC environment where children's social and emotional wellbeing is paramount and valued as being more crucial for learning and development than academic achievement. Educators advocate that children's learning will be optimised when they feel that they belong, and are supported, safe and secure (DEEWR 2009)—aspects assessed in the emotional support domain of CLASS Pre-K. Furthermore, in a study that measured the relationship between CLASS Pre-K emotional support domain scores and teacher efficacy, educators felt comfortable in a nurturing role, which aligns with indicators in the emotional support domain, such as sensitivity and creating a positive environment (Pakarinen et al. 2010).

Alongside the consideration that educators place high value on aspects in the emotional support domain, indicators in this domain, such as verbal and physical affection and providing comfort and assistance, may be more instinctive for educators compared with indicators in the instructional support domain, which scored the lowest. The instructional support domain relies on several skill-based concepts, such as advanced language, scaffolding, analysis and reasoning. Therefore, educators may require specific and intentional professional development to develop confidence in this domain. Accordingly, educators have indicated that they require further professional development to best support children's outcomes (Coleman and Dyment 2013; Tucker et al. 2011), and it may be this provision of professional development that results in higher instructional support domain scores.

The overall scores from CLASS Pre-K in this study indicate that the emotional support and classroom organization domains are in a high range of interaction quality, and that the instructional support domain is in the medium range. These ranges are higher than in other studies using CLASS Pre-K. For example, in other studies the mean scores for the emotional support and classroom organization domains were in the medium range, and the mean Instructional Support scores were in the low-medium range (Tayler et al. 2013; Sandilos and DiPerna 2011). Conversely, a study in Finland using CLASS (Pakarinen et al. 2010) found similar patterns to the current study with higher ranges reported. Possible explanations for this include the interpretation and evaluation of the dimensions; the absence of literature on CLASS Pre-K specifically in outdoor environments which has resulted in comparisons with indoor and/or outdoor rather than outdoor environments specifically; and the suitability of the CLASS Pre-K assessment in its entirety for outdoor environments which may have resulted in misrepresented scores. Further studies specifically in ECEC outdoor environments are needed to provide a more accurate comparison and interpretation.

The highest scores in the Emotional and lowest in the instructional support domain may have been influenced by the assessment being in the outdoor environment. Indicators in the instructional support domain suggest that high-quality interactions are formed through defined exchanges, often requiring a high level of verbal interaction ('there are frequent conversations in the classroom' and 'the teacher often provides additional information to expand on students' understanding or actions'), whereas, in the emotional support domain, several indicators depend on non-verbal interactions ('there are frequent displays of positive affect by the teacher and/or students' and 'students have freedom of movement and placement during activities'). Affordances in outdoor environments differ from those in an indoor environment as the space is typically larger and opportunities for different experiences are available. For example, experiences that promote greater and faster movements such as climbing and bike riding are present, resulting in increased movement of and distances between educators and children. In these cases, measuring the quality of interactions by assessing verbal interactions may be compromised as the movement and location of educators and children may affect the level of verbal interactions that occur, as is linked to high-quality interactions in the instructional support domain. Interactions in outdoor environments may be more dependent on the educator's non-verbal involvement and interactions with children rather than verbal interactions. Subsequently this presents challenges in the assessment of the quality of interactions based on language modelling and conversations, as is indicated in the instructional support domain, more so than in the emotional support or classroom organization domains.

In addition to the suitability of the indicators of Instructional Support, the actions of the educators in this outdoor environment may influence the Instructional Support scores. Due to the specific features and affordances of an outdoor environment, such as gardens, climbing equipment, bikes and typically more active play, educators may perceive that their main role during outdoor play is the supervision and safety of children (Coleman and Dyment 2013). Consequently the outdoor environment may be underestimated as an intentional learning space. This perception may increase emotional support, to the detriment of instructional aspects such as concept development, effective feedback and language modelling (Pianta et al. 2008)—all indicators in the instructional support domain.

The Relationship Between Quality of Interactions and Routines and Time Spent Outdoors

ECEC centers are diverse and there are many factors, such as location, educator-child ratios, available space and resources (van Zandvoort et al. 2010), regulations and policies, as well as environmental factors such as the weather (Poest et al. 1989; Tucker and Gilliland 2007) that influence practice and therefore children's experiences and outcomes. These may have a greater influence in outdoor environments. ECEC centers may not have the capacity to manage all potential influences; however, it is evident in this study that there are factors, such as the type of routine and time spent outside, that educators can modify that may influence the quality of interactions between educators and children during time spent in outdoor environments.

When educators offered a free routine, such as children having access to indoor and outdoor environments at any time throughout the day, compared to a routine that was structured (e.g., children were indoors in the morning and outdoors in the afternoon) the quality of interactions between educators and children in an ECEC outdoor environment were consistently greater. Furthermore, other research has shown the benefits of a free routine that allows children to move freely between environments of choice on the amount of time children spend in experiences such as physical activity (Hesketh and van Slujis 2016). When children spend increased periods of time in experiences, this allows their play to extend and develop, and opportunities for sustained shared thinking (Siraj-Blatchford 2009), which are key aspects for learning and development, are increased. Enabling children to move freely between environments also allows children to make choices for their play, and therefore may have an influence on the quality of their play and interactions. Additionally, allowing children to move freely between environments of choice has the potential to minimise the number of children in each space, therefore ensuring resources and equipment are accessible, avoiding waiting times and conflicts that may arise. Identifying such influences on the quality of educator and child interactions is important to being able to design interventions that promote high quality environments.

Teacher sensitivity and instructional learning formats were related to both free routines and increased time spent outside. Teacher sensitivity focuses on awareness, responsiveness, addressing problems and student comfort (Pianta et al. 2008) whilst instructional learning formats focuses on effective questioning, teacher involvement and hands on opportunities. In an ECEC center when a free routine is provided, children have opportunities to move freely between environments, around peers, educators and experiences and potentially regulate their social and emotional experiences. In this emotional climate, children may be more comfortable and confident as they have a greater agency over their learning environment. Accordingly, the response of educators may reflect the disposition of the children within the environment, resulting in interactions that lead to more advanced motor skill development and opportunities for extended interactions. More time in an environment allows for these indicators to develop as transition times may be reduced, and children and educators have more opportunities to engage in sustained interactions (Siraj-Blatchford 2009).

Consistent results were also found when greater amounts of time were spent outdoors. When ECEC centers provided children with more time in the outdoor environment across the day, higher quality interactions were reported. Increased time in an environment allows sustained periods of time engaged in experiences, as well as reducing the 'novelty' factor that may occur when children have shorter periods of time in an environment. Sustained periods of time in an outdoor environment provides opportunities free from interruption due to transitions, preparation and packing away of equipment. Accordingly, sustained opportunities in experiences have the potential for higher-level engagement, challenge and problem solving (Siraj-Blatchford 2009) and subsequently environments that are stimulating (Melhuish 2004). These factors may have influenced the quality of the interactions in this study, as greater time allowed better quality environments to develop. Interestingly, other studies indicate that it is the quality of the time, and what occurs within experiences that is important for children's outcomes, such as physical activity (Dowda et al. 2004, 2009; Tonge et al. 2016). Recognising the influence of the quality as well as the quantity of the time spent outdoors is critical. The need for deliberate planning of time, experiences, interactions and intentional teaching in outdoor environments is essential and has the potential to influence the quality of interactions in the environment and subsequently child experiences and outcomes.

Possibilities with CLASS Pre-K

This was an exploratory study measuring each domain and dimension from CLASS Pre-K. Using the scale solely in outdoor environments was unique and has presented some areas for further consideration. The assessment of the quality of interactions in outdoor environments with CLASS Pre-K needs to consider the assessment scales and aspects of the items being measured. For example, the dimension productivity includes the criteria of maximising learning time and transitions. In an outdoor environment which is typically less structured, these aspects may not be as frequent. Additionally, due to outdoor environments in ECEC centers having a tendency to be more spontaneous, the clarity of learning objectives from the dimension instructional learning formats—as well as indicators in the classroom organization domain—may not be as pronounced. Future studies measuring the quality of interactions in outdoor environments need to consider possible misrepresentations of dimension scores and report according to the observed environment. As was suggested in a study using the inCLASS measurement tool (Downer et al. 2010), it is apparent that CLASS Pre-K has the potential to provide a contextualised assessment of educator and child interactions, one that may complement other ECEC center assessments. In the absence of any other appropriate tools for the outdoor environment, this assessment tool is currently the best choice and hence the reason it was used in this study.

Strengths and Limitations

This study has a number of strengths: (1) CLASS Pre-K assessed the quality of educator and child interactions in outdoor environments which has not been reported previously; and (2) identification of modifiable and achievable practices that support better quality interactions.

The focus on ECEC outdoor environments offers new information to what is already known about the quality of educator and child interactions in ECEC centers. The potential of outdoor environments as valuable learning spaces are often underestimated; therefore it is important to demonstrate the opportunities that they hold for children's learning and development. Further, it is important for educator and child interactions to be meaningful in ECEC center outdoor environments as this has the potential to enhance children's physical activity, physical activity promotion and skill development for children's health and wellbeing.

Identifying modifiable aspects of practice that educators have the ability to manage is empowering for educators. There are some aspects of ECEC centers such as the size of the yard, geographic location and number of children enrolled that cannot be modified, yet reviewing and modifying the routine provided and the amount of time spent outside are somewhat more achievable. As this study shows, these changes can have significant effects on the quality of interactions between educators and children, and therefore child outcomes.

The results of the study should, however, be considered in light of a number of limitations, including the limited observation time in some ECEC centers, and the design and nature of CLASS Pre-K being perhaps better suited for indoor than outdoor environments.

Although the CLASS manual (Pianta et al. 2008) suggests that the results are reflective of typical practice, this may be a limitation of the present study. The total observation time which is measured with CLASS Pre-K may not be representative of the quality of educator and child interactions throughout the day. In this study the collection of observations only in outdoor environments meant that not all educators were observed, and the timing of the observations was set to a timeframe, for example only when the children and educators were in outdoor environments. In some ECEC centers that offered a free routine, it was only selected educators that engaged in the outdoor environment, and although the observations were random, there were limitations as to which educators were observed. Additionally, a small number of educators chose not to be involved in the observations and recordings. In these free-routine ECEC centers, as educators and children had the potential to move between environments, this movement between environments sometimes would result in the observation ceasing. Further research comparing the quality of interactions between educators and children in outdoor and indoor environments is warranted.

ECEC center environments are diverse and features of ECEC center indoor and outdoor environments vary. Outdoor environments are typically larger and provide less structured experiences than indoor environments, and experiences may encourage more movement within and between areas, for example ball games, climbing equipment and portable equipment such as bikes and scooters. Consequently, children's and educators' movements may be different between these environments. It is apparent that the CLASS Pre-K tool has been designed for the indoor environment and previous studies using this tool may have only investigated the indoor environment. This warrants consideration of its application in outdoor environments. Central to CLASS Pre-K assessments are verbal interaction and as indoor environments are generally smaller environments it is easier to capture conversations, whereas in outdoor environments which are generally larger and more open this may be difficult. As such, it is paramount that observers utilise the most effective methods of capturing all verbal interactions within any environment without influencing typical practice. Observations in this study were video recorded allowing the movement of educator and children while still recording vital information. To ensure accuracy in audio information, the educator selected for the observation also wore a wireless microphone. This further improved clarity of audio data collected, particularly from a distance or while the educators were moving. To reduce the effects of wearing the microphone on typical practice, such as reactivity which may result in participating in additional interactions, or perhaps not as many interactions, multiple observations were collected across the period of data collection in the ECEC center.

Conclusion

High quality environments provide opportunities that support children's learning and development, and it is crucial that value is placed on both indoor and outdoor environments as opportunities to develop quality interactions. Recommendations for future research include further investigations into the influence of quality interactions in ECEC outdoor environments that will support all areas of children's learning, development, health and wellbeing. It is important that quality interactions are established to achieve positive outcomes and therefore it is important to understand potential factors that influence the quality of educator and child interactions in all environments. This study recommends that educators have the capacity improve the quality of interactions by considering modifiable practices and opportunities that are available. Providing an aspect of a free flowing routine each day where children can select to be indoors or outdoors, as well as increasing the amount of time spent outdoors, has shown a significant influence on quality educator and child interactions in outdoor environments. Consequently, establishing quality interactions throughout the ECEC environment has the potential to provide the best possible environments for children's learning, development, health and wellbeing.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interests.

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8.5 Appendix E. Ethics Approval

APPROVAL LETTER

In reply please quote: HE14/330

10 November 2014

Professor Anthony Okely Faculty of
Social Sciences
University of Wollongong NSW 2522

Dear Professor Okely,

Thank you for your response dated 31/10/14 to the HREC review of the application detailed below. I am pleased to advise that the application has been approved.

Ethics Number:	HE14/330
Project Title:	The relationship between Educator Engagement & Interaction and Children's Physical Activity in Early Childhood Education and Care Services
Researchers:	Professor Anthony Okely, Dr Rachel Jones, Mrs Karen Tonge
Documents Approved:	Initial Ethics Application Participant Information Sheet for Educators version 3, 28/10/14 Participant Information Sheet for Directors version 3, 28/10/14 Participant Information Sheet for Parents version 3,28/10/14 Consent Form for Educators version 3, 28/10/14 Consent Form for Directors version 3, 28/10/14 Consent Form for Parents version 3, 28/10/14 Survey Questions version 3, 28/10/14 Class Observation Sheet Class Scoring Sheet
Approval Date:	06 November 2014
Expiry Date:	05 November 2015

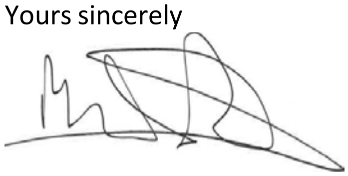
The University of Wollongong/Illawarra Shoalhaven Local Health District Social Sciences HREC is constituted and functions in accordance with the NHMRC *National Statement on Ethical Conduct in Human Research.* The HREC has reviewed the research proposal for compliance with the *National Statement* and approval of this project is conditional upon your continuing compliance with this document.

Approval by the HREC is for a twelve month period. Further extension will be considered on receipt of a progress report prior to expiry date. Continuing approval requires:

- The submission of a progress report annually and on completion of your project. The progress report template is available at http://www.uow.edu.au/research/ethics/human/index.html. This report must be completed, signed by the researchers and the appropriate Head of Unit, and returned to the Research Services Office prior to the expiry date.
- Approval by the HREC of any proposed changes to the protocol including changes to investigators involved
- Immediate report of serious or unexpected adverse effects on participants
- Immediate report of unforeseen events that might affect continued ethical acceptability of the project.

If you have any queries regarding the HREC review process, please contact the Ethics Unit on phone 4221 3386 or email rso-ethics@uow.edu.au.

Yours sincerely



Dr Mark Rix
Acting Chair, Social Sciences Human Research Ethics Committee

Ethics Unit, Research Services Office
University of Wollongong NSW 2522 Australia Telephone (02) 4221 3386 Facsimile (02) 4221 4338 Email: rso-ethics@uow.edu.au Web: www.uow.edu.au

8.6 Appendix F. Participant Information Sheet for Director and /or Educational Leader

University of Wollongong

PARTICIPANT INFORMATION SHEET FOR DIRECTOR and/or EDUCATIONAL LEADER (D1)

TITLE
The Relationship between Educator Engagement & Interaction and Children's Physical Activity in Early Childhood Education and Care Services.

PURPOSE OF THE RESEARCH
The purpose of the research is to investigate the role of educators in promoting physical activity for children, and the ways educators engage and interact with children during physical activity experiences.
Previous research has evaluated the quality and quantity of physical activity in young children in preschools, yet no research has been published that discusses the specific role of the early years educator during interactions involving physical activity, and therefore this is a significant area for research.

The research is being undertaken for a PhD at UOW by student Karen Tonge, and will be supervised by Prof Tony Okely and Dr Rachel Jones. These researchers may be contacted if you have any questions about the research.

RESEARCHERS

Prof. Tony Okely	Dr Rachel Jones	Karen Tonge
Early Start Research Institute	Early Start Research Institute	Early Start Research Institute
Faculty of Social Sciences	Faculty of Social Sciences	Faculty of Social Sciences
School of Education	School of Education	School of Education
02 4221 4641	0467 084 168	02 4221 4951
tokely@uow.edu.au	rachelj@uow.edu.au	ktonge@uow.edu.au

METHOD AND DEMANDS ON PARTICIPANTS
Your Early Childhood Education and Care Service has agreed to be involved in this study. You have the opportunity to participate in this study as you are the Director and/or the Educational Leader within this service.

If you choose to participate, you will be asked to wear a light weight activity monitor and an activity wrist watch over a period of a week while you are at the service during work hours. The activity monitor will be attached to a belt and worn around your waist. It will monitor your level of physical activity during the day. The activity wrist watch is also light weight and will be worn on your wrist. It will monitor your location throughout the day (i.e. if you are inside or outside).

We also request your permission to observe a period of time of approximately 3 hours each day of the week when you are with the children in an outside environment. This observation will be completed by the researcher, using the CLASS (Classroom Assessment Scoring System) observation tool while you are completing normal daily activities with the children. For this observation period, you will be asked to wear a small wireless microphone, and the session may be video recorded.

These will not interfere with your normal daily activities. At any time the device can be removed, data discarded, and/or recording stopped if you are not feeling comfortable.

Prior to this main data collection, we ask that you complete a short survey for the study, which can be completed in your own time and returned to the researchers.
An example of questions that may be included in the survey are: In your opinion, what is the role of physical activity or active play in Early Childhood Education and Care services? How does this compare with the opinion of other educators?

As the Director and/or Educational Leader of your service, you will be invited to participate in a 40 min interview that will be audiotaped. The purpose of the interview will be to identify practices within the service that support children's physical activity and educator involvement. The researcher will conduct the interview.
An example of questions that may be included in the interview are: Are some educators more physically active with the children than others? What do you think are the reasons for this? Explain what occurs during these experiences.

All data collected will remain confidential, and kept in a secure location.

The information gathered will be used in a Thesis, future grant submissions and may be used in presentations and publications.

BENEFITS AND RISKS INVOLVED IN THIS STUDY

This study will benefit your Early Childhood Education and Care Service by providing information upon the relationship between educator engagement and interaction on children's physical activity. This study will also provide a basis for the development of programs to support educators' interactions with children during physical activity experiences.

Through this study, educators may become more aware of their engagement and interaction practices in relation to children's physical activity. This awareness may have a flow-on effect for the programs and practices offered to children at the preschool, which may result in improved practices, as well as improved health and wellbeing outcomes for children. Following the study, the researcher may visit the service and provide information on the results.

This study will be trialing the wrist watches, as a new to way to collect information in this area of research. Apart from the short time that it takes to place the activity monitor and wrist watch on and off each day over the week, we foresee no risks for you. Your involvement in the study is voluntary and you may withdraw your participation from the study at any time and withdraw any data that you may have provided to that point. Refusal to participate in the study will not affect your relationship with the University of Wollongong or the service which you are currently employed at or the organisation in which you are employed by.

ETHICS REVIEW AND COMPLAINTS
This study has been reviewed by the Human Research Ethics Committee of the University of Wollongong. If you have any concerns or complaints regarding the way this research has been conducted, you can contact the UOW Ethics Officer on (02)4221 3386 or email rso-ethics@uow.edu.au.

Thank you for your interest in this study.

Karen Tonge
PhD Student
Early Start Research Institute
Faculty of Social Sciences
School of Education
(02) 4221 4951
ktonge@uow.edu.au

8.7 Appendix G. Consent Form for Directors and/or Educational Leaders

University of Wollongong

CONSENT FORM FOR DIRECTORS and/or EDUCATIONAL LEADERS (D1)

The Relationship between Educator Engagement & Interaction and Children's Physical Activity in Early Childhood Education and Care Services: A Research Study

Researchers: Prof Tony Okely, Dr Rachel Jones and Karen Tonge

I have been given information about the research study entitled '*The Relationship between Educator Engagement & Interaction and Children's Physical Activity in Early Childhood Education and Care Services*'. I understand that this research is a part of Karen Tonge's PhD degree at the University of Wollongong supervised by Tony Okely and Rachel Jones.

I understand that if I consent to participate in this research study, while I am at my Early Childhood Education and Care Service, I may be asked to:
-wear a light weight activity monitor over a period of a week,
-wear a light weight wrist watch over a period of a week, and
-wear a small wireless microphone while outside with the children.

I also consent to being observed during this time, and to participate in a survey and interview to be conducted by the researcher.

I understand that my contribution will be confidential and that there will be no personal identification in the data that I agree to allow to be used in the study. All data collected will be stored securely at UOW.

I understand that there are no potential risks or burdens associated with this study.

I have had an opportunity to ask Karen Tonge any questions that I may have about the research and my participation. I understand that my participation in this research is voluntary and I am free to refuse to participate and I am free to withdraw from the research at any time. My refusal to participate or withdrawal of consent will not affect my relationship with the Faculty of Social Sciences, School of Education at the University of Wollongong, or the service that I am currently employed at.

If I have any questions about the research, I can contact Karen Tonge (02) 4221 4951 and/or Tony Okely (02) 4221 4641.
If I have any concerns or complaints regarding the way the research is or has been conducted, I can contact the Ethics Officer, Human Research Ethics Committee, University of Wollongong on 4221 3386 or email rso-ethics@uow.edu.au.

By signing below I am indicating my consent to participate in the research as has been described to me in the Information Sheet for Directors and/or Educational Leaders. I understand that the data collected from my participation will be used primarily for a PhD Thesis, in future grant submissions and may also be used in presentations and publications, and I consent for it to be used in that manner.

As a participant in this research I understand that by signing the Consent Form, I am agreeing to:
- wear an activity monitor that will monitor my physical activity,
- wear a wrist watch that will track my location,
- be observed through direct observation and video
- wear a small microphone
- complete a survey
-complete an interview

Signed ………………………………………………………..

Date ……/……/……

Name (please print) ………………………………………………………..

8.8 Appendix H. Participant Information Sheet for Parents / Carers

University of Wollongong

PARTICIPANT INFORMATION SHEET FOR PARENTS / CARERS (P1)

Dear Parent / Caregiver

Your child has been invited participate in a research project conducted by the University of Wollongong. The project is entitled *The Relationship between Educator Engagement & Interaction and Children's Physical Activity in Early Childhood Education and Care Services*.
We write to seek your approval and assistance to conduct research and to involve your child as a participant.

PURPOSE OF THE RESEARCH
The purpose of the research is to investigate the role of educators in promoting physical activity for children, and the ways educators engage and interact with children during physical activity experiences.
Previous research has evaluated the quality and quantity of physical activity in young children in preschools, yet no research has been published that discusses the specific role of the early years educator during interactions involving physical activity, and therefore this is a significant area for research.

The research is being undertaken for a PhD at UOW by student Karen Tonge, and will be supervised by Prof Tony Okely and Dr Rachel Jones. These researchers may be contacted if you have any questions about the research.

RESEARCHERS

Prof. Tony Okely	Dr Rachel Jones	Karen Tonge
Early Start Research Institute	Early Start Research Institute	Early Start Research Institute
Faculty of Social Sciences	Faculty of Social Sciences	Faculty of Social Sciences
School of Education	School of Education	School of Education
02 4221 4641	0467 084 168	02 4221 4951
tokely@uow.edu.au	rachelj@uow.edu.au	ktonge@uow.edu.au

METHOD AND DEMANDS ON PARTICIPANTS
Your Early Childhood Education and Care Service has agreed to be involved in this study. If you agree for your child to be included, they will be asked to wear a light weight activity monitor and a watch on the days that they attend the service during one week. The activity monitor will be attached to a belt and worn around their waist. It will monitor their level of physical activity during the day. The activity wrist watch is also light weight and will be worn on their wrist. It will monitor their location throughout the day (i.e. if they are inside or outside). These monitors and watches are non-intrusive and will not interfere with normal daily activities (ie children will be able to participate in all activities planned for that day and the normal curriculum will be able to be implemented).

During the data collection, some outdoor play experiences that occur within the service will be audio and video recorded.

If you agree for your child to participate, a Consent form is to be completed which includes a request for your child's sex, date of birth and days of attendance at the preschool.

All data collected will remain confidential, and kept in a secure location.

The information gathered will be used in a Thesis, future grant submissions and may be used in presentations and publications.

BENEFITS AND RISKS INVOLVED IN THIS STUDY

This study will benefit your Early Childhood Education and Care Service by providing information upon the relationship between educator engagement and interaction on children's physical activity. This study will also provide a basis for the development of programs to support educators' interactions with children during physical activity experiences.

Through this study, educators may become more aware of their engagement and interaction practices in relation to children's physical activity. This awareness may have a flow-on effect for the programs and practices offered to children at the preschool, which may result in improved practices, as well as improved health and wellbeing outcomes for children. Following the study, the researcher may visit the service and provide information on the results.

This study will be trialing the wrist monitors, as a new to way to collect information in this area of research. Apart from the short time that it takes to place the activity monitor and wrist watch on and off each day over the week, we foresee no risks for your child. Your child's involvement in the study is voluntary and you may withdraw your child from the study at any time and withdraw any data that may have provided to that point. Withdrawal or refusal to participate in the study will not affect your relationship with the service that your child is enrolled in, nor the University of Wollongong.

Confidentiality is assured, and your child will not be identified in any part of the research.

ETHICS REVIEW AND COMPLAINTS

This study has been reviewed by the Human Research Ethics Committee of the University of Wollongong. If you have any concerns or complaints regarding the way this research has been conducted, you can contact the UOW Ethics Officer on (02)4221 3386 or email rso-ethics@uow.edu.au.

Thank you for your interest in this study.

Karen Tonge
PhD Student
Early Start Research Institute
Faculty of Social Sciences
School of Education
(02) 4221 4951
ktonge@uow.edu.au

8.9 Appendix I. Consent Form for Parents / Carers on behalf of their Child

University of Wollongong

CONSENT FORM FOR PARENTS / CARERS ON BEHALF OF THEIR CHILD (P1)

The Relationship between Educator Engagement & Interaction and Children's Physical Activity in Early Childhood Education and Care Services: A Research Study

Researchers: Prof Tony Okely, Dr Rachel Jones and Karen Tonge

I have been given information about the research study entitled '*The Relationship between Educator Engagement & Interaction and Children's Physical Activity in Early Childhood Education and Care Services*'. I understand that this research is a part of Karen Tonge's PhD degree at the University of Wollongong supervised by Tony Okely and Rachel Jones.

I understand that if I consent for my child to participate in this research study, while they are at the Early Childhood Education and Care Service, *s*(he) will be asked to:
-wear a light weight activity monitor over a period of a week while they are at the service, and
-wear a light weight wrist watch over a period of a week.

I understand that my child's contribution will be confidential and that there will be no personal identification in the data that I agree to allow to be used in the study. All data collected will be stored securely at UOW.

I understand that there are no potential risks or burdens associated with this study.

I understand that my child's participation in this research is voluntary and I am assured that my child is free to refuse to participate and I am free to withdraw my child from the research at any time.

If I have any questions about the research, I can contact Karen Tonge (02) 4221 4951 and/or Tony Okely (02) 4221 4641.
If I have any concerns or complaints regarding the way the research is or has been conducted, I can contact the Ethics Officer, Human Research Ethics Committee, University of Wollongong on 4221 3386 or email rso-ethics@uow.edu.au.

By signing below I am indicating my consent for my child to participate in the research as it has been described in the Information Sheet for Parents/Carers. I understand that the data collected from my child's participation will be used primarily for a PhD Thesis, in future grant submissions and may also be used in presentations and publications, and I consent for it to be used in that manner.

By providing consent for my child(ren) to participate in this research I understand that by signing the Consent Form, I am agreeing for my child(ren)to:
- wear an activity monitor that will monitor their physical activity,

- wear a wrist watch that will track their location,
- be observed through direct observation and video.

I give permission for my child…………………………………………………………. to participate in this research.
(child's name)

Parent / Carer Signature…………………………………………… Date ……/……/……

Parent / Carer Name (please print)…………………………………………………..

Child's Sex M F (please circle)

Child's DOB …………………………..

Child's Days of attendance at this preschool (please circle)

Monday Tuesday Wednesday Thursday Friday

8.10 Appendix J. Participant Information Sheet for Educators

University of Wollongong

PARTICIPANT INFORMATION SHEET FOR EDUCATORS (E1)

TITLE
The Relationship between Educator Engagement & Interaction and Children's Physical Activity in Early Childhood Education and Care Services.

PURPOSE OF THE RESEARCH
The purpose of the research is to investigate the role of educators in promoting physical activity for children, and the ways educators engage and interact with children during physical activity experiences.
Previous research has evaluated the quality and quantity of physical activity in young children in preschools, yet no research has been published that discusses the specific role of the early years educator during interactions involving physical activity, and therefore this is a significant area for research.

The research is being undertaken for a PhD at UOW by student Karen Tonge, and will be supervised by Prof Tony Okely and Dr Rachel Jones. These researchers may be contacted if you have any questions about the research.

RESEARCHERS
Prof. Tony Okely
Early Start Research Institute
Faculty of Social Sciences
School of Education
02 4221 4641
tokely@uow.edu.au

Dr Rachel Jones
Early Start Research Institute
Faculty of Social Sciences
School of Education
0467 084 168
rachelj@uow.edu.au

Karen Tonge
Early Start Research Institute
Faculty of Social Sciences
School of Education
02 4221 4951
ktonge@uow.edu.au

METHOD AND DEMANDS ON PARTICIPANTS
Your Early Childhood Education and Care Service has agreed to be involved in this study. You have the opportunity to participate in this study as you are an educator within this service.

If you choose to participate, you will be asked to wear a light weight activity monitor and an activity wrist watch over a period of a week while you are at the service during work hours. The activity monitor will be attached to a belt and worn around your waist. It will monitor your level of physical activity during the day. The activity wrist watch is also light weight and will be worn on your wrist. It will monitor your location throughout the day (i.e. if you are inside or outside).

We also request your permission to observe a period of time of approximately 3 hours each day of the week when you are with the children in an outside environment. This observation will be completed by the researcher, using the CLASS (Classroom Assessment Scoring System) observation tool while you are completing normal daily activities with the children. For this observation period, you will be asked to wear a small wireless microphone, and the session may be video recorded. This will not interfere with your normal daily activities. At any time the device can be removed, data discarded, and/or recording stopped if you are not feeling comfortable.

Prior to this main data collection, we ask that you complete a short survey for the study, which can be completed in your own time and returned to the researchers.
An example of a question that may be included in the survey is: Have you undertaken any training relating to children's physical activity and/or providing physical activity experiences to children?

If you agree to participate, a Consent form is to be completed which includes a request for your sex, year of birth, qualification, position in the service and days of work at the preschool.

All data collected will remain confidential, and kept in a secure location.

The information gathered will be used in a Thesis, future grant submissions and may be used in presentations and publications.

BENEFITS AND RISKS INVOLVED IN THIS STUDY
This study will benefit your Early Childhood Education and Care Service by providing information regarding the relationship between educator engagement and interaction and children's physical activity. This study will also provide a basis for the development of educator professional development and programs to support educators' interactions with children during physical activity experiences.

Through this study, educators may become more aware of their engagement and interaction practices in relation to children's physical activity. This awareness may have a flow-on effect for the programs and practices offered to children at the preschool, which may result in improved practices, as well as improved health and wellbeing outcomes for children. Following the study, the researcher may visit the service and provide information on the results.

This study will be trialing the wrist watches, as a new to way to collect information in this area of research. Apart from the short time that it takes to place the activity monitor and activity wrist watch on and off each day over the week, we foresee no risks for you. Your involvement in the study is voluntary and you may withdraw your participation from the study at any time and withdraw any data that you may have provided to that point. Refusal to participate in the study will not affect your relationship with the University of Wollongong and the service in which you are currently employed at.

ETHICS REVIEW AND COMPLAINTS
This study has been reviewed by the Human Research Ethics Committee of the University of Wollongong. If you have any concerns or complaints regarding the way this research has been conducted, you can contact the UOW Ethics Officer on (02)4221 3386 or email rso-ethics@uow.edu.au.

Thank you for your interest in this study.

Karen Tonge
PhD Student
Early Start Research Institute
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ktonge@uow.edu.au

8.11 Appendix K. Educator Consent Form

University of Wollongong

CONSENT FORM FOR EDUCATORS (E1)

The Relationship between Educator Engagement & Interaction and Children's Physical Activity in Early Childhood Education and Care Services: A Research Study

Researchers: Prof Tony Okely, Dr Rachel Jones and Karen Tonge

I have been given information about the research study entitled '*The Relationship between Educator Engagement & Interaction and Children's Physical Activity in Early Childhood Education and Care Services'*. I understand that this research is a part of Karen Tonge's PhD degree at the University of Wollongong supervised by Tony Okely and Rachel Jones.

I understand that if I consent to participate in this research study, while I am at my Early Childhood Education and Care Service, I will be asked to:
-wear a light weight activity monitor over a period of a week,
-wear a light weight wrist watch over a period of a week, and
-wear a small wireless microphone while outside with the children.

I also consent to being observed during this time, and to participate in a survey to be conducted by the researcher.

I understand that my contribution will be confidential and that there will be no personal identification in the data that I agree to allow to be used in the study. All data collected will be stored securely at UOW.

I understand that there are no potential risks or burdens associated with this study.

I have had an opportunity to ask Karen Tonge any questions that I may have about the research and my participation. I understand that my participation in this research is voluntary and I am free to refuse to participate and I am free to withdraw from the research at any time. My refusal to participate or withdrawal of consent will not affect my relationship with the Faculty of Social Sciences, School of Education at the University of Wollongong, or the service that I am currently employed at.

If I have any questions about the research, I can contact Karen Tonge (02) 4221 4951 and/or Tony Okely (02) 4221 4641.
If I have any concerns or complaints regarding the way the research is or has been conducted, I can contact the Ethics Officer, Human Research Ethics Committee, University of Wollongong on 4221 3386 or email rso-ethics@uow.edu.au.

By signing below I am indicating my consent to participate in the research as has been described to me in the Information Sheet for Educators. I understand that the data collected from my participation will be used primarily for a PhD Thesis, future grant submissions and may also be used in presentations and publications, and I consent for it to be used in that manner.

As a participant in this research I understand that by signing the Consent Form, I am agreeing to:
- wear an activity monitor that will monitor my physical activity,
- wear a wrist watch that will track my location,
- be observed through direct observation and video
- wear a small microphone
- be asked to complete a survey.

Signed ………………………………………………………..

Date ……/……/……

Name (please print) ………………………………………………..

Sex M F (please circle)

Year of birth ………………………………………..

Qualification ……………………………..

Position in the centre …………………………………

Days of work at this preschool (please circle)

Monday Tuesday Wednesday Thursday Friday

8.12 Appendix L. Letter to Early Childhood Education and Care Service Director

University of Wollongong

LETTER TO EARLY CHILDHOOD EDUCATION AND CARE SERVICE DIRECTOR (L1)

Dear Director

We would like to invite your Early Childhood Education and Care Service to participate in a research project conducted by the University of Wollongong. The project is entitled *The Relationship between Educator Engagement & Interaction and Children's Physical Activity in Early Childhood Education and Care Services*. We write to seek your approval and assistance to conduct this research.

The purpose of the research is to:
- investigate the relationship between educator physical activity and children's physical activity, and
-understand how educators engage and interact with children to influence physical activity.
At present, a lot of information is known about preschoolers' physical activity, but little is known about the interaction between educators and children, and the role of educators with regards to physical activity in preschool settings.

Approval is sought to visit your preschool over a week. Each day the researcher will invite all children and educators to wear an activity monitor and an activity wrist watch. These monitors and watches are non-intrusive and will not interfere with normal daily activities (ie children and educators will be able to participate in all activities planned for that day and the normal curriculum will be able to be implemented).
In addition to this, observations will be carried out throughout the week. These observations will be completed by the researcher, using the CLASS (Classroom Assessment Scoring System) observation tool. For this observation period, educators will be asked to wear a small wireless microphone, and the session may be video recorded. This microphone or video recording will not interfere with normal daily planned activities.
Educators will also be asked to complete a short survey. Once again, this will not interfere with normal daily planned activities.

For further details, please find attached to this letter the Participant Information Sheets for the Educators, and Parents/Carers.

This study will benefit your Early Childhood Education and Care Service by providing information upon the relationship between educator engagement and interaction on children's physical activity. Information from the study will be shared with the service Director and Educational Leader, to assist in their understanding of practices of the service. This study will also provide a basis for the development of programs to support educators' interactions with children during physical activity experiences. The data may also be presented at a professional development session, or at a staff meeting, at the discretion of the Director. The information gathered will be used in a Thesis, and may be used in presentations and publications.

If there are any ethical concerns you can contact the UOW Ethics Officer on (02)4221 3386 or email rso-ethics@uow.edu.au.

Should you require any further information please do not hesitate to contact members of the research team.

Your Sincerely,

Prof. Tony Okely	Dr Rachel Jones	Karen Tonge
Early Start Research Institute	Early Start Research Institute	Early Start Research Institute
Faculty of Social Sciences	Faculty of Social Sciences	Faculty of Social Sciences
School of Education	School of Education	School of Education
02 4221 4641	0467 084 168	02 4221 4951
tokely@uow.edu.au	rachelj@uow.edu.au	ktonge@uow.edu.au

8.13 Appendix M. Educator Surveys

University of Wollongong

Educator Survey

Research title: The Relationship between Educator Engagement and Interaction and Children's Physical Activity

Prof Tony Okely, Dr Rachel Jones & Karen Tonge

All responses will remain confidential and secure, and will only be used for the purposes of the study as described in the Participant Information sheet.

Name:____

Qualification:____

Positon in the service:____

1. **Have you undertaken formal education or training in providing physical activity experiences to children?**

Yes   No   (please circle your answer)

If yes, please provide any details of this training. (include dates, title, content covered & any other relevant information)

____

____

____

____

If no, why may this be?

____

____

____

____

2. **Do you know of any centre policies that discuss physical activity?**

Yes No (please circle your answer)

If yes, please provide details.

____

____

____

____

3. **Does your centre facilitate any particular programs that promote children to be physically active?**

Yes No (please circle your answer)

If yes, please provide details (include title, duration, frequency, key content, the role of educators & any other relevant information).

____

____

____

____

Thank you for your time!

8.14 Appendix N. Media Coverage

Online PR Media – PR News

September, 2015.

online PR media

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CSL RTLS Wrist Tags Enable Groundbreaking Early Childhood Research Study

Personnel tracking with RFID real time location tags allow researchers to study influences on children's physical activity to encourage healthy lifestyles

Online PR News – 01-September-2015 – HONG KONG – Today, Convergence Systems Limited (CSL), a global provider of passive RFID products and active RTLS equipment, announced that CSL real-time location system (RTLS) RFID technology is being used in a research offering the potential to improve children's health and wellbeing.

Karen Tonge, a researcher with the Early Start Research Institute (ESRI) at the University of Wollongong, Australia, elicited the help of CSL for her unique PhD research project. The three-year study, begun in early 2014, examines the relationship between educator engagement and the physical activity levels of their preschool students.

To track the location of study participants and their proximity to each other throughout the day, children and educators wear CS3151 RTLS Wrist RFID Tags, that transmits positional data to wireless mesh network of CSL RTLS RFID Fixed Readers positioned in the area to triangulate the tag's real-time movement. Additional data is collected with lightweight accelerometers worn on a belt around the waist to measure the amount and intensity of physical activity, and direct observations are recorded as well as educator surveys.

> "The CSL RTLS system offers the accuracy, real-time performance and data collection capabilities that we needed for the project, all within our budget guidelines."

"This is the first time that RTLS monitoring has been used to study how educators are engaging and interacting with children to influence physical activity," said Tonge. "The CSL RTLS system offers the accuracy, real-time performance and data collection capabilities that we needed for the project, all within our budget guidelines."

Research has shown that educator engagement and interaction with children relates to better child outcomes for learning and development. To determine if a correlation exists between educators' physical activity and that of their students, the study looks at where and when participants are most active, as well as what strategies educators use to promote physical activity.

The research study follows approximately 600 children ranging from 2-5 years of age and 100 educators working in Australia's Early Childhood Education and Care (ECEC) services across 15 preschools in New South Wales. To protect the privacy of participants, RTLS tags are identified by codes that are kept in a secure location.

"The CSL RTLS system adds a new dimension to research that is crucial for useful for documenting and promoting healthy lifestyles," said Jerry Garrett, managing director, Convergence Systems Limited. "With an accuracy of +/- one meter, the CS3151 RTLS Wrist RFID Tag is ideal for real-time people tracking applications; such as children, the elderly, security guards and even animals."

About Convergence Systems Limited

Founded in 2000, Convergence Systems Limited is a leading design engineering company and provider of radio frequency ID (RFID) tags, readers, antennas, modules and custom RFID hardware. CSL is unique in providing both passive Electronic Product Code™ (EPC) Gen 2 RFID products, as well as a full line of active RTLS RFID products. CSL delivers a broad portfolio of RFID hardware for logistics management, supply chain, manufacturing, pharmaceutical, access control, and transportation and retail industries around the world. A member of standards organization EPCglobal, CSL is headquartered in Hong Kong with a global distribution channel. For more information, visit http://www.csl-rfid.com/.

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RFID Journal

September, 2015.

Australian Researcher Uses RFID to Track Preschoolers' Activity Levels

The project's goal is to learn how teachers can influence their students' behavior, with the premise being that greater physical activity improves a child's health and well-being.

By Claire Swedberg

Tags: Asset Tracking, Health Care

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Sep 21, 2015— Karen Tonge, a researcher with the University of Wollongong's Early Start Research Institute (ESRI), is using an RFID-based solution to track the movements and proximity of students and educators in preschool playgrounds, thereby providing insight regarding how much teacher engagement influences the level of activity in children. The study will aim to provide educators and other interested parties with information regarding the extent to which teachers can influence how active children are during their early education years. The premise is that the more physically active a child is, the better that individual's health and well-being will become.

To track the locations and movements of students and teachers, Tonge is employing battery-powered RFID tags and fixed readers provided by Convergence Systems Ltd. (CSL). The students and teachers also wear ActiGraph battery-powered devices that contain accelerometers for measuring the quantity and intensity of a person's movements. The collected movement data is then manually compared against the RFID-based location data to determine where an individual was, and with whom. However, Tonge says, she is currently working with other researchers to develop a software program that would integrate the ActiGraph accelerometer data with the RFID real-time location system (RTLS) data, in order to create an automatic link between location and movement intensity.

At each participating school, Tonge installs several CSL RTLS RFID anchor readers, each plugged into a power source.

Tonge is working with the Early Start Research Institute to earn her doctorate in education. She began the three-year study in early 2014 after discussing her research project with Tony Okley, ESRI's research head, who was familiar with CSL's RFID technology. Simply observing children's activity would not provide the detail of activity data that the study would require, she explains, so she launched the project using the RFID wristbands and readers.

By the time the project is finished, it will have involved up to 600 preschoolers (ages two to five) at 15 preschools located in New South Wales, as well as up to 100 educators who work with those children. To date, Tonge has installed the technology at six preschools in the Wollongong area, for about one week at each site.

Tonge opted to conduct the study only during outdoor playtime, when children are expected to be most active.

Each participant, whether adult or child, wears an ActiGraph wGT3X-BT device attached to his or her waist to track movement intensity, as well as a CS3151BBCD RFID tag, which looks a wristwatch. Tonge installs CSL RTLS RFID anchor readers, each plugged into a power source. The anchor readers transmit location data to a CSL RTLS RFID gateway reader connected to a laptop running CSL software, which computes each person's location.

Tonge arranges the readers in such a way that they provide data that the software can use to triangulate the tags as they move through a playground. That means she must, at times, be creative in how those devices are installed. "They can be in a shopping bag," Tonge states, "hanging from a tree," for instance, or mounted on a fence, wall or shelf. She installs at least four readers but sometimes as many as eight, depending on a playground's size and shape. "Some [playgrounds] are a lovely rectangle, but others have an L shape or a more awkward shape, in which case I have used up to eight readers."

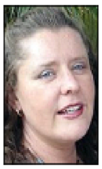
One of the project's preschoolers, wearing a CSL RFID tag on her wrist and an ActiGraph battery-powered activity monitor on her waist.

Once Tonge installs the readers, she registers each device's GPS coordinates into the CSL software, which is then used to display a map of the playground. The interrogators themselves create a wireless mesh network to funnel their data to the gateway reader. The CSL software running on the laptop uses triangulation to track each tag's movements. Tonge then inputs data that can be overlaid on the map, such as the location of a sandpit, a picnic table or playground equipment. "I want to be able to see the different features in each environment," she explains, in order to determine how those features might influence activity as well.

Each RFID tag uses a proprietary air-interface protocol to transmit a 2.4 GHz signal encoded with a unique ID number. That ID is associated with a student or teacher wearing that tag, although the individual's identity is not tracked. When adults or children wearing the tags are in the playground in which the readers are deployed, the CSL software identifies each wristband's location in real time and displays an icon (E for educator or C for child) as the person wearing it moves around the playground.

"I can also watch movements as they are actually happening," Tonge adds, recalling one day in which a garbage truck came within viewing range of a preschool playground. As the truck arrived, she says, "I could watch all the little dots go to the fence, and then follow along the fence" as the vehicle passed.

The study, which is slated to conclude in 2017, has already generated considerable data, Tonge says, though she has yet to perform much analysis of the results. "The information we are getting from the services [preschools] is so diverse," she states. For example, some schools have more educators per the number of children, some vary routines and programs, and some have a higher level of activity among both children and educators.



Karen Tonge

Wearing the RFID wristbands was an easy sell for students, Tonge says. "The children love them. I'm known as the watch lady," she states, adding that the kids are eager to put the devices on their wrists. The tags must be durable, she notes, since they are being issued to small children. For instance, they have been buried in sand, as well as covered with paint and modeling clay. But according to Tonge, they still operate well under such conditions.

The technology itself has a lot of potential for schools, Tonge says, since it enables a preciseness of tracking student and teacher behavior that isn't possible manually.

Describing her goals for the research project, Tonge says, "I hope to contribute to my field by informing educators of their role in engagement with children and the resulting activity levels, in hopes of influencing policy and practice."

Tonge adds, "By 2017, I will have a very clear picture of how an educator can influence activity levels in children." She plans to make the results of her work available to researchers, teachers and others in the education sector, for use in organizing preschool programs, preschool-age activities, environments, teacher training and student-per-teacher structures.

Illawarra Health and Medical Research Institute

Research Matters. Summer, 2015.

OUR NEWS

A new game of tag for pre-schoolers

An innovative study led by PhD candidate Karen Tonge from the IHMRI-affiliated Early Start Research Institute (ESRI) uses radio-frequency identification (RFID) tags to provide insights on the extent to which teachers/educators influence the amount of physical activity that pre-schoolers get.

Previous research has identified the fact that Australian children in Early Childhood Education and Care (ECEC) services are not engaging in sufficient physical activity as recommended by the national guidelines, and levels of sedentary behaviours in ECECs are also not meeting recommended levels.

"Educators spend considerable periods of time with the children, so it's important for us to understand their role," said Karen.

"However, simply observing children's activity would not provide the kind of detailed activity data we required."

In this study, which commenced in 2014, the children and their educators are fitted with RFID wristbands and wear lightweight accelerometers around their waists. The wristbands transmit data to real-time location system (RTLS) readers which triangulate the tag's movement to give Karen and other members of the ESRI team (including Professor Tony Okely and Dr Rachel Jones) information on the participants' location and their proximity to each other while playing outdoors. The accelerometers measure the amount and intensity of physical activity.

"The technology locates and tracks the movements of participants and, in conjunction with the accelerometers, identifies the relationship between participants and how this may influence physical activity behaviours," explained Karen, who also records observations and conducts educator surveys.

To date, she has been able to install the technology at eight preschools around Wollongong, but by the time the project finishes in 2017, it will involve 15 services across the Illawarra-Shoalhaven region and around 600 pre-schoolers and 100 educators.

While it is too soon to report on the findings, the potential of the technology in this context has been featured in the *International RFID Journal* and on several technology news sites.

"As far as we know, this is the first time that RTLS monitoring has been used to study how educators are engaging and interacting with children to influence physical activity," said Karen.

"This research has the potential to influence ECEC policy and practice and have a positive impact on the health and wellbeing of young children in the region and beyond."

Study participants Hayley Steggles and her educator, Jodie-Anne Asplet, from Big Fat Smile in Helensburgh. Hayley is seen wearing the wristband and waist accelerometer, which transmit data to the real-time location system reader (insert).