MAXIMISING YOUTH SPORT AS A CONTEXT FOR PHYSICAL ACTIVITY PROMOTION: A SELF-DETERMINATION THEORY APPROACH

By

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ABSTRACT

Youth sport has been advocated as a vehicle through which more physically active lifestyles can be encouraged among children and adolescents. Employing objective assessments of physical activity (PA), the purpose of this thesis was to investigate the value of youth sport as a context for PA promotion and obesity prevention.

Results from Study 1 indicated 37% of youth sport football participants did not meet recommended levels of moderate-to-vigorous PA (MVPA) during their youth sport engagement. Study 2 demonstrated negative associations between daily PA levels of grassroots footballers and obesity linked health outcomes, with the reverse true for sedentary time (ST). Guided by self-determination theory (Deci & Ryan, 1987), findings from Studies 3 and 4 revealed perceptions of coach provided autonomy support were positively associated with sport related autonomous motivation, and in turn, higher MVPA participation (daily MVPA as well as PA accrued during youth sport) and lower ST.

This thesis underlines the value of youth sport as a setting through which levels of PA can be increased, and ST reduced among youth. Research described within also points to the important role of the coach-created environment and player motivation in predicting variability in PA engagement and ST among young grassroots footballers.

I would like to dedicate this thesis to my parents,

Carol and Mike Fenton

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LIST OF PAPERS

This thesis is comprised of the following four papers. Study design, data collection, statistical analysis and writing were conducted by Sally Fenton. Professor Joan Duda and Professor Timothy Barrett advised on study design and data analysis, and provided feedback on all written work. Where listed, co-authors also advised on data analysis and paper editing.

1. **Fenton, S.A.M.,** Duda, J.L., & Barrett, T.G. (under review). The contribution of youth sport football to weekend physical activity: Variability related to age and playing position, *Pediatric Exercise Science*

2. **Fenton, S.A.M.,** Duda, J.L., & Barrett, T.G. (under review). Independent associations between physical activity and sedentary time with indicators of adiposity and cardiovascular risk in youth sport participants, *Journal of Sport Sciences*

3. **Fenton, S.A.M.,** Duda, J.L., & Barrett, T.G. (under review). Optimising physical activity engagement during youth sport: A self-determination theory perspective¸ *Journal of Sport and Exercise Psychology*

4. **Fenton, S.A.M.,** Duda, J.L., Quested, E., & Barrett, T.G. (published online 4th May 2014). Coach autonomy support predicts autonomous motivation and daily moderate-to-vigorous physical activity and sedentary time in youth sport participants, *Psychology of Sport and Exercise*

During the period of post graduate study within the School of Sport, Exercise and Rehabilitation Sciences at the University of Birmingham, the following articles and conference abstracts were accepted for publication/presentation.

Publications

1. Van Hoye A.L, **Fenton S**, Krommidas C, Heuzé J-P, Quested E, Papaioannou A, Duda J.L. (2013). Physical activity and sedentary behaviours among grassroots football players: A comparison across three European countries. *International Journal of Sport and Exercise Psychology, 11*(4), 341-350.

2. **Fenton, S.A.M.,** Duda, J.L., Quested, E., & Barrett, T.G. (2014). Coach autonomy support predicts autonomous motivation and daily moderate-to-vigorous physical activity and sedentary time in youth sport participants, *Psychology of Sport and Exercise, 15*(5), 453-463.

Conference Presentations

1. **Fenton, S.A.M.,** Duda, J.L., & Barrett, T.G. Perceptions of empowering and disempowering coach created climates as predictors of objectively measured daily physical activity in youth sport participants. *The International Society of Behavioral Nutrition and Physical Activity, 2014 Annual Meeting, San Diego, USA, May 2014.*

2. **Fenton, S.A.M.,** Duda, J.L., & Barrett, T.G. Independent associations between physical activity and sedentary time with indicators of adiposity and cardiovascular risk in youth sport participants. *The International Society of Behavioral Nutrition and Physical Activity, 2014 Annual Meeting, San Diego, USA, May 2014.*

3. **Fenton, S.A.M.,** Duda, J.L., & Barrett, T.G. The contribution of youth sport towards physical activity: Relationships with adiposity and markers of cardiovascular risk. *18th Annual Congress of the European College of Sports Sciences, Barcelona, Spain, June 2013*

4. **Fenton, S.A.M.,** Duda, J.L., Quested, E., & Barrett, T.G. Coach-provided autonomy support, intrinsic motivation and enjoyment as predictors of objectively measured physical activity levels in grassroots footballers. *17th Annual Congress of the European College of Sports Sciences, Bruges, Belgium,*

July 2012. (Paper awarded 2nd prize in the ECSS young investigators award and also presented as an invited talk at the *67th Annual Congress of the Japanese Society of Physical Fitness and Sports Medicine, Gifu-shi, Japan, September 2012*

5. Krommidas, C., Van Hoye, A.L., **Fenton, S.A.M.,** Galanis, E., Bosselut, G., Duda, J.L., Keramidas, P., Nicaise, V., Barrett, T.G., Zourbanos, N., Heuzé, J-P., Papaioannou, A., Sarrazin, P., & Quested, E. Comparison of objectively measured physical activity levels of youth soccer players between France, England and Greece. European Congress of Sport and Exercise Sciences, *17th Annual Congress of the European College of Sports Sciences, Bruges, Belgium, July 2012.*

6. **Fenton, S.A.M,** Van Hoye A.L, Krommidas C, Papaioannou A, Heuzé J-P, Barrett, T.G., & Duda J.L. Validation of physical activity measurement by accelerometry and self report. *13th FEPSAC European Congress of Sports Psychology, Madeira, July 2011.*

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CHAPTER 1

GENERAL INTRODUCTION

Overview

Overweight and obesity have been identified as the fifth leading risk factor for mortality, accounting for 2.8 million adult deaths globally each year (World Health Organisation, 2013). Childhood obesity has reached epidemic proportions worldwide, with the most recent data indicating around 14.5% of school-aged youth to be overweight, with approximately 4% of these being obese (International Association for the Study of Obesity, 2014). Studies demonstrate that youth with a high BMI-for-age are at increased risk for a variety of co-morbidities such as cardiovascular disease and type 2 diabetes in childhood, adolescence and adulthood (Reilly & Kelly, 2011; Reilly, 2007). Finding ways to prevent obesity during childhood is therefore paramount to our attempts to counteract this critical public health problem and associated disease burden.

Low levels of physical activity (PA) and an increase in sedentary pursuits (e.g., television (TV) viewing, computer use) among youth has been implicated in the aetiology of childhood obesity (Basterfield et al., 2012; Dencker & Andersen, 2008a; Dollman, Norton, & Norton, 2005; Mark & Janssen, 2011; Mitchell, Pate, Beets, & Nader, 2013; Moore et al., 2003; Nelson, Neumark-Stzainer, Hannan, Sirard, & Story, 2006; Saunders, 2011; Tremblay et al., 2011; Wareham, van Sluijs, & Ekelund, 2005). As a result, physical activity promotion, and more recently, reducing engagement in sedentary behaviour, has been a focal point of global attempts to reduce levels of obesity in both adults and children for the past few decades. Indeed, research has demonstrated higher levels of PA to be associated with reduced risk of obesity during childhood (Dencker & Andersen, 2008a; Jiménez-Pavon, Kelly, & Reilly, 2010; Mark & Janssen, 2011; Moore et al., 2003), in addition to preventing the development of risk factors for cardiovascular disease and type 2 diabetes (Berman, Weigensberg, & Spruijt-Metz, 2012; Ekelund et al., 2012; Gutin & Owen, 2011; Janssen & Leblanc, 2010).

Specifically, research in youth indicates engagement in PA above a moderate intensity [i.e., moderate-to-vigorous activity, MVPA (i.e., PA ≥ 3 metabolic equivalents (METS)[1]] is negatively associated with adiposity, cardiorespiratory fitness and cardiovascular and diabetes risk factors (Ekelund et al., 2012; Mark & Janssen, 2011; Ried-Larsen, Grøntved, Froberg, Ekelund, & Andersen, 2013; Ruiz, Ortega, Warnberg, & Sjostrom, 2007; Santos et al., 2013), with the reverse true for time spent engaged in sedentary behaviours (e.g., activity ≤ 1.5 METS) (Carson & Janssen, 2011; Martinez-Gomez et al., 2012a; Mitchell et al., 2013; Prentice-Dunn & Prentice-Dunn, 2011; Tremblay et al., 2011). Moreover, a dose-response relationship has been observed between PA intensity and health outcomes among youth, with studies reporting that vigorous physical activity (VPA, i.e., PA ≥ 6 METS) may be more strongly related to reduced adiposity and decreased risk factors for disease than moderate PA. Consequently, PA guidelines for MVPA, VPA and sedentary behaviour have been developed and endorsed by public health organisations across the globe (Australian Government: Department for Health and Ageing: 2004; Department of Health, 2011; Family guide to physical activity for youth 10-14 years of age, 2002; Physical Activity Guidelines Advisory Committee, 2008; Strong et al., 2005; US Department of Health and Human Services, 2013; World Health Organisation, 2011). However, despite evidence outlining the health benefits of engaging PA towards recommended levels, studies indicate currently a small percentage of children and adolescents are meeting national PA guidelines (Basterfield et al., 2012;

[1] Definitions of ≥3 METS, ≥6 METS and ≤1.5 MET for MVPA , VPA and sedentary time respectively are based on the most widely used definitions of PA intensity among studies involving youth (Cain, Sallis, Conway, Van Dyck, & Calhoon, 2013) and are the definitions used throughout this thesis.

Craig, Mindell, & Hirani, 2009; Laguna et al., 2013; Long et al., 2013; Riddoch et al., 2007). Moreover, research indicates youth spend large proportions of the day engaged in sedentary behaviours (Pate, Mitchell, Byun, & Dowda, 2011).

In order for children and adolescents to achieve sufficient levels of PA, we need to ensure the provision of optimal opportunities for PA engagement. To this end, researchers are seeking to investigate the value of different youth PA settings for increasing daily engagement in PA towards recommended levels. Health organisations have placed a particular focus on the utility of the school as an arena through which PA levels of youth may be increased, and as a result the majority of research conducted in the realm of PA promotion has targeted the school setting (Centers for Disease Control and Prevention, 2000; Jago & Baranowski, 2004; Lonsdale et al., 2013a). However, children and adolescents are active among a variety of settings both within and outside the school environment (e.g. physical education (PE), recess/school breaks, active play, extra-curricular activities, youth sport, and community clubs). Thus, there is a need for research focused on investigating the relevance of contexts outside the school environment for PA promotion. This is particularly important given that sedentary pursuits are frequently engaged in during leisure time (Biddle, Marshall, Gorely & Cameron, 2009). Accordingly, PA settings outside the school environment may reduce options for engagement in sedentary behaviours. This line of research will contribute towards gaining a comprehensive view of youth PA settings which can play a role in promoting engagement in MVPA and VPA, and reducing time spent engaged in sedentary behaviour in youth.

In 2007, the Government White Paper on sport advocated youth sport as a context through which higher levels of PA engagement may be encouraged among children and adolescents. Holding sport as a relevant domain for young people’s physical activity underlines its potential relevance as a setting for overweight and obesity prevention in youth (Commission of the European Communities, 2007). Indeed, millions of children participate in youth sport across the world (Australian Bureau of Statistics, 2009; National Council of Youth Sports, 2008), and as such, this setting represents a globally relevant context for PA promotion. However, only a small number of studies have employed objective measurement tools to investigate the frequency, intensity and duration of PA engagement among youth sport participants. Moreover, the levels of engagement in sedentary behaviour remain somewhat unstudied among these groups of youth. Consequently, conclusions drawn concerning the value of youth sport as a context to encourage PA participation and reduce engagement in sedentary pursuits, towards levels identified as preventing excess adiposity, are based on a limited body of evidence. Thus, there is a need to conduct additional research in the youth sport domain in order to more accurately characterise levels of PA engagement and sedentary behaviour associated with youth sport participation. Furthermore, it is necessary to determine associations between levels of engagement in PA (MVPA and VPA) and sedentary behaviour with obesity linked health outcomes among groups of youth sport participants in order to uncover the relevance youth sport setting for obesity prevention.

The few existing studies that have been conducted within the sport domain indicate that whilst youth sport may provide an opportunity for engagement in MVPA, PA accrued during youth sport alone is not sufficient to meet recommended guidelines (Guagliano, Rosenkranz, & Kolt, 2012; Leek et al., 2011; Sacheck et al., 2011; Wickel & Eisenmann, 2007). In addition, research indicates MVPA accrued on a sport day is not maintained on a non-sport day (Wickel et al., 2007), and levels of ST are reported to be high among youth sport participants (Machado-Rodrigues et al., 2012). It may therefore also be necessary to investigate avenues through which an individual's youth sport participation can be optimised. As such, identifying factors within the youth sport setting which can encourage higher engagement in PA and reduce engagement in sedentary behaviour across contexts, will likely be central to our attempts to maximise youth sport as a setting for PA promotion and obesity prevention. That is, it is also important to consider not only *where* we can promote PA participation among youth, but also *how* we can effectively utilise these settings to encourage higher levels of PA engagement among children and adolescents of all body weights/compositions.

Self-determination theory (SDT) has been successfully used within the context of PA promotion, and holds that the reasons 'why' we engage in a behaviour can carry important consequences for PA engagement (Deci & Ryan, 1987; Deci & Ryan, 2000; Deci & Ryan, 2008; Ryan & Deci, 2000a). Specifically, more autonomous and intrinsic reasons for PA participation are related to higher engagement in PA (Aelterman et al., 2012; Standage, Gillison, Ntoumanis & Treasure, 2012), with the opposite true for more controlled or external reasons for PA participation (Owen, Astell-Burt & Lonsdale, 2013). To this end, understanding why some children chose to engage in sport (i.e., their motivations for sport engagement) and how this relates to levels of engagement in MVPA, VPA and sedentary behaviour, both within and outside the youth sport setting, may help to inform PA promotion efforts targeting the youth sport context.

In response to the White Paper on sport (Commission of the European Communities, 2007), the broad aim of this thesis was two-fold. First, to determine PA levels associated with youth sport participation and relationships with obesity linked health outcomes. Second, to investigate the social-psychological correlates of PA engagement and sedentary behaviour among youth sport participants in order to identify avenues through which youth sport may be maximised as a context for increasing levels of engagement in MVPA and VPA and reducing sedentary behaviour. Utilising data collected as part of a European-wide research trial, namely, the Promoting Adolescent Physical Activity (PAPA; www.projectpapa.org) project, the focus of investigations contributing to this thesis was youth sport football. With over 22 million registered players worldwide, youth sport football is reported to be among the most popular youth sports internationally (Australian Bureau of Statistics, 2009; Kunz, 2007; National Council of Youth Sports, 2008; Women's Sports Foundation, 2008). Thus, the findings of the studies contained within this thesis may have implications for millions of children from countries across the world.

Childhood obesity

Definition

Obesity is defined as excess fat accumulation to such an extent it poses a serious threat to health (Rudolf, 2004). The most commonly used method to identify individuals with excess adiposity is body mass index [BMI, i.e. weight (kg) divided by height^2 (m^2)]. In adults, BMI can be interpreted fairly simply by defining overweight as a BMI ≥25 kg/m^2, and obesity as a BMI ≥ 30 kg/m^2 (World Health Organisation, 1995). These cut-offs are derived from the analysis of health risks at 25 kg/m^2 and 30 kg/m^2 and have demonstrated associations with health and mortality in many populations (World Health Organisation, 1995; World Health Organisation, 1998). However, BMI is lower in children than adults and varies with age and gender due to differences in growth and maturation. Consequently, the single cut-off values used to identify excess adiposity during adulthood cannot be applied to accurately define overweight and obesity at different ages during childhood. As a result, age and gender specific percentile charts have been developed in numerous countries across the globe. These percentile charts are developed from national reference populations of healthy children and adolescents, to enable the identification of an increased BMI such that poses a threat to health. For example, in the United Kingdom, the British 1990 reference curves have been developed from a reference population of youth aged 2 to20 years (Cole, Freeman, & Preece, 1995). Where percentile charts are used in epidemiological and population based research, cut-off values of a BMI ≥85th or ≥ 95th percentile are used to define overweight and obesity respectively (Reilly, 2010). Clinical cut offs are set higher at ≥91st (overweight) or ≥ 98th (obese) percentile (Zaninotto, Wardle, Stamatakis, Mindell, & Head, 2006). Reference data can also be used to calculate BMI standard deviation score (BMI-SDS) representing increases or decreases around the 50th percentile or mean value (Cole, Freeman, & Preece, 1998). This standardised definition is needed when not simply classifying children as overweight or obese, but also in cases where researchers are examining associated factors which might prevent or increase BMI in youth over time (i.e., levels of PA engagement).

International cut-off points have also been developed using population reference data collected from six countries (International Obesity Task Force (IOTF) (Cole, Bellizzi, Flegal, & Dietz, 2000). However, a recent review found the national approach superior to the international approach for classifying overweight and obesity among youth. Consequently, in the UK, the National Institute for Health and Clinical Excellence (NICE) recommend measurement of BMI in children should be related to the UK 1990 BMI reference charts (Zaninotto et al., 2006).

Whilst BMI offers a simple means of assessing excess body fat, it has been criticised as being a fairly crude measure of adiposity due to its inability to distinguish between fat free mass (i.e., muscle and bone) and fat mass (Georgiades, Reilly, Stathopoulou, Livingston, & Pitsiladis, 2003; Maynard et al., 2001). Consequently, individuals with a large muscle mass may be incorrectly classified as overweight or obese and at increased risk of poor health. Highlighting issues associated with using BMI as a proxy for identifying elevated health risk, Romero-Corral et al., (2006) reported that overweight adults (BMI = 25 – 29.9) demonstrated lower risk for total mortality and cardiovascular mortality compared to normal weight adults (BMI = 20 – 24.9). The authors concluded that findings could be explained by the lack of discriminatory power of BMI to differentiate between body fat and lean mass. In a recent study, Flegal, Kit, Orpana & Graubard et al., (2013) reported similar findings, revealing that relative to normal weight (BMI = 18.5 – 24.9), overweight (i.e., BMI = 25 – 29.9) was associated with a significantly lower all-cause mortality in adults. However in this study, it was suggested that results may be explained by the earlier identification of overweight patients in recent years due to increased public and professional knowledge of the negative health consequences of obesity (Oreopoulos et al., 2009), greater likelihood of receiving optimal medical treatment for conditions such as cardiovascular disease and type 2 diabetes (Schenkeveld et al., 2012) and the benefits of higher metabolic reserves (i.e., the excess adipose tissue acts as a greater metabolic reserve to deal with the metabolic demands of chronic diseases) (Doehner, Clark & Anker, 2010). Future studies are therefore needed in order to investigate the extent to which such propositions may be true, or whether this ‘obesity paradox’ (Doehner et al., 2010), is more likely due to misclassification of people with a large muscle mass as overweight or obese.

To somewhat overcome of the issues surrounding the use of BMI as an indicator of excess body fat, other indicators of adiposity are also often employed to identify individuals at risk for obesity and associated co-morbidities (Lobstein, Baur, & Uauy, 2004). Indeed, research has demonstrated that body composition and the distribution of excess fat to have important implications for metabolic and cardiovascular health (Huang, Liao & Hsu, 2012; Recio-Rodriguez et al., 2012).Thus, employing such measures may be useful in studies seeking to determine factors associated with lowering health risks associated with excess adiposity. For example, waist circumference offers a further indirect measure of adiposity and can be used specifically to estimate central adiposity, a risk factor for the metabolic syndrome (Bitsori, Linardakis, Tabakaki, & Kafatos, 2009). Direct measures of adiposity include percent body fat (BF%) and fat mass. Both are markers of general adiposity and can be measured directly using magnetic resonance imaging (MRI), dual energy x-ray absorptiometry (DEXA) and bio-electrical impedance analysis (BIA). All of these techniques have been validated for use in paediatric populations (Barreira, Staiano, & Katzmarzyk, 2013; Hosking, Metcalf, Jeffery, Voss, & Wilkin, 2006; Lobstein et al., 2004; Pietrobelli et al., 2003).

Prevalence

The global prevalence of childhood overweight and obesity has increased markedly in the last few decades (Wang & Lobstein, 2006). In 2005, it was estimated that over 155 million school-aged children worldwide were obese (British Medical Association, 2005). Moreover, the most recent data representing the WHO regions (i.e., Africa, Americas, Europe, Eastern Mediterranean, South East Asia, Western Pacific) indicate approximately14.5% of youth to be overweight, with 4% of these young people being obese (International Association for the Study of Obesity, 2014). In 2006, a review summarised available prevalence data from 60 of the 191 member countries of the WHO. Results revealed the prevalence of overweight and obesity increased in virtually all countries between 1980 and 2005 (Wang & Lobstein, 2006). The data reviewed represented over half of the world population in 2000, clearly demonstrating the emergence of this global public health crisis. More recently, attention has been drawn towards the growing rate of obesity prevalence among developing countries (Gupta, Goel, Shah, & Misra, 2012; Reilly, 2006a), with a recent report indicating prevalence rates in adults nearly double those observed in high income countries (Overseas Development Institute, 2014). Figure 1.1 illustrates the reported upward trend in levels of child overweight between 1965 and 2010 from selected countries worldwide.

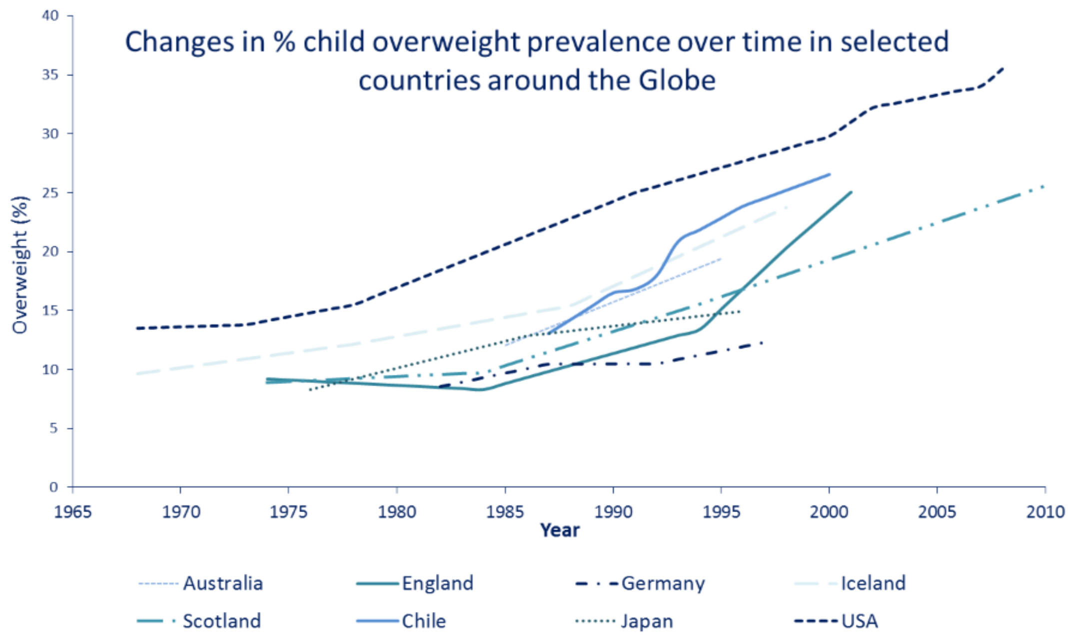

Figure 1.1 Change in % child overweight prevalence over time in selected countries around the globe (International Association for the Study of Obesity, 2012)

In England, the National Study of Health and Growth (NSHG; 1974-1994), National Child Measurement Programme (NCMP; 2005 - present) and the Health Survey for England (HSE; 1995 - present) have provided the best means of monitoring the epidemic via data collected over the past 35 years. Between 1984 and 1994, the prevalence of obesity (≥ 95^{th} percentile) among English boys aged 4 to 11 years almost doubled (5.4%

to 9%) and increased by approximately 50% in girls of the same age (9.3% to 13.5%). Such findings provide evidence that the occurrence of childhood obesity was beginning to increase (Chinn & Rona, 2001). Data taken from the HSE over the past ten years has clearly confirmed an upward trend in the levels of childhood and adolescent obesity in England. The most recent data available from the HSE (2011) indicate that 31% of boys and 28% of girls aged 2 to15 years were overweight (including those who are obese), with obesity prevalence rates of 17% and 16% respectively (Health and Social Care Information Centre, 2012). Figure 2.1 demonstrates trends in child obesity prevalence between 1995 and 2011 as recorded by the HSE.

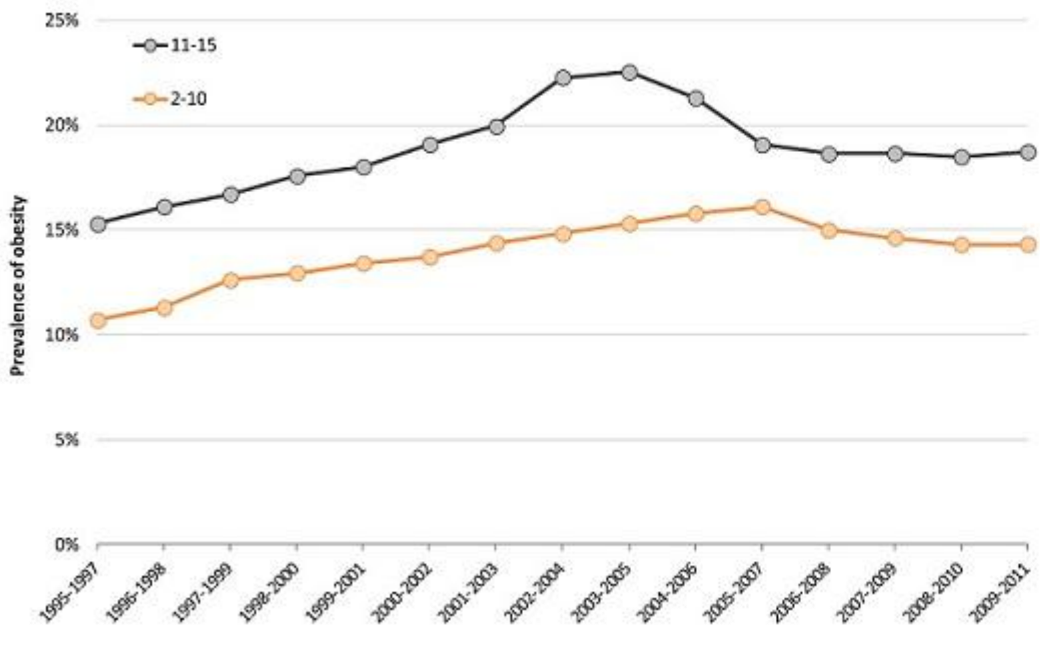

Figure 1.2 Trends in child (aged 2-15 years) obesity prevalence (HSE) (Public Health England, 2014)

Strategies and public health schemes to combat obesity have been overtaken by the scale and speed of the epidemic (Reilly, 2007). It has been predicted that without clear action, the prevalence of childhood overweight and obesity will rise to 40% and 25%

respectively by 2050 (Foresight, 2007). However, the HSE (2011) reported a steady decrease in levels of obesity between 2004 and 2011 (Health and Social Care Information Centre, 2012). Furthermore, a recent review indicated the rate of increase in prevalence of child and adolescent obesity in Western nations has decreased and in some countries, may have levelled off (Rokholm, Baker, & Sorensen, 2010). This recent statistic is promising. However, attention should be drawn to the fact that data taken since 1995 has shown peaks and troughs in obesity prevalence, and this lack of statistical change may simply be part of the continuing trend upwards. Reasons cited for the reported plateau in obesity prevalence include sample bias and inconsistent approaches concerning measurement of adiposity. For example, it has been suggested an underrepresentation of overweight and obese youth in more recent epidemiological studies may mask a continuing trend upwards (Reilly, 2006b), and the use of BMI may not afford detection of population changes in adiposity (Reilly, 2012). Indeed, a population based study reported detectable changes in adiposity when assessed via waist circumference but not BMI (McCarthy, Ellis, & Cole, 2003). Also important to note is that reported trends in health behaviours suggest the lifestyles of UK children have not changed in recent years to warrant reductions in levels of overweight and obesity (Health Social Care and Information Centre, 2012; National Obesity Observatory Data Briefings, 2014). Epidemiological and population based research conducted over the next few years will be important in determining whether recent findings represent a temporary pause in the epidemic, rather than a levelling off or decline in levels of overweight and obesity across the world (Reilly, 2012).

Consequences

Children and adolescents with a high BMI-for-age are at increased risk for a variety of morbidities in childhood, adolescence and in adulthood (Reilly et al., 2003; Reilly & Kelly, 2011). The immediate negative health consequences associated with childhood obesity can be both physical and psychological. In the physical domain, childhood obesity is frequently linked to asthma, sleep apnea and orthopaedic problems (Mathew & Narang, 2013; Pulgaron, 2013; Reilly et al., 2003; Rudolf, 2004). Increasing numbers of children are also being diagnosed with the metabolic syndrome (clustering of cardiovascular disease risk factors such as hypertension, hyperlipidaemia, hyperinsulinaemia and insulin resistance) (Burke, 2006; Nathan & Moran, 2008; Poyrazoglu, Bas, & Darendeliler, 2014) and type 2 diabetes (American Diabetes Association, 2000; Dabelea, 2013; May, Kuklina, & Yoon, 2012). However, the psychosocial consequences of childhood obesity are perhaps the most widespread (De Niet & Naiman, 2011; Dietz, 1998). Obese children become the targets of early discrimination and are often subjected to teasing, bullying and stigmatisation from their peers, which can lead to depression, poor self-esteem and other mental health problems manifesting themselves during childhood (De Niet & Naiman, 2011; Reilly et al., 2003; Strauss, 2000). For example, Strauss et al., (2000) found that 34% of obese girls aged 13to14 had low self-esteem (defined as <10th percentile), compared to 8% of non-obese girls of the same age.

In the long term, childhood obesity is associated with increased risk of obesity and associated co-morbidities during adulthood (Camhi & Katzmarzyk, 2010; Nathan & Moran, 2008; Reilly & Kelly, 2011; Srinivasan, Myers, & Berenson, 2002). Research has indicated that at least 70% of obese adolescents will remain obese as adults (Reilly, 2006a) and the risk of the persistence into adulthood increases with age and the severity of obesity (Singh, Mulder, Twisk, van Mechelen, & Chinapaw, 2008). The increased likelihood of the persistence of obesity into adulthood brings with it a whole host of adverse health consequences, including; increased chance of developing fatty liver disease, heart disease, certain cancers, psychological and psychiatric problems, osteoarthritis, type 2 diabetes and premature mortality (Burke, 2006; Nathan & Moran, 2008; Reilly et al., 2003; Reilly & Kelly, 2011; Wyatt, Winters, & Dubbert, 2006). Field et al. (2001) reported the risk of developing type 2 diabetes is about two times greater for adults with a BMI >35 kg/m^2, compared to individuals with a BMI between 18 kg/m^2 and 25 kg/m^2 (Field et al., 2001). Research has also indicated severe obesity in adulthood is associated with a shorter life expectancy of as much as 11 years, comparable in some cases to the reduction in life expectancy from smoking (Fontaine, Redden, Wang, Westfall, & Allison, 2003). Further, adults who were obese as children carry a risk of poorer health and increased mortality compared with adults who were not obese as children (Reilly & Kelly, 2011). For example, Gunnell, Frankel, Nanchahal, Peters & vey Smith, (1998), reported the significant effects of weight during adolescence on mortality and morbidity persisted into adulthood even when weight at 53 years of age was controlled for (Gunnell, Frankel, Nanchahal, Peters, & vey Smith, 1998). Thus, adverse health risks associated with excess levels of body fat are apparent for the obese child, and also the adult who was obese as a child (Reilly et al., 2003; Reilly & Kelly, 2011).

In addition to the health consequences of obesity, the pressure placed on the NHS and society should not be forgotten. It is estimated that, at present, the direct costs of obesity to the NHS are around £4.2 billion and are forecast to reach 50 billion each year by 2050 based on current trends (Foresight, 2007). The English government has set itself an ambition to reverse increases in obesity to around the levels seen in 2000 by 2020. Preventing obesity or slowing the dramatic increase in prevalence will probably require societal changes which facilities the modification of diet and increases physical activity levels in children and their families.

Physical activity and obesity

Physical activity can be defined as any bodily movement that is produced by the contraction of skeletal muscle and that substantially increases energy expenditure (Caspersen, Powell & Christenson, 1985). Physical activity can include active living, active play (free play), sport, physical education and active transport. The health related components of physical activity include cardiorespiratory fitness (i.e., the ability of the circulatory and respiratory systems to supply oxygen during sustained physical activity), muscular endurance (i.e., the ability of muscle groups to exert external force for successive exertions), muscular strength (i.e., the amount of external force that a muscle can exert), body composition (i.e., the relative amounts of muscle, fat, bone and other vital parts of the body) and flexibility (i.e., the range of motion available at a joint) (Caspersen et al., 1985). The amount of energy required to accomplish an activity can be measured in kilojoules or kilocalories, and used to substantiate 'energy expenditure'.

Obesity is the result of long term excessive positive energy balance; i.e., where energy intake consistently exceeds energy expenditure (Hill, Wyatt, & Peters, 2012). A shift in the behaviour patterns of youth in recent years towards lower levels of physical activity (PA) and increased time spent engaged in sedentary pursuits is becoming ever more apparent (Dollman et al., 2005; Nelson, Neumark-Stzainer, Hannan, Sirard, & Story, 2006; Saunders, 2011). This adverse behavioural profile, and the resultant reduction in energy expenditure, is thought to contribute towards creating a positive energy balance and is consistently implicated in the aetiology of childhood obesity (Must & Tybor, 2005). However, our understanding of the role of physical activity and sedentary behaviour in the development of overweight and obesity relies on the accurate estimation of these behaviours among youth.

Measurement of physical activity and sedentary behaviour

Children's PA is sporadic and intermittent in nature, and consequently, is difficult to accurately assess. Methods frequently used to measure PA in youth fall under two main categories: self-report measures such as questionnaires, diaries or proxy-reports from parents and teachers, and objective methods such as direct observation, heart rate monitoring, motion sensors (i.e., pedometers or accelerometers) and doubly labelled water (Kohl, Fulton, & Caspersen, 2000; Trost, 2007).

Criterion standards for assessment of PA include direct observation and doubly labelled water (DLW) (Klein et al., 1984; Kohl et al., 2000). The DLW technique allows estimation of energy expenditure related to PA via calculating the rate of loss of stable isotopes from the body resulting from carbon dioxide production. However, the DLW method is costly and does not allow quantification of intensity and duration of PA. Consequently, where researchers are interested in examining engagement in specific dimensions of PA (i.e., MVPA and VPA), other objective PA measurement methods are required (Trost, 2001). Frequency, intensity and duration of PA can be determined via the method of direct observation. Several observation systems have been developed for youth and have been validated against oxygen consumption and heart rate monitoring (Sirard & Pate, 2001). Whilst protocols vary, direct observation typically involves observing a child within a specific setting and recording PA behaviours at time intervals ranging from 5 seconds to 1 minute. The use of this method affords the ability to capture short term patterns and sudden changes in PA behaviours inherent with the nature of PA among youth. Still, direct observation requires considerable time and effort on the part of the researcher and thus, is expensive and impractical for assessing habitual PA levels in large groups of children (Kohl et al., 2000; Sirard & Pate, 2001; Trost, 2007; Welk, Corbin, &

Dale, 2000). As such, this method has been recommended for use as a criterion standard against which to validate other PA measurement tools (Welk et al., 2000).

Due to low cost and ease of administration, self-report methods are commonly employed to assess PA engagement in youth, particularly in epidemiology and population based studies (Brener, Collins, Kann, Warren, & Williams, 1995; Craig et al., 2009). Various methods of self-report exist, including validated questionnaires [e.g., the Previous Day Physical Activity Recall questionnaire (Weston, Petosa, & Pate, 1997)], daily PA diaries and proxy reports from significant others (Bender, Brownson, Elliott, & Haire-Joshu, 2005). However, the intermittent nature of PA in youth and a comparatively lower cognitive functioning than adults is likely to result in inaccuracies in recall of PA engagement (Baranowski et al., 1984; Trost, 2007). Self-report methods have also been shown to vary considerably in their reliability and validity when utilised among samples of children and adolescents (Kohl et al., 2000; Sallis & Saelens, 2000). This lack of accuracy in measurement limits the extent to which we can make inferences regarding associations between frequency, intensity and duration of PA with health outcomes in youth. Consequently, more objective PA measurement tools are recommended for use in paediatric populations (Trost, 2007).

The methods most widely used to objectively assess PA among youth are heart rate monitors, pedometers and accelerometers. Heart rate monitors provide an indication of the physiological effect of PA. This method involves the recording of minute by minute heart rates from which dimensions of PA can be determined based on the linear relationship between heart rate and energy expenditure. However, whilst heart rate monitoring offers an attractive approach to objectively assess PA, this technique has been shown to overestimate energy expenditure in youth (Emons, Groenenboom, Westerterp, & Saris, 1992). Moreover, this measurement method also requires calibration of the association between heart rate and energy expenditure for each individual.

Pedometers are a simple and relatively inexpensive device that can be used to measure number of steps per day. These devices have been demonstrated to be valid and reliable measures of PA in youth (McNamara, Hudson, & Taylor, 2010), yielding correlations of $r = 0.80 - 0.97$ and $r = 0.62 - 0.92$ when compared against direct observation and oxygen consumption, respectively (Eston, Rowlands, & Ingledew, 1998; Puhl, Greaves, Hoyt, & Baranowski, 1990). However, whilst useful for assessing the volume of PA, pedometers do not provide information concerning frequency, intensity and duration of PA. Therefore, similar to self-report, their application in studies investigating dose-response associations between PA and health are limited (Trost, 2007). Even so, pedometers offer a useful alternative to self-report when seeking to determine changes in PA over time (e.g., epidemiology, in response to intervention) or to examine differences in total levels of PA engagement between individuals (McNamara et al., 2010).

Accelerometers are being used with increasing regularity to assess PA among both adults and children due to their ability to determine frequency, intensity and duration of PA with reference to specific time periods (e.g., hours, days, weeks). Accelerometers detect accelerations of body segments to which they are attached (e.g., hip, arm), converting these accelerations into counts. Counts are recorded over pre-specified time periods referred to as ‘epochs’ and interpreted to determine time spent in different intensities of PA. Accelerometers have been employed in numerous population based studies of children and adolescents (Craig et al., 2009; Rizzo, Ruiz, Hurtig-Wennlöf, Ortega, & Sjöström, 2007; Troiano et al., 2008) and have demonstrated high validity and reliability in samples of youth when compared against criterion estimates of PA (Plasqui & Westerterp, 2007;

Puyau, Adolph, Vohra, & Butte, 2002; Trost et al., 1998; Trost, 2007). Drawbacks of accelerometers include their inability to detect engagement in activities which require physical exertion but minimal acceleration of the body such as weight lifting, stair climbing and cycling. Nevertheless, the contributions of such activities towards daily PA for children and adolescents are often reported to be small (Trost, 2007), and as such, the benefits of accelerometry largely outweigh the limitations of this method. Consequently, accelerometers are viewed as the most promising tool for accurately assessing habitual PA in children and adolescents (Trost, 2007).

Whilst numerous approaches can be taken to measure PA in youth, relatively fewer methods exist for measurement of sedentary behaviour. To date, studies have largely employed self-report methods or accelerometry to estimate time spent sedentary (Tremblay et al., 2011). Self-report methods require participants to record engagement in specific sedentary pursuits at time intervals throughout the day. Accelerometers are used to determine total sedentary time (ST) by assuming that activity counts below a certain threshold indicate a participant is engaged in a sedentary activity. Self-report methods to assess sedentary behaviour have been validated against ST measured by accelerometer (Dunton, Liao, Intille, Spruijt-Metz, & Pentz, 2011). However, both methods of assessment carry advantages and disadvantages. Self-report methods enable researchers to determine time spent engaged in specific sedentary behaviours, allowing associations to be drawn between participation in certain sedentary pursuits and health outcomes. However, assessing sedentary behaviour using self-report also holds the same drawbacks as those outlined for measurement of PA (Trost, 2007). Measurement of ST via accelerometer allows quantification of the total amount of time spent at very low activity levels. However, this method does not enable identification of the behaviours which contribute towards total ST. As such, a combination of the two methods is sometimes used to determine both the frequency and duration of engagement in, and context of sedentary behaviour (Chinapaw et al., 2012; Henderson et al., 2012; Martinez-Gomez et al., 2012a).

Physical activity, sedentary behaviour, adiposity and risk factors for disease

Physical activity

The relationship between PA and obesity is complex. Whilst we are aware that PA and adiposity appear to have an inverse relationship, the strength of the relationship between the two can be dependent on a multitude of factors related to different dimensions of PA (i.e., type, frequency, duration and intensity). The widespread application of accelerometers in studies investigating the dose-response relationship between PA intensity and health in recent years, has allowed researchers to more accurately quantify the dimensions of PA related to markers of obesity and associated disease.

Numerous cross-sectional and longitudinal studies have reported negative associations between moderate-to-vigorous PA (MVPA) and indicators of adiposity in youth (Chaput et al., 2012; Dencker & Andersen, 2008a; Fisher, Hill, Webber, Purslow, & Wardle, 2011; Mark & Janssen, 2011; Martinez-Gomez, Eisenmann, Tucker, Heelan, & Welk, 2011; Riddoch et al., 2009; Strong et al., 2005). Mark and Janssen (2011) investigated the relationship between objectively measured PA and body composition in 1165 youth aged 8 to 17 years and revealed MVPA was significantly negatively related to total trunk fat. In a longitudinal study, an extra 15 minutes MVPA per day at age 12 was associated with between 9-12% lower body fat at age 14 years (Riddoch et al., 2009). Additional evidence for the inverse relationship between MVPA and adiposity comes from a wealth of intervention studies demonstrating exercise programmes aimed at increasing moderate intensity exercise in youth were associated with significant reductions in body fat

(Lemura & Maziekas, 2002). For example, Buchan et al., (2011) conducted a 7 week exercise study in children aged 15 to 16 years and reported participants who were required to exercise at a moderate intensity (70% VO_2 max) for at least 20 minutes, 3 times per week, showed significant reductions in percent body fat (Buchan et al., 2011). Negative relationships between MVPA and markers of cardiovascular disease and type 2 diabetes, such as insulin resistance, waist circumference, systolic blood pressure and markers of inflammation (e.g., C reactive protein) have also been reported (Carson & Janssen, 2011; Ekelund et al., 2007; Ekelund et al., 2012; Gutin & Owen, 2011; Jago et al., 2008; Mitchell, Gaul, Naylor, & Panagiotopoulos, 2014). Therefore, in addition to directly addressing the problem of obesity by reducing levels of adiposity, engagement in MVPA may have the potential to lessen the disease burden of children who are obese and already displaying markers of associated diseases. Also important to note is that recent studies have demonstrated the negative association between MVPA and markers of obesity and related disease remain after controlling for total PA and ST (Chaput et al., 2012; Ekelund et al., 2012; Mark & Janssen, 2011; Steele, van Sluijs, Cassidy, Griffin, & Ekelund, 2009).

More recently, evidence has emerged suggesting that, in particular, engagement in vigorous PA (VPA) may be protective against the development of excess adiposity and related poor health (Dencker & Andersen, 2008a; Rizzo et al., 2007; Ruiz et al., 2006; Steele et al., 2009). For example, studies have demonstrated VPA, but not MPA, to be negatively related to indicators of adiposity (Hay, Maximova, & Durksen, 2012; Ruiz et al., 2006) and cardiometabolic risk (Ried-Larsen et al., 2013). Carson et al (2013) examined changes in cardiometabolic risk factors among Canadian youth aged 9 to 15 years over a two year period. When stratified by level of engagement in VPA, results revealed children in the highest quartile for VPA demonstrated greater increases in cardiorespiratory fitness, and greater decreases in waist circumference and systolic blood pressure than participants in the lowest VPA quartile. Moreover, greater decreases in BMI were observed among children in the second and third VPA quartiles compared to those in the lowest quartile. However, waist circumference was the only cardiometabolic risk factor to be negatively associated with baseline levels of moderate intensity PA in this study (Carson et al., 2013). Thus, research findings underline the need to consider VPA separately, or in addition to MVPA, when examining the relationships between PA and health.

Sedentary behaviour

Sedentary behaviour refers to any waking behaviour characterised by low energy expenditure (typically ≤ 1.5 metabolic equivalents) and little physical movement (e.g., behaviours undertaken in a sitting or reclining posture) (Sedentary Behaviour Research Network, 2012). Common sedentary behaviours engaged in by youth include, television viewing (TV), computer use, homework, socialising (e.g., talking on the phone) and motorised transport (Pate et al., 2011). To date, research has typically investigated associations between total ST measured by accelerometer (i.e., the sum of all sedentary behaviours) and indicators of adiposity and cardiometabolic health, or has examined the relationship between self-reported time spent engaged in a specific sedentary behaviours (e.g., TV viewing) and health outcomes.

Evidence for the relationship between total ST and health outcomes in youth is somewhat equivocal. For example, studies have demonstrated positive associations between ST and indicators of adiposity, cardiovascular risk and type 2 diabetes (Gaya et al., 2009; Henderson et al., 2012; Sardinha et al., 2008; Steele et al., 2009), while others have reported no relationship (Chaput et al., 2012; Ekelund, Brage, Griffin, & Wareham, 2009). Contradictory findings may be due to analytical decisions employed (Atkin et al., 2013), including inconsistencies across studies relating to adjustment for potential confounders. For example, Henderson et al., (2012) reported the positive association between ST and insulin sensitivity was no longer significant after adjusting for percent body fat. Similarly, where studies have adjusted for time spent in MVPA, associations between ST and obesity related health outcomes are sometimes attenuated and non-significant (Ekelund et al., 2012; Steele et al., 2009). However, it is important to note that studies also demonstrate ST to be related to health outcomes independent of time spent in MVPA (Hsu et al., 2011; Martinez-Gomez et al., 2011; Mitchell et al., 2013; Santos et al., 2013). Conflicting findings highlight the complexities underlining the associations between ST and health and emphasise the need for further research in this area. Nevertheless, a recent systematic review concluded that decreasing any type of ST is associated with lower health risks in youth aged 5 to 17 years. In particular, findings revealed that lowering ST leads to reductions in BMI (Tremblay et al., 2011).

Studies examining associations between engagement in specific sedentary behaviours and health outcomes report more consistent findings. Numerous studies demonstrate positive relationships between time spent engaged in sedentary behaviours such as TV viewing and computer use, with obesity associated health outcomes (Prentice-Dunn & Prentice-Dunn, 2011; Tremblay et al., 2011). Hancox, Milne and Poulton (2004) conducted a 26 year longitudinal study investigating the associations between TV viewing and health indicators. This research revealed time spent watching TV between the ages of 5 and 15 years was positively associated with higher BMI and serum cholesterol, and negatively associated with fitness at follow up. In addition, results indicated that 17% of overweight could be attributed to watching television for more than 2 hours a day during adolescence (Hancox, Milne, & Poulton, 2004). Two recent studies in European youth also indicated that both TV viewing and time spent playing console video games were positively associated with the presence of biomarkers of cardiometabolic risk in adolescents (Martinez-Gomez et al., 2012a; Martinez-Gomez et al., 2012c). The authors concluded time spent engaged in these sedentary behaviours may play a key role in the development of cardiovascular and metabolic disease during adolescence.

Based on the available evidence, it seems higher levels of MVPA (and particularly VPA) and less time spent sedentary are conducive to preventing the development of overweight, obesity and associated poor health among youth. Whilst these two behaviours are often found to be moderately (and inversely) correlated, emerging evidence for the independent associations between both MVPA and sedentary behaviours with markers of obesity and related diseases suggest these two behaviours may hold somewhat different implications for health (Biddle, Gorely, Marshall, Murdey, & Cameron, 2004; Biddle et al., 2009; Ekelund et al., 2012; Melkevik, Torsheim, Iannotti, & Wold, 2010; Mitchell et al., 2013; Santos et al., 2013; Steele et al., 2009). In essence, there is evidence that both behaviours are playing a central role in the development of child and adolescent overweight and obesity.

Physical activity guidelines

In an attempt to increase levels of PA and reduce sedentary behaviour in youth, evidence based PA guidelines have been developed. These guidelines advise that children and adolescents should engage in at least 60 minutes and up to several hours of MVPA per day and ST should be minimised (Australian Government: Department for Health and Ageing: 2004; Department of Health, 2011; Physical Activity Guidelines Advisory Committee, 2008; Strong et al., 2005; US Department of Health and Human Services, 2013; World Health Organisation, 2011). A particular emphasis is placed on limiting recreational screen time to no more than two hours per day as research indicates exceeding this threshold is associated with the development of excess adiposity and poor cardiometabolic health (Grøntved et al., 2014; Tremblay et al., 2011). Evidence for the dose-response relationships between PA intensity and health has also resulted in a recommendation for engagement in VPA on at least 3 days a week. In keeping with the health related components of physical activity (i.e., cardiorespiratory fitness, muscular strength and endurance, body composition and flexibility), these guidelines indicate that vigorous physical activities should include activities that strengthen muscle and bone. Concerning the volume of VPA, a recent study in European youth aged 12.5 to 17.5 years demonstrated that children who engaged in less than 15 minutes of VPA per day were at greater risk of overweight and obesity compared to those who exceeded this level of VPA (Martinez-Gomez et al., 2010). However, no general consensus has been reached concerning the advised volume of VPA. Consequently, existing studies examining compliance with PA guidelines have largely focused on investigating compliance with recommendations for MVPA, and examining daily levels of both total ST and TV viewing time.

Participation rates

The measurement of PA has implications for understanding participation rates and consequently, identifying the number of individuals at risk of not engaging in recommended level of PA. Where self-report measures are employed, participation rates are frequently reported to be higher than when PA has been assessed via objective methods such as accelerometry (Adamo, Prince, Tricco, Connor-Gorber, & Tremblay, 2009; Leblanc & Janssen, 2010). Further, where accelerometers are used to measure PA, the analytical decisions employed have considerable effects on estimates of the number of children and adolescents meeting PA recommendations. For example, to determine time spent in different intensities of PA, cut-points must be applied to counts recorded by accelerometers. A number of cut-points have been developed for use among children and adolescents which vary in their classification of different PA intensities (Evenson, Catellier, Gill, Ondrak, & McMurray, 2008; Freedson, Pober, & Janz, 2005; Mattocks et al., 2007; Puyau, Adolph, Vohra, & Butte, 2002). Consequently, the cut point chosen to analyse accelerometer data can substantially affect the reported levels of engagement MVPA (and VPA) (Guinhouya et al., 2006; Kim, Beets, & Welk, 2012; Trost, Loprinzi, Moore, & Pfeiffer, 2011). Results pertaining to levels of engagement in MVPA among youth should therefore be interpreted taking these differing analytical decisions into account.

Population based studies employing self-report methods indicate that currently, only a small percentage of children and adolescents are meeting national PA guidelines (Craig et al., 2009; Foulds, Warburton, & Bredin, 2013). For example, the most recent self-report PA data from the Health Survey for England indicate only 32% of boys and 24% of girls aged 2 to 15 years are achieving the recommended 60 minutes of MVPA per day (Craig et al., 2009). Similarly, a recent review of studies employing various self-report measures indicated 26.5% of youth in the United States of America (USA) and Canada met recommended levels of MVPA (Foulds et al., 2013). Further, self-report data from the National Health And Nutrition Examination Survey (NHANES) reported only 14.7% of youth aged 12 to 17 years engaged in 60 minutes of MVPA per day (Song, Carroll, & Fulton, 2013). The Avon Longitudinal Study of Parents and Children (ALSPAC) objectively assessed PA via accelerometer and reported only 2.5% of children aged 11-12 years met recommended levels of MVPA (Riddoch et al., 2007). In contrast, accelerometer-based data from the European Youth Heart Study (EYHS) reported a higher proportion of youth met recommended levels of MVPA, indicating on average, 35.8% of children aged 9 years, and 21.2% of adolescents aged 15 years met PA guidelines (Laguna et al., 2013). The comparatively higher estimates in the latter study are likely explained by the lower cut point used to classify MVPA compared to those used in the ALSPAC (i.e., EYHS = ≥ 2000 versus ALSPAC = ≥ 3600 counts per minute). Indeed, studies comparing different accelerometer cut-points demonstrated the use of a more conservative cut point resulted in a dramatic drop in the number of children reported to be meeting PA recommendations (Guinhouya et al., 2006; Trayers et al., 2006). Nevertheless, population based studies across the world that have employed accelerometers to assess PA have reported average daily levels of MVPA below 60 minutes per day in English (Basterfield et al., 2012; Collings et al., 2014; Craig et al., 2009; Mitchell et al., 2009; Ness et al., 2007), Irish, (Woods, Tannehill, Quinlan, Moyna, & Walsh, 2010), Canadian (Chaput et al., 2012), European (Laguna et al., 2013), and American (Long et al., 2013; Troiano et al., 2008) children and adolescents.

Concerning engagement in sedentary behaviour, Pate et al., (2011) recently conducted a systematic review of studies that have assessed engagement in specific sedentary pursuits via self-report [i.e., screen-based (e.g., TV viewing), non-screen based (e.g., sitting, talking, sedentary hobbies) and total ST via accelerometer in children and adolescents (Pate et al., 2011). Findings from studies employing self-report to assess engagement in sedentary pursuits revealed that on average, children across the globe reported spending 1.4 to 3.7 hours per day watching TV. Further, data from the NHANES demonstrated between 49% and 56% of American children and adolescents aged 6 to 15 years watched 2 or more hours of TV per day, exceeding the recommended guideline (Sisson et al., 2009). When not limiting self-report of sedentary behaviour to TV time, studies revealed that children spent between 3 and 8 hours per day engaged in a range of sedentary pursuits (Biddle, Gorely, Marshall, & Cameron, 2009; Gorely, Marshall, Biddle, & Cameron, 2007; Hamar, Biddle, Soós, Takács, & Huszár, 2010; Hardy, Dobbins, Booth, Denney-Wilson, & kely, 2006; Wight, Price, Bianchi, & Hunt, 2009). For example, Hardy et al., (2006) asked Australian children and adolescents to report time spent in screen-based, educational and social sedentary behaviours, in addition to motorised travel and sedentary hobbies. Results demonstrated participants spent between 4.7 and 6.5 hours per day sedentary (Hardy et al., 2006). In the UK, children were asked to record time spent sedentary while not in school (Biddle et al., 2009). Findings indicated boys and girls engaged in sedentary activities such as TV viewing, computer and video game use, motorised travel and sedentary social and educational behaviours (e.g., talking on the phone, doing homework) for 4.1 and 3 hours per day respectively (Biddle et al., 2009). Similarly, Gorely et al., (2007) reported children from the UK to engage in sedentary pursuits for 3.7 to 5.8 hours per day (Gorely et al., 2007).

Pate et al., (2011) observed ST assessed by accelerometer was estimated to be comparatively higher than levels recorded in self-report studies. Date from the NHANES indicated American children and adolescents aged 6 to 19 years spent between 6 to 8.1 hours per day sedentary (Matthews et al., 2008). For European children, findings from the Sport, Physical activity and Eating Behaviour: Environmental Determinants in Young people (SPEEDY) study, reported that 10 year old boys in the UK engaged in sedentary activities for 7.5 to 7.7 hours per day (Steele et al., 2010). Data from the EYHS similarly reported adolescents aged 15 years spent up to 7.8 hours per day sedentary (Nilsson et al., 2009b) and children and adolescents spent approximately 41% to 55% of their day engaged in sedentary activity (Nilsson et al., 2009a).

Despite disparities in the research methods and analysis decisions employed, the general consensus points towards a generation of children and adolescents who are insufficiently active to accrue benefits to health. Therefore, given the evidence base for PA recommendations (Strong et al., 2005), and with obesity prevalence estimates reaching double figures worldwide, there is a need for preventative action in the line of increasing MVPA and reducing sedentary behaviour (total ST and engagement in specific sedentary pursuits) in youth. Moreover, PA participation and engagement in sedentary behaviours track from childhood and adolescence into adulthood (Biddle, Pearson, Ross & Braithwaite, 2010; Telama et al., 2013; Trudeau, Laurencelle, & Shephard, 2004). Therefore, adolescence is a life stage during which the development of positive PA habits may be critical in promoting lifelong PA participation. To be successful in our attempts at PA promotion, this first relies on finding and creating engaging opportunities for youth to be physically active.

Youth Sport and physical activity engagement

In 2007, the government published a White Paper on sport, advocating youth sport as a valuable setting for PA promotion and obesity prevention (Commission of the European Communities, 2007). Indeed, millions of children participate in sport across the globe, and as such, youth sport represents an important and globally relevant domain for interventions seeking to encourage PA engagement in youth. However, few studies have examined the frequency, intensity and duration of PA engagement among youth sport participants. In particular, a paucity of studies have employed objective methods to examine PA levels associated with youth sport participation. Moreover, existing research has largely neglected to go beyond simply characterising duration of engagement in MVPA among youth sport participants. Consequently, little is known regarding levels of engagement in different dimensions of PA (i.e., MVPA and VPA) and ST, and associations with obesity linked health outcomes in these groups of youth. In addition, factors related to duration of engagement in MVPA, VPA and ST both within and outside the youth sport setting (e.g., individual, contextual, social and environmental) are not well understood. The following sections will review research conducted in the youth sport domain and underline the contributions the present thesis makes to this important line of inquiry. Table 1.1 provides a summary of accelerometer based research conducted in the youth sport domain to date.

Youth sport and physical activity engagement: what we know so far

Only three studies to date have utilised accelerometers to examine daily PA levels of engagement among sport participants. Wickel and Eisenmann (2007) investigated weekday levels of MVPA among male sport participants aged 6 to 12 years. Findings demonstrated average weekday MVPA and VPA to be 110 and 40 minutes per day (mpd) respectively, among flag football, soccer and basketball participants (Wickel & Eisenmann, 2007). Importantly, this study also reported levels of MVPA to be 30 minutes lower on a non-sport day compared to a sport day. Machado-Rodrigues et al., (2012) reported similar level of engagement in weekday MVPA among male youth sport participants aged 13 to16 years, demonstrating male participants representing a variety of different youth sports engaged in MVPA for 114 mpd (Machado-Rodrigues et al., 2012). Concerning average daily PA (i.e., data representing both weekdays and weekend days), this study revealed average daily MVPA of youth sport participants to be 97 mpd (minutes in VPA not reported) and daily ST to be 11 hours per day on average. Recently published data from the PAPA project reported average daily MVPA to be 122 mpd, and daily VPA to be 25 mpd among youth sport footballers aged 9 to 15 years from France, Greece and England (Van Hoye et al., 2013). Whilst levels of ST reported in the study of Van Hoye and colleagues were lower than those observed by Machado-Rodrigues et al., (2012), results still indicated youth sport football participants spent between 7 and 8 hours per day engaged in sedentary behaviours.

A similar number of studies have investigated levels of PA engagement during youth sport time in order to determine the extent to which youth sport contributes towards participants meeting guidelines for MVPA and daily levels of VPA. Leek et al., 2011, reported male and female youth sport soccer (football) and softball/baseball participants, aged 7 to 14 years, accrued approximately 45 minutes of MVPA, and 20 minutes of VPA during youth sport practice time (Leek et al., 2011). Results also revealed that 23% of participants met the recommended 60 minutes of MVPA per day during youth sport time. Wickel et al., (2007) reported comparatively lower levels of engagement in MVPA during youth sport (i.e., 26 minutes) than those observed by Leek et al., (2011). However, when taking into account the length of the youth sport session, levels of engagement in MVPA were similar to those reported by Leek et al., (2011) (i.e., 26 minutes = 49% vs 45 minutes = 46%). A study conducted in female netball, basketball and soccer participants (aged 11 to 17 years) sought to determine the contribution each hour of youth sport participation would make towards daily guidelines for MVPA (Guagliano et al., 2012). Findings revealed that for every hour of game play or practice time, participants accumulated approximately one third of the recommended 60 minutes of MVPA per day.

Existing youth sport studies have also sought to determine factors which may influence levels of PA engagement during youth sport. Leek et al., (2011) reported levels of MVPA (and percent session time engaged in MVPA) to be higher in soccer participants (compared to softball/baseball), participants aged 7 to 10 years (relative to 11 to 14 years), and males (relative to females). Similarly, Wickel et al., (2007) found younger participants to engage in higher levels of MVPA than older participants. Guagliano et al., (2012) demonstrated PA to vary as a function of youth sport context (i.e., training sessions versus match play). Sacheck et al., (2011) also reported overweight and obese participants to engage in lower levels of MVPA and VPA during youth sport football matches than their normal weight peers.

Taken together, existing studies indicate that participation in youth sport may offer children and adolescents the opportunity to accrue substantial amount of MVPA and VPA. However, whilst youth sport participation may indeed be valuable for advancing levels of PA engagement, results also indicate MVPA accrued during youth sport alone is not sufficient to meet recommended levels of MVPA, and the benefits of youth sport participation (i.e., opportunity for engagement in MVPA and VPA) may not extend beyond the day on which sport is participated in (Wickel et al., 2007). Moreover, recent results suggest youth sport participants may spend large proportions of their day engaged in sedentary behaviour.

Table 1.1

Summary of accelerometer based studies conducted within the youth sport domain

Author	Sample demographics	Primary outcomes *(as related to accelerometer data)*	Main findings *(relevant to the present thesis)*
Guagliano et al., (2012)	94 females aged 11 to 17 yrs Sport type: Netball, basketball and outdoor soccer (football) Sydney, Australia	PA engagement during youth sport Compare levels of PA engagement between games and practices	% time in MVPA was higher during practices (33.8%) than during games (30.6%). During practices and games, girls spent 18 and 20 minutes per hour in MVPA respectively.
Leek et al., (2007)	200 youth aged 7 to 14 yrs (47.5% female) 17% Caucasian Sport type: Soccer (football) and baseball/softball San Diego, California	Minutes in PA and ST during youth sport practice time Variability related to age, sport type and gender	% time in MVPA = 46.1% (45.1 minutes) Participants on soccer teams, boys, and those aged 7 to 10 years had significantly more MVPA than their counterparts 24% of participants achieved ≥ 60 minutes of MVPA during youth sport time
Machado-Rodrigues et al., (2012)	165 male youth aged 13 to 16 yrs Sport and non-sport participants Sport type: 11 different sports, soccer was the most popular Portuguese Midlands	Daily PA and ST among sport and non-sport participants Variability related to weekday (weekend vs. weekday) and age group (13 to 14 years vs. 15 to 16 years).	Compliance = 75% (initial N = 219) Sport participants in both age groups engaged in more MVPA on weekdays and weekend days. Sport participants spent less time sedentary on weekdays and across total days but not on weekend days.

Sacheck et al., (2011)	111 children aged 7 to 10 yrs (68% female) 90% Caucasian Sport type: indoor soccer Acton Massachusetts, USA	Time spent in different PA intensity levels during soccer games Variability related to weight status (BMI)	49% of match time was spent sedentary (25.4 minutes) and 33% spent in MVPA (16.9 minutes). Contributing 25% towards daily recommendations for MVPA Youth with BMI ≥ 85^{th} percentile engaged in more ST and less MVPA during soccer games than their normal weight counterparts
Van-Hoye et al., (2013)	331 males aged 9 to 15 yrs Sport type: football Europe [England (N = 147), France (N = 132) and Greece (N = 136)]	Daily PA and ST engagement Variability related to country	Compliance = 79.76% (initial N = 415) Average daily MVPA = 122.33 mpd Average daily ST = 488.19 mpd Greek participants achieved 60 minutes of MVPA on more days then English and French participants.
Wickel et al., (2007)	113 boys aged 6 to 12 yrs >95% Caucasian Sport type: Basketball, soccer (football) and flag football American	Daily MVPA on a sport and non-sport day Contribution of youth sport, PE and recess towards total daily MVPA	Compliance = 95%, (initial N = 119) Average daily MVPA = 110 mpd on a sport day MVPA lower, and ST higher on a non-sport compared to a sport day Youth sport contributed 23% (26 minutes) towards total daily MVPA

Note: Compliance, location and ethnicities reported where data was available in published manuscripts. Participants recruited to studies contributing toward the present thesis were English male youth sport participants aged 9 to 16 years. Sample sizes following data reduction were: Study 1 = 109, Study 2 = 118, Study 3 = 73, Study 4 = 105

MVPA = moderate to vigorous physical activity, ST = sedentary time, PE = physical education, BMI = body mass index, mpd = minutes per day

The contribution of this thesis

Past studies offer a starting point towards elucidating the value of youth sport as a context for encouraging higher levels of PA engagement. However, a number of important limitations should be considered before drawing conclusions concerning the position of youth sport as a context to enhance PA and its relevance as a setting for obesity prevention.

First, despite the emphasis placed on youth sport as a vehicle for PA promotion (Commission of the European Communities, 2007; Weiss, 2000), few accelerometer-based studies have actually been conducted in this area. As such, conclusions drawn concerning the role of youth sport for encouraging PA engagement towards the frequency, intensity and duration outlined as being beneficial for health are based on a limited body of evidence. Moreover, the PA patterns of youth are complex and depend on a multitude of factors (e.g., age, gender, ethnicity, day of the week) (Dencker & Andersen, 2008a). Indeed, PA levels during youth sport have been found to vary as a function of such factors, in addition to sport type and youth sport context (i.e., training session versus match play) (Guagliano et al., 2012; Leek et al., 2011; Wickel & Eisenmann, 2007). As such, additional accelerometer-based research focused within the youth sport context is required to gain a more comprehensive view of the utility of different youth sports for PA promotion and to further identify factors affecting variability in PA engagement (Pate & O'Neill, 2011).

Second, the majority of existing youth sport studies have almost exclusively employed the age-dependent cut-points developed by Freedson et al., (2005) to classify engagement in MVPA (Freedson et al., 2005; Guagliano et al., 2012; Leek et al., 2011; Van Hoye et al., 2013; Wickel & Eisenmann, 2007). Research has demonstrated these cut points may misclassify light intensity PA as moderate intensity PA in children ≤ 10 years (Kim et al., 2012; Trost et al., 2011). Consequently, daily levels of PA, as well as PA during youth sport may have been overestimated in studies involving younger participants (e.g., Leek et al., 2011). As a result, the opportunity offered by the youth sport setting for engagement in MVPA and the role of youth sport for encouraging engagement in MVPA towards recommended levels may have been previously overvalued. One study to date has examined levels of engagement in MVPA and VPA during youth sport employing the single value cut-points developed by Puyau et al., (2002) (Sacheck et al., 2011). This study indicated soccer participants aged 7 to 10 years to engage in MVPA for 17 minutes during youth sport time, a value comparatively lower than reported by Leek et al., (2007) for soccer players of the same age, where data were analysed using age-dependent cut-points [i.e., MVPA = approximately 58 minutes (data taken from graph)]. Thus, the use of age-dependent cut-points among most existing youth sport studies somewhat limits the extent to which we can accurately evaluate the value of the youth sport setting as an opportunity for engagement in MVPA.

Finally, studies to date have neglected to examine the variability in daily levels of PA engagement among youth sport participants. Whilst previous studies have reported average daily levels of MVPA for youth sport participants to be above the recommended 60 mpd, the standard deviations reported for daily MVPA are large (e.g., 28 – 33 mpd) (Machado-Rodrigues et al., 2012; Van Hoye et al., 2013), indicating levels of PA engagement may vary substantially among youth sport participants. In addition, recent studies have revealed youth sport participants to engage in ST for between 7 and 11 hours per day. Examining the variability in daily levels of MVPA and ST among youth sport participants is therefore important in order to determine the extent to which youth sport participation is conducive towards engagement in recommended levels of MVPA for *all* participants, and is associated with high levels of engagement in ST. Moreover, given that youth sport has been advocated as a setting for obesity prevention, examining associations between variability in PA and ST and obesity associated health outcomes will be important to determine the degree to which interventions should seek to not only encourage and maintain sport engagement, but also to increase daily levels of MVPA and reduce ST among those active in the youth sport setting.

The first and second studies within this thesis therefore seek to address some of the main limitations to existing youth sport research, employing accelerometers to determine patterns of PA engagement among youth sport football participants and associations with obesity linked health outcomes. Due to recent findings demonstrating the superior validity of a single value cut-point to classify MVPA, relative to age-dependent cut-points validated for youth (Trost et al., 2011), studies throughout this thesis employed the cut-points developed by Evenson, Catellier, Gill, Ondrak & McMurray (2008), (i.e., MVPA = ≥ 2296 cpm, VPA ≥ 4012 cpm) and recommended for use by Trost et al., (2011) to classify PA intensity (Evenson et al., 2008; Trost et al., 2011).

The primary aim of the first study (Chapter 2) was to further understanding of the opportunity offered by youth sport football in particular for PA engagement towards the frequency, intensity and duration required to accrue benefits to health. Specifically, Study 1 (Chapter 2) examined accelerometer-assessed levels of MVPA and VPA during youth sport, and the contribution made to levels of physical activity at the weekend. In addition, variability between participants in terms of PA accrued during youth sport and the contribution towards daily weekend PA was determined with reference to participant age and playing position. To date, only one study has examined the contribution of youth sport towards daily MVPA on a weekday. Given that levels of MVPA are lower at the weekend compared to during the week, researchers have advocated the need to identify the main activities undertaken during weekend MVPA and VPA. Thus, determining the contribution of youth sport towards weekend PA will help to uncover the extent to which youth sport represents an important source of weekend PA.

Study 2 (Chapter 3) moved beyond past observations of daily and youth sport PA engagement, and more critically examined variability in daily MVPA, VPA and ST between youth sport participants, determining associations with indicators of adiposity and cardiovascular risk. Given the high estimates of ST recently observed in youth sport participants, and reported independent effects of ST on health (Chaput et al., 2012; Ekelund et al., 2012; Mitchell et al., 2013), particular emphasis was placed on determining the independent associations between MVPA, VPA and ST with adiposity and risk factors for cardiovascular disease.

Optimising the youth sport experience

In order to inform ways to increase daily engagement in MVPA and reduce daily ST in youth sport participants, we must first determine factors within the youth sport context related to PA engagement. Identifying factors associated with PA engagement *during youth sport* will help contribute towards higher daily levels of PA (MVPA and VPA) and meeting recommended levels of MVPA on sport days. Indeed, study findings demonstrate children spend up to 70% of youth sport time engaged in PA below a moderate intensity, and that PA accrued during this time is not sufficient to meet recommended guidelines for MVPA (i.e., light PA or sedentary behaviour) (see Table 1.1, Guagliano et al., 2012; Leek et al., 2011; Sacheck et al., 2011; Wickel & Eisenmann, 2007). Similarly, determining correlates of *daily* engagement in MVPA and ST will help to inform the development of interventions seeking to encourage the adoption and maintenance of positive habitual PA behaviours among youth sport participants.

Consequently, elucidating such concomitants will help to establish avenues through which an individual's youth sport participation can be optimised to encourage higher levels of PA engagement and lessen involvement in sedentary pursuits, maximising the potential role of youth sport as a context for PA promotion. As previously outlined, studies conducted in the youth sport setting have examined both individual (e.g., age, gender) and contextual (e.g., sport type) level factors and their associations with levels of PA engagement during youth sport. However, despite research identifying important psychological correlates of PA engagement (e.g., self-efficacy, enjoyment), no studies to date have adopted a theoretical lens when investigating factors within the youth sport setting likely to impact upon PA engagement among young participants.

International experts in the area of youth PA promotion recently identified *understanding the theory behind changing children's activity levels and behaviours* as a top research priority for child and adolescent PA and sedentary behaviour (Gillis et al., 2013). When considering theoretical frameworks attuned to encouraging behaviour change among youth, theories of motivation theories of motivation may offer attractive avenues for researchers to pursue.

Early theories define motivation as the direction and intensity of one's effort (Sage, 1997). Direction refers to an individual's decision to initiate engagement in a behaviour, whereas effort refers to the vigour that goes into pursuing that behaviour. However, this conceptualisation of motivation does not acknowledge the regulation of behaviour. That is, it does not consider 'why' an individual to motivated to act. Roberts (2001) argues that true theories of motivation address all aspects of achievement behaviour (i.e., direction, intensity and regulation). Over the past few decades, research has more readily adopted this multifaceted approach towards understanding why a person is 'moved to act' (Duda, 1992; Roberts, 1982; Roberts, 1997). Indeed, numerous theories of motivation have been employed in attempts to understand the psychological processes undergirding goal-orientated behaviour among youth across different contexts. However, the theoretical frameworks most commonly adopted to understand motivation in the sport domain include Social Cognitive Theory (Bandura, 1986), Theory of Planned Behaviour (Ajzen, 1985), Achievement Goal Theory (Nicholls, 1984) and Self-determination Theory (Deci & Ryan, 1987).

Briefly, Social Cognitive Theory postulates reciprocal interactions among personal (e.g., knowledge and attitudes), environmental (e.g., social norms) and behavioural (e.g., self-efficacy) factors. In contrast, the Theory of Planned Behaviour takes a more centred approach to understanding motivation, advocating intentions are the sole determinant of behaviour. The determinants of one's intentions are considered to be attitude towards engaging in a behaviour, perception of social norms surrounding that behaviour, and level of perceived behaviour control (i.e., beliefs regarding resources and opportunities to engage in a behaviour, e.g., self-efficacy). Overlapping with Social Cognitive Theory and the Theory of Planned behaviour, Achievement Goal Theory postulates an important pre-requisite for motivated behaviour is the desire to feel competent. As such, where an individual feels more competent, they are more likely to act. Importantly however, Achievement Goal Theory takes a more complex approach towards understanding the implications of one's perceptions of competence. Specifically, suggesting the way in which an individual defines their competence (i.e., as self-referenced (based on personal improvement and effort) vs. other referenced (or based on the competence of others) can govern behaviour and affect how an individual will interpret and respond in achievement related settings. Coined task and ego orientation (respectively), the former is linked to more adaptive cognitive, affective and behavioural outcomes (Roberts, 2001). Achievement Goal Theory also emphasises the importance of acknowledging how the social environment created within a specific domain (e.g., youth sport) interacts with an individual's predisposition towards a goal orientation when considering goal-orientated behaviours. Similar to Achievement Goal Theory, Self-determination Theory (SDT) underlines the importance of the social environment as an antecedent of one's motivation. However, in contrast to other theories of motivation, SDT points to the importance of *variability* in the reasons 'why' individual is motivated to act. Indeed, whilst other theories of motivation consider a multitude of factors influencing a 'why' a person's chooses to engage in a behaviour (e.g., social norms, self-efficacy), no emphasis is placed on the *type* or the *quality* of motivation experienced. That is, SDT considers the differing psychological processes that are likely to underpin the 'why' of motivation, and the resulting implications for one's behaviour, cognition and affect.

A central tenet of SDT is that the social environment operating within an achievement related context is central to the variability in the reasons 'why' we engage in a behaviour, (Deci & Ryan, 1987). In turn, such variability can hold highly variable consequences for one's cognition, affect and behaviour (Deci & Ryan, 1987; Deci & Ryan, 2000; Deci & Ryan, 2008; Ryan & Deci, 2000a). Research indicates that where an individual is motivated to engage in a behaviour for more autonomous reasons (i.e., for the inherent fun and enjoyment derived, or personally valuing the benefits of that behaviour) more adaptive cognitive, affective and behavioural outcomes will likely ensue (Deci & Ryan, 1987). Conversely, where an individual's reasons for engagement in a behaviour are more controlled (i.e., one is motivated to engage due to external factors or internal contingencies) this is likely to result in more negative and maladaptive outcomes (Deci &

Ryan, 1987). Within the context of youth sport, considering the 'quality' of one's motivation (i.e., whether the reasons underpinning one's sport participation are more autonomous or more controlled) may therefore have implications for promoting PA engagement among youth active within this setting. Indeed, where a child participates in sport for the inherent fun and enjoyment derived from that activity (i.e., autonomous motivation), they are perhaps more likely to be motivated towards, and engage in PA, both within and outside that setting (Vallerand, 1997). Certainly, SDT has been successfully used to understand the social environmental and motivation-related determinants of PA engagement among youth. Research conducted within other youth PA domains highlights that autonomous forms of motivation towards a behaviour (e.g., PE, PA engagement during recess) are linked to higher levels of PA engagement both within and outside that context (Aelterman et al., 2012; Standage et al., 2012; Stellino & Sinclair, 2013), with the reverse true for controlled motivation (Owen et al., 2013; Standage et al., 2012). However, to date, no research has employed the SDT framework towards understanding motivation and related levels of PA engagement within the youth sport setting.

Within the context of youth sport, the social environment is largely created by the interpersonal behaviours of the youth sport coach. The application of SDT towards research targeting the youth sport setting may therefore help to determine the potential role of the coach-created social environment and ensuing quality of motivation (i.e., social-psychological factors) for encouraging higher levels PA engagement and reducing ST among youth sport participants. Studies 3 (Chapter 4) and 4 (Chapter 5) within this thesis therefore adopted a SDT approach towards investigating the social environmental and motivation-related predictors of PA engagement during youth sport (Study 3), and daily engagement in MVPA and ST (Study 4).

Self-determination Theory

In order to encourage the adoption of positive PA behaviours in youth, we must first understand the psychosocial determinants of quality PA engagement. Understanding what motivates children and adolescents to be physically active as well as what processes lead to declines in PA has important implications for PA promotion and obesity prevention. Self-determination theory (SDT) is a theoretical framework which has guided researchers in their attempts to understand the interaction between the PA environment and motivational processes pertinent to PA engagement (Deci & Ryan, 1987; Deci & Ryan, 2000; Deci & Ryan, 2008; Ryan & Deci, 2000a). SDT diverges from other theories of motivation by considering motivation not as a unitary concept concerned only with the intensity of motivation, but as a multifaceted construct, outlining the importance of understanding not only to what extent an individual is motivated to act, but also 'why'(Deci & Ryan, 2000). Specifically, SDT advocates that initiation and engagement in a behaviour (such as PA) is regulated by the degree to which an individual's choice to engage in that behaviour emanates from the self (i.e., is self-determined), or is driven by external factors or internalised contingencies (e.g., the avoidance of shame or guilt).

SDT details several distinct types of motivation that vary in their degree of self-determination, each resulting in varied affective, cognitive and behavioural consequences (Ryan & Deci, 2000a). Central to SDT is the notion that these motivation regulations reside on a continuum ranging from those that are more self-determined (or autonomous) to those that are less self-determined (or controlled). At the top of the self-determination continuum is intrinsic motivation, the quintessential form of autonomous motivation that refers to engagement in a behaviour for the inherent interest and enjoyment derived from the activity. Adjacent to intrinsic motivation on the continuum is extrinsic motivation which involves engagement in a behaviour because the individual believes it will result in the attainment of some independent outcome (Deci & Ryan, 2008). Past perspectives have considered extrinsic motivation as the reverse of intrinsic motivation. However, SDT posits that extrinsically motivated behaviour can vary greatly in its relative autonomy (Ryan & Connell, 1989). That is, extrinsic motivation can still be somewhat self-determined and autonomous. For example, children who engage in PA because they personally identify with the physical and psychological benefits derived from PA are extrinsically motivated (i.e., their decision to engage in PA is not purely due to positive feelings resulting from that activity). However, children who engage in PA because they are obeying a parents instructions are also extrinsically motivated, but are relatively less self-determined in their behaviour.

Organismic integration theory (OIT) is a sub theory of SDT that details four different qualities of extrinsic motivation (Deci & Ryan, 1985). Figure 1.3 distinguishes between types of extrinsic motivation that are more self-determined on the right, to those that are more controlled on the left. OIT also refers to amotivation, the state of lacking intention or desire to engage in a behaviour that results from not valuing an activity (Ryan, 1995) or not expecting it to result in a desired outcome (Seligman, 1975). Amotivation is considered a non-regulation and is the least self-determined behavioural regulation. Neighbouring extrinsic motivation, amotivation lies at the bottom of the self-determination continuum.

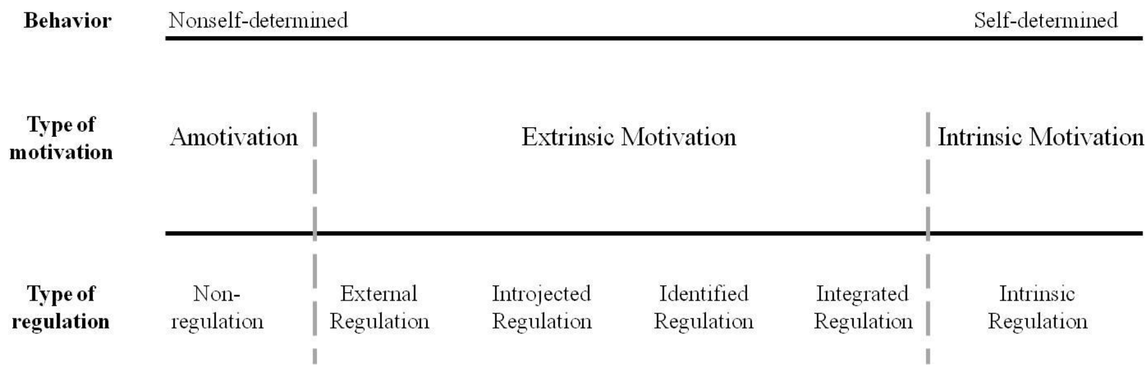

Figure 1.3 The self-determination continuum (Deci & Ryan, 2000)

The most controlled and least self-determined form of extrinsic motivation is external regulation. When an individual is externally regulated to engage in a behaviour, they do so because of external demands or pressures. Introjected regulation neighbours external regulation and is also considered a relatively controlled form of motivation. Introjection refers to the engagement in an activity to avoid feelings of shame or guilt, or to attain ego enhancements such as the maintenance of self-worth or pride. Introjected behaviours refer to behaviours that have been somewhat internalised but are not experienced as part of the self (i.e., they are intrapersonally controlled). For example, a child who engages in PA because they would otherwise feel like a failure is motivated by introjected regulation. Identified and integrated regulations are considered more self-determined regulations, both reflecting behaviour in which a person acts because they believe that behaviour to hold personal value and importance. Identified regulation sits next to introjected regulation on the continuum and is thought to operate when an individual engages in a behaviour to accomplish personally valued goals and outcomes. Where a child experiences identified regulation, they may participate in PA because they believe they may learn something useful. Integrated regulation[2] is directly adjacent to intrinsic motivation and is the most self-determined form of extrinsic motivation. Integrated regulation occurs when identified regulations are fully internalised and have become aligned with personally endorsed beliefs, goals and values.

The differentiation between autonomous and controlled motivation regulations within SDT has resulted in research which focuses on these two composite forms of motivation, rather than a comparison of intrinsic versus extrinsic motivation. More self-determined motivation regulations (i.e., intrinsic, identified and integrated regulations) are often combined to represent autonomous motivation. Similarly, less self-determined motivation regulations (i.e., introjected and extrinsic regulation) are joined to represent controlled motivation (Deci & Ryan, 2008). A central tenet of SDT is that where behaviours are guided by autonomous motivation, adaptive cognitive, affective and behavioural consequences will result (Deci & Ryan, 2008). Conversely, controlled motivation and amotivation are postulated to be associated with pressure, tension and conflict (Deci, Eghrari, Patrick, & Leone, 1994) and consequently, result in more maladaptive outcomes (Bartholomew, Ntoumanis, Ryan, & Thogersen-Ntoumani, 2011; Pelletier, Fortier, Vallerand, & Brière, 2001; Ryan & Deci, 2000b). Indeed, more autonomous motivation has been associated with positive affect, greater psychological well being, healthier lifestyles (e.g., PA engagement), and enhanced performance, productivity and persistence across multiple life domains (Deci & Ryan, 2008; Teixeira, Carraca,

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[2] Results from the literature indicate that identified and integrated regulation subscales do not separate clearly (Lonsdale, Hodge, & Rose, 2008; Mouratidis, Lens, & Vansteenkiste, 2010). Further, it has been it has been argued that integrated regulation is not prevalent until adulthood (Vallerand, 1997). Thus, integrated regulation was excluded from measures assessing motivation regulation within this thesis (see Viladrich et al., 2013). As a result, the studies herein do not consider the consequences of integrated regulations for children's' PA engagement.

Markland, Silva, & Ryan, 2012). In contrast, controlled motivation and amotivation are reported to be associated with poor mental and physical health (Ng et al., 2012), poor self-esteem (Quested & Duda, 2011), behavioural disengagement (Pelletier et al., 2001) and lower levels of PA engagement (Owen et al., 2013; Standage et al., 2012).

The social environment and quality of motivation

Research grounded in SDT consistently demonstrates that central to an individuals' motivation regulation is the social environment operating (Alvarez, Balaguer, Castillo, & Duda, 2009; Deci & Ryan, 1987; Deci & Ryan, 2008; Hagger et al., 2009; Rouse, Ntoumanis, Duda, Jolly, & Williams, 2011; Standage et al., 2012). Social environments are largely created by the interpersonal behaviours of significant others (e.g., authority figures) acting within these contexts (Deci & Ryan, 1987; Deci & Ryan, 2000; Deci & Ryan, 2008). The social environment is suggested to be particularly central to one's motivation regulation towards a behaviour in settings involving power differentials (e.g., doctor-patient, parent-child, teacher-student, coach-athlete) (Deci & Ryan, 1987).

Where these relationships operate, the more subordinate of the two are predominantly exposed to the social environment created by the interpersonal behaviours of the other. As such, a motivational sequence is proposed by SDT in which the social environment can serve to facilitate or forestall one's self-determined motivation (through satisfaction of the needs for autonomy, competence and relatedness[3]), which in turn, will

[3] SDT posits that humans have three basic psychological needs, autonomy, competence and relatedness (Deci & Ryan, 2000). Research consistently demonstrates positive relationships between satisfaction of these three basic needs and more autonomous motivation (Ryan & Deci, 2000b). Conversely, where the basic needs are not satisfied (i.e., the needs for competence, autonomy and relatedness are thwarted), less self-determined and controlled forms of motivation result (Bartholomew et al., 2011; Bartholomew, Ntoumanis, & Thogersen-Ntoumani, 2010). In Study 4, basic need satisfaction was not assessed. This study comprised pilot work for the PAPA project. In Study 3, the final sample size restricted analysis to testing a simple motivational sequence (i.e., the social

result in varied cognitive, affective and behavioural consequences depending on the degree to which behaviour is self-determined (Deci & Ryan, 1987; Deci & Ryan, 2000; Deci & Ryan, 2008; Ryan & Deci, 2000a).

Studies across multiple domains reveal that where the social environments created by significant others support an individual's sense of autonomy (e.g., there is promotion of choice and decision making), more autonomous motivation will result (Alvarez et al., 2009; Kins, Beyers, Soenens, & Vansteenkiste, 2009; Kopp & Zimmer-Gembeck, 2011; Ng, Ntoumanis, & Thøgersen-Ntoumani, 2013; Pelletier et al., 2001). In contrast, where social environments are controlling (i.e., one is pressured towards a specific outcome), autonomous motivation is undermined and controlled motivation will likely ensue (Bartholomew et al., 2011; Bartholomew et al., 2010; Pelletier et al., 2001). Autonomy support can be broadly conceptualised as providing a sense of choice, supporting self-initiative, acknowledging perspectives, and providing a rationale to foster consideration of personal relevance and importance of one's behaviour (Deci & Ryan, 1987; Deci & Ryan, 2000; Deci & Ryan, 2008). Conversely, controlling environments involve an individual exerting their sense of authority through pressure and coercion, and limiting the capacity for individual choice (Bartholomew et al., 2010; Deci & Ryan, 1987). Within the context of youth sport, a coach who provides players with meaningful choice, acknowledges athletes' preferences, explains the rationale behind the decisions they make during training sessions and matches, and welcomes players input into decision making, are likely to foster more autonomous motivation (Mageau & Vallerand, 2003). This in turn is expected to result in adaptive consequences such as the experience of vitality, enjoyment, sport persistence and improved performance (Alvarez et al., 2009; Iso-Ahola, 1995; Pelletier et

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environment, motivation regulation and PA behaviour). As such, basic need satisfaction was not included in our hypothesised models.

al., 2001; Vansteenkiste, Mouratidis, & Lens, 2010). By contrast, a coach who fails to listen to players' opinions and perspectives, is intimidating when interacting with players, displays negative conditional regard (i.e., withdraws attention if performance expectations are not met), and employs the use of rewards to engage players, is likely to undermine autonomous motivation (Bartholomew et al., 2010). Consequently, players in such environments are more likely to experience negative affective states, engage in antisocial behaviour towards teammates and opponents and drop out of sport (Hodge & Lonsdale, 2011; Pelletier et al., 2001; Vansteenkiste et al., 2010). Thus, the interpersonal behaviours of authority figures acting within PA settings (e.g., coaches, PE teachers) may offer malleable targets for interventions seeking to encourage PA engagement in youth.

SDT and physical activity engagement among youth: what we know so far

A cogent body of work has highlighted the positive consequences associated with autonomy supportive environments and autonomous motivation for PA across different PA settings in adults (Edmunds, Ntoumanis, & Duda, 2008; Fortier, Duda, Guerin, & Teixeira, 2012; Rouse et al., 2011; Teixeira et al., 2012). For example, a recent review demonstrated strong evidence for the positive associations between autonomous motivation and exercise adoption and adherence in adults (Teixeira et al., 2012). Research among youth has largely been conducted in the PE context and has revealed similar results. Overall, studies demonstrate perceptions of autonomy supportive PE environments to be positively related to autonomous motivation towards PA (general, PE and leisure time), and associated daily and leisure time PA engagement (Chatzisarantis & Hagger, 2009; Cox, Smith, & Williams, 2008; Hagger et al., 2009; Standage et al., 2012; Vierling, Standage, & Treasure, 2007). These patterns of relationships have been coined 'trans-contextual' or described as 'cross-domain'. That is, autonomous motivation, predicted by the social environment created within the PE setting, is related to participation in PA outside of this setting (i.e., daily and leisure time PA). For example, Standage and colleagues reported that where pupils perceived PE teachers to be more autonomy supportive, they reported higher autonomous motivation towards PE and exercise, which in turn, predicted higher total PA measured by pedometer (Standage et al., 2012).

Studies among youth have also reported within-context associations between motivation regulations and PA engagement during PE and recess (i.e., school breaks) (Aelterman et al., 2012; Owen et al., 2013; Stellino et al., 2013). Aelterman and colleagues (2012), reported that autonomous motivation towards PE was related to engagement in MVPA during PE classes and Stellino et al., (2013) were the first to demonstrate a positive association between autonomous motivation towards recess PA and pedometer assessed PA engagement during recess. In addition, Perlman (2013) conducted an intervention study whereby the PE teachers were trained to adopt autonomy supportive, controlling or ‘balanced’ (i.e., a 40–60% balance between autonomy-supportive and controlling statements) teaching styles. Those pupils who were in classes taught by autonomy supportive PE teachers reported higher self-determined motivation towards PE and higher levels of engagement in accelerometer assessed MVPA during PE relative to pupils assigned to controlling and ‘balanced’ conditions (Perlman, 2013). Studies have also revealed controlled motivation to be unrelated to engagement in MVPA during PE (Aelterman et al., 2012; Owen et al., 2013). However to date, less work has examined the potential consequences of controlled motivation for PA engagement both within and across contexts among youth.

The contribution of this thesis

Perhaps the main limitation to existing SDT-grounded research examining associations between perceptions of the social environment and PA engagement is an extensive reliance on self-report measures or the employment of pedometers to assess PA engagement. As previously outlined, the intermittent nature of PA in youth and a comparatively lower cognitive functioning than adults is likely to result in inaccuracies in recall of PA engagement (Baranowski et al., 1984; Trost, 2007). In addition, whilst pedometers provide an objective measure of PA (i.e., total steps taken indicating distance travelled), they are unable to determine frequency, intensity and duration of PA engagement. Consequently, the application of these methods in most previous SDT-based research limits our understanding of the degree to which the social environment and ensuing motivational processes are associated with engagement in PA of differing intensities (e.g., MVPA, VPA). Further, where accelerometers have been utilised to examine the relationships between the social environment, motivation regulation and PA participation, the focus has primarily been on the prediction of MVPA, neglecting to examine the motivation-related factors relevant to engagement in other dimensions of PA and ST.

To date, only one study has examined the association between the social environment and ST, demonstrating a PE environment which offered children the opportunity for free choice was related to less time spent sedentary during PE (Lonsdale et al., 2013b). Whilst the work of Lonsdale and colleagues offers a novel contribution to the literature, additional SDT-based research is warranted which further explores the psychosocial correlates of ST and the motivational processes underlying engagement in sedentary behaviours. In particular, given the high levels of daily ST reported among youth

(Pate et al., 2011) studies examining the motivational processes related to engagement in daily ST are paramount from a public health perspective.

Whilst a compelling body of work indicates more autonomy supportive PE teachers are likely to enhance students' autonomous motivation, an almost exclusive focus on the PE setting limits our understanding of the potential value of promoting autonomy support in other youth PA environments. Given that youth are physically active across a variety of settings throughout the week and curricular time allocated to PE is declining in many Western countries (Dollman, Norton & Norton, 2005), examining the motivational processes operating within other youth PA environments and their implications for levels of PA engagement, represents an important area of research. Indeed, the findings of Stellino & Sinclaire (2013) which point towards the association between motivation towards recess PA and PA accrued within this context, underscore the need to investigate the motivational processes pertinent to PA engagement across multiple contexts.

Past studies examining the trans-context associations between the social environment, motivation and objectively assessed PA engagement have demonstrated support for the motivational processes postulated by SDT. However, these studies have employed a self-determination index to represent overall quality of motivation, rather than distinguishing between autonomous and controlled forms of motivation. Consequently, little is known concerning the extent to which the social environment and ensuing autonomous and controlled motivation are independently linked to levels of PA engagement among youth across contexts. Recently, studies examining the within-context associations between motivation and objectively assessed PA engagement during PE have made the distinction between autonomous and controlled motivation, reporting controlled motivation to be unrelated to engagement in MVPA during PE (Aelterman et al., 2012;

Owen et al., 2013). However, these investigations have neglected to examine the role of the social environment as an antecedent of quality of motivation (both autonomous and controlled) and ensuing PA participation. In addition, recent intervention studies seeking to increase levels of MVPA during PE through targeting the interpersonal behaviours of PE teachers and related motivation, have neglected to examine the hypothesised motivational processes postulated by SDT (Lonsdale et al., 2013; Perlman, 2013). That is, the sequential relationships proposed by SDT (i.e., the social environment to motivation regulation) have not been examined with respect to PA accumulated within youth PA settings.

For youth sport football participants, creating autonomy supportive environments and fostering self-determined motivation towards sport (and football in particular) may hold value for encouraging PA engagement both within and outside of this setting. Conversely, controlling coach behaviours may hold deleterious consequences for young players' autonomous motivation and associated PA engagement. To date, no studies have examined the associations between the social environment, autonomous and controlled motivation and participation in PA, within the youth sport context. To this end, Study 3 (Chapter 4) and Study 4 (Chapter 5) adopted an SDT approach to examine the psychosocial factors operating within the youth sport environment and their associations with PA engagement (MVPA and VPA) during youth sport (i.e., within-context relationships) and daily engagement in MVPA and ST (i.e., trans-context relationships). Extending the literature, accelerometers were employed to determine relationships between the theorised motivational processes and engagement in MVPA, VPA and ST. A particular focus was placed on analysing the sequential relationships hypothesised by SDT, in order to determine the role of the social environment as an antecedent of both autonomous and controlled motivation, and related consequences for engagement in PA and ST.

Thesis aims:

In sum, this thesis examines the value of the youth sport context as a setting for PA promotion and obesity prevention utilising objective measures of PA as well as related health indicators. Chapters 2 (Study 1) and 3 (Study 2) specifically investigate PA levels related to youth sport football participation and associations with health. Chapters 4 (Study 3) and 5 (Study 4) take an SDT perspective to examine the social environmental and motivational processes operating within the youth sport football setting and their associations with youth sport PA (within-context) and daily PA and ST (trans-context). The aims of this thesis are:

1. To investigate the contribution of PA accumulated during youth sport football towards weekend levels of MVPA and VPA. Variability in these outcomes as a function of age and playing position was also determined.
2. Employing a cross-sectional design, to investigate variability between youth sport footballers in terms of their daily engagement in MVPA, VPA and ST, and to examine associations with indicators of adiposity and cardiovascular risk.
3. To explore the cross-sectional associations between perceptions of coach provided autonomy support and controlling coach behaviour, autonomous and controlled motivation towards football participation, and engagement in MVPA and VPA during youth sport football sessions.
4. To examine the cross-sectional relationships between perceptions of the coach created social environment (autonomy supportive and controlling), autonomous and controlled motivation towards sport and active games, and daily MVPA and ST.

Overview of participants recruited to Studies 1 to 4

Studies 1, 2 and 3 (Chapters 2, 3 and 4 respectively) utilised data collected from a subsample of English participants recruited to the PAPA project (N = 149) from whom objective physical activity data was collected via accelerometer. Study 1 (Chapter 2) also included additional data collected from a further 35 participants not recruited to the PAPA project (total N for Study 1 = 184). Data for Study 4 (Chapter 5) was collected from an independent sample of participants (N = 156) during the pilot testing phase of the PAPA project (Figure 3.1) .

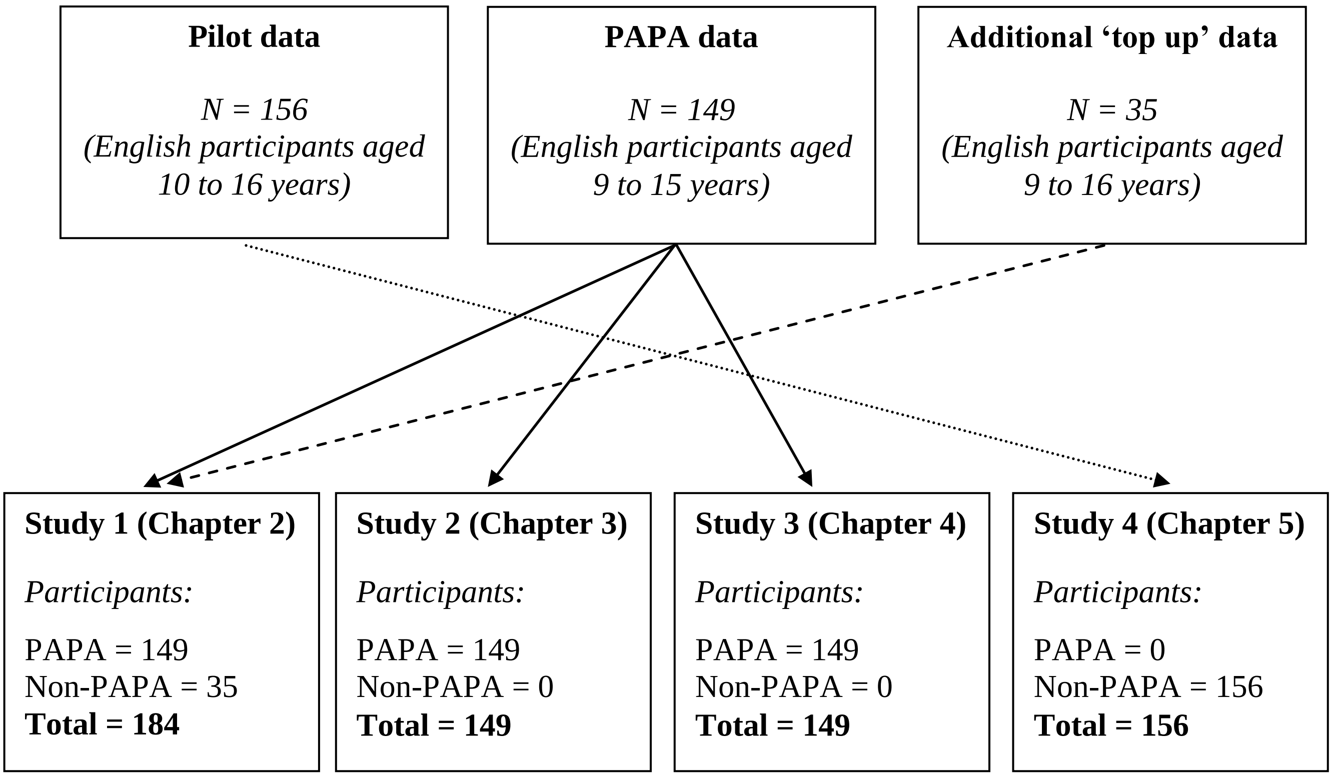

Figure 1.4 Overview of participants recruited to answer thesis aims

Note: ·········▸ Pilot data
——▸ PAPA data
- - - -▸ Top up data

Preliminary analysis of the English PAPA data corroborates the findings reported within Study 4 (Chapter 5).

Data for all studies represents English male youth sport football participants aged between 9 and 16 years; Study 1 = 9 to 16 years, Studies 2 and 3= 9 to 15 years, Study 4 = 10 to 16 years.

CHAPTER 2

THE CONTRIBUTION OF YOUTH SPORT FOOTBALL TO WEEKEND PHYSICAL ACTIVITY: VARIABILITY RELATED TO AGE AND PLAYING POSITION

Abstract

Aim: (1) To determine minutes of MVPA and VPA accrued in youth sport football and the contribution towards weekend MVPA and VPA, and (2) To investigate variability in minutes of MVPA and VPA accumulated during youth sport related to age and playing position **Method:** 109 male grassroots footballers aged 9 to 16 years wore a GT3X accelerometer for 7 days. Weekend youth sport participation and playing position were recorded. **Results:** Youth sport football MVPA (M = 51.51 ± 17.99, range = 14.00 – 91.00 minutes) and VPA (M = 27.78 ± 14.55, range = 3.50 – 67.25 minutes) contributed 60.27% and 70.68% towards daily weekend MVPA and VPA, respectively. Contributions to total weekly MVPA and VPA were 10.17% and 15.03%. During youth sport football, 36.70%, and 69.70% accumulated ≥ 60 minutes MVPA and ≥ 20 minutes of VPA respectively. For participants aged 13 to16 years, youth sport football MVPA and VPA were significantly higher, and contributed a greater amount towards daily weekend MVPA and VPA than for participants aged 9 to 12 years (p = <.01). **Conclusion:** Youth sport football offers an ideal opportunity for engagement in MVPA, and particularly VPA, towards health enhancing levels at the weekend. However, variability among levels of youth sport MVPA and VPA highlights the need to optimise the youth sport experience to ensure all children benefit more optimally from their participation in this physical activity context.

Introduction

As a result of the escalating global childhood obesity epidemic, considerable attention has been drawn towards the area of physical activity (PA) promotion among youth (Reilly & McDowell, 2003). Evidence of an inverse relationship between moderate-to-vigorous physical activity (MVPA) and indicators of adiposity (Mark & Janssen, 2011; Dencker & Andersen, 2008a; Chaput et al., 2012), has resulted in efforts to determine and optimise settings likely to be effective towards increasing engagement in MVPA in children and adolescents.

Evidence based guidelines state that children and adolescents should engage in ≥ 60 minutes of moderate to vigorous physical activity (MVPA) every day to accrue benefits to health (Strong et al., 2005; Janssen & Leblanc, 2010; Australian Government: Department for Health and Ageing: 2004; Department of Health, 2011; US Department of Health and Human Services, 2013). Due to recent studies indicating a dose-response relationship between PA intensity and health (Steele, van Sluijs, Cassidy, Griffin, & Ekelund, 2009a; Dencker & Andersen, 2008a), the latest guidelines have incorporated a recommendation for vigorous physical activity (VPA), advising participation in VPA on at least three days a week (Department of Health, 2011; US Department of Health and Human Services, 2013). Concerning the volume of VPA that should be accumulated, recommendations are lacking. However, a recent study demonstrated approximately 15 minutes of VPA discriminated between normal weight and overweight/obese European youth (Females = 10 minutes, males = 20 minutes) (Martinez-Gomez et al., 2010). However, despite the emphasis placed on the benefits of participating in MVPA and VPA for young people, few children engage in recommended levels of MVPA, and daily levels of VPA are reported to be low (Collings et al., 2014; Dencker & Andersen, 2008; Troiano et al., 2008; Riddoch et al., 2007; Steele et al., 2010).

The majority of research in the area of youth PA promotion has focused upon opportunities offered within the school setting to increase engagement in MVPA towards recommended levels, and to encourage higher participation in VPA (Ridgers, Salmon, Parrish, Stanley, & Okely, 2012a; Lonsdale et al., 2013a). In particular, Physical Education (PE) and school breaks (i.e., recess or lunchtime/break time) have received considerable attention, with numerous studies investigating the contribution of MVPA accumulated in these environments towards guidelines for MVPA and total daily MVPA and VPA (Ridgers, Timperio, Crawford, & Salmon, 2012b; Fairclough & Stratton, 2005; Meyer et al., 2012). Recently, research has also examined the extent to which MVPA and VPA accrued within different school PA settings contributes differential amounts for children of different ages and for males and females (Ridgers et al., 2012b; Meyer et al., 2012). However, to date, youth PA settings outside the school environment that are likely to offer opportunity for regular engagement in MVPA and VPA (i.e., weekday and weekend) have been relatively overlooked.

Government organisations across the globe have advocated youth sport as a potential vehicle through which levels of PA might be increased among youth (Commission of the European Communities, 2007; Centers for Disease Control and Prevention, 2000; NSW Department of Health, 2009). However, few studies have actually examined the opportunity offered by the youth sport setting for engagement in PA. Further, a paucity of studies have employed objective measures of PA (e.g., accelerometers) to assess MVPA and VPA during youth sport participation (Nelson et al., 2011). As such, conclusions drawn concerning the value of youth sport for encouraging engagement in MVPA and VPA are based on a limited body of evidence.

The few accelerometer-based studies that have been conducted within the youth sport domain have primarily examined the opportunity offered by youth sport for engagement in MVPA towards recommended levels (Leek et al., 2011; Guagliano, Rosenkranz, & Kolt, 2012; Sacheck et al., 2011). Results have revealed that whilst youth sport offers the opportunity to accrue substantial amounts of MVPA, most participants are unlikely to meet daily guidelines for MVPA during their involvement in youth sport (Leek et al., 2011; Sacheck et al., 2011; Guagliano et al., 2012). To our knowledge, no studies have examined the contribution of youth sport towards levels of VPA that have demonstrated associations with health. Given that past research indicates VPA may be more strongly linked to health outcomes than moderate PA (Steele, van Sluijs, Cassidy, Griffin, & Ekelund, 2009; Dencker & Andersen, 2008), research determining the role of youth sport for encouraging engagement in health enhancing levels of VPA is warranted.

Existing studies have also neglected to examine the degree to which youth sport may offer a source of weekend PA. Given that PA levels are reported to be lower at the weekend among youth (Nilsson et al., 2009b; Nader, Bradley, Houts, McRitchie, & O'Brien, 2008), determining settings likely to encourage PA participation towards heath enhancing levels at the weekend is important from a public health standpoint. Indeed, the nature of youth sport means weekend participation is likely, whereas, by contrast, research centred within the school environment will consequently result in a focus towards weekday engagement in PA. One study to date has examined the contribution of youth sport towards objectively measured total daily PA on a weekday, demonstrating youth sport accounts for 23% of weekday MVPA (Wickel & Eisenmann, 2007). Interestingly, this study also reported daily MVPA was significantly higher on a sport compared to a non-sport day, indicating that the additional PA likely accumulated as a result of youth sport participation may not be maintained beyond the day on which sport is participated in. Thus, investigating the extent to which youth sport offers a source of weekly MVPA and VPA warrants further attention.

Alongside observations of minutes of MVPA and VPA accrued during youth sport, past research has also examined factors related to levels PA participation within the youth sport setting. Findings have indicated MVPA and VPA accrued within youth sport to vary as a function of age, gender, sport type, weight status and context (i.e., training sessions versus matches) (Leek et al., 2011; Wickel & Eisenmann, 2007; Guagliano et al., 2012; Sacheck et al., 2011). As such, youth sport may offer differential opportunity for engagement in MVPA depending on a multitude of potential determinants. Accordingly, additional accelerometer based research seeking to determine levels of MVPA and VPA accrued in youth sport engagement should take such factors in consideration. Studies examining factors related to variability in youth sport PA engagement will help determine towards whom (i.e., which participants, sports and contexts) efforts need to be targeted to ensure all youth benefit more equally from their sport participation.

Also important to note is that the majority of existing investigations have utilised age-dependent cut points (Freedson, Pober, & Janz, 2005) to determine duration, frequency and intensity of PA engagement among sport participants (Leek et al., 2011; Wickel & Eisenmann, 2007; Guagliano et al., 2012; Van Hoye et al., 2013; Machado-Rodrigues et al., 2012). These cut points have been shown to misclassify light PA as moderate PA in children ≤ 10 years old (Trost, Loprinzi, Moore, & Pfeiffer, 2011). As a result, past studies which have included participants ≤ 10 years of age, may have overestimated the opportunity offered by the youth sport setting for engagement in MVPA (Kim, Beets, & Welk, 2012). The Evenson et al., (2008) cut points (Evenson, Catellier, Gill, Ondrak, & McMurray, 2008), have demonstrated superior reliability and validity over other independently validated cut points for youth [i.e., Freedson et al., 2005, Puyau et al., 2002, Treuth et al., (2004) Mattocks et al., (2007)], and are recommended for use in children and adolescents (Trost et al., 2011). Therefore, the application of the Evenson et al., (2008) cut-points to studies seeking to determine MVPA and VPA associated with youth sport participation, will likely result in a more accurate estimation of the opportunity offered by youth sport for engagement in these behaviours.

Extending the existent literature, the primary aims of the present study were two-fold. First, employing the Evenson et al., (2008) cut-points, to determine levels of MVPA and VPA accrued during youth sport football (also internationally referred to as soccer) and the contribution made towards daily weekend and total weekly MVPA and VPA. The number of youth football participants meeting recommended guidelines for MVPA (≥ 60 minutes) and engaging in levels of VPA identified as preventing excess adiposity among youth (≥ 20 minutes) (Machado-Rodrigues et al., 2012) were also determined. The second aim of the current study was to examine variability in these outcomes in relation to participant age and playing position.

Football was the sport focused on in the present study due to high rates of participation across the globe, and potential application of findings to large numbers of youth sport participants. Indeed, over 21 million children and adolescents participate in youth sport football across the world (Kunz, 2007), and research reports football to be among the most popular youth sports internationally (Australian Bureau of Statistics, 2009; National Council of Youth Sports, 2008).

Method

Participants and recruitment

Participants were 184 males aged 9 to16 years (teams, N = 49) recruited from youth sport football clubs in England. For inclusion in the study, participants were required to be regularly participating in youth sport football (i.e., training and/or match play ≥ once per week) at the recreational level. Initially, lead coaches at football clubs were contacted by a member of the research team. Interested coaches were provided with information about the study protocol and passed this information on to parents and players. Participants were then recruited to the study based on their willingness to take part. Only male footballers were recruited as a smaller number of female clubs showed interest in taking part. Where possible, a striker, defender, midfielder and goalkeeper were recruited from each team. Informed consent and assent was obtained from all parents and players before participating in the study. The present research was approved by the local National Health Service Research Ethics Committee (Research Ethics Committee application number: 10/H1207/39).

Protocol

A trained researcher visited training sessions to carry out the procedures. During the session, participants' height and weight were measured and accelerometers and PA diaries distributed. Participants were asked to wear the accelerometer for 7 days. Researchers returned one week later to collect accelerometers and PA diaries.

Measures

Anthropometrics. Height was measured to the nearest 0.1cm using a portable stadiometer (SECA, Leicester height measure). Weight was measured to the nearest 0.1kg using electric scales (Tanita, SC330). All measures were conducted in duplicate. Average values were calculated for height and weight and used to calculate BMI [weight (kg)/ height (m^2)].

Physical activity. The GT3X accelerometer (Actigraph; Pensacola, FL) was used to measure MVPA and VPA. Actigraph accelerometers are the most commonly used accelerometers in PA research and have been validated against criterion measures of PA youth (Trost, 2007; de Vries et al., 2009). Accelerometers were initialised to measure PA in 15 second epochs. Verbal instructions were given by the researcher on how the accelerometer should be worn and a demonstration given. Participants were asked to wear the accelerometer on the right hip for seven days during all waking hours, removing only for participation in water sports (e.g., swimming), bathing and sleeping. To try and increase compliance, it was emphasised that participants should try to wear the accelerometer for the full 7 days in which they were participating in the study. Researchers contact details were also made available to participants and parents in the event they had any issues, questions or concerns regarding wearing the accelerometer. Accelerometer log sheets and PA diaries were also distributed to enable participants to monitor compliance (i.e. record non-wear time) and to aid with data cleaning and interpretation. Participants were asked to report times they had participated in youth sport football on Saturday and/or Sunday in PA diaries and to record their playing positions (i.e., striker, midfielder, defender, goalkeeper). Log sheets, PA diaries and accelerometers were collected one week later.

Data processing

Physical activity data were downloaded from the GT3X to a computer and analysed using the Actilife software (Actilife version 6.2, Actigraph; Pensacola, FL). Data were checked for spurious values and periods of non-wear time. Non-wear time was determined by identifying strings of consecutive zeros in the movements counts recorded by the accelerometer for > 30 minutes, allowing for 1 minute of counts <100 (Cain, Sallis, Conway, Van Dyck, & Calhoon, 2013; Troiano et al., 2008). A day was considered valid where ≥ 8 hours of wear time had been recorded. Cut points derived by Evenson and colleagues were used to determine time spent in MVPA (≥2296 cpm) and VPA (≥ 4012 cpm) (Evenson et al., 2008).

Time spent in youth sport football at the weekend was identified from PA diaries (i.e., day and time). Diary entries were compared against graphed data to check for accuracy in self-reported timings. Following this, time filters were applied to the Actilife software for the identified time period to determine minutes in MVPA and VPA during youth sport football. Total daily MVPA and VPA for the day on which youth sport was participated in (i.e., a Saturday or Sunday) were also calculated to represent daily weekend MVPA and VPA. Total weekly MVPA and VPA was calculated by summing time spent in these activity intensities across the week.

Compliance with the complete protocol was 58.6 %. This is comparable to compliance levels reported in the Health Survey for England 2008, for boys aged 8 to 15 years (i.e., 45 to 49%) (Craig et al., 2009). Of the original 184 participants, 15.8% (N = 29) did not record valid weekend PA data and 15.8% (N = 29) did not record participation in youth sport at the weekend (e.g., monitor was removed for youth sport participation, youth sport session was cancelled). A further 9.2% (N = 17) failed to return PA diaries. Participants who did not comply with the complete protocol were excluded. The final sample therefore included 109 males aged 9 to16 years. Independent samples t-tests demonstrated excluded participants did not differ significantly from those included in the final sample with respect to age, height, weight or BMI (all p >.05).

Statistical analysis

Descriptive statistics [M ± SD, and ranges (minutes)], for youth sport MVPA and VPA were determined and used to calculate the contribution of weekend youth sport football towards daily weekend (i.e., the day on which youth sport was participated in) MVPA and VPA [(Weekend youth sport MVPA/VPA (mins)/ daily weekend MVPA/VPA) x100] and total weekly MVPA and VPA [(weekend youth sport MVPA/VPA (mins)/total weekly MVPA/VPA) x100]. Percentages of youth sport session time engaged in MVPA and VPA were also calculated[1]. Data was checked for normality and non-normally distributed data was log transformed. Where data transformations reduced data skewness, transformed variables were used in subsequent analysis. The number of participants meeting recommended guidelines for MVPA (i.e., ≥ 60 minutes) and achieving ≥ 20 minutes of VPA were determined.

Descriptive statistics were calculated for youth sport MVPA and VPA for different playing positions (strikers (N = 25), midfielders (N = 41), defenders (N = 32) and goal keepers (N = 6)[2] and age groups [(aged 9 to 12 years, N = 69 (M = 10.72, SD = .95), and 13 to 16 years, N = 40 (M = 13.98, SD = .83)]. Age groups were devised based on data demonstrating the age related decline in PA is steepest between the ages of 13 to18 years (Sallis, 2000). Variability in youth sport MVPA and VPA (minutes and percentage of session time) related to participant age and playing position were examined via ANCOVAs. Youth sport context (training versus match) was included as a covariate in all

[1] For the contribution towards total weekly MVPA and VPA only data from participants who had recorded = 7 (N = 57, compliance = 52.2%) valid days of accelerometer data respectively (i.e., a full week) were used in analysis (Mean age = 11.88 ± 1.86).
[2] Data were not available for playing positions from 5 participants. ANCOVAs conducted to determine differences between playing positions therefore included data from only 104 participants (Mean age = 11.96 ± 1.84).

ANCOVAs[3]. Where total minutes in MVPA and VPA were dependent variables, youth sport session length was also included as a covariate. Chi square tests were conducted to determine if participants were more likely to meet guidelines for MVPA and VPA during youth sport football based on age group and playing position. ANCOVAs controlling for youth sport context were carried out to determine if the contribution of weekend youth sport to daily weekend and total weekly MVPA and VPA differed significantly between age groups and playing positions.

Results

Participant characteristics

Physical characteristics by sample (total, included and excluded) are displayed in Table 2.1. According to UK BMI reference charts, 76.9 % of the total sample were classed as normal weight (N = 143, <85th percentile) with 14 % and 6.5 % of the sample being classed as overweight (N = 26, ≥ 85th percentile) and obese (N = 12, ≥ 95th percentile), respectively (Cole, Freeman, & Preece, 1995). Due to the time constraints faced at some football training sessions, height, weight and BMI data were not available for three participants (1.63%). Questionnaire responses for demographic variables were incomplete (non-respondents = 21%). Among respondents, 72.6 % were white, 14.4% were Asian, 9.6% were black and 3.4% were multi-racial. Chi square tests demonstrated the ethic distribution of participants included in the final sample differed significantly from those excluded (χ^2 (3) = 17.52, p = <.01, white = 83 %, Asian = 5.7%, black = 6.8%, multi-racial = 4.5% for included participants).

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[3] Due to the nature of youth sport, participants reported engaging in a mixture of training sessions and match play across the weekend (training, N = 49 match play = 60). Age was not significantly different across contexts (t (107) = -.75, p = .46, training M = 11.77 ± 1.73, match play = 12.03 ± 1.89), and there was no significant association between age and context (χ^2 (1) = 3.14 p = .07, Cramers V = <.17).

The contribution of youth sport to daily weekend MVPA and VPA

Weekend youth sport football session time was between 60 and 160 minutes (M = 106.74 ± 18.90). Total minutes and percentage of session time engaged in MVPA and VPA during weekend youth sport football are reported in Table 2.2. Ranges for youth sport MVPA and VPA were 77.0 and 63.75 minutes and 71.33% and 52.54% of session time, respectively. Results demonstrated 36.70% of participants met recommended guidelines for MVPA during youth sport and 69.70% of participants' accrued ≥ 20 minutes of VPA. Daily weekend MVPA and VPA were M = 91.26 ± 35.44 and M = 40.89 ± 20.73 respectively. MVPA accrued during weekend youth sport football contributed 60.27 % ± 19.48 (range = 25.31 % – 91.73%) towards daily weekend MVPA. For VPA, minutes accrued contributed 70.68 % ± 21.53 (range = 24.55% – 100%) towards daily weekend VPA (Figure 2.1). Contributions to total weekly MVPA (M = 537.52 ± 144.68) and VPA (M = 206.83 ± 84.71) were 10.17 % ± 4.29 (range = 3.73% – 24.28%) and 15.03 ± 8.29 (range = 3.56% - 43.26%) respectively.

Table 2.1

Physical characteristics of youth sport footballers

	Total (N = 184)	Included (N = 109) (i.e.,Valid youth sport PA data)	Excluded (N = 75)
Physical characteristics			
Age (years)	11.98 ± 1.75	11.92 ± 1.82	12.12 ± 1.64
Height (m)	1.55 ± 0.13	1.55 ± 0.14	1.55 ± 0.12
Weight (kg)	46.52 ± 13.56	46.08 ± 14.19	47.19 ± 12.59
BMI (kg.m^2)	18.98 ± 3.08	18.70 ± 3.14	19.45 ± 2.95
BMI-SDS	0.35 ± 1.08	0.26 ± 1.14	0.56 ± 0.95

Note: Values are Mean ± SD

For the total sample, N = 181 for height, weight, BMI and BMI-SDS. For participants with valid weekend youth sport PA data, N = 109 for all physical characteristics.

Due to time constraints at some football training sessions, height, weight and BMI data was not available for three participants (1.63%).

BMI = body mass index
BMI-(SDS) = body mass index (standard deviation score)

Variability related to age and playing position

Significant differences were found for time spent in weekend youth sport MVPA and VPA between age groups. Children in the older age group engaged in significantly more minutes of MVPA (*F* (1, 105) = 15.76, *p* = <.01 and VPA (*F* (1, 105) = 23.72, *p* = <.01), and spent a higher percentage of youth sport session time in MVPA (*F* (1, 106) = 14.11, *p* = <.01) and VPA (*F* (1, 106) = 21.13, *p* = <.01) than those in the younger age group (Table 2.1). Chi square tests indicated older participants were more likely to accrue ≥ 60 minutes MVPA (χ^2 (1) = 25.80, *p* = <.01), and ≥ 20 minutes of VPA during youth sport (χ^2 (1) = 6.99, *p* = .01), although the association was stronger for ≥ 60 minutes MVPA (Cramers V = .49 versus .25 for MVPA and VPA respectively). Weekend youth sport PA contributed a significantly greater amount towards daily weekend MVPA and VPA for older compared to younger participants (Figure 2.1, MVPA, *F* (1, 106) = 22.42, *p* = <.01, VPA, *F* (1, 106) = 18.20, *p* = <.01). Similarly, weekend youth sport PA contributed a greater amount towards total weekly levels of these behaviours for older (N = 19) compared to younger (N = 38) participants (MVPA contribution, 9 to 12 years, M = 9.04 ± 3.40 vs. 13 to 16 years, M = 12.42 ± 5.05, *F* (1, 54) = 7.85, *p* = <.01, VPA contribution, 9 to 12 years, M = 13.01 ± 6.62 vs. 13 to 16 years, M = 19.96 ± 9.89 , *F* (1, 54) = 6.45, *p* = .01)

No significant differences were reported between playing positions for minutes in youth sport MVPA (*F* (3, 98) = .41, *p* = .75) or VPA (*F* (3, 98) = .56, *p* = .65) and percent session time in MVPA (*F* (3, 99) = .74, *p* = .53) or VPA (*F* (3, 99) = .62, *p* = .61). Analyses were repeated to adjust for the significant association between age and youth sport MVPA and VPA and remained non-significant (all *p* = >. 26). There was no significant association between playing positions and meeting guidelines for MVPA (χ^2 (3)

= .20, *p* = .98) or accruing ≥ 20 minutes VPA, (χ^2 (3) = .52, *p* = .92). Youth sport did not contribute significantly different amounts towards daily weekend MVPA and VPA for participants in different playing positions (Figure 2.1, MVPA, *F* (3, 99) = .70, *p* = .55, VPA, *F* (3, 99) = .64, *p* = .59). Likewise, the contribution of youth sport to total weekly MVPA and VPA did not differ as a function of playing position (MVPA contribution, striker, M = 10.79 ± 5.38 vs. midfielder, M = 10.16 ± 4.74 vs. defender, M = 9.57 ± 3.11 vs. goalkeeper, M = 11.52 ± 5.45, *F* (3, 50) = .77, *p* = .52, VPA contribution, striker, M = 14.72 ± 8.64 vs. midfielder, M = 16.12 ± 10.48 vs. defender, M = 13.81 ± 5.25 vs. goalkeeper, M = 15.64 ± 7.92 *F* (3, 50) = .41, *p* = .75)

Table 2.2

Descriptive statistics for youth sport football MVPA and VPA, stratified by age and playing position

	Total sample M ± SD	Age groups M ± SD		Playing positions M ± SD			
		9-12 years (N = 69)	13-16 years (N = 40)	Striker (N = 25)	Midfielder (N = 41)	Defender (N = 32)	Goal keeper (N = 6)
Minutes (total)							
MVPA	51.51 ± 17.99	44.90 ± 14.24	62.89 ± 18.24*	48.59 ± 18.39	53.18 ± 18.52	51.69 ± 18.38	49.04 ± 14.11
VPA[¶]	27.78 ± 14.55	21.75 ± 10.04	38.19 ± 15.33*	25.00 ± 13.58	29.66 ± 15.35	27.81 ± 15.54	24.38 ± 10.23
Range (minutes)							
MVPA	14.00 – 91.00	19.25 – 79.00	14.00 – 91.00	20.50 – 84.50	19.25 – 91.00	14.00 – 81.75	34.50 – 69.75
VPA	3.50 – 67.25	6.50 – 53.25	3.50 – 67.25	6.50 – 60.00	8.25 – 67.25	3.50 – 57.50	16.00 – 44.25
Session time (%)							
MVPA	50.12 ±13.81	43.94 ± 11.03	54.41 ± 15.18*	45.88 ± 12.09	50.34 ± 14.63	47.50 ± 14.61	43.76 ± 8.82
VPA[¶]	27.38 ±12.10	21.73 ± 9.43	33.07 ±13.09*	23.73 ± 10.10	27.99 ± 13.11	25.42 ± 12.10	21.66 ± 7.12
Range (% time)							
MVPA	14.00 – 85.33	16.04 – 85.33	14.00 – 81.75	27.71 – 70.42	16.04 – 85.33	14.00 – 81.75	28.75 – 53.65
VPA	3.50 – 56.04	6.67 – 53.67	3.50 – 56.04	8.13 – 50.00	6.88 – 56.04	3.50 – 52.04	14.38 – 34.04

Note: * = <.01. Log transformed variables (SQRT)[¶]

MVPA = Moderate-to-vigorous physical activity, VPA = vigorous physical activity

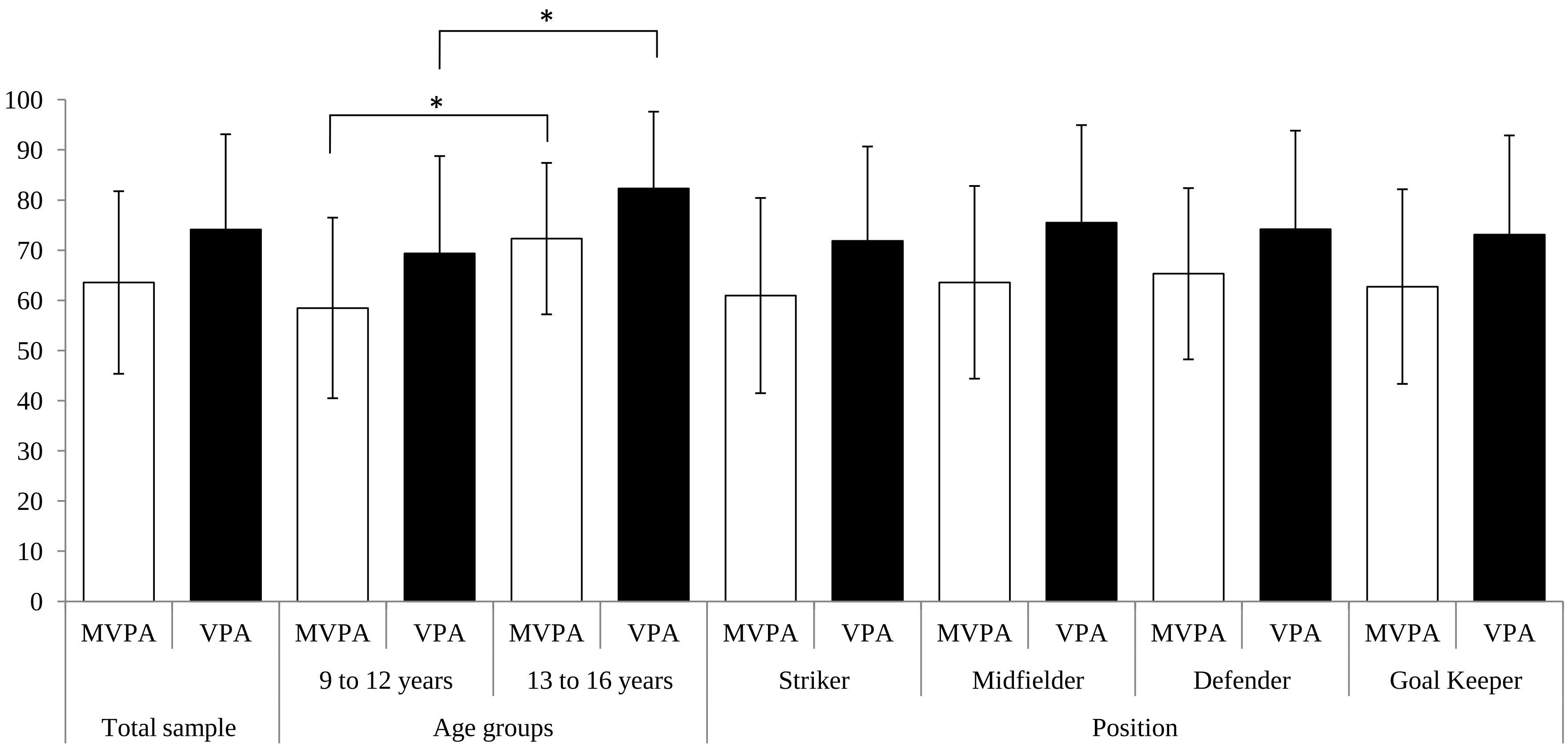

Figure 2.1 The contribution of youth sport to daily weekend MVPA and VPA stratified by age group and playing position

Note: * = p <.01 between groups

MVPA = moderate-to-vigorous physical activity, VPA = vigorous physical activity

Discussion

The present study examined levels of engagement in MVPA and VPA during youth sport football sessions and determined the contribution made towards daily weekend and total weekly MVPA and VPA. Further, variability in both youth sport MVPA and VPA, and the contribution towards daily weekend and total weekly MVPA and VPA were investigated relative to participant age and playing position. Results demonstrated participation in youth sport football offers opportunity to engage in health enhancing levels of MVPA and VPA at the weekend and contributes a substantial amount towards daily weekend MVPA and VPA. However, youth sport football may encourage higher engagement in MVPA and VPA, and represent a more important source of weekend MVPA and VPA, for older compared to younger participants.

Present results demonstrated that on average, male youth sport football participants engaged in approximately 52 and 28 minutes of MVPA and VPA, respectively. Findings therefore indicate that participation in youth sport football may encourage engagement in MVPA and VPA towards levels identified as being beneficial for health (Martinez-Gomez et al., 2010; Janssen & Leblanc, 2010). Past studies in which age-dependent cut points have been employed have reported lower absolute levels of PA engagement during youth sport (Guagliano et al., 2012; Leek et al., 2011; Wickel & Eisenmann, 2007). That is, previous investigations have demonstrated levels of MVPA and VPA to be between 30 and 45 and 15 and 20 minutes respectively, and reflect levels of PA engagement across a range of sports (e.g., basketball, soccer (football), netball, softball/baseball). However, after adjusting for the length of the youth sport session, percentage of time spent in MVPA is reported to be similar across studies. In the present research, youth sport football participants spent 48% of time engaged in MVPA, comparable to results reported by Leek et al., (2011) (i.e., 49%) and Wickel et al., (2007) (i.e., 46%). Thus, the higher levels of MVPA and VPA observed in the current study may be attributable to longer youth football sessions and resulting increased opportunity for PA engagement. Nevertheless, given that past studies utilising age dependent cut-points may have overestimated levels of MVPA participation during youth sport, present results may indicate youth sport football in particular is more conducive than some other youth sports for encouraging engagement in PA above a moderate intensity. Indeed, when stratified by sport type, Leek et al., (2011) reported soccer players (footballers) to engage in higher levels of MVPA (total and percent of time) during youth sport than softball/baseball players. Future studies should aim to characterise levels of MVPA and VPA engagement within different sports utilising the Evenson et al., (2008) cut points in order to more accurately characterise levels of PA engagement associated with participation in different sports.

The current study is the first to determine the contribution of youth sport towards daily weekend PA, and also to determine the contribution of VPA accumulated during youth sport to daily VPA participation. Results revealed weekend youth sport football to contribute approximately 71% towards daily weekend VPA, indicating youth sport football represents an important source of VPA at the weekend on days in which it is participated in. Previous work has emphasised the importance of finding opportunities to increase engagement in weekend VPA, and the necessity to study the main activities undertaken when engaged in VPA (Steele et al., 2010). Current findings therefore indicate that participation in youth sport football may be one such means to increase weekend engagement in VPA for male children and adolescents. To our knowledge, only one previous study has examined the contribution of youth sport towards objectively measured daily MVPA, reporting youth sport contributed 23% towards MVPA on a weekday

(Wickel & Eisenmann, 2007). The relatively higher contribution observed in the present study may indicate that youth sport likely becomes a more important source of MVPA at the weekend, in the absence of structured opportunities for PA engagement that are inherent with the school day (e.g., physical education, school breaks/recess).

The importance of considering youth sport as a principle source of health-enhancing PA is further highlighted by present results indicating a single youth sport session contributed approximately 10% and 15% towards total weekly engagement in MVPA and VPA respectively. Indeed, the contribution of youth sport football to *total weekly* MVPA and VPA is comparable to that reported in studies which have examined the contribution of other youth PA setting (e.g., PE, active transport and school breaks/recess) towards only *total daily* MVPA and VPA (Daly-Smith, McKenna, Radley & Long, 2011; Meyer et al., 2012; Ridgers, Stratton & Fairclough, 2006; Ridgers et al., 2012b). For example, Ridgers et al., 2012b, reported school breaks/recess to contribute between 14% and 28% towards *total daily* VPA for children aged 10 to 15 years. As such, results further underscore that youth sport may represent an important source, and offer valuable opportunity for engagement in MVPA, and particularly VPA for children and adolescents. However important to consider is that few studies have explored the value of unorganised forms of PA and their contribution towards engagement in health-related PA.

Active play or ‘free play’, refers to games or symbolic play played in recreational settings (e.g., the back yard or street) and is a typically unsupervised and self-directed by children. About half the time children are engaged in active play they are participating in light, moderate or vigorous PA (Belecastro, Morrison, Hicks & Matta, 2012). In a recent study, Janssen (2014) emphasised the importance of considering active play relative to organised forms of PA (i.e., youth sport, active transport and PE) for increasing daily energy expenditure among youth. Considering youth sport specifically, results from this study indicated that every hour per day a child spends participating in active play rather than screen time, increases daily energy expenditure by 49 kcal per day. For youth sport, results revealed children who participate in youth sport two to three times per week, increase their energy expenditure by a lesser amount (23 kcal per day averaged across the week) compared to if they had spent the equivalent amount of time sedentary. In contrast to organised activities such as youth sport and PE, active play can be participated in for long periods of the day and perhaps more frequently throughout the week. As such, these recent findings may suggest the nature of active play might be more conducive towards encouraging regular engagement in MVPA and VPA among youth. Indeed, Dunton, Kawabata, Intille, Wolch & Pentz (2012), reported 38% of PA among youth aged 9 to 13 years was accrued at home (either indoors or in the back/front yard) which is likely to reflect unorganised forms of PA.

Brockman, Jago & Fox, (2010) further highlighted the importance of considering unorganised forms of PA as contributors to health enhancing PA in their study which examined the contribution of active play towards weekly and weekend in 10 to 11 year olds. Results revealed frequent active play (i.e., participation ≥ 5 times per week) was positively associated with higher total PA (counts per minute) and MVPA on weekdays after school (relative to children who reported ‘never’ participating in active play). Interestingly however, frequent active play was not associated with children’s MVPA on weekend days. As such, results may indicate active play is a more important contributor towards MVPA during the week than at the weekend among youth. However, whilst such studies offer an insight into the contribution unorganised forms of PA likely make towards engagement in health enhancing PA among youth, additional studies are necessary in order to determine the relative contributions of unorganised and organised sources of PA among youth. Also interesting to determine would be the extent to which participation in youth sport encourages participation in active play outside the organised sport setting. Indeed, a recent qualitative study indicated boys aged 10 to 11 years frequently reported ‘having a kick about’ as one of their preferred forms of active play (Brockman, Fox & Jago, 2011).

Whilst findings indicate youth sport football may indeed offer opportunities to accrue substantial amounts of PA, results also suggest a large degree of variability exists between participants with respect to PA accumulated within this setting. Results revealed only 37% of participants met recommended guidelines for MVPA during youth sport football sessions. Thus, for a number of youth sport participants, participation alone is unlikely to promote engagement in MVPA toward levels required to lead to health benefits. Whilst the use of differing accelerometer cut points somewhat precludes comparisons across studies, current findings are in line with those of Leek et al., (2011) who reported only 24% of participants in their study met daily guidelines for MVPA during youth sport.

Adding a novel contribution to the literature, the present study was the first to examine the contribution of youth sport towards levels of VPA that have demonstrated associations with health. Results revealed 70% of participants’ accrued ≥ 20 minutes of VPA, a cut-off reported to discriminate between normal weight and overweight/obesity in male European youth (Martinez-Gomez et al., 2010). Relative to MVPA, participation in youth sport football may therefore be more conducive towards engagement in levels of VPA required to prevent the development of excess adiposity in young male footballers. However, whilst 20 minutes of VPA has been demonstrated to confer positive health benefits, this cut-off is based on the results of a single study of youth aged 12.5 to 17.5

years. Additional research is therefore necessary to inform evidence-based guidelines for VPA. Moreover, the evidence base informing guidelines for MVPA indicates engagement in MVPA for at least 60 minutes per day is associated with positive health benefits among youth (Strong et al., 2005; Janssen & Leblanc, 2010). Thus, given that almost half of youth sport football session time was spent engaged in PA below a moderate intensity, results suggest there is scope to increase the duration of engagement in MVPA and VPA to further optimise an individuals' youth sport football participation. Indeed, other studies have reported similar findings for other youth sports (Guagliano et al., 2012, Leek et al., 2011) Maximising youth sport as a context for PA engagement should help to contribute towards more youth achieving recommended levels of MVPA, and higher daily VPA on youth sport days.

Current findings revealed that participants, aged 13 to 16 years, accrued more minutes of MVPA and VPA, and spent a higher percentage time engaged in MVPA and VPA during youth sport football compared to those aged 9 to 12 years. Results also indicated that older participants were more likely to meet guidelines for MVPA and VPA during youth sport football. Thus, present findings imply that youth sport football participation may offer greater opportunity for engagement in MVPA and VPA, and represent a greater source of daily weekend PA for older compared to younger participants. As such, younger youth sport football participants may benefit most from efforts aimed at maximising youth sport as a context for PA engagement. However, important to consider is that variability in PA engagement was still observed among older participants. It would be interesting for future studies to determine factors related to youth sport PA variability among older and younger youth sport participants separately.

Given the lack of studies investigating age related variability in youth sport PA, discussion as to why older participants in the present sample engaged in higher levels of MVPA and VPA during youth sport than younger participants are somewhat speculative. Perhaps, as children reach adolescence, the focus of the coach is removed away from knowledge delivery and instruction regarding basic skills, towards learning and refining skills via game play and activities which facilitate aerobic conditioning to prepare for more competitive play. Indeed, research in the PE setting has demonstrated an inverse relationship between MVPA and time spent by the coach engaged in behaviours requiring verbal instruction (i.e., management and knowledge delivery) (Dudley, Okely, Cotton, Pearson, & Caputi, 2012). Such a change in the structure of the youth sport session, coupled with an inherent age related increase in strength and power (Roemmich & Rogol, 1995), may consequently result in increased engagement in high intensity PA as children progress into adolescent teams. Only one study to date has investigated age differences in PA levels during youth sport and revealed contrasting findings to present results. Leek et al. (2011) reported youth sport participants' aged 7 to 10 years engaged in 7 minutes more MVPA during youth sport than their older counterparts (aged 11 to 14 years). Differing findings may be explained by the use of age-specific cut-points in the past study and likely overestimation of MVPA in younger participants. The application of the Evenson et al. (2008) cut point in the present study means current results may more accurately reflect age differences among youth sport football participants than those reported previously.

Ours is the first study to investigate variability in youth sport PA relative to playing positions. Results revealed engagement in MVPA and VPA did not vary between strikers, midfielders, defenders and goal keepers. However, there was a trend towards lower levels of MVPA and VPA among goal keepers. The lack of a significant finding may be a consequence of the low number of goal keepers recruited and the high variability in youth sport MVPA and VPA among players. Nevertheless, the present study makes a novel contribution by demonstrating that PA levels of outfield players do not differ significantly. Thus, for strikers, midfielders and defenders, playing position is unlikely to affect levels of MVPA and VPA accrued during youth sport time.

Present findings also indicated that the contribution of youth sport football towards daily weekend and total weekly MVPA and VPA did not differ as a function of playing position. However, youth sport football contributed a significantly greater amount towards daily weekend and total weekly MVPA and VPA for older compared to younger participants. As such, findings may indicate that youth sport football represents a more important source of daily weekend and weekly MVPA and VPA for youth during adolescence than during childhood. Indeed, perhaps as children move into the adolescent years unstructured PA engagement (e.g., active play) declines as youth rely more on structured opportunities for PA engagement to accrue MVPA and VPA. Certainly, Nilsson et al., (2009a) reported frequency of outdoor play after school to be a significant correlate for daily MVPA in 9 year old European youth, which was attenuated in favour of participation in sport and exercise in clubs in 15 year olds (Nilsson et al., 2009a). Taken together, present results may indicate that encouraging participation in youth sport football may have implications for counteracting the age related decline in PA reported to occur as children progress into the adolescent years (Nader et al., 2008; Nilsson et al., 2009b; Sallis, 2000; Woods et al., 2010). Indeed, a recent study demonstrated a more marked decline in MVPA occurred between the ages of 13 and 16 in non-sport participants compared to sport participants (Machado-Rodrigues et al., 2012). Future studies should seek to determine how the contribution of youth sport, relative to other sources of PA (e.g., physical education, active play and recess/school breaks), varies as a function of age.

Strengths of the present study include the use of accelerometers to measure PA, allowing estimation of duration and intensity of activity during youth sport football sessions. In addition, the application of the Evenson et al., (2008) cut points is likely to result in a more accurate estimation of levels of PA engagement during youth sport football than previously reported. This is also the first study to examine youth sport participation in the context of levels of VPA which have demonstrated associations with health, thus adding an important and novel contribution to the literature. Limitations include possible sample bias; participants were self-selected and largely represent white English males who participate in youth sport football. However, the global popularity of grassroots football in both westernised and developing countries means findings are likely applicable to large populations of youth sport participants worldwide (Kunz, 2007). Further, in view of research demonstrating girls engage in lower level of PA during youth sport than boys, there is a need to examine context specific PA engagement in girls and boys separately (Pate & O'Neill, 2011). Nevertheless, the homogeneity of the sample used means results may not be applicable to other groups of youth sport participants (e.g., females, participants from other sports). Indeed, studies conducted within the youth sport domain highlight the multitude of factors which can affect PA engagement during youth sport (Guagliano et al., 2012; Leek et al, 2011; Sacheck et al., 2011; Wickel et al., 2007). For example, it may be that youth sport contributes a lesser amount towards daily weekend MVPA for netballers than footballers. Future studies should therefore seek to examine the questions raised herein among females, other youth sports and different cultures.

In conclusion, results demonstrate that participation in youth sport football offers male children and adolescents the opportunity to accrue substantial amounts of MVPA, and particularly VPA at the weekend. Present findings also indicate that participation in youth sport football may encourage higher levels of PA engagement, and represent a more important source of PA for adolescents compared to children. Observed variability among youth sport MVPA and VPA highlights the need to optimise the youth sport experience in regard to young people’s participation in PA.

CHAPTER 3

INDEPENDENT ASSOCIATIONS BETWEEN PHYSICAL ACTIVITY AND SEDENTARY TIME WITH INDICATORS OF ADIPOSITY AND CARDIOVASCULAR RISK IN YOUTH SPORT PARTICIPANTS

Abstract

Aim: Low levels of moderate-to-vigorous physical activity (MVPA) and increased sedentary time (ST) have been implicated in the aetiology of childhood obesity. Youth sport has been advocated as a setting for PA promotion and obesity prevention and participation may also reduce options for ST. However, no research has examined variability in objectively measured daily PA and sedentary time (ST) among sport participants and associations with obesity linked health outcomes. The present study examined simple and independent associations between (MVPA), vigorous PA (VPA) and ST with markers of obesity and cardiovascular disease in youth sport participants. **Method:** 118 male grassroots football participants (Mean age = 11.72 ± 1.60) wore a GT3X accelerometer for 7 days. Participants' body mass index (BMI), percent body fat (BF%), waist circumference (WC) and cardiorespiratory fitness (CRF) were assessed. **Results:** Daily MVPA and VPA were significantly negatively associated with BMI-SDS and BF% and positively associated with CRF. Daily ST was significantly and positively associated with BF% and WC and negatively related to CRF. Independent associations were not observed for MVPA, VPA and ST with measured health indicators. However, relationships were stronger for ST than for MVPA and VPA. **Conclusion:** Results suggest reducing ST may be more important than increasing MVPA and VPA in youth sport participants when considering markers of adiposity and cardiovascular risk. Still, given the observed co-dependent associations between MVPA and ST with the targeted health outcomes, interventions aimed at increasing engagement in activity above a moderate intensity are also relevant.

Introduction

In 2013, overweight and obesity were identified as the fifth leading risk for global deaths (World Health Organisation, 2013). Childhood overweight and obesity has reached epidemic proportions worldwide with global prevalence estimates of 14% (overweight including obesity) and 4% (obesity), respectively (International Association for the Study of Obesity, 2014). Given that obesity and its associated co-morbidities track from childhood to adulthood (Field et al., 2001; Reilly, 2006b; Reilly & Kelly, 2011), identifying preventative strategies to counteract this growing epidemic and associated negative health consequences in young people is a critical public health concern.

Low levels of engagement in moderate-to-vigorous physical activity (MVPA) and an increase in engagement in sedentary pursuits have been implicated in the aetiology of childhood obesity (Must & Tybor, 2005). Specifically, population based studies of youth demonstrate negative associations between MVPA and markers of obesity, cardiovascular disease and type 2 diabetes (Chaput et al., 2012; Dencker & Andersen, 2008; Ekelund et al., 2012; Mark & Janssen, 2011), with the reverse evidenced for time spent sedentary (Gaya et al., 2009; Henderson et al., 2012; Hsu et al., 2011; Mitchell, Pate, Beets, & Nader, 2013; Sardinha et al., 2008). More recently, research investigating associations between vigorous physical activity (VPA) and these same health outcomes has demonstrated stronger and more consistent associations than observed for MVPA (Dencker & Andersen, 2008; Hay, Maximova, & Durksen, 2012; Ried-Larsen, Grøntved, Froberg, Ekelund, & Andersen, 2013; Ruiz et al., 2006). Thus, VPA in particular may play an important role in the prevention of overweight, obesity and associated non-communicable diseases.

Research to date investigating associations between MVPA, VPA and ST with health outcomes among youth has led to the development of evidenced based guidelines.

These guidelines hold that school-aged youth should engage in at least 60 minutes and up to several hours of MVPA per day (Strong et al., 2005; Mark & Janssen, 2011). In addition, it is recommended that children and adolescents should minimise time spent sedentary, and participate in VPA on at least 3 days per week (e.g., Department of Health, 2011; Physical Activity Guidelines Advisory Committee Report; 2008). No recommendations have been made regarding the volume of VPA that should be accumulated. However, a recent study reported daily VPA of 15 minutes per day reduced the risk of overweight and obesity in European youth aged 12.5 to 17.5 years (Martinez-Gomez et al., 2010).

Evidence for associations between PA and health has prompted a great deal of research into the area of PA promotion in school-aged youth. Studies have examined the value of different youth PA settings as avenues toward increasing engagement in MVPA and VPA, in order to determine their potential as targets for interventions toward prevention of overweight and obesity (Brockman, Jago, & Fox, 2010; Fairclough & Stratton, 2005; Jago & Baranowski, 2004; Lonsdale et al., 2013a). Youth sport has been advocated as one such setting (Centers for Disease Control and Prevention, 2000; Commission of the European Communities, 2007). Indeed, research demonstrates youth sport participants engage in higher levels of MVPA than non-sport participants and average daily levels of MVPA participation to be above the recommended 60 minutes per day in sport participants (Machado-Rodrigues et al., 2012; Nelson et al., 2011; Silva et al., 2010; Wickel & Eisenmann, 2007). Consequently, there are strong calls from researchers and health organisations alike to increase participation in sport among youth (e.g., Centers for Disease Control and Prevention, 2000; Commission of the European Communities, 2007; NSW Department of Health, 2009; Pate & O'Neill, 2011).

Whilst results from past research are indicative of high levels of PA engagement among youth sport participants, it is important to note that studies to date have neglected to examine the variability in daily levels of PA engagement among these groups of children and adolescents (Machado-Rodrigues et al., 2012; Nelson et al., 2011; Van Hoye et al., 2013; Wickel & Eisenmann, 2007). Examining such variability is important in order to determine the extent to which youth sport participation is conducive towards engagement in recommended and health enhancing levels of MVPA and VPA for all participants. Indeed, where previous studies have demonstrated average daily levels of MVPA of youth sport participants to be above the recommended 60 minutes per day, the standard deviations reported are large (e.g., 28 – 33 mpd) (Machado-Rodrigues et al., 2012; Van Hoye et al., 2013). Thus, daily PA engagement may vary substantially among those children and adolescents active in the youth sport setting. Further, sport participation may not necessarily mitigate the health risks of low levels of MVPA participation (e.g., excess adiposity) (BeLue, Francis, Rollins, & Colaco, 2009; Dowda, 2001).

Recent studies have indicated youth sport participants to engage in up to 11 hours of ST per day (Machado-Rodrigues et al., 2012; Van Hoye et al., 2013). Importantly, research has demonstrated ST to have independent effects on adiposity and cardio-metabolic health after adjusting for MVPA (Henderson et al., 2012; Mitchell et al., 2013). In addition, Santos et al., (2013) reported that high levels of ST may negate the positive health benefit of engaging in MVPA. Their findings revealed a low sedentary profile (< 477 minutes per day) to be associated with a higher level of fitness, regardless of daily engagement in MVPA (Santos et al., 2013). Thus, even for youth sport participants who engage in recommended levels of MVPA, the high levels of ST apparent among some youth sport participants may contribute to adverse health effects for these children.

In order to determine the relevance of the youth sport setting as a vehicle for obesity prevention, it is important not only to accurately characterise daily levels of MVPA, VPA and ST among sport participants but also to determine associations with indicators of adiposity. However, to date, no studies have examined relationships between PA, ST and obesity linked health outcomes among youth sport participants. Investigating these associations will be instrumental in determining the degree to which interventions should seek to increase daily levels of MVPA and reduce ST in order to help prevent the development of overweight and obesity among children and adolescents active in the youth sport setting. The primary aim of the present study was therefore to determine variability in average daily levels of MVPA, VPA and ST among youth sport football participants and associations with indicators of adiposity and cardiovascular disease [i.e., body mass index (BMI), percent body fat (BF%), waist circumference (WC) and cardiorespiratory fitness (CRF)]. Given that associations between ST and health outcomes have been observed independent of MVPA, and vice versa, (Chaput et al., 2012; Ekelund et al., 2012; Fisher, Hill, Webber, Purslow, & Wardle, 2011; Henderson et al., 2012; Mitchell et al., 2013), independent associations between MVPA, VPA and ST with these outcomes were also investigated. With over 22 million participants worldwide (Kunz, 2007), grassroots football was the targeted youth sport in the present study given the popularity of this organised sport activity across the globe (Australian Bureau of Statistics, 2009; Kunz, 2007; National Council of Youth Sports, 2008; Womens Sports Foundation, 2008).

Method

Participants and recruitment

Participants were a subsample of grassroots football players (N = 149), recruited from the European PAPA project (Promoting Adolescent Physical Activity;

www.projectpapa.org) which delivered and evaluated a theoretically-grounded coach education intervention (i.e., Empowering Coaching™) with the aim to increase the quality of motivation and PA engagement in children. As part of the project, objective PA data (i.e., PA assessed via accelerometer) were collected in Greece, France and England (N = 417). The present study analysed data from the English sample (N = 149, 35.73%) only, representing grassroots footballers recruited from 39 teams across 18 clubs. The full protocol for the PAPA Project and the core objective PA measurement protocol are detailed elsewhere (Duda et al., 2013; Van Hoye et al., 2013, respectively). The following sections outline the protocol followed in England where supplementary measures were included (i.e., measurement of BF%, WC and PA diaries). In addition, data reduction procedures which relate only to the current research question are described below.

Lead coaches at football clubs were contacted by a member of the research team. Interested coaches were provided with information sheets detailing the study protocol to be passed on to players and parents. Four willing participants per team were then recruited to the study (i.e., a striker, midfielder, defender and goal keeper). Informed consent and assent were obtained from all players and their parents before participating in the study. The study was approved by the local National Health Service Research Ethics Committee (Research Ethics Committee application number: 10/H1207/39).

Protocol

A trained researcher visited training sessions to carry out the procedures. During the session, participants' height, weight, BF% and WC were measured and accelerometers and PA diaries distributed. Participants were asked to wear the accelerometer for 7 days. Researchers returned one week later to collect accelerometers and PA diaries.

Measures

Physical activity. The GT3X accelerometer (Actigraph; Pensacola, FL) was used to measure daily PA. Actigraph accelerometers have been shown to be valid and reliable measures of PA in youth (de Vries, Bakker, Hopman-Rock, Hirasing, & van Mechelen, 2006; Trost, 2007). The GT3X detects movements over pre-specified time periods called epochs. Movement counts within each epoch are summed and converted to activity counts and interpreted to determine frequency, intensity and duration of physical activity engagement. Accelerometers were initialised to measure PA in 15 second epochs (Edwardson & Gorely, 2010). Participants were asked to wear the accelerometer for 7 days during all waking hours, removing only for water-based activities (e.g., swimming and bathing). Trained researchers gave verbal and written instructions to players and their parents demonstrating how accelerometers should be worn. Participants were instructed to record daily participation in sport and physical activity (e.g., football, swimming, cycling) during the study week, and times when the accelerometer was removed/replaced (indicating reasons why) in PA diaries. To try and increase compliance, it was emphasised that participants should try to wear the accelerometer for the full 7 days in which they were participating in the study. Researchers contact details were also made available to participants and parents in the event they had any issues, questions or concerns regarding wearing the accelerometer.

Anthropometrics. Height, weight, BF% and WC were measured with participants being bare footed, and wearing light clothing (e.g., shorts and t-shirt). Height was measured using a portable stadiometer (SECA, Leicester height measure). Weight and BF% were measured using foot-to-foot bioelectrical impedance scales (Tanita, SC330). Foot-to-foot bioelectrical impedance utilising Tanita scales has BF% was measured following entry of the participant's height and weight into the BIA scales. BIA analysis was conducted at the start of the training sessions where possible to reduce potential errors in measurement resulting from prior strenuous exercise, dehydration and over-drinking (i.e., to compensate for water lost during training sessions). Participants were also asked to urinate before measurements were undertaken.

Bioelectrical impedance analysis (BIA) measures the resistance to a small electrical signal (50kHz) as it passes through the body water found in muscle and fat. The greater amount of water in a person's body, the easier it is for the electrical signal to pass through (i.e., there is less resistance). Muscle holds more water than fat (50-70% hydrated relative to 10-15% hydrated respectively). Thus, the more muscle a person has, the higher his or her body water content, and the less resistance to the electrical signal. Conversely, the more fat in an individual's body, the more resistance to the electrical current. The Tanita SC330 scales use an in-built prediction equation to estimate BF%. Foot-to-foot bioelectrical impedance analysis (utilising the manufacturer's (Tanita) prediction equations) has been validated against dual-energy x-ray absorptiometry estimates of adiposity in youth (Hosking, Metcalf, Jeffery, Voss, & Wilkin, 2006). In this study, the correlations between DEXA and BIA measures of total fat mass and BF% were high for both males and females (i.e., $r = \geq .92$). For males, $r = .97$ and $r = .92$ for total body fat and BF% respectively.

To enable measurement of WC, children were asked to stand with feet shoulder width apart and expose their waistline to enable measurement against bare skin. The uppermost lateral border of the iliac crest was identified on both sides of the waist as the measurement point. A non- elastic tape was wrapped snugly around the waist in a horizontal plane in line with these points. Measurement was taken at the end of expiration.

Measurements were recorded in duplicate to the nearest 0.1cm or 0.1kg. Where the first two measures differed by more than 0.4 cm or 0.5 kg, a third measure was recorded. Body mass index (BMI) was calculated using the equation: weight (kg) ÷ height (m^2). Children were classified as normal weight, overweight or obese according to UK BMI reference charts (Cole, Freeman, & Preece, 1995). BMI standard deviation scores (BMI-SDS) adjusted for age-and-sex were computed for use in subsequent analysis (Cole, Freeman, & Preece, 1998).

Cardiorespiratory fitness. CRF was assessed using the 20 meter multi-stage shuttle run test (Leger, Mercier, Gadoury & Lambert, 1988). This test is easy to administer in field based research, is frequently used to indicate CRF in children and adolescents worldwide (Olds, Tomkinson, Leger & Cazorla, 2006) and has been demonstrated to be a valid and reliable assessment of CRF in youth (Liu, Plowman & Looney, 1992). A shuttle was marked on the ground by two lines of cones 20 meters apart. Participants were asked to run back and forth between the 20 meter shuttle at a workload regulated by audio-signals emitted from a pre-recorded audio-CD. Players were asked to start at the first sound signal and follow the pre-scribed pace set by the audio-CD. Frequency of the sound signals was increased by 0.5 km/hour h-1 each minute from a starting speed of 8.5 km/hour. Participants were instructed to run in a straight line, pace themselves in accordance with the time intervals emitted from the audio-CD, and to pivot upon completing each shuttle. Testing was terminated when the player could no longer maintain the prescribed pace for 2 consecutive signals or withdrew due to exhaustion. The last stage number announced was used to predict maximal oxygen uptake (VO_2max (CRF) = *Y*, $ml \cdot kg^{-1}\ min^{-1}$) from the speed (*X*, $km \cdot hour^{-1}$) corresponding to that stage [speed = 8 + (0.5 x stage no.)] and age (*A*, year): $Y = 31.025 + 3.238X - 3.248A + 0.1536AX$) (Leger et al., 1988).

Data processing

Physical activity data were downloaded from the GT3X to a computer and analysed using the Actilife software (Actilife version 6.2, Actigraph; Pensacola, FL). Data were cleaned and checked for spurious values and periods of non-wear. Non-wear time was determined by identifying strings of consecutive zeros recorded by the accelerometer for >30 minutes, allowing for 1 minute of counts <100 (Cain, Sallis, Conway, Van Dyck, & Calhoon, 2013; Troiano et al., 2008). A day was considered valid where ≥ 8 hours of valid wear time data had been recorded on ≥ 4 days, including a weekend day (Cain et al., 2013). Cut points for MVPA [≥ 3 Metabolic equivalents (METS)], VPA (≥ 6 METS) and ST (≤ 1.5 METS) were ≥ 2296, ≥4012 and <100, respectively (Evenson, Catellier, Gill, Ondrak, & McMurray, 2008). Compliance to the protocol was 79.20%. Participants were excluded from subsequent analyses for failing to wear the accelerometer for ≥ 4 days (N = 21), failing to wear the accelerometer on a weekend day (N = 7) and for lack of anthropometric or CRF data (N = 3). The final sample therefore consisted of 118 males aged 9 to 15 years. Of these, 50.0 %, 26.3%, 13.6% and 10.1% recorded 7, 6, 5 and 4 days of valid PA data respectively.

Statistical analysis

Descriptive statistics (M ± SD) were calculated for all measured variables. Non-normally distributed data were log transformed using an LG10 transformation. Where data skewness was reduced, transformed variables were used in subsequent analyses. Hierarchical linear regressions were conducted to investigate relationships between daily PA variables (MVPA,VPA, ST) and health outcomes (BMI-SDS, BF%, WC and CRF). All regressions were initially adjusted for age, ethnicity, valid wear time and season to account for seasonal variation in levels of PA participation (Rich, Griffiths, & Dezateux, 2012) (model 1). To determine independent associations between MVPA and VPA to the targeted health outcomes, a second model was analysed adjusting for ST (model 2). Likewise, model 2 was adjusted for MVPA when examining independent associations between ST and health outcomes.

Results

Participant characteristics

Descriptive statistics for all measured variables are displayed in Table 3.1. Means and standard deviations are presented for the total sample and the subsample included participants who recorded valid daily PA data. Ranges (min-max) are also reported to demonstrate variability in levels of PA engagement and health indicators (BMI, BF%, WC and CRF) within the sample. Independent samples t-tests demonstrated age, height, weight and anthropometric measurements (i.e., BMI, BMI-SDS, BF% and WC) of included and excluded participants were not significantly different (Table 3.1, excluded; age, M = 11.81± 1.58, height, M = 1.54 ± .14, weight, M = 46.76 ± 11.20, BMI, M = 19.45 ± 2.79, BMI-SDS, M = .63 ± .86, BF%, M = 16.73 ± 4.4, WC, M = 69.89 ± 8.07. Significant differences between included and excluded participants were observed only for CRF (excluded, CRF, M = 40.63 ± 7.23, t (143) = 2.13, p = <.05).

The average daily MVPA for the sample was above the recommended guideline of ≥ 60 minutes per day. However, on average, 29.1% of participants did not meet guidelines for MVPA, and only 14.5% of participants (N = 17) met guidelines for MVPA on each day for which valid PA data (i.e., ≥ 8 hours) was recorded. Results also indicated participants spent between 7 and 8 hours per day sedentary. Ranges of 119.27, 57.08 and 282.21 minutes were observed for daily MVPA, VPA and ST, respectively.

Relationships between MVPA, VPA, ST and targeted health outcomes

Results from hierarchical regressions examining relationships between daily PA and ST with health outcomes are displayed in Table 3.2. Both MVPA and VPA were significantly and negatively associated with BF% and BMI-SDS, and significantly and positively associated with CRF. Neither MVPA nor VPA were associated with WC (model 1). ST was significantly positively associated with BF% and WC and significantly negatively associated with CRF. However no significant association was observed between ST and BMI-SDS (model 1).

After adjusting for ST, the previously significant associations between MVPA and VPA with all outcomes became non-significant (model 2[¶]). Similarly, after adjusting for MVPA, the relationships between ST with BF%, BMI-SDS and BF% were attenuated and became non-significant (model 2[§]). The strength of the relationship between ST and WC was increased after adjusting for MVPA, however this association also became non-significant (p = .06) (model 2[§]).

Table 3.1

Descriptive statistics for the total sample and participants with valid accelerometer data

	Total Sample (N = 149)		Valid PA data (N = 118)	
	Mean ± SD	Range (min – max)	Mean ± SD	Range (min – max)
Physical Characteristics				
Age (years)	11.72 ± 1.60	9 – 15	11.70 ± 1.62	9 –15
Height (m)	1.53 ± 0.13	1.29 – 1.90	1.53 ± 0.14	1.29 – 1.90
Weight (kg)	45.15 ± 13.44	24.90 – 92.30	44.76 ± 13.94	24.90 – 92.30
BMI ($kg.m^2$)	18.81± 3.14	13.81 – 29.90	18.66 ± 3.21	13.81 – 29.90
BMI-SDS	0.32 ± 1.10	-.2.46 – 2.81	0.24 ± 1.13	-.2.46 – 2.81
¶BF%	15.22 ± 5.54	5.30 – 41.70	14.88 ± 5.73	5.30 – 41.70
¶WC (cm)	68.32 ± 8.10	55.50 – 91.80	67.99 ± 8.12	55.50 – 91.80
CRF ($ml.kg^{-1} min^{-1}$)	43.64 ± 8.23	29.95 – 71.15	44.33 ± 8.32	29.95 – 71.15
Physical activity				
ST	465.07 ± 62.33	260.33 – 588.39	472.43 ± 56.64	306.18 – 588.39
MVPA	72.67 ± 21.22	26.94 – 146.21	73.64 ± 21.67	26.94 – 146.21
VPA	26.55 ± 11.57	6.31 – 63.39	27.29 ± 11.92	6.31 – 63.39
Valid hours	12.63 ± 0.96	9.23 – 14.91	12.78 ± 0.79	11.01 – 14.91

Note: For participants with valid PA data, BF% and WC, N = 107 and N = 92 respectively [(total sample, N = 131 (BF%), 111 (WC), 146 (BMI-SDS) and 145 (CRF)]

¶ = Non-normally distributed variables. These variables were log transformed (LG10) and used in subsequent regression analysis

BF% = percent body fat, WC = waist circumference, CRF = cardiorespiratory fitness BMI-(SDS) = body mass index (standard deviation score), MVPA = moderate-to-vigorous physical activity, VPA = vigorous physical activity, ST = sedentary time

Table 3.2

Associations between objectively measured daily MVPA, VPA and ST with indicators of adiposity and CRF

	BF%		**WC** (cm)		**BMI-SDS**		**CRF** (ml.kg^{-1} min^{-1})	
	β	*p*	β	*P*	β	*p*	B	*p*
ST								
Model 1*	.32	.01	.29	<.05	.16	.20	-.30	<.01
Model 2§	.27	.10	.31	.06	-.00	.99	-.14	.32
MVPA								
Model 1*	-.18	<.05	-.12	.19	-.17	<.05	.23	<.01
Model 2¶	-.06	.63	.02	.84	-.17	.14	.17	.09
VPA								
Model 1*	-.18	<.05	-.10	.27	-.17	<.05	.20	<.01
Model 2¶	-.09	.36	-.00	.99	-.16	.12	.13	.12

*Adjustment for age, ethnicity, valid wear time and season
§Adjustment for MVPA
¶Adjustment for sedentary time

Note: BF% = percent body fat, WC = waist circumference, CRF = cardiorespiratory fitness, BMI-(SDS) = body mass index (standard deviation score), MVPA = moderate-to-vigorous physical activity, VPA = vigorous physical activity, ST = sedentary time

Discussion

This study demonstrated variability in daily levels of PA (MVPA and VPA) and ST were associated with markers of obesity and cardiovascular disease (BMI, BF%, WC and CRF) in youth sport football participants. However, findings indicated the significant associations between MVPA, VPA with health outcomes were not independent of ST. Similarly, significant relationships between ST and health outcomes were not independent of time spent in MVPA. Nevertheless, findings demonstrated associations between ST and health outcomes were stronger than observed for MVPA. Results underscore the importance of increasing daily MVPA and VPA, and in particular, reducing daily ST among youth sport football participants.

Akin with previous studies, current findings indicated that youth sport football participants engaged in average daily levels of MVPA above the recommended 60 minutes per day (Machado-Rodrigues et al., 2012; Van Hoye et al., 2013; Wickel & Eisenmann, 2007). However, the minimum values observed for average daily MVPA and VPA were reported to be 27 minutes and 6 minutes, respectively. Further, results revealed 29% of participants did not meet guidelines for MVPA, and only 14.5% achieved recommended levels of MVPA on every valid PA measurement day. Findings therefore denote a certain level of variability to exist with respect to daily levels of MVPA engagement among those active in the youth sport football setting. Moreover, results suggest youth sport participation may not necessarily encourage regular engagement in MVPA towards recommended levels across the broad spectrum of children who participate at the grassroots level. Present results parallel findings reported in the Children's Sport Participation and Physical Activity study (CSPPA). This study reported 19% of Irish youth aged 10 to 18 years met guidelines for accelerometer assessed MVPA on every day of the week (Woods et al., 2010). Thus, results also indicate variability in daily levels of MVPA reported in the present sample of youth sport footballers may be comparable to that observed in the general population of youth. Importantly, results also indicated daily ST to be between 7 and 8 hours per day in the present sample of male grassroots footballers. Again, these levels are comparable to those observed in population based studies of youth (Pate, Mitchell, Byun, & Dowda, 2011). As such, current findings support recent observations indicating participation in youth sport may also be associated with engagement in high amounts of ST (Machado-Rodrigues et al., 2012; Van Hoye et al., 2013), and indicate that similar to MVPA, youth sport footballers levels of engagement in ST may be comparable to those observed across the wider population of children and adolescents.

The high levels of ST observed among youth sport footballers may partly be attributable to compensatory behaviours. That is, youth may compensate for the energy expended during PA (e.g., sport participation) by reducing their energy expenditure (via increased ST) in other periods of the day or on consecutive days. Indeed, studies in adults have documented increases in ST following structured exercise interventions (Kozey-Keadle et al., 2013; Rosenkilde, Auerbach, Reichkendler, Ploug, Stallknecht & Sjodin, 2012) and a recent study demonstrated that for every additional 10 minutes in MVPA per day, children reduced their PA engagement (MVPA and light PA) by 30 minutes following the following day (Ridgers, Timperio, Cerin, & Salmon, 2014). As such, where studies may focus on increasing engagement in MVPA and VPA, additional strategies should be employed which also focus on reducing engagement in ST. Indeed, the correlates of sedentary behaviours are likely to differ to those of PA (Biddle et al., 2004). Thus, interventions which focus their efforts towards targeting the modifiable correlates of both

PA and ST in parallel are likely to be the most effective. In the context of youth sport, PA engagement may likely be increased by identifying ways through which enjoyment of PA can be fostered (e.g., increasing intrinsic motivation). Likewise ST may be reduced through targeting parental behaviours (e.g., parenting style, modelling) (Jago et al., 2010; Jago et al., 2011a, Jago et al., 2011c). However, an important first step would be towards identifying the specific sedentary behaviours contributing towards high ST in these groups of youth.

Population based research has demonstrated associations to exist between daily levels of engagement in MVPA and VPA and health outcomes related to obesity and cardiovascular disease (Basterfield et al., 2012; Dencker & Andersen, 2008; Ekelund et al., 2012; Fisher et al., 2011; Gutin & Owen, 2011). Specifically research in children from both westernised and non-westernised countries has reported negative relationships between daily MVPA and VPA with indicators of adiposity (Dencker & Andersen, 2008; Mark & Janssen, 2011; Strong et al., 2005), as well as positive associations with CRF (Dencker et al., 2008; Ekelund et al., 2007; Ruiz et al., 2006; Santos et al., 2013), with the opposite true for ST (Ekelund et al., 2007; Mitchell et al., 2013; Must & Tybor, 2005; Santos et al., 2013). The present study was the first to provide evidence of these associations in a group of youth sport participants. That is, the observed levels of variability in daily MVPA, VPA and ST were related to variability in levels of adiposity and cardiovascular risk factors in grassroots footballers. Consequently, present results indicate that patterns of engagement in PA and ST among youth sport football participants, and the implications held for health, reflect those observed among general populations of children and adolescents. As such, youth sport football may represent a valuable setting through which to target behaviours of children who may be at risk of engaging in levels of

MVPA, VPA and ST that are adversely associated with markers of obesity and cardiovascular disease.

Our findings are inconsistent with recent studies that have reported MVPA and ST to be independently related to obesity linked health outcomes (Henderson et al., 2012; Hsu et al., 2011; Mitchell et al., 2013). That is, significant independent associations between MVPA, VPA and ST to adiposity indicators and CRF did not emerge. Rather, present results suggest the observed relationships between MVPA and ST with presently assessed health outcomes are somewhat co-dependent in youth sport football participants. As such, it may be important to advance levels of participation in both PA above a moderate intensity (i.e., MVPA and VPA) and reduce ST among groups of youth sport football participants. However, whilst independent associations were not observed in the present study, it is important to note that in general, associations were stronger for ST in relation to the targeted health outcomes than for MVPA or VPA. Further, whilst the association between ST and BF% was attenuated after adjustment for MVPA ($\beta = .32$ to .27), the relationship between MVPA and BF% was reduced to almost zero following inclusion of ST as a predictor variable ($\beta = -.18$ to -.06). Similarly, the relationship between ST and WC was increased and approached significance after adjustment for MVPA ($\beta = .29$ to .31), whereas no significant association was reported between MVPA and WC even before adjustment for ST. Thus, whilst results indeed highlight the importance of increasing participation in MVPA among youth sport football participants, reducing ST may hold greater implications for obesity and related disease prevention in these groups of children. Certainly, this contention is further supported by the observed lack of significant independent associations between MVPA and the targeted health outcomes, where previous studies have reported negative associations between MVPA and adiposity after adjustment for ST (Chaput et al., 2012; Ekelund et al., 2012; Steele et al., 2009).

Divergent findings reported across existing studies in the PA and health domain highlight the need for additional research which examines the independent associations between MVPA, ST and health outcomes among children and adolescents. Interestingly, recent studies have indicated it may be that engagement in specific sedentary behaviours (such as TV viewing) are independently related to health outcomes, rather than total ST per se (Carson & Janssen, 2011; Colley et al., 2013; Martinez-Gomez et al., 2012). Further, researchers have suggested that the relationship between sedentary pursuits and health may be mediated by engagement in other health related behaviours that often occur in parallel to such sedentary pursuits (e.g., TV time snacking) (Cleland, Schmidt, Dwyer, & Venn, 2008; Jean et al., 2006; Martinez-Gomez et al., 2012). Time spent engaged in specific sedentary behaviours were not assessed in the present investigation. Thus, as outlined above, future studies should seek to examine the sedentary behaviours most commonly engaged in by youth sport participants to determine the behaviours that contribute most towards high levels of ST in this group of young people. Investigating associations between engagement in different sedentary pursuits and adiposity will be important in order to identify which sedentary behaviours in particular may hold negative health consequences for youth sport participants.

Current findings are also inconsistent with studies that report VPA to demonstrate stronger and more consistent associations with markers of obesity and cardiovascular disease than MVPA (Dencker & Andersen, 2008; Ruiz et al., 2006). For example, the magnitude of the associations between MVPA and VPA with BF% and BMI-SDS were similar. Further, daily MVPA demonstrated a stronger association with cardiovascular fitness than daily VPA. The somewhat equivocal findings and only marginal differences in the strength of the reported associations are likely due to the fact that MVPA incorporates VPA, and thus, some of the reported variance in health outcomes explained by MVPA is likely due to associations with VPA. Nevertheless, combined MVPA demonstrated significant associations with the health outcomes examined in the present study, highlighting the importance of increasing engagement in both moderate and vigorous PA in youth sport football participants.

Strengths of the present study involve the use of accelerometers to assess engagement in health-related PA behaviours and ST in the targeted population of children. Further, measures of both central and general adiposity were assessed. Central adiposity is more closely associated with cardiometabolic risk factors than general adiposity (Klein et al., 2007). Thus, results from this study may help contribute towards determining the potential value of youth sport as a setting towards improving cardiometabolic health among youth. Moreover, this is the first study to employ a combination of objective assessments to measure PA, CRF and adiposity via BIA in youth sport participants. Previous youth sport studies have assessed adiposity largely via measurements of BMI and WC. Thus, the present study adds a novel contribution to literature, characterising levels of PA engagement, adiposity and CRF in youth sport participants as well as examining associations between these variables.

Important to note is that the cross-sectional nature of the present study limits the extent to which we can make inferences regarding the direction of causality. For example, a recent longitudinal study reported that BF% predicted daily levels of PA engagement, contradicting a large body of research suggesting the reverse association to be true (Kwon, Janz, Burns, & Levy, 2011). Nevertheless, longitudinal studies demonstrate PA engagement and ST to predict health outcomes related to obesity and cardiovascular disease (Carson et al., 2013; Kimm et al., 2005; Mitchell et al., 2013; Moore et al., 2003), and exercise interventions targeting increases in moderate intensity PA engagement have demonstrated decreases in adiposity among youth (Lemura & Maziekas, 2002). Longitudinal studies examining the associations between daily MVPA, VPA and ST with indicators of adiposity and cardiovascular risk in groups of youth sport participants are necessary in order to first determine the fuller potential of this environment as a context for PA promotion and related disease prevention.

A further limitation to the present study is the possibility of sample bias. Participants were male footballers recruited from England. As such, results presented may not be generalisable to young people representing the wider ethnic distribution of the English population, females and children and adolescents who participate in other youth sports. However, the global popularity of youth sport football means findings may be applicable to large numbers of children worldwide (Kunz, 2007). In addition, associations between PA, ST and health have been reported to occur in both males and females, and in different cultures and ethnic groups (Janssen & Leblanc, 2010; Tremblay et al., 2011). Nevertheless, further research that includes samples comprising girls, different ethnic groups and different youth sports, are required before the conclusions drawn can be generalised to the wider population of youth sport participants.

It is also possible that the field based nature of the present study may have contributed to errors in data collected, analysis and results reported. For example, for accurate measurement of body composition, it is advised that BIA analysis should not be conducted in the 12 hours following hard exercise, within 3 hours of eating or drinking, or when dehydrated. It is also recommended that measurements are conducted under standardised conditions (i.e., in the same place, same temperature). Given participant data was collected in the early evening during youth sport football sessions, it was not possible to control (restrict) their food or fluid intake and their engagement in PA as advised. Consequently, this may have caused errors and inconsistencies in estimates of BF%. Indeed, estimates of BF% are reported to vary between states of dehydration, rehydration and normal conditions among athletes (Saunders, Blevins & Broeder, 1998). Whilst attempts were made to reduce the level of exercise and food and fluid intake before BIA measures were obtained (i.e., measurements conducted at the start of training sessions), results pertaining to BF% should be interpreted with caution. For CRF, differing testing conditions between teams may also affect participants' performance on the 20 metre shuttle run test. However, in this instance, all data were collected outdoors and in dry weather (with the exception of 2 participants). As such, for CRF, differences in testing conditions are expected to be minimal and are unlikely to have affected the association reported herein.

In conclusion, present results support the value of youth sport football as a setting for obesity prevention. Findings indicate a certain level of variability to exist with respect to daily levels of MVPA, VPA and ST among those active in grassroots football setting, and that this variability is associated with health outcomes related to obesity and cardiovascular disease. As such, there is a need to increase levels of engagement in MVPA and VPA, and reduce engagement in ST even in these groups of children traditionally considered to be among the most active (Nelson et al., 2011). Further, whilst not independently related, ST appears to be more strongly associated with markers of adiposity than MVPA or VPA. Consequently, high levels of ST associated with youth sport participation may negate some of the benefits associated with engaging in MVPA and

VPA. To this end, interventions seeking to reduce ST may be more important towards the prevention and treatment of overweight and obesity in youth sport participants than those targeting engagement in MVPA and VPA.

CHAPTER 4

OPTIMISING PHYSICAL ACTIVITY ENGAGEMENT DURING YOUTH SPORT: A SELF-DETERMINATION THEORY PERSPECTIVE

Abstract

Aim: To test a model investigating the relationships between perceptions of the coach-created environment, motivation for sport participation and engagement in objectively measured moderate-to-vigorous physical activity (MVPA) and vigorous physical activity (VPA) within the youth sport setting. **Method:** Participants were 73 male youth sport footballers aged 9 to 15 years (Mean age = 11.72 ± 1.60). Height and weight were recorded and physical activity was measured over 7 days via accelerometer (GT3X). Participation in youth sport football during the targeted week was recorded in physical activity diaries. Participants also completed a multi-section questionnaire assessing perceptions of coach provided autonomy support and controlling coach behaviours, and motivation towards football participation. **Results:** Results supported a model in which perceptions of autonomy support significantly positively predicted autonomous motivation towards football, which in turn significantly and positively predicted time spent engaged in MVPA during youth sport football. A significant indirect effect was observed for perceptions of autonomy support on both MVPA and VPA during youth sport football via autonomous motivation. Perceptions of controlling coach behaviour were positively related to controlled motivation. However, controlled motivation was unrelated to time spent in MVPA and VPA during youth sport football. **Conclusion:** Results suggest that where coaches adopt a more autonomy supportive interpersonal style, children will experience higher autonomous motivation towards their sport participation and are more likely to engage in higher levels of MVPA during youth sport football. Results have implications for optimising PA engagement during youth sport and increasing daily MVPA towards recommended levels on youth sport days.

Introduction

In recent decades, the childhood obesity epidemic has drawn considerable attention towards the need for physical activity (PA) promotion in school-aged youth (Reilly & McDowell, 2003). Evidenced based PA guidelines state children and adolescents should engage in at least 60 minutes of moderate-to-vigorous physical activity (MVPA) per day (Australian Government: Department for Health and Ageing: 2004; Department of Health, 2011; Janssen & Leblanc, 2010; Strong et al., 2005; US Department of Health and Human Services, 2013). More recently, evidence for a dose-response relationship between PA intensity and markers of obesity and cardiovascular disease (Dencker & Andersen, 2008; Gutin & Owen, 2011; Ruiz et al., 2006), has led to the development of guidelines for vigorous physical activity (VPA), advising participation on at least 3 days per week (e.g., (Department of Health, 2011). Concerning the volume of VPA, no widely accepted recommendations exist. However, a recent study indicated European youth who did not engage in at least 15 minutes of VPA per day were at greater risk of being overweight or obese (Martinez-Gomez et al., 2010).

Youth sport has been advocated as a potential vehicle through which PA engagement can be increased among children and adolescents (Centers for Disease Control and Prevention, 2000; Commission of the European Communities, 2007; NSW Department of Health, 2009). However, recent accelerometer-based studies have demonstrated that whilst indeed, youth sport offers an ideal opportunity for engagement in activity above a moderate intensity, participation alone (i.e., PA accrued during youth sport) is insufficient to meet recommendations for MVPA (Leek et al., 2011; Sacheck et al., 2011). Present work has also indicated children and adolescents can spend up to 70% of youth sport time sedentary or engaged in light PA (Guagliano, Rosenkranz, & Kolt, 2012; Leek et al., 2011;

Sacheck et al., 2011; Wickel & Eisenmann, 2007). Thus, it appears there is scope to optimise young people's sport participation to increase engagement in MVPA and VPA during sport time. Identifying the determinants of PA engagement during youth sport may therefore have implications for helping the millions of children and adolescents active among the youth sport context meet recommended and health enhancing levels of MVPA and VPA on days in which sport is participated in (Guagliano et al., 2012; Pate & O'Neill, 2011).

To date, studies have investigated how PA engagement during youth sport may vary as a function of both demographic and contextual factors [e.g., body mass index (BMI), gender, age, sport and session type (i.e., training sessions versus matches) (Guagliano et al., 2012; Leek et al., 2011; Sacheck et al., 2011; Wickel & Eisenmann, 2007). For example, studies have shown obese youth are less active than their normal-weight peers during youth sport (Sacheck et al., 2011), and that female youth sport participants engage in higher levels of MVPA during training sessions compared to match play (Guagliano et al., 2012). Numerous studies have identified important psychological correlates of PA engagement such as perceptions of competence, autonomy, self-efficacy and enjoyment within PE and leisure time settings (Carroll & Loumidis, 2001; Dishman et al., 2005; Fairclough, 2003; Gao, 2008; Kalaja, Jaakkola, Liukkonen, & Watt, 2010). However, existing research has neglected to adopt a social psychological perspective when investigating factors likely to impact upon variability in PA engagement within youth sport.

From a practical standpoint, theoretically-grounded research allows identification of the particular processes that can be targeted to elicit a change in behaviour within a particular setting. Self-determination theory (SDT, (Deci & Ryan, 1987; Deci & Ryan,

2000) offers a theoretical framework to understand the psychological processes likely to impact upon PA engagement in youth sport. Central to SDT is the premise that it is important not only to take into account the quantity of an individual's motivation (i.e., whether 'high' or 'low' in motivation), but also the quality (i.e., 'why' an individual chose to engage or disengage in a certain behaviour) (Deci & Ryan, 2000). SDT advocates that an individual's behaviour is undergirded by motivation regulations that lie on a continuum, ranging from more autonomous (i.e., higher quality) to more controlled (i.e., lower quality) motivation (Deci, Eghrari, Patrick, & Leone, 1994a; Ryan & Deci, 2000).

At the top of the self-determination continuum is intrinsic motivation, the quintessential form of autonomous motivation that refers to engagement in an activity for its own sake, and for the inherent fun and interest in that activity (i.e., because I enjoy it). Adjacent to intrinsic motivation is identified regulation, an autonomous form of motivation that occurs when an individual engages in a behaviour to accomplish valued and internalised goals and outcomes (i.e., because it is important to me). Next is introjected regulation, thought to operate when an individual's reasons for engagement in an activity have not been fully internalised. That is, engagement occurs due to internal pressures such as the avoidance of shame or guilt, or to enhance internal feelings of pride or self-esteem (i.e., because I would feel guilty if I did not participate). At the lower end of the continuum is external regulation, referring to engagement in an activity to receive reward or to avoid punishment (i.e., because people push me to).

Intrinsic motivation and identified regulation are considered to be autonomous forms of motivation, and are assumed to be associated with positive cognitive, affective and behavioural outcomes (Deci & Ryan, 2008). Introjected and external regulations are considered controlled forms of motivation that are thought to lead to negative and more maladaptive outcomes (Bartholomew, Ntoumanis, Ryan, & Thogersen-Ntoumani, 2011; Deci et al., 1994a). Finally, SDT refers to the state of amotivation which is defined as a lack or absence of motivation (Deci & Ryan, 2000; Seligman, 1975). The occurrence of amotivation is thought to result in deleterious outcomes and behavioural disengagement (Aelterman et al., 2012; Brunet, Burke, & Sabiston, 2013; Gao, Hannon, Newton, & Huang, 2011; Pelletier, Fortier, Vallerand, & Brière, 2001).

A fundamental tenet of SDT is that the social environment surrounding an individual can either facilitate or undermine an individual's autonomous motivation (Deci & Ryan, 1987). Specifically, perceptions of an autonomy supportive context (i.e., one which offers a choice, provides rationale and promotes understanding) are likely to facilitate more autonomous motivation (Alvarez, Balaguer, Castillo, & Duda, 2009; Deci & Ryan, 1987; Kins, Beyers, Soenens, & Vansteenkiste, 2009; Kopp & Zimmer-Gembeck, 2011). Conversely, perceptions of a controlling environment (i.e., a coercive environment in which pressure is exerted upon individuals and choice is limited), are likely to undermine autonomous motivation and are associated with more controlled forms of motivation (Balaguer et al., 2012; Bartholomew et al., 2011; Bartholomew, Ntoumanis, & Thogersen-Ntoumani, 2010; Pelletier et al., 2001). Within youth PA settings [e.g., physical education (PE), youth sport], the social environment is largely created by the interpersonal behaviours of adults active within those settings, for example, teachers (PE) and coaches (youth sport).

Studies examining the associations between the social environment, motivation and PA engagement among youth have largely been conducted with a focus on examining the psychosocial correlates of daily or leisure time PA (Chatzisarantis & Hagger, 2009; Hagger et al., 2009; Standage, Gillison, Ntoumanis, & Treasure, 2012; Vierling, Standage,

& Treasure, 2007). Results from these studies provide support for the motivational processes theorised by SDT to underlie adaptive behavioural outcomes. That is, past research indicates that perceptions of autonomy support to be positively related to more autonomous motivation, which in turn, is related to higher levels of daily or leisure time PA.

Relatively fewer studies exist which have taken an SDT perspective towards identifying the correlates of PA engagement within the immediate PA setting (i.e. within context PA). To date, research which has examined the within-context associations between the social environment, motivation and PA engagement have focused almost exclusively on the school setting (Aelterman et al., 2012; Lonsdale et al., 2013b; Owen, Astell-Burt, & Lonsdale, 2013; Perlman, 2013; Stellino & Sinclair, 2013). Overall, findings demonstrate autonomous motivation to be positively related to objectively assessed PA during PE and recess (Aelterman et al., 2012; Owen et al., 2013; Stellino & Sinclair, 2013), and controlled motivation to be unrelated to engagement in MVPA measured by accelerometer during PE (Aelterman et al., 2012; Owen et al., 2013). However, only two studies have examined the role of autonomy supportive interpersonal behaviours for encouraging engagement in MVPA within the immediate PA setting (Lonsdale et al., 2013b; Perlman, 2013). Perlman (2013) conducted a teacher-led intervention and found that students assigned to an autonomy supportive teaching condition reported higher autonomous motivation towards PE and engaged in higher levels of MVPA during PE than students assigned to controlling or 'balanced' (i.e., (i.e., a 40–60% balance between autonomy-supportive and controlling statements) conditions. Lonsdale et al., (2013b) examined how the opportunity for choice and explaining rationale (i.e., a dimension of autonomy support) within PE classes influenced pupils levels of engagement in MVPA and ST. Results revealed pupils in free choice PE classes engaged in higher levels of MVPA and spent less time sedentary than pupils assigned to a control group, and other experimental conditions (i.e., explaining rational and limited choice (2-4 activity options) conditions). However, whilst these are the first studies to examine the salience of the social environment for encouraging higher levels of within-context PA, the sequential relationships or processes through which the social environment is theorised to impact upon levels of PA engagement (e.g., via motivation regulations) were not examined (Deci & Ryan, 1987; Deci & Ryan, 2008).

To date, the associations between the social environment, motivation regulation and within-context PA engagement have not been explored within the youth sport context. Research has demonstrated the need to optimise PA engagement during youth sport if this setting is to be viewed as an effective domain for children to achieve recommended levels of MVPA and engage in levels of VPA demonstrated as being beneficial for health (Guagliano et al., 2012; Leek et al., 2011; Pate & O'Neill, 2011). To this end, the primary aim of the present study was to investigate the sequential associations between perceptions of the social environment created by the coach (autonomy supportive and controlling), motivation for sport participation (autonomous and controlled) and engagement in MVPA and VPA within the youth sport setting. Due to its global popularity and the resulting potential for widespread application of findings, youth sport football was the targeted sport examined in the current research (Kunz, 2007).

Method

Participants and recruitment

Participants were a subsample of youth sport football players (N = 149), recruited within a larger multi-method trial (the Promoting Adolescent Physical Activity Project

(PAPA) Project; www.projectpapa.org). Objective PA data (i.e., PA assessed via accelerometer) were collected from a subsample of participants recruited to the larger project. The full protocol for the PAPA Project and the core objective PA measurement protocol are detailed elsewhere (Duda et al., 2013; Van Hoye et al., 2013). The following sections outline the protocol followed in England where supplementary measures were included (i.e., PA diaries). Data reduction procedures which relate only to the current research question are described below.

Lead coaches at football clubs were contacted by a member of the research team. Interested coaches were provided with information about the study protocol and this information was passed on to parents and players. Informed participant assent and parental consent was obtained from all interested players before they were recruited to the study. Only male footballers were recruited as a smaller number of female clubs showed interest in taking part. The study was approved by the local National Health Service Research Ethics Committee (Research Ethics Committee application number: 10/H1207/39).

Protocol

A researcher visited two training sessions of participating teams one week apart to carry out anthropometric measurements, distribute accelerometers and administer questionnaires. During the first visit, participants were fitted with an accelerometer and measures of height and weight were recorded. PA diaries were also distributed to aid with data cleaning and interpretation. During the second visit, participants were asked to complete a questionnaire assessing perceptions of the coach created social environment, and PA diaries and accelerometers were collected.

Measures

Perceptions of the coach created social environment. Perceptions of coach-provided autonomy support and controlling coach behaviour were assessed via a validated multidimensional measure of the coach-created social environment (Appleton, Ntoumanis, Quested &Duda, 2013). The development of this measure stemmed from previously validated scales (Adie, Duda, & Ntoumanis, 2012; Alvarez et al., 2009; Bartholomew et al., 2010; Reinboth, Duda, & Ntoumanis, 2004; Williams, Grow, Freedman, Ryan, & Deci, 1996). Following the stem "So far this season....," twelve items were used to assess perceptions of the social environment as autonomy supportive (5 items, e.g., my coach gives players choices and options) and controlling (7 items, e.g., my coach threatens to punish players to keep them in line during training). Players were asked to rate their agreement with questionnaire items on a 5-point Likert-scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Motivation regulations. An adapted version (Viladrich et al., 2013) of the Behavioral Regulation in Sport Questionnaire was employed to measure autonomous and controlled young sport participants' motivation towards engagement in football (Lonsdale, Hodge, & Rose, 2008; Viladrich et al., 2013). Following the stem: "I play football for this team…", sixteen items were used to tap external (4 items), introjected (4 items) and identified (4 items) regulations, and intrinsic motivation (4 items). Players were asked to rate their agreement with questionnaire items on a 5-point Likert-scale ranging from 1 (strongly disagree) to 5 (strongly agree). Autonomous motivation (intrinsic motivation + identified regulation) and controlled motivation (introjected regulation + external regulation) were computed for use in subsequent analysis.

Anthropometrics. Height was measured using a portable stadiometer (SECA, Leicester height measure). Weight was measured using electronic scales (Tanita, SC3310). Measurements were recorded with participants' bare footed and wearing light clothing. Height and weight were measured to the nearest 0.1cm and 0.1kg respectively. All measures were conducted in duplicate. Where the first two measures differed by more than 0.4 cm or 0.5 kg, a third measure was recorded. Average values were calculated for height and weight and used to determine body mass index [BMI; weight (kg)/(height m^2)]. Participants were classified as normal-weight, overweight or obese according to UK BMI reference charts (Cole, Freeman, & Preece, 1995). BMI standard deviation scores (BMI-SDS) adjusted for age-and-sex were computed and used in subsequent analysis (Cole, Freeman, & Preece, 1998).

Physical activity. The GT3X accelerometer (Actigraph; Pensacola, FL) was used to objectively measure PA in the PAPA Project. Actigraph accelerometers have been validated against criterion measures of PA in youth (de Vries, Bakker, Hopman-Rock, Hirasing, & van Mechelen, 2006; Trost, 2007). The GT3X uses a tri-axial accelerometer to detect movements in three planes, recorded over pre-specified time periods called epochs. Movements within each epoch are summed and converted to 'activity counts'. Counts are interpreted to determine time spent in different intensities of activity. Accelerometers were initialised to measure PA in 15 second epochs (Edwardson & Gorely, 2010). Participants were asked to wear the accelerometer for seven days during all waking hours, removing only for water-based activities (e.g., swimming, bathing). Verbal instructions were given by a trained researcher on how the accelerometer should be worn and a demonstration given. Participants were asked to record non-wear time (i.e., removal of accelerometers) and participation in youth sport football in PA diaries. To try and increase compliance, it was emphasised that participants should try to wear the accelerometer for the full 7 days in which they were participating in the study. Researchers contact details were also made available to participants and parents in the event they had any issues, questions or concerns regarding wearing the accelerometer

Data processing

Physical activity data were downloaded from the GT3X to a computer and analysed using the Actilife software (Actilife version 6.2, Actigraph; Pensacola, FL). Time spent in youth sport football was identified from PA diaries for each participant. Diary entries were compared against graphed data to check for accuracy in self-reported timings. Following this, time filters were applied to the Actilife software to calculate minutes in MVPA and VPA during youth sport football. Cut points of ≥ 2296 and ≥ 4012 counts per minute were used to determine time spent in MVPA and VPA respectively (Evenson, Catellier, Gill, Ondrak, & McMurray, 2008). These cut points have been shown to demonstrate significantly better classification accuracy across a range of PA intensities than other validated cut points developed for youth (Trost, Loprinzi, Moore, & Pfeiffer, 2011).

Compliance with the complete protocol was 49.67 %. Reasons for participant exclusion are detailed in Figure 4.1. Participants were excluded where they did not record valid youth sport PA data during the study week or failed to complete questionnaires assessing psychological variables (i.e., due to non-attendance at training sessions during the research team's second visit). Therefore, the final sample included 73 males aged 9 to 14 years, representing participants from 33 teams across 18 clubs.

Statistical analysis

Descriptive statistics were calculated for the total sample and for the final subsample of 73 participants. Independent samples t-tests were conducted to determine if excluded participants differed from those included in terms of age, height, weight, BMI, BMI-SDS and daily minutes in MVPA and VPA. Chi-square independence tests were conducted to determine the existence of associations between exclusion and ethnicity and exclusion and BMI-classification (i.e., normal-weight versus overweight/obese).

Preliminary analysis. To represent PA engagement during youth sport football, percent time spent engaged in MVPA (%MVPA) and VPA (%VPA) were calculated to adjust for the length of youth sport sessions (i.e., youth sport (YS) %MVPA/VPA = (MVPA/VPA minutes ÷ youth sport session time) x100). Youth sport PA data represented a mixture of both football training sessions and matches (training sessions, N = 34, matches, N = 39). Age, BMI and youth sport context (i.e., training sessions versus matches) have been shown to demonstrate associations with PA during youth sport (Guagliano et al., 2012; Leek et al., 2011; Sacheck et al., 2011). To this end, Pearsons correlations were conducted to investigate the relationship between YS %MVPA and %VPA with age and BMI-SDS, and independent samples t-tests were performed in order to determine whether YS % MVPA and %VPA varied as a function of youth sport context.

Partial correlations. Following preliminary analysis, partial correlations were conducted to determine the relationships between perceptions of the targeted dimensions of the social environment (i.e., perceptions of autonomy support and controlling coach behaviour), motivation (i.e., autonomous and controlled) and youth sport PA, controlling for individual and contextual level variables demonstrating significant associations with YS %MVPA and %VPA. Results from partial correlations were used to inform the development of models to be tested in subsequent path analysis. Preliminary analyses were conducted using SPSS, version 21.0.

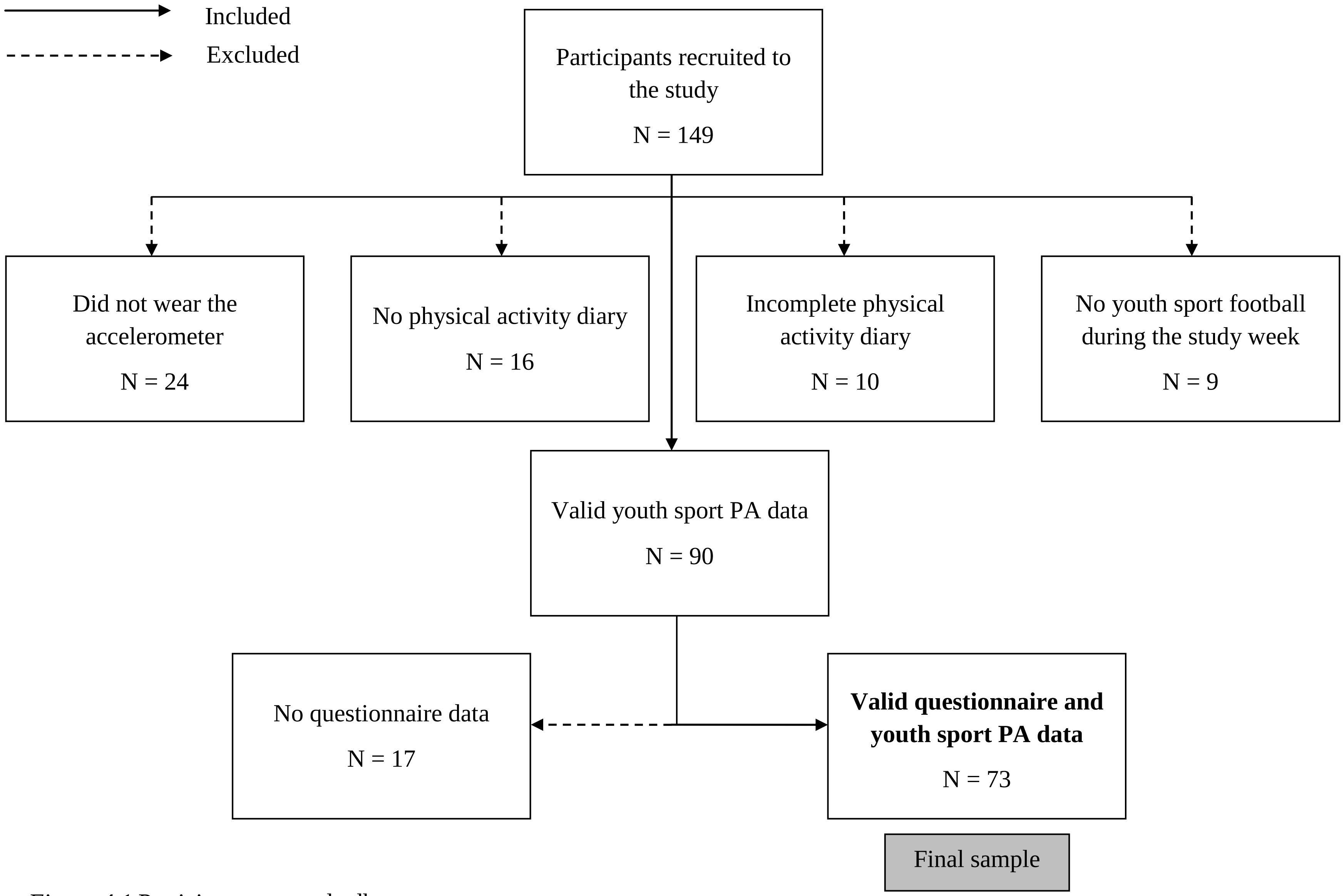

Figure 4.1 Participant protocol adherence

Path analysis. Path analysis with maximum likelihood estimation was employed in conjunction with the bootstrapping procedure to test the theorised relationships using AMOS version 21.0 (Arbuckle & Wothke, 1999). Model fit was analysed using chi squared (χ^2), comparative fit index (CFI), the root square mean error of approximation (RMSEA) and the standardised root square mean residual (SRMR) (Hu & Bentler, 1999). Both the CFI and RMSEA were appropriate to assess model fit in the present study as they are less sensitive to sample size than other goodness-of-fit indices (Fan, Thompson, & Wang, 1999). A non-significant χ^2 ($p = < .05$) and values of $\leq .06$ (RMSEA) and $\leq .08$ (SRMR) indicate a well-specified model. For the CFI, thresholds of > .90 and > .95 indicate acceptable and excellent fit of the data to the hypothesised model respectively (Hu & Bentler, 1999). To examine indirect effects, bootstrap-generated 95% bias corrected confidence intervals were constructed for 2000 samples on the hypothesised model (Preacher & Hayes, 2008; Shrout & Bolger, 2002). Where the confidence interval does not cross zero, a significant indirect effect is assumed. Advantages of the bootstrapping approach include its reported superiority to alternative tests with respect to Type 1 error rates and power, and increased stability of parameter estimates under conditions of non-normality (Preacher & Hayes, 2008).

Results

Participant characteristics

Physical characteristics for the total sample and the final sub-sample are reported in Table 4.1. Results demonstrated participants included in the final subsample (N = 73) did not differ from those excluded in terms of age, height, weight, BMI and average daily minutes in MVPA and VPA (all $p = > .10$). Conversely, BMI-SDS was significantly higher in excluded compared to included participants (Table 4.1). However, the proportion of normal-weight to overweight/obese participants was not significantly different between the included and excluded groups (i.e., BMI ≥ 85^{th} percentile; *excluded* = 24.66%, χ^2 (1) = 1.51, *p* = .22). Significant associations between exclusion and ethnicity were observed (χ^2 (3) = 10.88, *p* = .01), though these associations were small (Cramers V = <.30). Compared to excluded participants, those included in the final subsample constituted a higher percentage of white participants, and lower percentages of Asian, black and multi-racial participants (*included*, white = 86.1%, Asian = 5.6%, Black = 6.9%, multi-racial = 1.4%, vs. *excluded*, white = 62.9%, Asian = 21.4%, Black = 12.9%, multi-racial = 2.8%).

Psychological measures

Table 4.2 reports the means, standard deviations and Cronbach's α for all psychological variables assessed. Internal reliabilities were acceptable for the composite variables of autonomous and controlled motivation. For perceptions of autonomy support and controlling coach behaviour, internal reliabilities were just below the conventionally used α of >.70. Observed means reflected high values for perceptions of autonomy support and autonomous motivation, and moderate levels of perceptions of controlling coach behaviours and controlled motivation for the present sample.

Preliminary analysis

Figure 4.2 illustrates YS %MVPA and %VPA during youth sport football. Participants engaged in MVPA and VPA for almost half (48.70% ± 14.09), and one quarter (25.77 ± 12.23) of youth sport session time respectively. Participants who reported engaging in youth sport match play spent a significantly higher percentage of time engaged in MVPA and VPA than those who reported engaging in training sessions (Figure 2, MVPA, *t* (71) = 2.89, *p* = <.01, VPA, *t* (71) = 2.21, *p* = <.05). Pearson correlations indicated YS % MVPA and %VPA were both positively associated with age (% MVPA, *r*

= .57, *p* = <.01, %VPA, *r* = .63, *p* = <.01). BMI-SDS was not associated with either YS %MVPA or %VPA (%MVPA, *r* = .12, *p* = .32, %VPA, *r* = .07, *p* = .55).

Partial correlations

Results from the calculated partial correlations are displayed in Table 4.2. After controlling for confounding factors identified in preliminary analysis (i.e., age and youth sport context), partial correlations revealed significant positive relationships between perceptions of coach provided autonomy support with both YS %MVPA and %VPA, and a significant negative relationship between perceptions of controlling coach behaviour and YS %MVPA. For motivation regulations, results indicated a significant positive association between autonomous motivation and YS %MVPA, whilst the relationship between autonomous motivation and YS %VPA was positive but not significant. Controlled motivation was unrelated to both YS %MVPA and %VPA.

Table 4.1

Physical characteristics of the total sample and final subsample with valid youth sport PA and questionnaire data

	Total sample (N = 149)		**Included (N = 73)** *(i.e., valid PA and questionnaire data)*		**Excluded (N = 76)**	
	Mean ± SD		Mean ± SD		Mean ± SD	
Physical characteristics						
Age (years)	11.72 ± 1.60		11.70 ± 1.64		11.74 ± 1.58	
Height (cm)	1.53 ± 0.13		1.53 ± 0.14		1.53 ± 0.12	
Weight (kg)	45.15 ± 13.44		44.32 ± 14.13		45.97 ± 12.77	
BMI (kg.m^2)	18.81 ± 3.14		18.39 ± 3.20		19.24 ± 3.04	
BMI-SDS*	0.33 ± 0.11		0.11 ± 1.18		0.52 ± 0.97	
BMI classification	N	%	N	%	N	%
Normal weight	116	77.85	61	83.56	55	75.34
Overweight	19	12.76	7	9.59	12	16.44
Obese	11	7.38	5	6.85	6	8.22

Note: * = significantly different between the included and excluded participants (BMI-SDS, t (144) = -2.35, p = <.05)

BMI (SDS) = body mass index (standard deviation score)

BMI; total sample, N = 146 (missing data = N = 3, 2%)

Table 4.2

Reliability analysis (Cronbach's coefficient α), descriptive statistics and partial correlations among psychological and youth sport PA variables, controlling for age and youth sport context

Variables	M ± SD	α	1	2	3	4	5	6
1. Autonomy support	4.00 ± 0.59	.67						
2. Controlling behaviour	2.40 ± 0.72	.69	-.54**					
3. Autonomous motivation	4.39 ± 0.50	.78	.43**	-.13				
4. Controlled motivation	2.38 ± 0.91	.84	-.05**	.35**	-.02			
5. YS %MVPA	48.70 ± 14.09		.33**	-.25*	.26*	.04		
6. YS%VPA	25.77 ± 12.23		.30**	-.21	.21	-.04	.84**	

Note: * = *p* <.05, ** = *p* <.01

YS =youth sport, MVPA = moderate to vigorous physical activity, VPA = vigorous physical activity

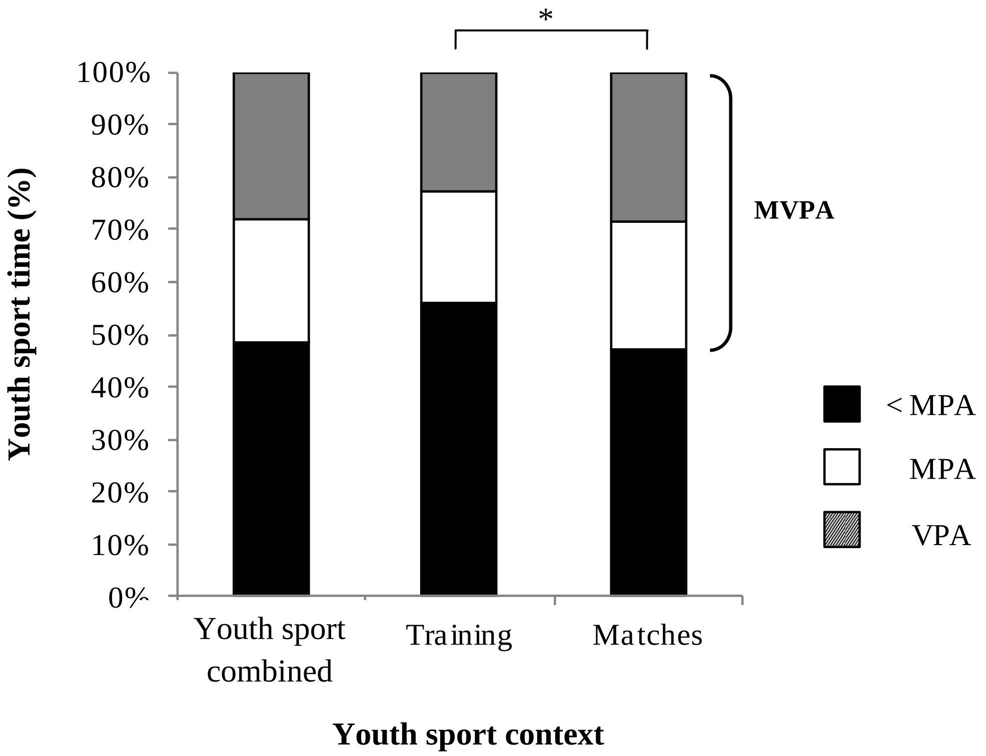

Figure 4.2 Percent youth sport football time engaged in MVPA and VPA by context

Note: * = *p* <.05, significant differences across contexts for youth sport MVPA and VPA

MPA = moderate physical activity, MVPA = moderate-to-vigorous physical activity, VPA = vigorous physical activity

Path analysis

Four path models were tested to further examine the associations between the social environment, motivation towards football participation and YS%MVPA and %VPA. Due to sample size restrictions, two initial models were tested in order to examine the significant association between autonomous motivation and YS %MVPA (Figure 4.3a) and YS %VPA (Figure 4.3b). Following this, two further models were tested in order to investigate the associations theorised by SDT more fully (inclusion of controlled motivation) and to confirm results reported from initial path analysis (i.e., Figures 4.3a and 4.4b).

The initial models testing only autonomous motivation demonstrated an excellent fit to the data (Figure 4.3a, χ^2 (9) = 10.01, p = .35, CFI = .99, RMSEA = .04, SRMR = .06, Figure 4.3b, χ^2 (9) = 9.46, p = .40, CFI = .99, RMSEA = .03, SRMR = .06. Perceptions of coach provided autonomy support positively predicted autonomous motivation in each model. In turn, autonomous motivation positively predicted YS %MVPA (Figure 4.3a). However, autonomous motivation was not significantly related to YS %VPA (Figure 4.3b, p = .07). The 95% bootstrap-generated bias-corrected confidence intervals demonstrated perceptions of coach-provided autonomy support to have a significant positive indirect effect on YS %MVPA (Figure 4.3a, β = .10 [95% CI = .02 to .24]) and YS%VPA (Figure 4.3b, β = .08 [95% CI = .01 to .19]). No significant indirect effect was observed for perceptions of controlling coach behaviour. The variance in autonomous motivation explained by perceptions of coach provided autonomy support was 18.8% (Figure 4.3a and 4.3b). Together, autonomous motivation and perceptions of autonomy support accounted for 7.4% of the variance in YS%MVPA (autonomous motivation = 4.1%, autonomy support = 3.3%), and 5.6% of the variance in YS %VPA (autonomous motivation = 2.4%, autonomy support = 3.2%).

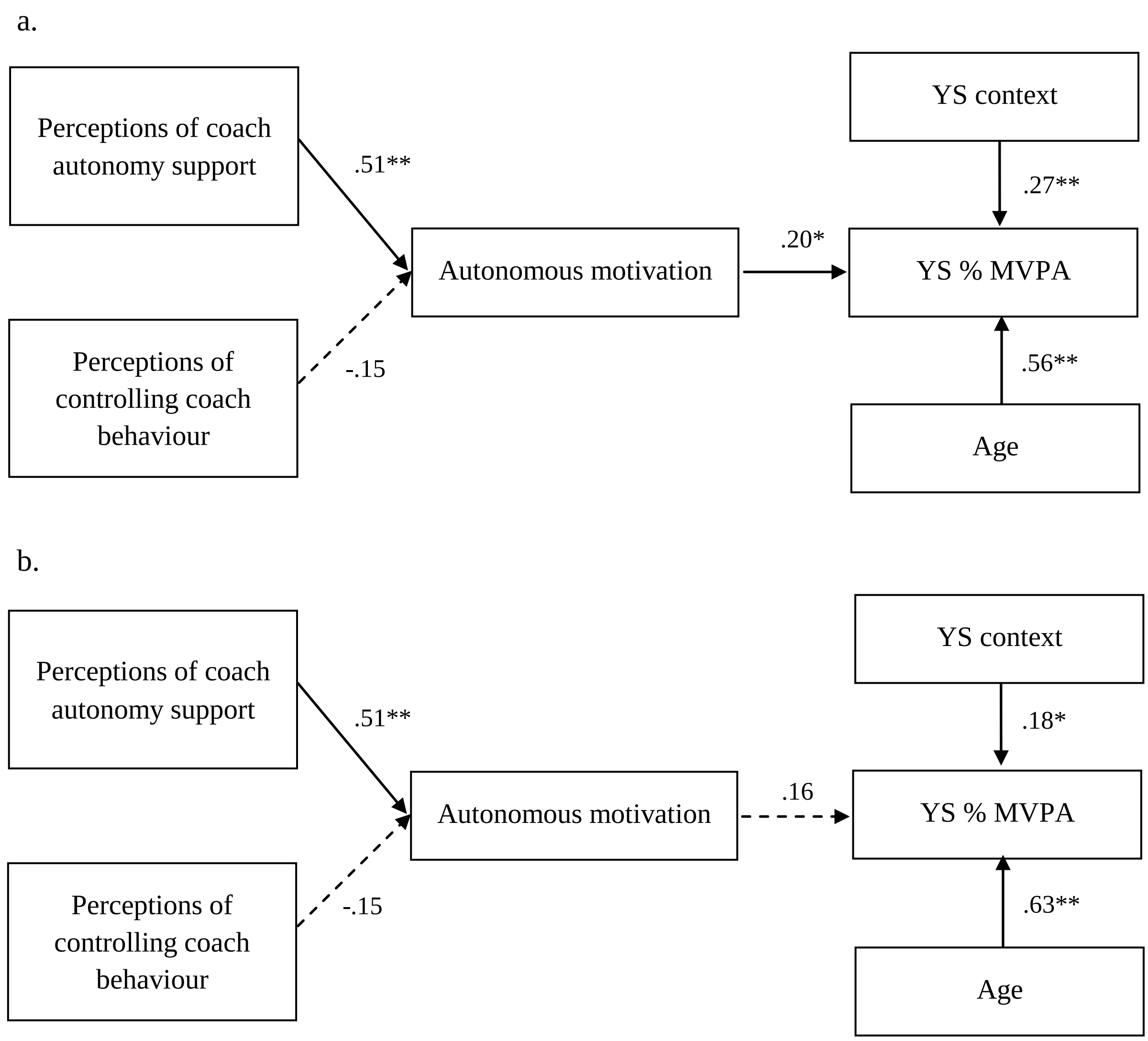

Figure 4.3 Path models demonstrating associations between perceptions of the social environment, autonomous motivation and youth sport football MVPA and VPA

Note: * = *p* = <.05, ** = *p* <.01

Values indicate path coefficients (β). Dashed lines indicate non-significant relationships

YS = youth sport, MVPA = moderate-to-vigorous physical activity, VPA = vigorous physical activity
Dashed lines indicate non-significant relationships

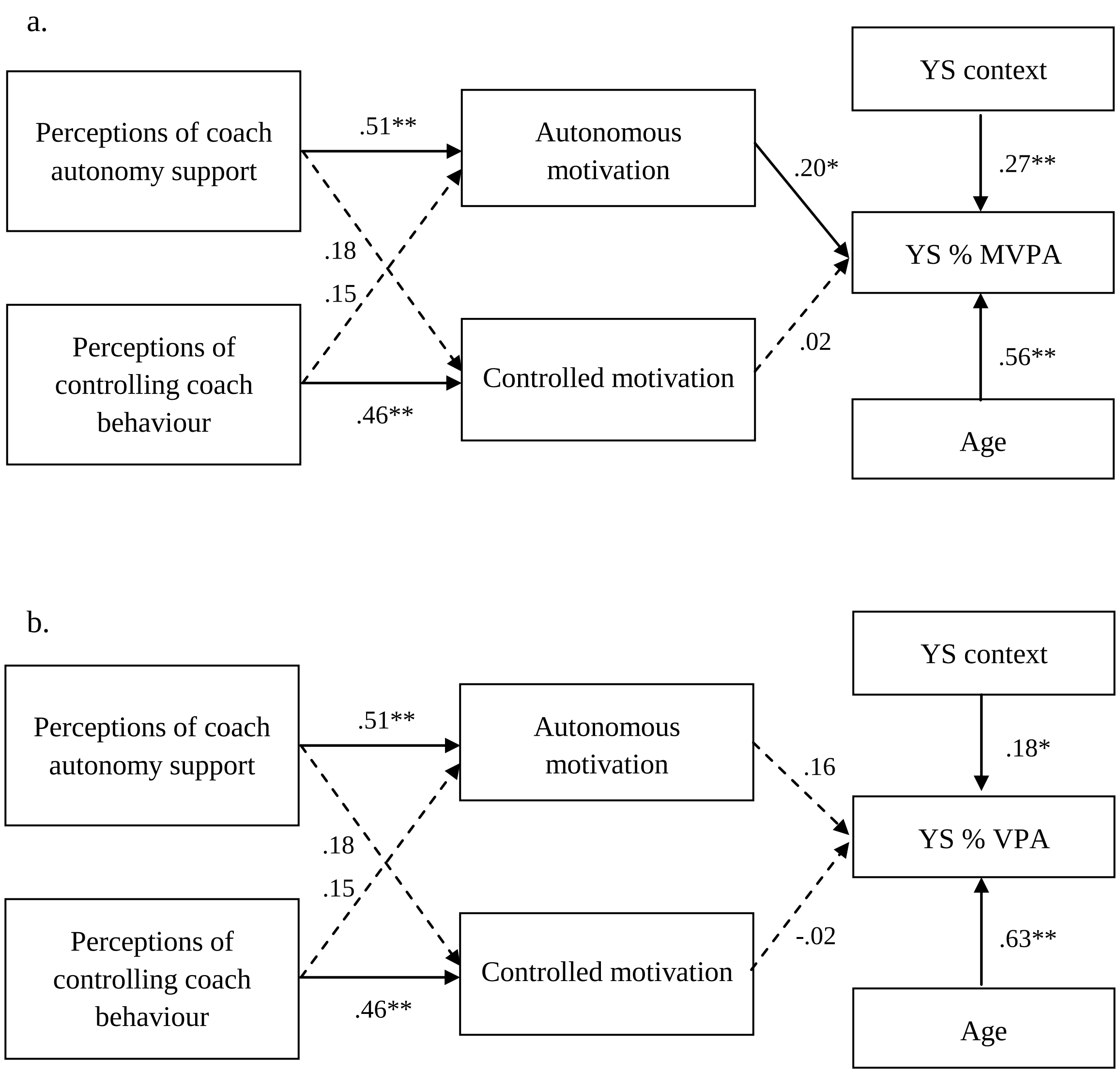

Figure 4.4 Path models demonstrating associations between perceptions of the social environment, autonomous and controlled motivation and youth sport football MVPA and VPA

Note: * = *p* = <.05, ** = *p* <.01

Values indicate path coefficients (β). Dashed lines indicate non-significant relationships

YS = youth sport, MVPA = moderate-to-vigorous physical activity, VPA = vigorous physical activity

Figure 4.4 reports results from path models adapted to further include controlled motivation. Both models demonstrated an excellent fit to the data (Figure 4.4a, χ^2 (12) = 11.41, *p* = .49, CFI = 1.00, RMSEA = .00, SRMR = .06, Figure 4.4b, χ^2 (12) = 10.32, *p* = .60, CFI = 1.00, RMSEA = .00, SRMR = .06). Results reported in initial path models remained significant and path coefficients were unaltered. Controlled coach behaviour positively predicted controlled motivation. However, controlled motivation in turn was not related to YS% MVPA (Figure 4.4a) or YS% VPA (Figure 4.4b).

Discussion

Our study is the first to examine how perceptions of the social environment created by the youth sport coach are related to accelerometer assessed MVPA and VPA in the youth sport setting. Informed by self-determination theory (Deci & Ryan, 1985; Deci & Ryan, 1987; Deci & Ryan, 2000), we examined whether perceptions of coach-provided autonomy support and controlling coach behaviour were associated with engagement in MVPA and VPA during youth sport football sessions. Results indicated that where coaches were perceived to adopt a more autonomy supportive coaching style, participants reported higher levels of autonomous motivation towards football participation, which in turn, corresponded to higher levels of engagement in MVPA during youth sport football. Moreover, results revealed perceptions of autonomy support to have an indirect effect on levels of engagement in VPA during youth sport football via autonomous motivation.

Results demonstrated perceptions of coach-provided autonomy support were positively associated with time spent engaged in MVPA during youth sport football as a result of fostering higher levels of autonomous motivation. That is, where coaches adopt an interpersonal style which provides players with a sense of choice, supports self-initiative, acknowledges their perspectives, and provides a rationale to foster consideration of personal relevance, youth are more likely to engage in sport for the inherent fun and enjoyment derived from the activity, and in turn, are more active during their sport time. Consequently, the present findings have implications for optimising engagement in MVPA within the youth sport setting, and as a result, increasing daily MVPA towards recommended levels on days in which young people engage in youth sport. In addition, evidence for the dose-response relationship between PA and health (Dencker & Andersen, 2008), points toward the importance of identifying correlates of engagement in VPA among youth (Steele et al., 2010). Results indicating the presence of an indirect effect of perceptions of autonomy support on youth sport football VPA via autonomous motivation may therefore also hold implications for increasing VPA towards levels to prevent overweight and obesity among youth (Martinez-Gomez et al., 2010). As such, present results underline the important role of the coach for optimising PA engagement during youth sport. Specifically, our findings suggest that where coaches are more autonomy supportive, higher levels of engagement in MVPA and VPA within the youth sport setting will likely result, which in turn, may contribute towards youth engaging in levels of MVPA and VPA identified as being beneficial for health on youth sport days.

Previous studies which were grounded in SDT, and investigated the psychosocial correlates of objectively assessed PA engagement during PE and recess, have demonstrated similar results to those reported presently (Aelterman et al., 2012; Owen et al., 2013; Perlman, 2013; Stellino & Sinclair, 2013). Specifically, cross-sectional studies have reported more autonomous motivation towards PE and recess to be positively linked to engagement in objectively assessed within-context PA, where controlled motivation is unrelated to MVPA participation during PE (Aelterman et al., 2012; Owen et al., 2013; Stellino & Sinclair, 2013). In addition, Perlman et al., (2013) reported perceptions of autonomy support from PE teachers to result in higher levels of autonomous motivation and increased participation in MVPA during PE classes. However, the present study is the first to support the sequential associations/hypothesised processes postulated by SDT within a youth PA context. Thus, the present study makes a novel contribution to the literature, demonstrating higher levels of engagement in MVPA during youth sport football are related to perceptions of more autonomy supportive social environment and ensuing autonomous motivation. Taken together, past and present work underlines the salience of the social environment for fostering a higher quality of motivation and related levels of PA engagement within youth PA settings. Future studies should seek to examine the motivational processes advocated by SDT within other environments in which children are frequently active across the week (e.g. PE, school breaks). Such research will help to set the stage for interventions targeting the social environment toward increasing regular engagement in PA above a moderate intensity.

Interesting to note is that partial correlations demonstrated a direct association between perceptions of controlling coach behaviour and MVPA during youth sport football. SDT would postulate that this relationship would likely be a consequence of the association between perceptions of a controlling climate and more controlled motivation (Deci & Ryan, 1987; Deci & Ryan, 2008; Deci, Eghrari, Patrick, & Leone, 1994b; Pelletier et al., 2001). Whilst controlling behaviour was negatively linked to controlled motivation in the present study, controlled motivation was unrelated to MVPA and VPA during youth sport football. As such, other motivational processes or affective states associated with perceptions of controlling interpersonal behaviours may play a more prominent role in the association between controlling coach behaviour and youth sport MVPA. For example, a recent study reported controlling coach behaviours positively predicted thwarting of the three basic needs for competence, autonomy and relatedness, which in turn, corresponded to increases in player burnout (Balaguer et al., 2012). It would be interesting for future research to investigate the associations between controlling coach behaviours, basic need thwarting and within-context PA engagement among youth in order determine the processes by which this interpersonal behaviour may lead to further maladaptive behavioural consequences.

The finding that autonomous but not controlled motivation was linked to MVPA engagement during youth sport football corroborates previous results reported within the PE context (Aelterman et al., 2012; Owen et al., 2013). Current results suggest that autonomous motivation is likely a more salient determinant of PA engagement within youth PA settings than controlled motivation. These findings imply that adults central to shaping the social environment within youth PA environments should therefore seek to enhance autonomous reasons for engagement in PA and minimise external motives for participation (e.g., pressure from others, feelings of guilt) in order to encourage higher levels of PA engagement. Nevertheless, a paucity of studies investigating the associations between controlled motivation and PA engagement both within and outside (i.e., daily PA) youth PA settings mean the consequences of controlled motivation are not well understood. Additional research is therefore necessary before conclusions can be drawn concerning the impact controlled motivation may have for levels of PA participation among youth.

Current findings indicated perceptions of autonomy support and autonomous motivation explained 3.3% and 4.1% of the variance in MVPA participation during youth sport football respectively. These results parallel those reported in a recent study, in which personal autonomous motivation towards PE was reported to account for 4% of the variance in MVPA during PE classes (Aelterman et al., 2012). Thus, whilst past and present findings point towards the social environment and ensuing autonomous motivation as pertinent correlates of within-context PA engagement, results also underscore the importance of acknowledging other influences upon PA participation within youth PA settings. Indeed, Aelterman et al., (2012) revealed gender and course topic (i.e., activity type) to be a significant predictors of in-class MVPA. Similarly, whilst not a primary aim, the current study highlighted both youth sport context and age as factors associated with PA engagement during youth sport football. Specifically, results indicated higher levels of MVPA and VPA during match play compared to training sessions, and a positive association between age and engagement in youth sport football PA behaviours. The association between age and youth sport PA was stronger for VPA than MVPA, and may partly explain the lack of a significant direct association between autonomous motivation and VPA. That is, age may be a more prominent predictor of engagement in VPA than autonomous motivation. Reasons for the present findings could be related to the differential structure and organisation of youth sport across contexts (Guagliano et al., 2012), a move towards more competitive and high intensity play as children progress into adolescent teams (Balyi & Hamilton, 2004), and the inherent age related increase in strength and power likely to result in more physical capacity to engage in VPA (Roemmich & Rogol, 1995). Nevertheless, whilst there is certainly a need to recognise the role of individual and contextual level factors in the context of youth PA promotion, significant positive associations between perceptions of autonomy support, autonomous motivation and MVPA engagement during youth sport football were observed in the present study after accounting for such factors. Encouraging youth sport football coaches to adopt autonomy supportive coaching styles may therefore go some way towards ensuring all youth football participants benefit more equally from their sport participation.

Other studies have reported age and the youth sport context (i.e., training sessions versus match play) to be related to levels of PA engagement during youth sport per se. However, past research has demonstrated opposing findings to those observed presently (Guagliano et al., 2012; Leek et al., 2011). Specifically, previous research has reported engagement in MVPA to be higher during training sessions (relative to match play) (Guagliano et al., 2012) and among younger participants (aged 7 to 10 years relative to participants aged 10 to 14 years) (Leek et al., 2011). With regards to context related differences, contrasting findings may be a result of sport type. Indeed, Guagliano et al., (2012) examined differences in levels of PA engagement across youth sport contexts among female netball, basketball and soccer participants. When stratified by sport type, results revealed context related differences in PA engagement existed only for netballers and basketballers. Indeed, court restrictions placed on netballers during match play (i.e., related to playing position), and the frequent substitutions made during basketball games, may result in lower levels of PA engagement within this context. By contrast, netball and basketball players may be more consistently involved in drills and practices during training sessions (Guagliano et al., 2012). The divergent findings reported with respect to participant age may likely be a result of the application of age-dependent cut-points in the previous study (Freedson, Pober, & Janz, 2005), and resulting overestimation of MVPA in children ≤ 10 years of age (Trost et al., 2011). Contradictory findings further highlight the complexities of factors affecting objectively assessed PA engagement among sport participants. Additional research is therefore necessary to identify factors related to PA engagement within different sports. The present study should therefore be replicated across different youth sports in order to determine if the interpersonal behaviours of the youth sport coach are a prominent and consistent factor affecting PA engagement across a variety of sports.

Strengths of the study include utilising accelerometers to measure PA which allows quantification of both frequency and intensity of PA engagement. In addition, the analytical approach adopted adjusted for factors which were likely to influence levels of PA engagement during youth sport. Past SDT-based studies have not adjusted for age when examining the influence of motivation on objectively assessed PA engagement (Aelterman et al., 2012; Owen et al., 2013; Stellino & Sinclair, 2013). Limitations of the present study should also be acknowledged. Due to low protocol adherence, the final sample constituted 48.99% of the initial sample. Nevertheless, the sample represented 33 of the original 39 teams recruited to the study, and preliminary analysis indicated that participants included in the final analysis did not differ from those excluded for most demographic variables and in terms of daily PA levels. Whilst significant associations were observed between exclusion with BMI and ethnicity, for BMI, the proportions of participants classified as normal-weight vs. overweight and obese were not significantly different between samples. It should also be noted that whilst Asian and black participants represented a relatively larger proportion of excluded participants than white participants, the final sample was representative of the ethnic distribution of the larger sample of English grassroots footballers recruited to the PAPA project (N = 1343, white = 87.2%, Asian = 6%, Black = 2.5%, multi-racial = 4.1%). And also the distribution of ethnicities within the UK population (Office for National Statistics, 2012).

The cross-sectional nature of this study means inferences regarding direction of the relationships reported presently cannot be made and longitudinal studies are warranted.

Finally, all participants recruited were male grassroots footballers from England. Thus, present findings may not extend into other sport types, females or countries. However, the processes by which the social environment is thought to impact upon positive behavioural outcomes are shown to be invariant across genders and countries (Quested et al., 2013; Standage et al., 2012; Viladrich et al., 2013). It would also be interesting for future studies to validate the assumptions of perceived coach autonomy via objective assessment of coach behaviour. In turn, examining the implications this may have for players' accelerometer assessed engagement in MVPA and VPA during their sport time. For example, employing an observational tool such as the recently developed Multidimensional Motivational Climate Observation System, might offer one such avenue through which to objectively monitor autonomy supportive and controlling coach behaviours within the youth sport setting (Tessier et al., 2013).

Overall the results of the present study imply that where more autonomy supportive environments are created within youth sport football settings, children are likely to experience higher levels of autonomous motivation and in turn, engage in higher levels of MVPA and VPA. Findings have implications for optimising engagement in MVPA and VPA during youth sport and consequently, increasing levels of daily MVPA and VPA towards recommended guidelines and health enhancing levels on youth sport days. Longitudinal studies are needed to determine whether theoretically-grounded interventions that encourage adults central to shaping youth PA environments to adopt more autonomy supportive behaviours hold potential value for increasing within-context engagement in MVPA and VPA among youth.

CHAPTER 5

COACH AUTONOMY SUPPORT PREDICTS AUTONOMOUS MOTIVATION AND DAILY MODERATE-TO-VIGOROUS PHYSICAL ACTIVITY AND SEDENTARY TIME IN YOUTH SPORT PARTICIPANTS

Abstract

Aim: Guided by self-determination theory (Deci & Ryan, 1987), this study tested a trans-contextual model linking perceptions of the social environment created by the youth sport coach to levels of autonomous motivation and objectively measured daily moderate-to-vigorous physical activity (MVPA) and sedentary time (ST) in young football players. **Method:** The study employed a cross-sectional design, assessing physical activity using accelerometers. 105 male youth sport footballers (*M age* = 12.79 ± 1.85 years) wore a GT3X accelerometer for 7 days. Measures of height and weight were recorded. Participants completed a multi-section questionnaire assessing perceptions of autonomy support and controlling coaching behaviours, and motivation toward their participation in sport and physically active games. **Results:** Path analysis supported a model in which players' perceptions of coach-provided autonomy support positively predicted autonomous motivation for sport engagement. In turn, autonomous motivation was positively associated with MVPA, and negatively related to ST (min/day). Controlling coach behaviours were positively linked to controlled motivation. However, controlled motivation for sport and physically active games was unrelated to daily MVPA and ST. Perceptions of coach-provided autonomy support had a significant positive indirect effect on daily MVPA and a significant negative effect on daily ST. **Conclusion:** Results suggest that autonomy supportive coach behaviours are related to daily physical activity patterns in young male footballers. Theory-based interventions that aim to encourage autonomy supportive coaching, and subsequently foster autonomous reasons for sport engagement, may enhance the potential of youth sport for increasing daily MVPA and reducing ST among children and adolescents active in this setting.

Introduction

A wide body of research indicates engagement in PA above a moderate intensity (i.e., moderate-to-vigorous physical activity, MVPA) is related to positive health outcomes in children (Carson & Janssen, 2011; Ekelund et al., 2012; Janssen & Leblanc, 2010; Mark & Janssen, 2011; Martinez-Gomez, Eisenmann, Tucker, Heelan, & Welk, 2011; Ness et al., 2007; Prentice-Dunn & Prentice-Dunn, 2011). Specifically, higher levels of MVPA are associated with reduced risk of obesity during childhood (Ness et al., 2007), improved cardio-metabolic health (Ekelund et al., 2012) and a reduction in the presence of inflammatory markers associated with cardiovascular disease and type II diabetes in youth (Carson & Janssen, 2011). Such findings have led to the development of evidence-based guidelines which state children should engage in at least 60 minutes and up to several hours of MVPA per day (Janssen & Leblanc, 2011; Strong et al., 2005).

More recently, researchers have begun to investigate the negative effects of sedentary behaviour on health outcomes related to obesity and non-communicable diseases (Carson & Janssen, 2011; Chaput et al., 2012; Gaya et al., 2009; Henderson et al., 2012; Martinez-Gomez et al., 2012; Mitchell, Pate, Beets & Nader, 2013; Prentice-Dunn & Prentice-Dunn, 2011). Sedentary behaviour refers to any waking behaviour characterised by low energy expenditure (typically ≤ 1.5 metabolic equivalents) and little physical movement (e.g., behaviours undertaken in a sitting or reclining posture) (Sedentary Behaviour Research Network, 2012). Existing research focused on sedentary behaviour and health has largely examined associations between total sedentary time (ST) (i.e., the sum of the time spent in all sedentary behaviours), and/or time spent engaged in a specific sedentary behaviour (e.g., television viewing) and health outcomes (Tremblay et al., 2011). Results from studies investigating the relationships between total ST and health are somewhat equivocal. For example, some studies have reported positive associations between ST and indicators of adiposity, cardiovascular risk and type 2 diabetes (Gaya et al., 2009; Henderson et al., 2012; Mitchell et al., 2013; Sardinha et al., 2008) where others have reported no associations (Carson & Janssen, 2011; Chaput et al., 2012; Colley et al., 2013; Ekelund, Brage, Griffin & Wareham, 2009). Conversely, engagement in specific sedentary behaviours are more consistently linked to negative health outcomes, with positive relationships reported between TV viewing and computer use with obesity associated health outcomes (Carson & Janssen, 2011; Martinez-Gomez et al., 2012; Tremblay et al., 2011). Nevertheless, a recent systematic review concluded that decreasing any type of sedentary time is associated with lower health risks in youth aged 5 to 17 years (Tremblay et al., 2011). As such, the most recent PA guidelines have included a recommendation for children to minimise time spent engaged in sedentary pursuits (Department of Health, 2011; US Department of Health and Human Services, 2013).

Despite the endorsement of evidence-based recommendations for MVPA and ST across the globe, youth are becoming increasingly sedentary (Nelson, Neumark-Stzainer, Hannan, Sirard, & Story, 2006), and only a small percentage of children are engaging in sufficient levels of MVPA to meet recommended guidelines (Craig & Mindell, 2008; Riddoch et al., 2007). Thus, there is a need to understand what motivates children to engage in MVPA, as well as the psycho-social factors that might contribute towards engagement in ST in order to promote health-conducive PA patterns in youth. Concerning the encouragement of MVPA in particular, past work has suggested that physically active children are more likely to become physically active adults (Telama et al., 2005). Thus, childhood seems to be a critical developmental period in which the formation of positive PA habits (i.e., higher levels of MVPA participation) may be relevant to the promotion of lifelong PA engagement and reduced risk of overweight and associated diseases during adulthood.

Youth sport as a setting for physical activity promotion

Traditionally, efforts to increase MVPA and reduce ST among youth across the globe have targeted the school setting. Certainly, the school is uniquely placed as the only environment which almost all youth experience from early childhood to adolescence. However, recent survey data indicates between 34% and 68% of school-aged youth engage in youth sport in western countries (Australian Bureau of Statistics, 2009; National Council of Youth Sports, 2008; UK Statistics Authority, 2013). As such, youth sport also represents an important and globally relevant domain with regard to promoting engagement in MVPA and reducing ST in children and adolescents. Studies have demonstrated youth sport participants are more active than their non-sporting counterparts (Nelson et al., 2011). However, recent research indicates that whilst youth sport can offer children and adolescents the opportunity to engage in MVPA, MVPA accrued during youth sport time alone is not sufficient to meet recommended guidelines (Leek et al., 2011, Wickel & Eisenmann, 2007). Studies have also revealed youth sport participants to spend as much as 11 hours per day sedentary (Machado-Rodrigues et al., 2012, Van-Hoye et al., 2013). Thus, participation in youth sport may not necessarily mitigate the health risks associated with engaging in low levels of MVPA and high levels of ST. Indeed, past studies have reported that around one in four youth sport participants are overweight (Dowda, 2001), and 48% of obese youth report participation in sport (BeLue, Francis, Rollins & Colaco, 2009). It seems, therefore, that a consideration of factors that predict daily engagement in MVPA and ST among youth sport participants may have important implications for encouraging healthier PA-related behaviours (i.e., higher daily MVPA and less ST) during non-youth sport time, and subsequently, reducing the risk of poor health among children and adolescents active in the youth sport setting. However, despite the potential utility of youth sport as a context for PA promotion, studies to date have largely neglected to examine the concomitants of MVPA engagement and ST among youth sport participants.

Self-determination Theory

Self-determination theory (SDT; (Deci & Ryan, 1987; Deci & Ryan, 2000) is a theoretical framework increasingly used to explain why some individuals are more likely to engage in PA than others (Chatzisarantis & Hagger, 2009; Edmunds, Ntoumanis, & Duda, 2008; Hagger et al., 2009; Standage, Gillison, Ntoumanis, & Treasure, 2012; Teixeira, Carraca, Markland, Silva, & Ryan, 2012; Vierling, Standage, & Treasure, 2007). A central tenet of SDT is that behaviour is directed by motivation regulations that vary in levels of self-determination. These motivation regulations are on a continuum ranging from those that are more autonomous to more controlled, with the former linked to more adaptive outcomes (Alvarez, Balaguer, Castillo, & Duda, 2009; Bartholomew, Ntoumanis, Ryan, & Thogersen-Ntoumani, 2011; Cox, Smith, & Williams, 2008; Deci & Ryan, 1987; Deci & Ryan, 2008; Owen, Astell-Burt, & Lonsdale, 2013; Pelletier, Fortier, Vallerand & Brière, 2001; Teixeira et al., 2012).

Intrinsic motivation is the quintessential form of autonomous motivation and represents the most self-determined (autonomous) regulation. When intrinsically motivated, individuals engage in an activity primarily for the inherent rewards such as interest, fun and satisfaction (Deci & Ryan, 2000). Four types of extrinsic motivation exist which vary in the extent to which they are self-determined; i.e., integrated, identified, introjected and external regulations. Integrated (i.e., the individual participates in sport because this behaviour is integrated with his/her sense of self and reflects the individual's true goals and values) and identified (i.e., the person identifies with the value of sport and chooses to take part as a means to achieve personal goals and outcomes) regulations are autonomous forms of extrinsic motivation, as the source of behaviour regulation emanates from the self. However, it has been argued that the advanced nature of integrated regulation (i.e., established and fully internalised values and goals) means this behavioural regulation is often not prevalent until adulthood (Vallerand, 1997). As a result, studies among youth largely focus on examining the consequences of intrinsic and identified regulations, often combining the two to represent autonomous motivation. Introjected (i.e., participation in sport regulated by contingencies that have been partially internalized, for example to avoid feelings of shame or guilt, or to attain ego enhancement) and external (i.e., sport participation regulated by external demands, rewards or pressures) regulation are considered controlled forms of extrinsic motivation (Deci & Ryan, 2008). SDT also recognises amotivation, characterised by a lack of or absence of motivation (Ryan, 1995). Previous research has indicated more autonomous forms of motivation towards PA (e.g., daily, and/or within leisure time, exercise, physical education settings) to be positively associated with levels of PA engagement among both adults and children (Aelterman et al., 2012; Gillison, Standage, & Skevington, 2011; Owen et al., 2013; Standage et al., 2012; Taylor, Ntoumanis, Standage, & Spray, 2010; Vierling et al., 2007; Sebire, Jago, Fox, Edwards, & Thompson, 2013; Teixeira et al., 2012). Conversely, controlled motivation towards PA has been negatively linked to levels of PA engagement (Owen et al., 2013; Standage et al., 2012; Teixeira et al., 2012), although these associations are reported less consistently than observed for autonomous motivation (in a positive direction).

According to SDT, the social environment surrounding an individual is a central determinant of autonomous motivation to be physically active (Deci & Ryan, 2008;

Pelletier, et al., 2001; Standage et al., 2012). In the PA contexts most frequently experienced by children (e.g., PE classes, youth sport), the social environment is largely coloured by the interpersonal styles of adults acting within these settings (i.e., the teacher/coach created social environment). SDT advocates that more autonomous forms of motivation are promoted in social environments that support an individual's sense of autonomy, (i.e., contexts that promote choice, decision making, acknowledge the others' perspectives, provide a rationale for what individuals are requested to do). Conversely, when controlling atmospheres are most pronounced (i.e., contexts which limit choice, exert pressure, are coercive and in which negative conditional regard is displayed), more controlled/less autonomous motivation will result (Deci & Ryan, 1987; Deci & Ryan, 2000; Deci & Ryan, 2008). For example, within the youth sport context, an autonomy supportive coach may provide players with meaningful options in training, acknowledges athletes' preferences and explain the rationale behind the decisions they make during training sessions and matches (Mageau & Vallerand, 2003). A controlling coach may fail to listen to players' opinions and perspectives, display negative conditional regard (i.e., withdraw attention if performance expectations are not met), and employ the use of rewards to 'motivate' players to perform better (Bartholomew, Ntoumanis, & Thogersen-Ntoumani, 2010).

Self-determination theory and physical activity among youth

To date, studies exploring the relationships between perceptions of the social environment and PA engagement in youth have largely been conducted with a focus on the social environment created by teachers in the PE setting. These studies have principally investigated the associations between autonomy support, autonomous motivation and subsequent engagement in PA. Overall, findings have revealed perceptions of teacher-provided autonomy support in PE classes to be positively related to daily, leisure time and PE class PA engagement as a result of fostering more autonomous forms of motivation (Chatzisarantis & Hagger, 2009; Cox et al., 2008; Hagger et al., 2009; Standage et al., 2012; Vierling et al., 2007). In addition, based on bivariate associations, studies have demonstrated controlled motivation to be negatively linked to daily and leisure time PA (Owen et al., 2013; Standage et al., 2012).

Perhaps most importantly, results from studies conducted in this domain have highlighted the presence of a trans-contextual effect, demonstrating autonomous motivation fostered by the social environment in the PE setting, is related to PA engagement outside this setting (i.e., daily and leisure time PA). Such findings are in line with Vallerand's hierarchical model of motivation which suggests that motivation to engage in a behaviour (e.g., PE) can generalise across contexts (Vallerand, 1997). That is, where individuals are autonomously motivated towards PA participation in one setting, they may also be autonomously motivated towards PA outside of this context. Subsequently, higher levels of engagement both within and outside the setting in question may ensue.

With respect to existent studies examining the motivational processes through which the social environment created within youth PA settings may impact upon young people's PA engagement, a number of limitations should be acknowledged. First, an almost exclusive focus on the PE setting limits our understanding of the potential value of promoting autonomy support in other youth PA environments so that we might enhance children's levels of daily PA engagement. Given that youth are physically active across a variety of settings throughout the week and curricular time allocated to PE is declining in many Western countries (Dollman, Norton & Norton, 2005), examining the motivational processes operating within other youth PA environments and their implications for levels of PA engagement, is an important area of research. Second, studies to date have largely neglected to examine the impact a controlling interpersonal style may have upon levels of PA engagement among youth. As controlling social environments are linked to more controlled motivation, studies examining the implications of controlling behaviours among adults central to shaping youth PA environments are warranted. Finally, previous research in this area has tended to largely rely on self-report questionnaires and pedometers to assess PA engagement among children and adolescents. The questionable validity of self-report measures of PA (particularly among youth) and the inability of pedometers to determine different dimensions of PA (e.g., intensity) limit our understanding of how social contextual factors operating in youth PA settings are related to engagement in specific PA behaviours (e.g., MVPA).

Accelerometers provide an accurate means of assessing frequency, intensity and duration of PA (Trost, 2007). In SDT-grounded research on adults, accelerometers have been utilised to investigate the relationships between motivation and MVPA (Sebire, Standage & Vansteenkiste, 2011; Standage, Sebire & Loney, 2008; Teixeira et al., 2012). However, among youth, very few studies exist that have employed accelerometers to investigate the associations between the psychosocial correlates of PA and daily, leisure time, and/or domain specific engagement in MVPA within the framework of SDT (Aelterman et al., 2012; Lonsdale et al., 2013b; Owen et al., 2013; Perlman, 2013; Roemmich, Lambiase Ms, McCarthy, Feda, & Kozlowski, 2012; Sebire et al., 2013).

Self-determination theory and prediction of MVPA

Existing accelerometer-based studies which have examined the motivational processes postulated by SDT have typically investigated the bivariate associations between a single facet of the SDT model (i.e., the social context *or* motivation regulations) and MVPA (Aelterman et al., 2012; Owen et al., 2013). In general, results have been consonant with SDT tenets with respect to the prediction of engagement in MVPA. Only one study has examined these associations at the multivariate level, testing a sequential SDT based model which demonstrated a positive association between basic psychological need satisfaction (See Ryan and Deci, 2000 for an overview of basic needs theory) and intrinsic motivation towards PA, which in turn was positively linked to daily MVPA (Sebire et al., 2013). However, the role of social contextual factors as determinants of the targeted psychological antecedents and PA engagement was not examined. Owen et al., (2013) conducted the only study to date which sought to examine the trans-contextual associations between motivation and MVPA. Findings revealed more autonomous motivation (and specifically intrinsic motivation) towards PE to be positively related to leisure time MVPA (Owen et al., 2013). In contrast, external regulation was negatively associated with leisure time MVPA, providing initial support for the contention that quality of motivation in one context, may be related to engagement in MVPA in another.

Self-determination theory and sedentary time

The recent advancement towards using accelerometry has gone some way toward testing the theoretical tenets of SDT with respect to the prediction of MVPA. However, only one study to date has pulled from SDT in the investigation of the psychosocial correlates of ST. In this intervention study, Lonsdale et al., (2013b) sought to determine if the creation of autonomy supportive PE environments would result in changes in students' motivation towards PE and time spent sedentary during a 20 minute PE session. Results revealed where the PE teacher provided opportunity for free choice of activities during PE, motivation towards PE remained unchanged, but ST during the PE lesson was reduced

(Lonsdale et al., 2013b). Whilst this study offers a novel contribution to the literature, further SDT-based research is warranted which further explores the psychosocial correlates of ST and the motivational processes underlying engagement in ST behaviours. In particular, given the high levels of daily ST reported among youth (Pate, Mitchell, Byun & Dowda, 2011), studies examining the motivational processes underlying engagement in daily ST are paramount from a public health perspective.

As previously highlighted, initial support has been provided for the presence of a trans-contextual association between motivation in one context and engagement in MVPA in another (Owen et al., 2013). However, less is known concerning whether contextual motivation to engage in PA in one setting, would be related to time spent engaged in sedentary behaviours outside this context. Consonant with Vallerand's hierarchical model of motivation (Vallerand, 1997), a lower quality of motivation towards PA, may mean that children chose to spend their time engaged in activities of a more sedentary nature across multiple contexts. Whilst there may be other important mediators in this relationship, exploring the trans-contextual association between quality of motivation towards PA fostered in one context and engagement in ST across other contexts, is an important first step in determining the relevance of youth PA environments as trans-contextual settings for reducing ST among children and adolescents. .

When arguing the relevance of determining trans-contextual associations between domain specific motivation for PA and daily ST, it is important to consider the PA and sedentary behaviour paradigm as discussed across the literature (Biddle, Marshall, Gorely, & Cameron, 2009; Katzmarzyk, 2010; Maher, Olds, Mire & Katzmarzyk, 2014). Indeed, in contrast to evidence demonstrating MVPA and ST are two distinct behaviours (Biddle et al., 2009), there is evidence to suggest that MVPA and ST are related behaviours with similar correlates (Epstein, Roemmich, Paluch & Raynor, 2005; King et al., 2010). Based on the latter assertion, it is likely that where motivation in one context is positively related to MVPA in another, the opposite association may be observed for ST (i.e., an increase in MVPA may be correspond to a decline in ST, Epstein, Roemmich, Paluch & Raynor, 2005; Loucaides, Jago & Theophanous, 2011). Thus, determining associations between PA motivation and both MVPA and ST may also contribute to an important body of research seeking to determine the extent to which these two behaviours are related among youth.

The present study

The current study sought to build upon existing research by extending previous findings from the PE context to an important setting for PA promotion in youth outside the school (i.e., youth sport). We addressed this by testing a sequential SDT-based model examining the trans-contextual associations between the social environment created by coaches in the youth sport setting (i.e., its autonomy supportive and controlling features), sport and PA related autonomous and controlled motivation and accelerometer-assessed daily MVPA and ST (Figure 5.1). The inclusion of ST in our hypothesised model served a secondary and more exploratory aim; i.e., we wanted to secure preliminary data regarding the potential value of the youth sport context as an avenue through which levels of ST may be reduced among youth sport participants. The indirect effects of perceptions of coach-provided autonomy support and controlling coach behaviour on autonomous and controlled motivation were also examined in order to explore the psychosocial mechanisms linking the social environment created in youth sport football to daily engagement in MVPA and ST. Due to its popularity across the world, our focus in the present study was on youth sport football participants. Globally it is estimated over 22 million youth participate in youth sport football (Kunz, 2007) and in some westernised countries, footballers comprise between 40% and 68% of all youth sport participants (Australian Bureau of Statistics, 2009; UK Statistics Authority, 2013; Womens Sports Foundation, 2008).

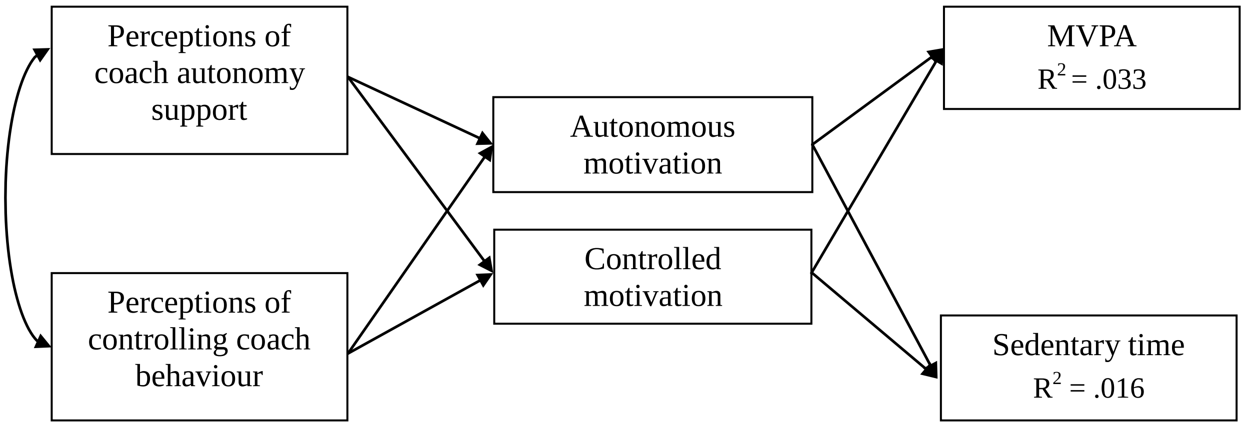

Figure 5.1 The self-determination theory process model

Note: Arrows indicate all paths tested

MVPA = moderate-to-vigorous physical activity

Method

Participants and procedures

Males aged 10 to 16 years (N = 156, *M age* = 12.78 ± 1.91) were recruited from 24 football clubs. To be eligible for the study, participants were required to be playing grassroots football regularly (i.e., ≥ one training session and/ or match per week) for a community club team outside school. Following initial contact with coaches at football clubs, trained researchers visited clubs to distribute consent forms and information sheets to interested participants and parents. Researchers returned one week later to administer a multi-section questionnaire assessing perceptions of coach behaviour and players' motivation regulations. Following this, measures of height and weight were recorded and accelerometers (GT3X Actigraph, Pensacola, FL) were distributed. Study procedures and assessments were approved by the local National Health Service Research Ethics Committee (Research Ethics Committee application number: 10/H1207/39). Informed parental consent and participant assent were obtained before participation in the study. All data were collected six to seven months into the competitive football season (i.e., between February and March), allowing time for the social environment within the youth sport setting to have been established.

Measures

Perceptions of the coach created social environment. Perceptions of coach-provided autonomy support and controlling coach behaviours were assessed via previously validated scales (Adie, Duda, & Ntoumanis, 2012; Bartholomew et al., 2010; Williams, Grow, Freedman, Ryan, & Deci, 1996). Following the stem “So far this season....,” five items (e.g., my coach gives players choices and options) and six items (e.g., my coach threatens to punish players to keep them in line during training) were used to measure players’ perceptions of coach-provided autonomy support and controlling coach behaviours, respectively. Players were asked to rate their agreement with the items on a 5-point Likert-scale ranging from 1 (strongly disagree) to 5 (strongly agree). Both scales had acceptable internal consistency (autonomy support, α = .67; controlling behaviours, α = .74).

Motivation regulations. Behaviour regulations for participation in sport and active games were assessed using an adapted version of the Behavioural Regulation in Sport Questionnaire (BRSQ, Lonsdale, Hodge, & Rose, 2008). Following the stem “I participate in sport and active games because....,” three items measured intrinsic motivation (e.g., because it is fun)[1], and four items tapped identified (e.g., because I value the benefits), introjected (e.g., because I would feel guilty if I quit) and external (e.g., Because if I don't other people will not be pleased with me) motivation. Items were responded to on a 7-point Likert scale ranging from 1 (not true at all) to 7 (very true). The BRSQ subscales demonstrated acceptable internal consistency in this study (intrinsic motivation, α = .75, identified regulation, α = .74, introjected regulation, α = .80 and external regulation , α = .84), and have been validated in research involving a large sample of youth sport football participants of similar age to those targeted in this study (Viladrich et al., 2013). Consonant with SDT and the approach used in other SDT-based studies in sport and other physical activity settings (Aelterman et al., 2012; Chan & Hagger, 2012), autonomous motivation (intrinsic motivation + identified regulation) and controlled motivation (introjected regulation + external regulation) variables were computed and used as primary variables in subsequent analysis.

Anthropometry. Height was measured with a stadiometer (SECA, Leicester height measure) to the nearest 0.1cm. Weight was measured with electronic scales (WW, precision scale) to the nearest 0.1 kg. Body mass index (BMI) was calculated using the equation, weight (kg) ÷ height (m^2), and participants were classified as normal-weight, overweight or obese according to UK BMI reference charts (Cole, Freeman, & Preece, 1995). BMI standard deviation scores (BMI-SDS) adjusted for age-and-sex were computed (Cole, Freeman, & Preece, 1998).

[1] The original BRSQ measure uses four items to tap intrinsic motivation. In the present study, the item "because it feels pleasurable" was removed as this term was not thought to reflect the language used by children and adolescents aged 10-16 years when referring to their sport participation. In particular, perceptions of the term 'pleasurable' may vary across the age range studied. This three item scale demonstrated good construct validity in the present sample (χ^2 (84) = 113.04, p = .02, CFI = .96, RMSEA = .05, SRMR = .06, factor loading all ≥.55, p = < .001) and in a recent study among youth aged 7 to 11 years (Sebire et al., 2013).

Physical activity. Daily MVPA and ST were measured using the Actigraph GT3X accelerometer. The Actigraph accelerometer has been shown to be a valid and reliable measure of PA among youth (Trost, 2007). The GT3X detects movements over pre-specified time periods called epochs. Movements within each epoch are converted to 'activity counts' which are interpreted to determine time spent at different activity intensities. Accelerometers were initialised in 15 second epochs in the present study (Riddoch et al., 2007). A trained researcher distributed the accelerometers and provided participants and parents with verbal and written instructions on how accelerometers should be worn. For assessment of PA among youth, a seven-day measurement protocol is recommended to obtain a reliability coefficient of 0.8 or above (Trost, Pate, Freedson, Sallis, & Taylor, 2000). As such, participants were asked to wear the accelerometer for seven days following their training session (i.e., five week days and two weekend days) during all waking hours, and instructed to remove the accelerometer when bathing and/or engaged in water sports (e.g., swimming). Participants were asked to record time periods when the accelerometer was removed (indicating reasons why), and daily participation in sports and PA (e.g., cycling) in activity logs to aid with data cleaning. To try and increase compliance with the seven day monitoring protocol, it was emphasised that participants should try to wear the accelerometer for the full 7 days in which they were participating in the study. Further, researchers contact details were made available to participants and parents in the event they had any issues, questions or concerns regarding wearing the accelerometer.

Data processing

Data from the GT3X were downloaded and analysed using Actilife software (Actilife version 6.2, Actigraph; Pensacola, Florida). Questionnaire and PA data were cleaned and checked for missing and spurious values respectively. Periods of accelerometer non-wear were determined by strings of consecutive zeros lasting > 30 minutes, allowing for 1 minute of counts < 100 (Cain, Sallis, Conway, Van Dyck, & Calhoon, 2013). Participants were excluded from further analysis where they failed to record valid PA data (N = 41, ≥ 4 days, with ≥ 8 valid hours of activity per day, including one weekend day), and/or provided incomplete responses to questionnaire items (N = 10). The final sample consisted of 105 males (compliance = 66.88%), representing youth sport football players from all 24 of the football clubs initially recruited. Of these, 45.7 %, 38.1%, 8.6% and 7.6% recorded 7, 6, 5 and 4 days of valid PA data respectively. Mean scores for questionnaire variables were calculated from responses to the targeted scales, and average daily levels of MVPA and ST were determined (minutes/day). MVPA and ST were defined as ≥ 2296 and <100 and cpm respectively based on the cut points derived by Evenson and colleagues (Evenson, Catellier, Gill, Ondrak, & McMurray, 2008). One-way analysis of variance indicated the final sample (N = 105) did not differ from those excluded for physical characteristics (age, height, weight and BMI-SDS), or because of missing questionnaire data (all p = ≥ .15).

Statistical analysis

Descriptive statistics (M ± SD) were calculated for all measured variables using SPSS. Pearsons correlations were calculated to examine bivariate relationships between variables in the hypothesised model (Figure 5.1), and to identify confounding factors that may impact upon these relationships (i.e., BMI-SDS, age and valid-wear time). Where confounding relationships were identified, the hypothesised model was adjusted accordingly to control for these relationships (i.e., direct paths were stipulated between confounding factors and PA variables where necessary; see Figure 5.2).

Path analysis with maximum likelihood estimation was employed in conjunction with the bootstrapping procedure to test the hypothesised model (Figure 5.1) (Arbuckle & Wothke, 1999). Bootstrapping is a nonparametric resampling procedure that does not impose the assumption of normality of the sampling distribution (Preacher & Hayes, 2008). Previous research has shown this approach to be superior to alternative tests with respect to Type 1 error rates and power (Preacher & Hayes, 2008), Bootstrap-generated 95% bias corrected confidence intervals were constructed for 2000 samples on the hypothesised model (Preacher & Hayes, 2008; Shrout & Bolger, 2002). Model fit was evaluated using the chi-square statistic (χ^2), comparative fit index (CFI), root square mean error of approximation (RMSEA), and standardised root mean square residual (SRMR) (Hu & Bentler, 1999). Both the CFI and RMSEA were appropriate to assess model fit in the present study as they are less sensitive to sample size than other goodness-of-fit indices (Fan, Thompson, & Wang, 1999). A non-significant χ^2 (p = < .05) and values of > .90 (CFI) ≤ .06 (RMSEA) and ≤ .08 (SRMR) were used as cut off criteria to indicate good fit of the data to the hypothesised model. In the case of a CFI value > .95, the model is considered to have excellent fit (Hu & Bentler, 1999).

Where significant associations between motivation regulations and MVPA and ST were observed, the phantom model approach for testing specific effects was used to examine the indirect effects of coach-provided autonomy support and/or controlling coach behaviour on MVPA and ST (via motivation regulations) (Macho & Ledermann, 2011). This method involves creating a separate latent variable model (i.e., the phantom model) that represents the specific effect to be tested as a total effect (Figure 5.2). Bootstrap bias corrected 95% confidence intervals were used to determine significance. Where the confidence interval does not cross zero, a significant indirect effect is assumed. Results are reported in their unstandardised form as the phantom approach does not allow estimation of standardised effects.

Results

Participant characteristics

Descriptive statistics are shown in Table 5.1. The sample largely consisted of normal-weight participants (73.3%, N = 77), with 18.1% and 8.6% classified as overweight (BMI ≥ 85^{th} percentile, N = 19) and obese (BMI ≥ 95^{th} percentile, N = 9), respectively (Cole et al., 1995). Mean scores for the targeted social psychological variables indicate high levels of autonomous motivation and perceptions of autonomy support across the sample. Perceptions of controlling coach behaviour and controlled motivation were comparatively lower than perceptions of coach-provided autonomy support and autonomous motivation. On average, participants engaged in MVPA for over 1 hour per day and spent between 8-9 hours per day engaged in sedentary behaviours.

Pearson correlations

Table 5.2 reports the bivariate associations between all measured psychological variables[2] and PA behaviours. Results indicate that perceived autonomy support was significantly and positively correlated with autonomous motivation, and was unrelated to controlled motivation. Perceived controlling coach behaviour was significantly and positively correlated with controlled motivation, and significantly negatively correlated with autonomous motivation. Autonomous motivation was also significantly positively associated with daily MVPA and negatively related to daily ST. No relationships were observed between controlled motivation and MVPA or ST.

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[2] The factoral validity for each of the psychological scales was supported by confirmatory factor analysis. Please contact the first author for further details

BMI-SDS was not associated with MVPA (*p* = .46) or ST (*p* = .88) Further, age was not related to MVPA (*p* = .09). However, both age and valid-wear time were significantly positively correlated with ST (*r* = .51, *p* = < .01 and *r* = .52, *p* = < .01 respectively), and valid wear time was also significantly positively associated with MVPA (*r* = .23, *p* = < .05). The hypothesised model was therefore adjusted to control for these relationships in the subsequent path analysis (i.e., direct paths were stipulated between valid wear time and MVPA and ST, and between age and ST; see Figure 5.2).

Table 5.1

Descriptive statistics: psychological measures, physical characteristics, daily MVPA and ST

	Mean ± SD (N = 105)	**Range (min – max)**
Psychological Variables		
Autonomy support	3.98 ± 0.55	2.40 – 5.00
Controlling coach behaviour	2.19 ± 0.64	1.00 – 4.18
Autonomous motivation	6.24 ± 0.69	4.00 – 7.00
Controlled motivation	2.93 ± 1.55	1.00 – 6.83
Intrinsic motivation	6.55 ± 0.56	4.75 – 7.00
Identified regulation	5.75 ± 0.97	2.75 – 7.00
Introjected regulation	2.85 ± 1.50	1.00 – 6.65
External regulation	2.33 ± 1.45	1.00 – 6.75
Physical Characteristics		
Age (years)	12.77 ± 1.85	10 – 16
Height (m)	1.60 ± 0.13	1.31 – 1.90
Weight (kg)	51.81 ± 14.13	26.0 – 92.30
BMI (kg.m^2)	20.01 ± 3.26	13.16 – 30.17
BMI-SDS	.55 ± 1.05	-2.93 – 2.79
Physical Activity		
MVPA (min/day)	70.29 ± 24.58	20.54 – 143.11
ST (min/day)	486.66 ± 66.21	320.45 – 616.13
Valid-wear days	6.22 ± 0.90	4.00 – 7.00
Valid-wear time (hours/day)	12.83 ± 0.88	10.75 – 14.91

Note: MVPA = moderate-to-vigorous physical activity, ST = sedentary time, BMI(SDS) = body mass index (standard deviation score)

Table 5.2

Pearson correlations between psychological variables, daily MVPA and ST

Variables	1	2	3	4	5
1. Autonomy support					
2. Controlling coach behaviour	-.32**				
3. Autonomous motivation	.58**	-.23*			
4. Controlled motivation	-.12	.42**	-.07		
5. MVPA	.14	-.11	.22*	.13	
6. ST	-.01	.04	-.09	-.07	-.46**

Note: * = p < .05, ** = p < .01

MVPA = moderate-to-vigorous physical activity, ST = sedentary time

Path analysis

The hypothesised model demonstrated an excellent fit to the data (Figure 5.2; χ^2 (14) = 18.64, p = .18, CFI = .98, RMSEA = .06, SRMR = .07). Perceptions of coach-provided autonomy support positively predicted autonomous motivation, which in turn, positively predicted daily MVPA and negatively predicted ST. Perceptions of controlling coach behaviour positively predicted controlled motivation. Controlled motivation was unrelated to MVPA and ST. Perceptions of autonomy support and controlling coach behaviour were not associated with controlled motivation and autonomous motivation, respectively. The 95% bootstrap-generated bias-corrected confidence intervals revealed perceptions of coach-provided autonomy support had a significant positive indirect effect on MVPA (unstandardised β = 4.90 [95% CI = .11 to 9.75]), and a significant negative indirect effect on ST (unstandardised β = -9.90 [95% CI = -20.35 to -.27]), via autonomous motivation. Squared multiple correlations indicated perceptions of coach-provided autonomy support accounted for 18.1% of the variance in autonomous motivation. Perceptions of coach-provided autonomy support and autonomous motivation together explained 4.9% of the variance in PA behaviours (MVPA = 3.3% ST = 1.6%). Significant path coefficients can be interpreted to indicate that every standard deviation unit increase in autonomous motivation (i.e., 0.65) is associated with an increase in daily MVPA by 4.82 minutes per day, and a reduction in daily ST of 9.87 minutes per day. Over a week, this equates to an extra 34 minutes of MVPA, and over 1 hour (69 minutes) less ST.

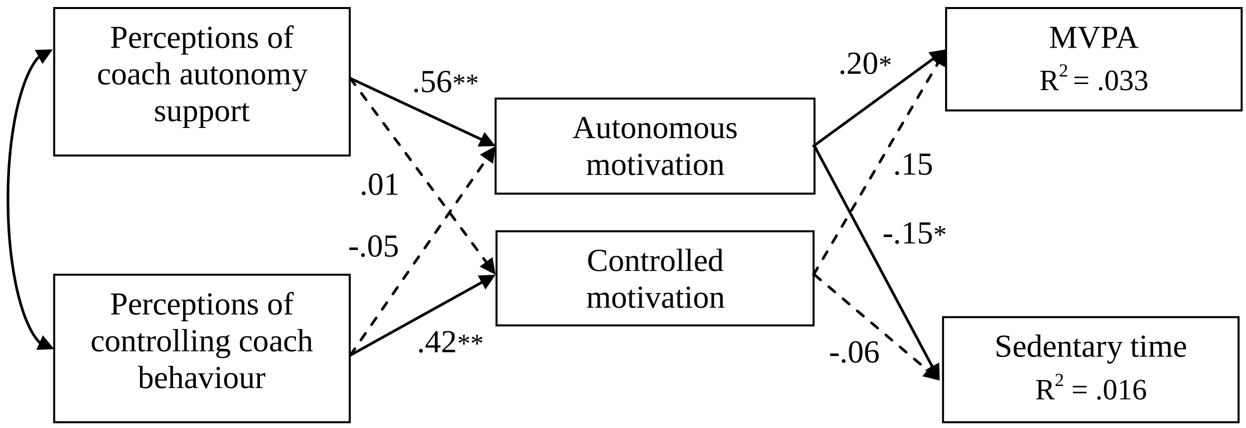


Figure 5.2 Data fit to the hypothesised model

Note: ** *p* = <.01, * *p* = <.05. Dashed lines indicate a non-significant relationship (*p* >.05).

Age and valid wear time were also included as endogenous variables in the model. Previously identified confounding relationships were controlled for by stipulating direct paths between *a)* valid wear time and MVPA, *b)* valid wear time and ST *c)* age and ST, *d)* age and valid wear time. These relationships are excluded from the figure to allow ease of interpretation.

MVPA = moderate-to-vigorous physical activity

Discussion

Grounded in self-determination theory (Deci & Ryan, 1987; Deci & Ryan, 2000), this is the first study to test the relationships between perceptions of the autonomy supportive and controlling features of the coaching environment, player motivation regulations to participate, and accelerometer assessed daily MVPA as well as ST. Results are in line with the theoretical tenets of SDT, and demonstrated perceptions of coach-provided autonomy support to positively correspond to autonomous motivation towards sport and active games. In turn, autonomous motivation was positively associated with daily MVPA and negatively predicted daily ST in youth sport footballers. Perceptions of controlling coach behaviour were significantly and positively associated with controlled motivation. However, controlled motivation towards sport and active games was unrelated to both daily MVPA and ST.

The present study builds upon existing research by extending findings from the PE context to an important setting for PA promotion outside the school environment, namely youth sport. It is the first to demonstrate that the social environment created in the youth sport setting is linked to daily levels of MVPA and ST. Given growing evidence for a positive relationship between MVPA and markers of obesity and cardio-metabolic risk, and a negative association between ST and these same health indicators (Gaya et al., 2009; Henderson et al., 2012; Mitchell et al., 2013; Sardinha et al., 2008), findings have important health implications for the millions of children active within youth sport settings.

Present results indicated that for every increase in autonomous motivation by one standard deviation (i.e., 0.65), MVPA would increase by almost 5 minutes per day (approximately 35 minutes per week). These findings are consonant with the work of Sebire et al., (2013) who reported an increase in intrinsic motivation (the quintessential form of autonomous motivation) by the same amount (i.e., SD = 0.65) would have equated to an increase in MVPA of 4.45 minutes per day. Reflecting a new contribution to the literature, findings also revealed autonomous motivation to be negatively related to daily ST. In particular, for every SD increase in autonomous motivation, ST would decrease by approximately 10 minutes per day (over an hour per week). The clinical significance of the present findings can be illustrated when we consider past work investigating the associations between MVPA, ST and health. Research has demonstrated an additional 10 minutes of MVPA is reported to be associated with a 6% to7% reduction in biomarkers of insulin sensitivity. Conversely, an additional 10 minutes of ST per day is associated with up to a 2% to 4% increase in these same biomarkers (Henderson et al., 2012). Moreover, data from the International Children's Accelerometry Database (ICAD) demonstrated an additional 10 minutes of MVPA per day is associated with a 0.5cm decrease in waist circumference (Ekelund et al., 2012). A recent study reported that for every 1cm increase in waist circumference, the odds of having levels of Alanine aminotransferase (a marker of the metabolic syndrome) above those associated with increases in insulin sensitivity and central adiposity, increased by 1.06 (Trilk et al., 2013). Thus, present results suggest that fostering autonomous motivation towards sport and active games may contribute towards increasing daily MVPA and reducing ST towards levels which may lead to clinical health benefits. However, longitudinal studies and, in particular, intervention studies are necessary to determine whether increasing autonomy supportive coaching behaviours corresponds to increased levels of MVPA and reduced ST among youth sport participants.

Akin with previous studies (Cox et al., 2008; Hagger et al., 2009; Owen et al., 2013; Standage et al., 2012), present results demonstrated domain specific autonomous motivation fostered within a specific youth PA context (i.e., youth sport) was related to engagement in PA outside this setting (i.e., daily MVPA). Thus, findings suggest the presence of a trans-contextual effect, indicating that motivation towards sport and active games cultivated in the youth sport setting, was related to engagement in MVPA and the time spent in sedentary pursuits across multiple contexts. Past work has indicated MVPA accrued during youth sport is not sufficient to meet recommended guidelines (Leek et al., 2011). As such, children and adolescents need to engage in additional MVPA outside the youth sport environment to achieve recommended levels. The presently observed trans-contextual associations may therefore have implications for increasing daily MVPA towards levels identified as being beneficial for health among sport participants. Our findings suggest that if the coach-created climate is perceived by players to be more autonomy supportive, and young football players are more autonomously motivated, then they are more likely to exhibit higher levels of daily MVPA. These results are in line with Vallerand's hierarchical model of motivation which suggests motivation regulation for engagement in a particular behaviour (e.g., PA) can generalise across life domains (e.g., sport, the home, school) (Vallerand, 1997). Whilst we did not measure participants' motivation towards PA across other contexts in this study, other research has demonstrated motivation towards PA (and subsequent PA engagement) to transfer across contexts. For example, Standage et al., (2012) reported autonomous motivation towards PE to be positively related to autonomous motivation towards exercise related PA, which in turn, was positively associated with 4 day pedometer step count (i.e., total PA). Current and past findings therefore indicate that autonomous motivation fostered by the social environment created within different youth PA settings (e.g., PE and youth sport) is likely an important determinant of PA engagement outside the immediate PA context. Future studies should seek to determine whether motivation towards sport and physically active games predicts autonomous motivation towards PA across other contexts.

We also observed autonomous motivation towards sport and physically active games to exhibit a negative trans-contextual association with ST. The present findings serve an important first step in determining how quality of motivation in one setting, may relate to engagement in ST outside of this setting. As such, results highlight the potential of youth sport as a domain through which levels of ST may be reduced among youth. That is, results suggest that enhancing autonomous motivation towards sport and active games may offer an avenue through which ST can be attenuated among youth sport participants. However, important to note is that autonomous motivation accounted for 1.6% of the variance in ST. Thus, it is likely that other psychosocial variables are influencing young footballers' time spent in sedentary activities.

The finding that autonomous motivation towards sport and active games was related to both MVPA and ST (positively and negatively, respectively) also warrants further discussion. Specifically, results may indicate that these two behaviours are somewhat related among the current sample of youth sport footballers, and that higher levels of MVPA may correspond to lower levels of ST in this group of children and adolescents. Indeed, research among youth has indicated that where engagement in MVPA is increased, time spent sedentary is reduced (Epstein et al., 2005; Loucaides et al., 2011). Whilst this opposes studies suggesting that these two behaviours are independent (Biddle et al., 2009), the correlation between MVPA and ST observed in the present research is higher than that reported in population based studies of youth (Biddle et al., 2004; Ekelund et al., 2012). In addition, our findings indicated youth sport participants spent approximately 72% of their day engaged in MVPA or ST. Thus, it may be that when not engaged in sport and active games, youth sport participants are likely to be engaged in ST. However, important to note is that the present correlation between MVPA and ST (r = -0.46) indicates there is a substantial portion of the variance in ST that cannot be explained by engagement in MVPA.

This study makes a further novel contribution to the literature, demonstrating the presence of a significant indirect effect of perceptions of coach-provided autonomy support on daily MVPA and ST via autonomous motivation. Results therefore support the basic tenets of SDT, underlining the central role of autonomous motivation for encouraging adaptive behavioural outcomes (i.e., PA engagement). Previous studies conducted in the PE setting report contradictory findings to present results, revealing no significant indirect effect of teacher-provided autonomy support on PA engagement via motivation regulations for PE or leisure time (Standage et al., 2012; Vierling et al., 2007). Contrasting findings may result from inconsistencies in terms of the variable used to represent differences in motivation regulations. The present study focused specifically on autonomous motivation representing intrinsic and identified regulations, whereas past research which examined indirect effects have employed a relative autonomy/self-determination index (Hagger et al., 2009; Standage et al., 2012). Thus, differing findings might indicate perceptions of autonomy support are related to PA engagement via a positive association with autonomous motivation, rather than a negative association with controlled motivation. Such detailed information is lost when a self-determination index is employed.

The current study is also the first to investigate the motivational processes through which perceptions of a controlling interpersonal style may be related to objectively assessed MVPA and ST among youth. Past research conducted in youth sport and PE settings has largely focused on investigating the role of perceptions of autonomy support as an antecedent of motivation and related outcomes, neglecting to examine the possible deleterious consequences of controlling behaviours (Bartholomew et al., 2011). Our findings revealed perceptions of controlling coach behaviour to be positively related to controlled motivation, but unrelated to autonomous motivation. Controlled motivation, in turn, was unrelated to daily MVPA and ST. Results are in line with previous studies demonstrating perceptions of controlling behaviours to be more strongly related to motivation regulations which fall lower on the self-determination continuum (i.e., introjected or external motivation) (Deci & Ryan, 1987; Deci, Eghrari, Patrick, & Leone, 1994; Pelletier et al., 2001). Indeed, SDT posits that perceptions of a controlling interpersonal style are related to less overall internalisation and more controlled motivation (Ryan & Deci, 2000). However, in contrast to present findings, a recent study demonstrated controlled motivation towards leisure time PA to be negatively related to leisure time MVPA (Owen et al., 2013). Differing findings may be due to the fact analysis was only conducted at the bivariate level in the previous study. Future studies should aim to further investigate the potentially maladaptive consequences of controlling interpersonal styles and controlled motivation in the context of PA engagement among youth within and across PA-related settings. Further, in explicating the lack of significant relationships between controlled motivation and daily MVPA and ST in the present study, the cross-sectional design employed should be kept in mind. Longitudinal studies have demonstrated controlled motivation to be related to dropout among sport participants (García Calvo, Cervelló, Jiménez, Iglesias, & Moreno Murcia, 2010). Thus, in the long term, controlled motivation may result in lower levels of MVPA (and perhaps increased ST) as a result of discontinued sport engagement (Kjonniksen, Anderssen, & Wold, 2009; Nelson et al., 2011).

Whilst present results highlight the value of the youth sport setting as a context for PA promotion, youth sport is only one setting in which children and adolescents have the opportunity to be physically active during a typical week. Consequently, the psychosocial factors operating in this environment are likely one of many influences on daily/weekly levels of PA engagement and ST pursuits. In line with this, the theoretical model tested in the present study accounted for only 3.3 % of the variance in daily MVPA, variance similar to that reported by Sebire et al., 2013, who demonstrated intrinsic motivation to account for 4% of the variance in daily MVPA among youth (Sebire et al., 2013). Such findings point towards the importance of considering the broader context of youth PA, i.e., the many social, psychological and physical-environmental factors (e.g., teachers, parents, peers, the built environment) operating within various settings in which children have the opportunity to be physically active (e.g., sport, PE, the school yard, the home, recreational environments). Research exploring the salience of such factors across a variety of youth PA settings will help to identify malleable targets for interventions aimed at increasing PA engagement in youth. As such, a more comprehensive approach to PA promotion among youth is likely to be most effective towards increasing daily MVPA and reducing ST towards levels identified as being beneficial for health.

A notable strength of the current study is the use of accelerometers to measure PA. Accelerometers provide a more accurate, objective assessment of PA over and above that of self-report measures (Trost, 2007), and allow researchers to quantify intensity and frequency of PA. Moreover, the analytical approach adopted enabled a model to be tested that adjusted for significant associations between accelerometer wear time, age and MVPA and ST. Previous studies that have not controlled for these relationships may have overestimated the variance accounted for in PA behaviours by motivation (e.g., Standage et al., 2012). Thus, present results may reflect a more accurate representation of the potential influence of quality of motivation on engagement in PA relative to existing research.

Certain considerations should be made when interpreting current findings. Youth sport football was the sport examined due to the potential for widespread application of findings to large numbers of youth sport participants across the globe. However, caution should be taken before generalising current findings to other sports. In addition, a lack of access to and interest from female football teams regarding participation in the study resulted in an exclusively male sample. Nevertheless, the basic tenets of SDT are not assumed to differ as a function of gender, and previous research investigating the relationships between perceptions of autonomy support, motivation regulations and PA measured by pedometers, reported model fit was invariant across samples of male and female youth (Standage et al., 2012). Future research should seek to replicate the present research via the inclusion of both males and females from a variety of different sports. Further, the cross-sectional design of this study limits inferences concerning the direction of causality. For example, it is possible that a coach's interpersonal behaviour may be influenced by a player's motivation. Therefore, it is important to replicate the present study employing a longitudinal design to explore the targeted relationships over time. Finally, whilst this study makes an important contribution to the literature regarding the role of motivation towards sport for reducing ST in leisure time, findings do not allow speculations to be generated regarding how perceptions of the social environment created in youth sport might be linked to time spent engaged in specific sedentary pursuits (e.g., TV viewing, video games, and computer use). Future studies would do well to employ a mixed methodology, combining self-report measured of sedentary behaviour and accelerometer assessed ST in order to further understand the implications of youth sport participation for children's engagement in sedentary behaviours (Sebire, Jago, Gorely, Hoyos Cillero, & Biddle, 2011).

In conclusion, extending findings focused largely within the PE context, our results suggest that more autonomy supportive environments within youth sport appear conducive to higher levels of autonomous motivation towards sport and active games, and are associated with more positive PA-related behaviours (i.e., higher engagement in MVPA and less ST per day) in this sample of young male footballers. Thus, encouraging autonomy supportive behaviours among youth sport coaches may hold implications for increasing daily MVPA towards recommended guidelines and reducing daily ST in youth. Overall, this study points to the promise of the youth sport setting as a context for PA promotion (and sedentary time reduction) among children and adolescents.

CHAPTER 6

GENERAL DISCUSSION

Overview

The overarching aim of this thesis was to investigate the value of youth sport football as a context to enhance levels of physical activity (PA) engagement and its relevance as a setting for obesity prevention among youth. Specifically, the aims of this thesis were two fold. First, to determine levels of moderate-to-vigorous physical activity (MVPA), vigorous physical activity (VPA) and sedentary time (ST) associated with youth sport football participation and associations with obesity linked health outcomes (Studies 1 and 2). Second, to examine relationships between psychosocial factors operating in the youth sport setting and levels of PA engagement ST among youth sport football participants (Studies 3 and 4). Figure 6.1 illustrates the contribution of the present thesis to these areas of research.

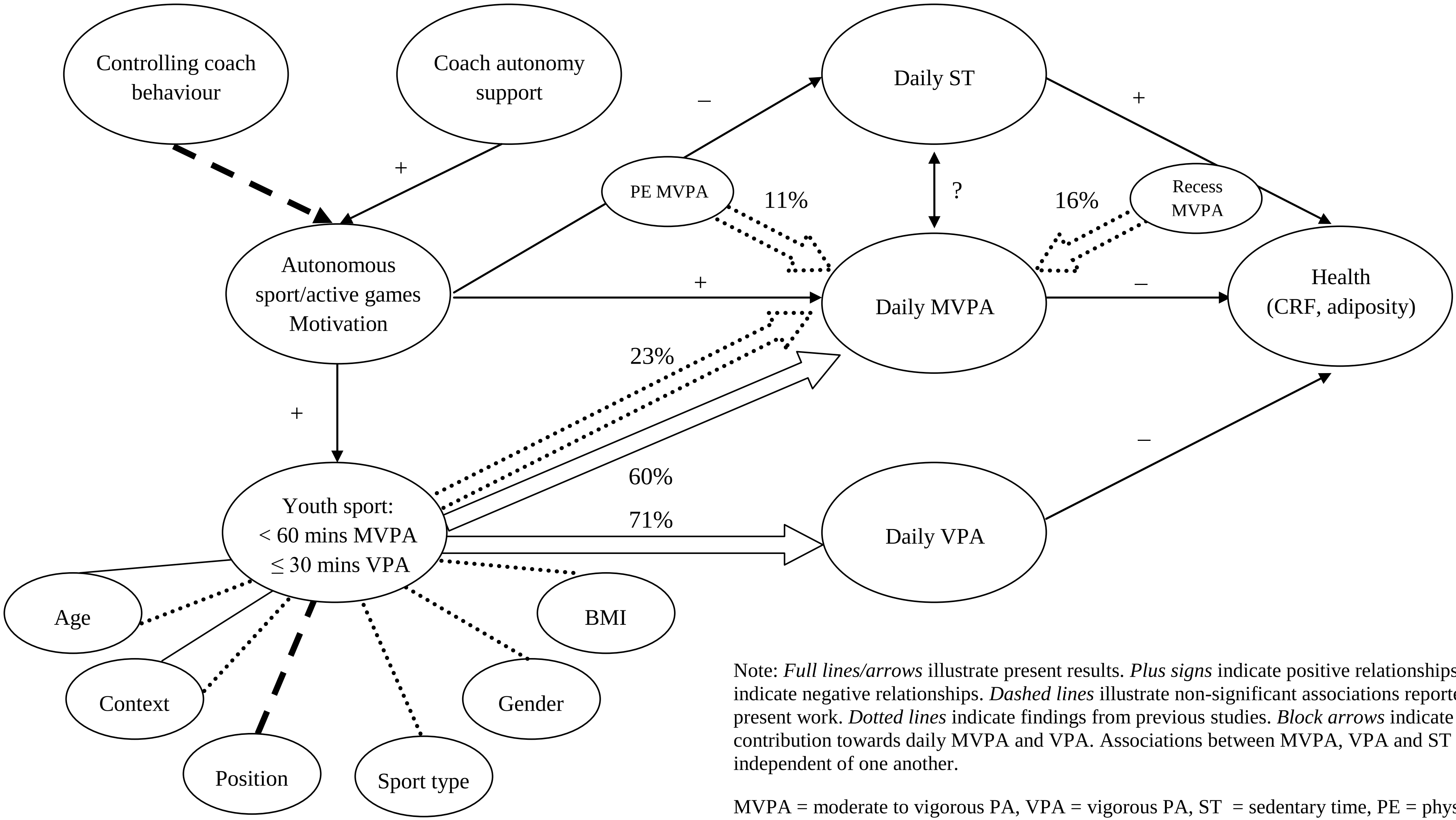
Results highlight that whilst the youth sport environment offers male children and adolescents the opportunity to engage in substantial amounts of MVPA and VPA, variability in levels of PA engagement (both within and outside the youth sport context) and daily ST among youth sport football participants is apparent. Moreover, variability in daily PA and ST is related to indicators of adiposity and cardiovascular risk, underlining the necessity to identify avenues through which PA engagement can be encouraged and ST reduced in these groups of youth. In line with this, findings revealed more autonomy supportive youth sport environments are likely to encourage higher levels of PA engagement and less ST among youth sport footballers.

Overall, the results of this thesis suggest the youth sport setting has the potential to play an important role in advancing levels of PA engagement and reducing ST among youth. However, the creation of more adaptive youth sport environments may help to further optimise the youth sport setting as a context for PA participation and associated implications for young people's health. Such an approach may contribute towards preventing the development of overweight and obesity in children and adolescents active among the youth sport setting. The final chapter of this thesis discusses the main results presented herein, and considers the practical implications of these findings. Future research questions brought to light by the findings presented by Studies 1 to 4 (Chapters 2 to 5) are identified, and limitations to these investigations are discussed.

Summary of research findings

Youth sport football: physical activity engagement and associations with obesity linked health outcomes

As previously highlighted, few studies have utilised accelerometers to determine levels of PA engagement associated with youth sport participation. Thus, conclusions regarding the opportunity offered by youth sport for engagement in MVPA and VPA, and daily levels of PA engagement among youth sport participants are based on a small body of evidence. In addition, the majority of existing youth sport studies have employed age-dependent cut-points to determine levels of MVPA and VPA (Guagliano, Rosenkranz, & Kolt, 2012; Leek et al., 2011; Machado-Rodrigues et al., 2012; Wickel & Eisenmann, 2007). Consequently, existing studies may have overestimated daily and youth sport PA levels among youth sport participants where studies included participants that were ≤ 10 years of age (Trost, Loprinzi, Moore, & Pfeiffer, 2011). Studies 1 and 2 therefore address an important limitation to previous research, analysing accelerometer data with respect to the single value cut points devised by Evenson et al., (2008). As such, levels of MVPA and VPA reported throughout this thesis are likely to more accurately reflect the frequency, intensity and duration of PA engagement among youth sport football participants.



Note: *Full lines/arrows* illustrate present results. *Plus signs* indicate positive relationships. *Minus signs* indicate negative relationships. *Dashed lines* illustrate non-significant associations reported in the present work. *Dotted lines* indicate findings from previous studies. *Block arrows* indicate the contribution towards daily MVPA and VPA. Associations between MVPA, VPA and ST were not independent of one another.

MVPA = moderate to vigorous PA, VPA = vigorous PA, ST = sedentary time, PE = physical education, CRF = cardiorespiratory fitness.

Figure 6.1 Youth sport as a context for physical activity promotion: the contribution of the present thesis

Youth sport football as a source of physical activity

The first study (Chapter 2) within this thesis examined duration of engagement in MVPA and VPA during youth sport football among males aged 9 to 16 years. A particular focus of Study 1 was to examine the value of youth sport football as a source of weekend PA. Specifically, the contribution of youth sport MVPA and VPA towards total daily MVPA and VPA on a weekend day was examined. Adding a further novel contribution to the literature, this study also investigated variability in youth sport football MVPA and VPA with reference to participant age and playing position.

Results from Study 1 indicated youth sport football participants engaged in 52 and 28 minutes of MVPA and VPA, respectively, during youth sport football. Findings therefore indicate that participation in youth sport football may offer boys (aged 9 to 16 years) the opportunity to engage in levels of MVPA and VPA towards those which past research has indicated to be beneficial for health (Mark & Janssen, 2011; Martinez-Gomez et al., 2010; Strong et al., 2005). Past studies investigating duration, intensity and frequency of engagement in PA across different sports have reported lower absolute levels of MVPA and VPA to be accumulated during youth sport (Guagliano et al., 2012; Leek et al., 2011; Sacheck et al., 2011; Wickel & Eisenmann, 2007). However, when the length of the youth sport session is taken into account, percent time spent in MVPA is reported to be similar across studies (Guagliano et al., 2012; Leek et al., 2011; Wickel & Eisenmann, 2007). The present study reported youth sport football participants spent 48% of time engaged in MVPA, comparable to results reported by Leek et al., (2011) (i.e., 49%) and Wickel et al., (2007) (i.e., 46%). The higher levels of MVPA and VPA observed in the present work may be attributable to longer youth sport sessions. Nevertheless if we consider that MVPA and VPA may have been overestimated in past studies utilising age-dependent cut points, present results suggest that youth sport football in particular may be more conducive than some other youth sports for encouraging engagement in MVPA and VPA. Indeed, Leek et al., (2011) reported soccer (football) participants to engage in higher levels of MVPA and VPA during youth sport than softball/baseball participants. Future studies could aim to characterise levels of MVPA and VPA engagement within different sports utilising the Evenson et al., (2008) cut points.

To date, no studies have examined the contribution of youth sport towards daily VPA, nor have they examined the contribution of youth sport towards levels of both MVPA and VPA accrued on a weekend day (i.e., daily weekend MVPA and VPA). The importance of determining the main activities undertaken during VPA, particularly at the weekend, has been emphasised (Steele et al., 2010). Results from Study 1 revealed that youth sport contributed 71% towards daily weekend VPA (Figure 6.1), suggesting this activity domain may offer an important source of VPA at the weekend. Only one other study has examined the contribution of accelerometer-assessed youth sport MVPA towards total daily MVPA. Wickel and colleagues (2007) investigated the contribution of youth sport towards daily MVPA on a weekday and reported youth sport to contribute 23% towards total weekday MVPA (Figure 6.1). Thus, the higher contribution observed in the present study towards weekend MVPA, may indicate that youth sport is a more principal source of MVPA on a weekend day than compared to during the week. Indeed, other structured opportunities for PA engagement are offered regularly throughout the day during the week (e.g., PE and recess) (Ridgers, Timperio, Crawford, & Salmon, 2012; Wickel & Eisenmann, 2007) and have been shown to contribute 27% (PE = 11%, recess = 16%) towards weekday MVPA in youth sport participants (Wickel et al., 2007).

Importantly, results from this study also underlined the necessity to acknowledge youth sport as a principle source of levels of health-enhancing PA accumulated across the week. Findings revealed a single youth sport session at the weekend contributed approximately 10% and 15% towards total weekly engagement in MVPA and VPA respectively. These contributions towards weekly PA are comparable to those reported for other youth PA setting (e.g., PE, active transport, school breaks/recess) towards only total daily MVPA and VPA. As such, findings from Study 1 further highlight the value of weekend youth sport as an important source of MVPA and VPA for children and adolescents. However, important to note is that little research to date has examined the potential value of unstructured PA (e.g., active play/free play) as a source of health enhancing PA, and its contribution towards daily or weekly MVPA or VPA. Indeed, the few studies that have explored PA levels associated with active play have revealed this type of PA is likely an important source of PA above a moderate intensity for children and adolescents (Belecastro et al., 2012; Brockman et al., 2010; Janssen et al., 2014). For example, Brockman et al., 2010) reported frequency of active play across the week was positively associated with engagement in MVPA in children aged 10 to 11 years during the week. Certainly, the self-directed and unstructured nature of free play means it is likely conducive to regular participation, perhaps for long periods of the day. As such, active play as a source of MVPA and VPA relative to other organised opportunities for PA engagement among youth (e.g., PE, youth sport) should be further examined (Janssen, 2014).

Study 1 also revealed that whilst youth sport football may offer the opportunity to accrue substantial amounts of MVPA and VPA, a degree of variability between participants exists with respect to PA accumulated within this setting. Specifically, results revealed that whilst average levels of MVPA approached recommended guidelines, only 37% of participants accrued ≥ 60 minutes of MVPA during youth sport. Thus, results indicate that whilst for some, participation in youth sport football may advance PA participation towards recommended levels, for a number of participants, participation alone may not be enough to promote levels of MVPA engagement required to accrue positive benefits to health. Although the use of differing accelerometer cut points somewhat precludes comparisons across studies, current findings are in line with those of Leek et al., (2007) who reported only 24% of participants met recommended guidelines for MVPA during youth sport engagement.

Study 1 is the first to examine levels of VPA participation during youth sport with respect to levels which have demonstrated associations with health. Results revealed 70% of participants accrued ≥ 20 minutes of VPA, levels reported to reduce the risk of overweight and obesity in male European youth (Martinez-Gomez et al., 2010). Thus, youth sport football participation may promote participation in VPA towards levels required to prevent the development of excess adiposity. However, whilst 20 minutes of VPA has been demonstrated to confer positive health benefits, this cut-off is based on the results of a single study. Additional research is necessary to determine levels of VPA required to prevent overweight and obesity among children and adolescents. Certainly, longitudinal studies are necessary to determine daily levels of VPA participation that are conducive to maintaining a healthy weight among youth. Moreover, the evidence base informing guidelines for MVPA demonstrates engagement in MVPA for at least 60 minutes per day is associated with positive health benefits among youth (Janssen & Leblanc, 2010; Strong et al., 2005). Thus, given that almost half of youth sport football session time was spent engaged in PA below a moderate intensity, results suggest there is scope to increase the duration of engagement in MVPA and VPA during youth sport to further optimise young people's sport participation. Maximising youth sport as a context for PA engagement will help to contribute towards more youth achieving recommended levels of MVPA, and higher daily VPA on days in which youth sport is participated in.

A final important finding from Study 1 was that both youth sport football MVPA and VPA, and the contribution of youth sport football to daily weekend and total weekly MVPA and VPA, varied as a function of age but not playing position (Figure 6.1). Specifically, adolescents (participants aged 13 to 16 years) engaged in higher levels of MVPA and VPA (total minutes and percent time) during youth sport football than children (participants aged 9 to 12 years). In addition, youth sport football contributed a significantly greater amount towards daily weekend MVPA and VPA for older compared to younger participants. Findings therefore indicate that youth sport football may encourage higher levels of engagement in MVPA among adolescent participants, whereas younger participants may benefit most from efforts aimed at maximising MVPA engagement within this setting. In addition, results indicate youth sport football may offer a valuable context for engagement in MVPA and VPA as children progress into the adolescent years. By contrast, the lack of significant differences observed across playing positions in Study 1 suggests participation in youth sport football is likely to offer similar opportunity for PA engagement for youth who participate as strikers, midfielders, defenders or goal keepers.

The relationship between physical activity, sedentary time and health in young male grassroots footballers

Study 2 (Chapter 3) built upon findings from Study 1, more critically examining daily PA levels of youth sport footballers and determining associations with obesity linked health outcomes. More specifically, Study 2 examined the variability in daily MVPA, VPA and ST among youth sport participants and associations with indicators of adiposity and cardiovascular risk (Figure 6.1). Importantly, Study 1 also sought to determine independent associations between MVPA, VPA and ST with these health outcomes in order to determine whether the potential benefits of engaging in MVPA and VPA may be negated by the high levels of ST reported among these youth sport football participants. To date, no previous investigations have examined these associations in youth sport participants. In addition, Study 2 constitutes the first investigation to characterise levels of accelerometer-assessed PA engagement alongside objective markers of general and central adiposity (i.e., percent body fat and waist circumference) and cardiovascular fitness in a sample of youth sport participants.

Results from Study 2 indicated that daily MVPA and VPA ranged from 27 to 146, and 6 to 63 minutes per day, respectively. In addition, whilst daily MVPA was above 60 minutes per day, only 14.5% of participants met guidelines for MVPA on every day for which valid PA data was recorded. Moreover, daily ST was reported to be between 7 and 8 hours per day [range 306 to 588 minutes (5.1 to 9.8 hours)]. This is the first study to determine daily compliance with guidelines for objectively assessed MVPA and to examine daily variability in duration of engagement in MVPA, VPA and ST among youth sport participants. Results suggest that a number of participants may be at risk of not regularly engaging in levels of MVPA towards recommended levels, and that some youth sport football participants may also spend large proportions of the day sedentary.

Variability in daily MVPA, VPA and ST was associated with variability in levels of adiposity and CRF in Study 2. Specifically, results revealed negative associations between MVPA and VPA with indicators of adiposity, and positive associations between MVPA and VPA with CRF, with the reverse being evident for ST (Figure 6.1). Parallel relationships have been observed in numerous population based studies of children (Dencker & Andersen, 2008; Janssen & Leblanc, 2010; Mitchell, Pate, Beets, & Nader, 2013; Must & Tybor, 2005). Moreover, levels of adiposity observed in the present study are similar to those reported in population based studies of youth across Europe (Collings et al., 2014; Ekelund et al., 2012; Woods et al., 2010). Consequently, findings from Study 2 indicate patterns of engagement in PA and ST among youth sport football participants, and the implications held for health, reflect those observed among general populations of children and adolescents. That is, youth sport football participants represent a group of children who may be at risk of engaging in levels of MVPA, VPA and ST that are adversely associated with markers of obesity and cardiovascular disease. Results therefore indicate the need to increase levels of engagement in MVPA and VPA and reduce ST among youth sport football participants, and underline the importance of enhancing the role of youth sport setting as a context for obesity prevention.

Important to note is that findings from Study 2 also indicated that the associations between MVPA, VPA and ST were co-dependent (i.e., they were not independent of one another). Thus, the results suggest that high amounts of ST engaged in by some participants may negate the possible health benefits that are likely to result from engaging in MVPA and VPA. Interestingly though, Study 2 findings revealed the magnitude of the associations between ST and indicators of adiposity and cardiovascular risk were greater than observed for MVPA and VPA. In other words, the present results suggest ST may be more strongly related to adiposity and CRF in male youth sport football participants aged 9 to 15 years than MVPA or VPA.

Optimising the youth sport context for physical activity engagement

Few studies to date have examined factors related to levels of PA engagement among youth sport participants. Past research has focused largely on how individual and contextual level factors are linked to engagement in MVPA. For example, studies have demonstrated PA levels during youth sport to differ as a function of age, gender, BMI, sport type and context (i.e., training sessions versus matches) (Guagliano et al., 2012; Leek et al., 2011; Sacheck et al., 2011; Wickel & Eisenmann, 2007). Whilst these studies allow identification of children who are likely to benefit least from their youth sport participation (e.g., the least active), and point towards objective contextual factors which may affect levels of youth sport PA engagement, they have neglected to examine the social and psychological factors (e.g., the social environment, motivation) likely to be effective avenues for PA promotion among youth sport participants. Adopting a SDT perspective (Deci & Ryan, 1987; Deci & Ryan, 2000), the main aims of Studies 3 (Chapter 4) and 4 (Chapter 5) were to examine the social-psychological factors operating within the youth sport football setting with respect to levels of engagement in MVPA and VPA during youth sport football (Study 3), and daily MVPA and ST among youth sport football participants (Study 4).

Social-psychological factors related to physical activity engagement during youth sport football

Study 3 examined the within-context associations between the social environment, motivation towards football participation, and PA engagement during youth sport football. In particular, the relationships between perceptions of coach behaviour (autonomy supportive versus controlling), motivation regulations (autonomous versus controlled) and engagement in MVPA and VPA during youth sport football were investigated. To date, past research examining these associations have been conducted largely within the PE context and has neglected to examine the hypothesised processes postulated by SDT (Aelterman et al., 2012; Lonsdale et al., 2013; Owen, Astell-Burt, & Lonsdale, 2013; Perlman, 2013). Moreover, existing studies have not included VPA as a separate outcome, focusing only on engagement in MVPA. Study 3 therefore extends the literature by investigating the motivational processes theorised by SDT in an important youth PA setting outside the school environment. More specifically, Study 3 determined whether the social environment created by the youth sport coach (and ensuing motivation regulation) is related to engagement in both MVPA and VPA during youth sport football sessions (i.e., training sessions and matches).

Results demonstrated perceptions of coach-provided autonomy support were positively related to autonomous motivation towards football, which in turn, was positively linked to engagement in MVPA during youth sport football time (Figure 6.1). Further, there was a significant positive indirect effect of perceptions of coach–provided autonomy support on MVPA via autonomous motivation. Thus, findings suggest that where players perceive their coaches to be more autonomy supportive, they are more likely to experience higher levels of autonomous motivation towards their football participation, and consequently, this is related to more time spent engaged in MVPA during youth sport football sessions. Findings from Study 3 also revealed that whilst the direct relationship between autonomous motivation and VPA was not significant, there was a significant indirect effect of perceptions of coach-provided autonomy on VPA during youth sport via autonomous motivation. Results from Study 3 therefore also suggest that where coaches adopt a more autonomy supportive interpersonal style, higher levels of engagement in VPA within youth sport football setting may be realised.

Past work conducted in the PE context has demonstrated similar results to those reported in Study 3 indicating autonomous motivation towards PE is related to higher levels of engagement in MVPA during PE classes (Aelterman et al., 2012; Owen et al., 2013; Perlman, 2013). However, evidence for the role of the social environment in PE as an antecedent of motivation regulation is lacking. To date, only two studies have examined the social environment in relation to motivation and levels of engagement in MVPA during PE (Lonsdale et al., 2013b; Perlman, 2013). For example, Perlman (2013) reported that pupils in PE classes of those teachers trained to be more autonomy supportive engaged in higher levels of MVPA during PE, relative to pupils in controlling or ‘balanced’ (i.e., 40-60% balance between autonomy supportive and controlling statements) conditions. However, the motivational sequence outlined by SDT was not examined in either of these studies. Consequently, the extent to which changes in the social environment post-intervention were related to changes in levels of engagement in MVPA, as a result of increasing autonomous motivation, could not be determined. Study 3 therefore offers a novel addition to the literature. Firstly, this study provided support for the hypothesised motivational processes through which SDT posits the social environment is related to immediate levels of PA engagement among youth. Second, Study 3 determined the variance in levels of PA engagement that can be explained by the social environment manifested within a youth PA context and resulting implications for PA related motivation (namely, motivation towards football participation).

In line with the theoretical tenets of SDT (Deci & Ryan, 1987), there was a significant positive association between perceptions of controlling coach behaviour and controlled motivation towards football. However, controlled motivation was unrelated to engagement in MVPA and VPA. Moreover, the positive association between autonomous motivation and MVPA remained after inclusion of controlled motivation in the path model. Studies conducted in the PE context have reported similar findings, revealing autonomous but not controlled motivation to be related to in class MVPA (Aelterman et al., 2012; Owen et al., 2013). Taken together, past and present findings suggest autonomous motivation may be more strongly related to engagement in MVPA than controlled motivation. Specifically, findings from Study 3 indicate that fostering autonomous motivation for engagement in youth sport football and minimising external motives for participation may help optimise PA engagement during youth sport football sessions.

Social-psychological factors related to daily MVPA and sedentary time among youth sport footballers

Study 4 examined the theoretical associations examined in Study 3 with a focus on engagement in daily MVPA and daily ST (i.e., trans-contextual associations; (Hagger et al., 2009; Vallerand, 1997). Previous SDT-driven research examining the relationships between the social environment, motivation and daily PA engagement have again, focused almost exclusively on the PE setting (Chatzisarantis & Hagger, 2009; Cox, Smith, & Williams, 2008; Hagger et al., 2009; Standage, Gillison, Ntoumanis, & Treasure, 2012; Vierling, Standage, & Treasure, 2007). Moreover existing studies have relied largely on pedometers and self-report to assess levels of PA engagement, limiting the extent to which conclusions can be drawn concerning the potential role of the social environment in encouraging engagement in behaviours linked to obesity associated health outcomes (e.g., MVPA and ST). In addition, past research has examined the targeted motivational processes using a ‘self-determination index’ or ‘relative autonomy index’ to reflect ‘quality’ of motivation (i.e., different weights are assigned to motivation regulations, e.g., intrinsic motivation x 3 + identified regulation x 2 + introjected regulation x -1 + external regulation x -2 + amotivation x -3) (e.g., Standage et al, 2012). In studies in which this approach is adopted, the independent influence of autonomous and controlled motivation on daily PA engagement can not be understood. Consequently, the relevance of findings towards the development of interventions likely to be most effective in encouraging motivation for PA and subsequent PA engagement is limited. Therefore, Study 4 extends previous research by examining the trans-contextual associations between perceptions of the social environment created within the youth sport context, autonomous and controlled motivation towards sport and physically active games and daily engagement in MVPA and ST.

Results from Study 4 indicated that coach-provided autonomy support positively predicted autonomous motivation towards sport and active games, which in turn, was positively related to daily MVPA and negatively linked to daily ST (Figure 6.1). Thus, where coaches engage in more autonomy supportive behaviours, higher levels of autonomous motivation towards sport and active games is likely to be fostered, and more adaptive patterns of PA engagement may likely result. Findings from this study support past research conducted in the PE domain, indicating positive trans-contextual relationships between perceptions of teacher-provided autonomy support, autonomous motivation towards PE, and daily or leisure time PA (Hagger et al., 2009; Standage et al., 2012). Study 4 therefore furthers existent research specific to the PE context by extending to an important setting for PA promotion outside the school environment. That is, the results of Study 4 indicate that autonomous motivation fostered by the motivational climate created by the coach within youth sport, is likely to be an important determinant of engagement in MVPA and ST outside this environment.

Past and present findings are in line with Vallerand's hierarchical model of motivation which suggests motivation regulation for behaviour (e.g., PA) can generalise across life domains (e.g., sport, the home, school) (Vallerand, 1997). Whilst we did not measure participants' motivation towards PA across other contexts in this study, other research has demonstrated motivation towards PA (and subsequent PA engagement) to transfer across contexts (Hagger et al., 2009; Standage et al., 2012). Given that Study 1 indicated MVPA accrued during youth sport football is not sufficient to meet recommended guidelines, the presently observed trans-contextual associations may have implications for increasing daily MVPA towards levels identified as being beneficial for health among youth sport footballers. Future studies should seek to determine whether motivation towards sport and physically active games predicts autonomous motivation towards PA manifested in other contexts. Understanding these associations would help to further understand the complex motivational processes underlying engagement daily MVPA among children and adolescents active in the youth sport setting and their implications for encouraging the adoption of health enhancing PA behaviours.

The results of Study 4 also advance previous studies by indicating that perceptions of autonomy support are related to levels of PA engagement via a positive association with autonomous motivation, rather through a negative association with controlled motivation (i.e., rather than via lower levels of controlled motivation). Findings therefore further underline the central role of autonomous motivation for encouraging adaptive behavioural outcomes. Study 4 also added a novel contribution to the literature, demonstrating an indirect effect of perceptions of autonomy support on MVPA via autonomous motivation. This is the first study to report the presence of a significant indirect effect of the social environment on objectively assessed PA engagement. As a result, findings emanating from Study 4 underscore the importance of encouraging autonomy supportive behaviours among those adults central to shaping youth PA environments.

Whilst autonomous motivation was related to both MVPA and ST in the present study, controlled motivation was unrelated to both of these behaviours. Thus, controlling coach behaviour and likely ensuing participants' controlled motivation may not be related to daily PA patterns of youth sport participants. However, the cross-sectional nature of Study 4 means that the long term impact of controlled motivation on levels of engagement in MVPA cannot be ascertained. Past research though has demonstrated longitudinal associations between controlled motivation and drop out in youth sport participants (García Calvo, Cervelló, Jiménez, Iglesias, & Moreno Murcia, 2010). Thus, if we consider the opportunity offered by youth sport for engagement in MVPA, daily participation in MVPA may likely be reduced among those players who experience controlled motivation and drop out of youth sport. In addition, sport participation as a child is reported to predict higher levels of PA engagement, a lower BMI, and reduced risk of developing the metabolic syndrome during adulthood (Alfano, Klesges, Murray, Beech, & McClanahan, 2002; Cleland, Dwyer, & Venn, 2012; Kjonniksen, Anderssen, & Wold, 2009; Yang, Telama, Hirvensalo, Viikari, & Raitakari, 2009). Thus, minimising controlled motivation towards sport engagement and encouraging maintained participation in youth sport may have implications for PA engagement and associated health not only during childhood and adolescence, but also during adulthood.

Findings from Study 4 also brought to light some important questions concerning the independence of MVPA and ST among youth sport football participants. Results revealed autonomous motivation towards sport and physically active games to be a positive and negative correlate respectively of both MVPA and ST (Figure 6.1). Specifically, results suggested that among youth sport footballers, MVPA and ST may be somewhat inter-related behaviours. That is, higher levels of MVPA may correspond to lower levels of ST in this group of children and adolescents. Indeed, research among youth has indicated that where engagement in MVPA is increased, time spent sedentary is reduced (Epstein et al., 2005; Loucaides et al., 2011). Whilst this opposes studies suggesting that these two behaviours are independent (Biddle et al., 2009), the correlation between MVPA and ST observed in the present research is higher than that reported in population based studies of youth (Biddle et al., 2004; Ekelund et al., 2012). Moreover, results demonstrated participants spent approximately 72% of their day engaged in either MVPA or sedentary activity. Thus, it may be that during periods where youth sport participants are not engaged in activities that are moderate-to-vigorous in intensity requirements (e.g., sport and active games), they are likely to be engaged in sedentary pursuits (Matthews et al., 2008). Nevertheless, the correlation between MVPA and ST reported in Study 4 (i.e., r = -.46) indicates the shared variance in these two behaviours is approximately 21%, suggesting increased engagement in MVPA will not always parallel reductions in ST. Future studies should extend upon the findings reported herein and seek to identify the differential correlates of engagement in both MVPA and ST among those active in the youth sport setting. A greater understanding of the factors affecting engagement in both of these behaviours is necessary in order to elucidate avenues through which we may likely encourage PA participation and reduce engagement in sedentary pursuits among these groups of children.

Practical implications

This thesis has built upon previous studies conducted in the youth sport domain, providing a critical examination of the value of the youth sport setting as an opportunity for engagement in MVPA and VPA. The work comprising this thesis also points to the youth sport setting as a context through which engagement in these behaviours can be maximised and ST reduced. Research studies comprising this thesis suggest that, whilst youth sport offers children and adolescents an opportunity to engage in substantial amounts of MVPA and VPA, there is scope to optimise this context towards further increasing PA engagement and reducing ST. As a result, youth sport participation can play a heightened role in preventing the development of overweight and obesity among youth sport participants.

Numerous government reports advocate increasing participation in youth sport as an avenue through which the growing obesity crisis may be addressed (Centers for Disease Control and Prevention, 2000; Commission of the European Communities, 2007; NSW Department of Health, 2009). Certainly, research employing self-report methods to assess PA has demonstrated sport participants engage in higher levels of PA, and are more likely to meet recommended levels of MVPA than non-sport participants (Nelson et al., 2011; Silva et al., 2010; Woods et al., 2010). Results from Study 1 corroborate these findings, suggesting that participation in youth sport football may have implications for encouraging daily engagement in MVPA and VPA towards levels associated with reduced risk of overweight and obesity among children and adolescents. However, both Studies 1 and 2 highlighted PA levels of youth sport football participants to vary considerably both within (Study 1) and outside (Study 2) the youth sport setting, and Study 2 demonstrated youth sport football participants spend large proportions of their day spent in sedentary pursuits. For example, only 37% of participants met guidelines for MVPA during youth sport football, and 15% engaged in recommended levels of MVPA each monitored day. Moreover, the observed variability in daily MVPA, VPA and ST between youth sport participants was associated with indicators of adiposity and cardiovascular risk. Thus, some youth sport participants may be at risk of engaging in levels of MVPA and ST adversely associated with obesity linked health outcomes.

In sum, findings from Studies 1 and 2 suggest the way in which we appraise the youth sport setting as a vehicle for PA promotion and related obesity prevention should perhaps be readdressed. That is, whilst encouraging participation in youth sport may provide children and adolescents with an ideal opportunity to engage in substantial amounts of MVPA and VPA, results indicate that for some, participation alone may not be enough to promote levels of PA engagement required to accrue positive benefits to health (e.g., the prevention of overweight and obesity). The findings of Studies 1 and 2 imply that our efforts should not only be focused towards increasing participation in youth sport, but also optimising this participation to help children and adolescents increase their engagement in MVPA and VPA, and reduce their ST both within and outside the youth sport setting. Results from Study 1 indicate children and adolescents are not optimally active during youth sport football time, thus, interventions targeting the youth sport context may be a starting point to increase engagement in MVPA and VPA on sport days, helping youth sport footballers achieve recommended levels of MVPA. However, the associations reported in Study 2 indicate PA promotion efforts focused on increasing engagement in daily MVPA and reducing daily ST (i.e., habitual PA engagement) are likely central to obesity prevention among these groups of children.

Studies 3 and 4 are the first to offer insight into the motivational processes operating in the youth sport setting and their potential influence on levels of PA engagement and ST both within and outside this context. As such, results may hold implications for how we can increase levels of engagement in MVPA and VPA, and reduce daily ST among youth sport participants on both sport and non-sport days. Specifically, Study 3 adds valuable information to the literature concerning ways in which PA engagement during youth sport can be optimised. Importantly, Study 4 also highlights that interventions targeting the youth sport setting may be an effective means of increasing daily engagement in MVPA and reducing daily ST. Results suggest that where coaches adopt more autonomy supportive interpersonal styles, autonomous motivation will be fostered, and participants will spend more youth sport time participating in MVPA and VPA, and engage in more MVPA and less ST per day.

Taken together, results from Studies 3 and 4 highlight the role of the coach as a significant contributor to levels of PA engagement among youth sport participants not only within, but also outside the youth sport context. The interpersonal behaviours of youth sport coaches may therefore offer promising targets for interventions seeking to maximise the youth sport context for PA promotion. Specifically, where coaches are encouraged to adopt more autonomy supportive coaching styles, autonomous motivation will likely be enhanced, and higher daily PA engagement and reduced time spent sedentary will ensue.

Future directions

Results from the studies contained within this thesis have highlighted some important areas for future research. First, whilst findings underline the value of the youth sport setting as a context for PA promotion, youth sport is only one setting in which children and adolescents have the opportunity to be physically active during a typical week. Consequently, the psychosocial factors operating in this environment are likely to be one of many influences on daily/weekly levels of young people’s PA engagement. Indeed, the variance in youth footballers’ daily MVPA accounted for by autonomous motivation was less than 4%. As such, findings highlight the need to take a comprehensive approach when seeking to understand factors that influence PA participation among youth.

Figure 6.2 depicts a broader look at the context of youth PA engagement and highlights areas in which studies could build upon the findings presented within this thesis. Specifically, future studies may seek to examine the role of significant others besides the coach (e.g., peers, parents) with respect to fostering or undermining young people's motivation to participate within different youth PA settings. For example, whilst results indicate coach autonomy supportive behaviours are linked to more autonomous sport related motivation, we are unaware of the influence that the peer and parent behaviours (e.g., interpersonal behaviours, modelling behaviours, attitudes) may hold for levels of PA engagement within and outside the sport context (Brockman et al., 2009; Jago et al., 2011a; Jago et al., 2011b; Joesaar, Hein, & Hagger, 2012). With respect to peers, research has demonstrated that the peer-created motivational climate within youth sport is associated with motivation regulations towards sport engagement (Joesaar et al., 2012) and boys who have active friends spend more minutes in MVPA (Jago et al., 2011b). Indeed, a recent qualitative study identified, 'being with friends' as a key factor influencing children's levels of PA engagement (Tannehill, MacPhail, Walsh, & Woods, 2013). Research employing qualitative methodologies may therefore also contribute towards our understanding of the factors influencing children's participation in PA and sedentary pursuits across different domains (Tannehill et al., 2013; Thompson et al., 2010).

Research also points to the implications of the parent-created climate, and parental modelling for children's engagement in PA and sedentary behaviours (Brockman et al., 2009; Jago et al., 2011a; Jago et al., 2011c; O'Rourke, Smith, Smoll, & Cumming, 2012; White, Duda, & Hart, 1992; White, Kavussanu, & Guest, 1998). In a study of youth sport swimmers, O’Rourke et al., (2012) reported the parent-initiated motivational climate was associated with children’s degree of autonomous motivation towards swimming. In addition, social support provided by the family has been shown to be positively associated with participation in PA (Woods, Tannehill, Quinlan, Moyna, & Walsh, 2010). Concerning modelling behaviours, Jago, Fox, Page, Brockman and Thompson (2010) reported higher parental TV viewing (2 to 4 hours per day) was associated with increased risk of high levels of TV viewing (i.e., > 4 hours per day) for both boys and girls (Jago, Fox, Page, Brockman, & Thompson, 2010).

Figure 6.2 also outlines the need to determine how domain specific autonomous motivation may transfer within and across various PA environments. Indeed, the need to identify factors encouraging a positive transition from school based PA (e.g., PE and recess) to sport and beyond has been underlined (Woods et al., 2010). Examining these associations will help to elucidate important mediators though which context-specific motivation may be related to PA engagement outside the immediate youth PA setting. Initial support for such trans-contextual associations has been garnered (Hagger et al., 2009; Standage et al., 2012). However, additional studies are needed, particularly focused on understanding how domain specific motivation may impact upon more global PA motivation. Such research will help to determine the potential role of the social environment created within different youth PA settings for encouraging the adoption of positive PA habits (e.g., active transport) and higher levels of total daily PA participation.

A further important advancement of not only future studies within the youth sport domain, but other SDT grounded PA research, is to understand the role of basic need satisfaction (BNS) for fostering autonomous PA related motivation among youth (Deci & Ryan, 2000). To date, only one study has examined the role of BNS as an antecedent of PA related motivation (Sebire et al., 2013). Sebire et al., (2013) reported a positive association between BNS and intrinsic motivation towards PA, which in turn was related to higher daily MVPA. Indeed, 'lack of competence' has been cited as a reason for non-participation in sport and PA (Woods et al., 2010). In addition, examining the affective consequences of autonomous and controlled forms of motivation (e.g., enjoyment, boredom) will help to uncover possible mediating variables in the association between motivation and PA engagement. Few SDT-based studies have examined affective consequences of quality of motivation in the context of PA. However, Cox et al., (2008) reported enjoyment of activities during PE to mediate the positive association between more self-determined PE related motivation and leisure time MVPA. Moreover, Tannehill et al., (2013) reported 'experiencing fun' was an important influence on levels of PA engagement among boys and girls in primary and post primary education, across the domains of sport, PE and general PA. Such findings underline the role of affective motivational consequences in transferring positive PA behaviours across domains.

The present thesis contributed towards a growing body of research seeking to understand the correlates and consequences of sedentary behaviour among youth. However, whilst Study 2 was the first to determine associations between ST and obesity linked health outcomes among youth sport participants, we were unable to examine the extent to which engagement in specific sedentary behaviours (e.g., TV viewing) were related to health outcomes (Carson & Janssen, 2011). Similarly, in Study 4, we could not determine the degree to which sport related autonomous motivation was negatively associated with time spent engaged in different sedentary pursuits. Future studies would do well to employ a mixed methodology, combining self-report measures of sedentary behaviour (Dunton, Whalen, Jamner, Henker, & Floro, 2005), and accelerometer assessed

ST in order to further understand the implications of youth sport participation for children's engagement in sedentary behaviours and associations with health.

Building upon the results from Study 4, an important avenue of future research would be to understand the SDT-referenced motivational processes associated with engagement in sedentary pursuits (Figure 6.2). For example, to what extent is satisfaction of the need for autonomy associated with autonomous motivation towards, and engagement in computer games? Conversely, is autonomous motivation to limit TV time related to less time spent watching TV (Lubans et al., 2013)? Determining the possible psychosocial correlates of engagement in particular sedentary pursuits will help to inform future interventions which seek to reduce engagement in targeted sedentary behaviours among youth. Emerging evidence for a positive association between engagement in screen based sedentary behaviours and cardiometabolic risk factors (Carson & Janssen, 2011; Martinez-Gomez et al., 2012a; Martinez-Gomez et al., 2012c), also underscores the relevance of this line of research toward uncovering the value of SDT-based interventions for producing clinically meaningful improvements in cardiometabolic health. Of particular interest would be to further examine the extent to which 'TV time snacking' mediates the association between TV viewing and health (Cleland, Schmidt, Dwyer, & Venn, 2008; Martinez-Gomez et al., 2012a). Figure 6.2 outlines the processes by which understanding individual differences in the motivation for engagement in sedentary pursuits and related health behaviours could have implications for improving health outcomes related to obesity and cardiovascular disease among youth.

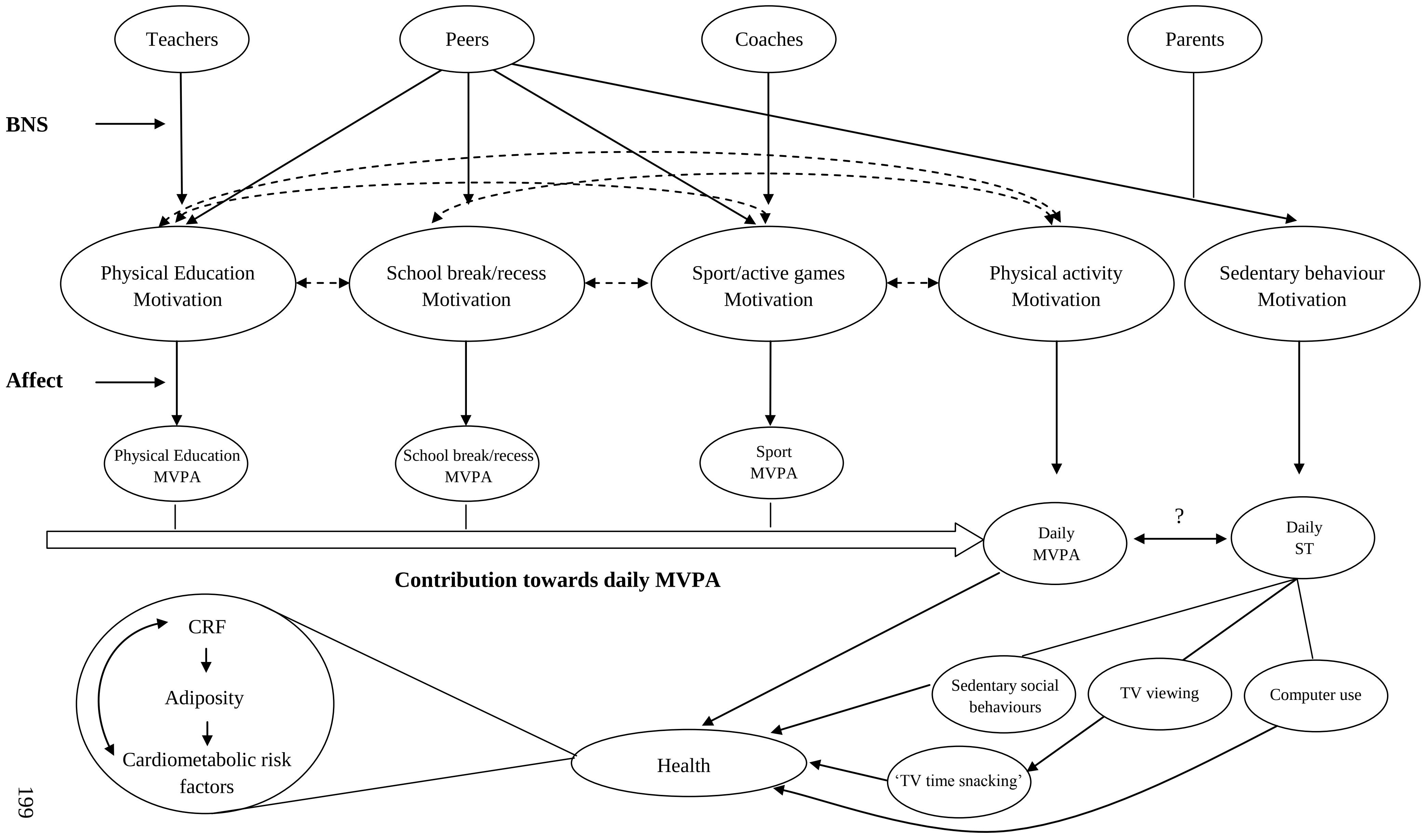


Figure 6.2 Future directions for SDT-PA research among youth

Note: *Dashed lines* indicate trans-contextual associations

Limitations

The studies within this thesis provide support for the role of youth sport as a vehicle for PA promotion and obesity prevention. Further, results underline the relevance and application of SDT (Deci & Ryan, 1987; Deci & Ryan, 2000) towards PA promotion efforts targeting the youth sport setting. However, whilst some novel findings are presented, it is important to acknowledge the limitations of the research described within this thesis when drawing conclusions.

A primary focus of this thesis was to objectively assess levels of PA engagement among youth sport participants via accelerometry. Whilst accelerometers have been advocated as the best choice to assess PA engagement in youth (de Vries et al., 2009; Trost, 2007), they are not without their limitations and complications. Accelerometers are unable to detect engagement in activities which may require high levels of physical exertion but little acceleration of body segments (e.g., stair climbing, weight lifting, cycling). As such the PA levels of individuals who regularly engage in such activities may be underestimated (Kohl, Fulton, & Caspersen, 2000; Trost, 2007). However, among child and adolescent PA studies, the contribution of these activities to daily PA is often reported to be small (Trost, 2007). Self-report data were collected in Studies 1 to 4 (via PA diaries) to aid with data cleaning, and indicated minimal engagement in activities such as cycling. Football was reported to be the main activity participated in, as revealed via the information inputted into the diaries. The nature of football requires engagement in largely ambulatory movements (i.e., jogging, running, sprinting) of which accelerometers are able to accurately detect (Trost et al., 1998). Thus, concerns regarding the underestimation of PA among participants contributing data towards the present thesis should be somewhat minimised.

Related to the use of accelerometers to assess PA engagement among youth are issues linked to protocol compliance. Studies 1 to 4 reported compliance to be between 50% and 78%. Compliance rates for Studies 1 and 3 were lower than described for studies 2 and 4. The lower compliance reported in the former investigations is likely due to extra self-report data required to determine levels of PA engagement during youth sport sessions and resulting increased participant burden. When considering ways in which accelerometer protocol compliance may have been increased presently, a recent study indicated that utilising text messages increased compliance with accelerometer protocols among secondary school students (Belton, O'Brien, Wickel & Issartel, 2013). However, whilst participant phone numbers were requested during data collections for all studies, few participants were able to provide this information. As such, attempts to increase compliance via phone calls and text message were not carried out to ensure a standardised protocol was followed where all participants were concerned.

Similar compliance rates to those observed herein have been reported among other studies in which accelerometers have been employed to measure levels of PA engagement among youth (Craig et al., 2009; Machado-Rodrigues et al., 2012). For example, the HSE 2008 reported compliance to be 48% to 49 % in boys aged 8 to 15 years. Also important to note is that the final sample sizes reported across Studies 1 to 4 are comparable to those reported in the published youth sport literature (see Table 1.1, Chapter 1, Guagliano et al., 2012; Leek et al., 2007; Machado-Rodrigues et al., 2012; Sacheck et al., 2012; Wickel et al., 2007). Nevertheless, limitations to the present thesis resulting from low compliance should be acknowledged.

First, low compliance and resulting smaller sample sizes will likely have resulted in high sampling variability. As such, the small samples in Studies 1 to 4 may mean results do not reflect those of the wider population of male grassroots footballers. This is particularly important given that PA is also highly variable in nature among this population, and may have contributed towards contrasting results when drawing comparisons with other studies. However, with the exception of age related variability in youth sport PA (Study 1), the current studies are addressing questions which have not yet been examined within the youth sport literature. In addition, given the sample size of Study 1 is comparable to that of Leek et al., (2011), (in the case of males), the contrasting results observed are less likely to result from sample size, and more likely to be related to the differences in accelerometer cut points applied employed between studies. Second, low compliance rates can also limit the nature and sophistication of the statistical tests that can be computed on the data, and as such, interesting questions may remain unanswered. Indeed, a larger sample size in Study 3 would have permitted the inclusion of BNS in the hypothesised model, which would have enabled investigation of the salience of the satisfaction of the basic needs towards promoting engagement in MVPA and VPA during youth sport. Nevertheless, the final sample size allowed for the generation of pertinent results regarding the role of quality of motivation in optimising PA engagement during youth sport.

A further issue associated with the low compliance reported in Studies 1 to 4 is the possibility of sample bias resulting from exclusion of participants with invalid data. That is, the participants retained in the final sample may not be reflective of the original sample recruited. For example, a recent study reported that overweight children, compared with normal-weight children, were more likely to provide invalid accelerometry data (Loprinzi et al., 2013). The same was also true for children who engaged in ≥ 4 hours of computer use a day compared to no computer use. Thus, where accelerometers are employed to determine levels of PA and ST, data may represent the leanest and least sedentary children within the population sampled. As a result, the associations between PA and health outcomes may be underestimated (Loprinzi et al., 2013).

To determine the occurrence of sample bias within this thesis, independent samples t-tests and chi square tests were conducted in all studies to examine differences between participants retained in the final sample and those excluded due to invalid data (PA, anthropometric and questionnaire data). Results demonstrated a certain degree of sample bias within studies 1, 2 and 3. For example, excluded participants in Study 2 had significantly lower levels of CRF. However, given that the least fit participants were excluded from analysis, the resulting sample bias may have only led to an underestimation of the strength of the association between PA and CRF. Thus, the exclusion of these participants is unlikely to have affected the probability of reporting a false significant result. In addition, sample bias relating to participants height, weight, age, BMI-classification, PA or questionnaire data (where not excluded on the basis of missing questionnaire or PA data) were not evident for studies 1 to 4. Thus, conclusions drawn are unlikely to result from the exclusion of participants with invalid data.

A further limitation to the studies comprising the empirical chapters within this thesis is the homogeneity of the sample used. Participants were largely representative of white, English, male football participants. Thus, results presented may not be generalisable to young people representing the wider ethnic distribution of the English population, females and children and adolescents who participate in other youth sports. Indeed, studies conducted within the youth sport domain highlight the multitude of factors which can affect PA engagement during youth sport (Guagliano et al., 2012; Leek et al, 2011; Sacheck et al., 2011; Wickel et al., 2007). For example, when considering the findings from Study 1 (Chapter 2), it may be that youth sport contributes a lesser amount towards daily weekend MVPA and VPA for netballers than footballers. Certainly, Leek et al., (2011) reported PA engagement during youth sport to vary as a function of sport type. Similarly, the associations reported in Study 2 (Chapter 3) may vary depending on the gender and ethnicity of the participant. Studies have indicated that whilst daily engagement in ST is high among youth, the sedentary behaviours which contribute most towards total ST differs for males and females (Pate et al., 2011). In particular, the predominant sedentary behaviours engaged in by males include TV viewing and computer use, whereas for females socialising contributes most towards total ST (Gorely, Atkin, Biddle & Marshal, 2009). Given research indicating TV time in particular may be related to excess adiposity and poor cardiometabolic health among youth, rather than ST per se (Martinez-Gomez et al., 2012a), the adverse associations between ST and health outcomes reported presently may not be evident among female youth sport participants.

Whilst the generalisability of the findings contributing towards this thesis might be limited, important to note is that associations between PA, ST and health have been reported to occur in both males and females, and in different cultures and ethnic groups (Janssen & Leblanc, 2010; Tremblay et al., 2011). Furthermore, the relationships theorised by SDT have been supported among research conducted in children and adolescents across different life domains (Standage et al., 2012; Stellino & Sinclair, 2013), and have been shown to be invariant across genders and countries (Quested et al., 2013; Standage et al., 2012). Finally, in view of research demonstrating girls engage in lower level of PA during youth sport than boys (Leek et al., 2011), there is a need to examine youth sport PA engagement among girls and boys separately (Pate & O'Neill, 2011). Nevertheless, further research that includes samples comprising girls, different ethnic groups and different youth sports, are required before the conclusions drawn in this thesis can be generalised to the wider population of youth sport participants.

In line with issues related to possible sample bias is the self-selected nature of the overall sample recruited throughout Studies 1 to 4. All participants volunteered to participate and as such, may represent those youth that are the least ‘hard to reach’ among the population. Moreover, the potential exclusion of participants who represent the most overweight and least fit, and those from ethnic groups reported to be among the least active may further exacerbate this problem. Consequently, the present findings may be less applicable to young people whom may likely benefit most from the overall focus of the current research (e.g., overweight and obese children). Future investigations are warranted which seek to examine the psychosocial concomitants of health-related levels of PA engagement among children and adolescents in these ‘hard to reach’ groups of children. For example, studies should target children from a lower socio-economic status, those that are predominantly overweight or obese and those that represent cultures in which low levels of PA engagement are observed. In the context of youth sport in particular, examining the associations reported throughout this thesis among sports in which greater numbers of overweight and obese children (e.g., rugby, boxing), females (e.g., netball, dance) and children from different ethnic groups participate, may present an important avenue for future research.

As discussed throughout this thesis, a lack of consensus concerning accelerometer data processing limits comparisons across studies employing this methodology. Disparities in the approaches taken to analyse accelerometer data should be acknowledged as the analytical decisions made can result in largely variable estimates of PA engagement. (Atkin et al., 2013; Mâsse et al., 2005). For example, the number of days and hours over which PA is monitored, epoch length, the criteria used to determine intensity of PA, and the decision of how to determine non-wear time versus ST vary greatly across studies in youth (Cain, Sallis, Conway, Van Dyck, & Calhoon, 2013).

Relevant to this latter point, a recent review highlighted the occurrence of an increasing diversity of methods used to process Actigraph accelerometer data over time (Cain et al., 2013). In sum, across 273 articles, the described methods included 6 different epoch lengths, 13 valid day definitions (i.e., hours of recorded data required within a day to constitute valid measurement of PA), 8 minimum wearing thresholds (i.e., number of valid days required to represent habitual PA), and the application of 12 and 11 different cut points for MVPA and ST, respectively. The least variable methodological decisions reported were those pertaining to minimum wearing thresholds and valid day definitions. The majority of studies reviewed reported between 8 and 10 hours of recorded PA data were used to define a valid day (40.4% and 57.1% for children and adolescents respectively). Similarly, over 55% of the studies examined reported using either 3 or 4 days as a minimum wearing threshold to be included in analysis. Based on this review, it is important to note that the analytical approach taken throughout the present thesis concerning the minimum wearing threshold (i.e., 8 hours per day) and definition of a valid day (i.e., 4 days including one weekend day), are in line with those most widely reported across the youth PA literature.

Perhaps most pertinent to the discussion concerning divergence in accelerometer processing decisions is the increasing number of cut points being used to classify activity intensity (Kim, Beets, & Welk, 2012; Trost et al., 2011). The lack of a standardised approach for classifying intensity of PA makes comparisons between studies difficult as differing cut points can substantially affect the reported level of engagement in different intensities of PA (Guinhouya et al., 2006; Kim et al., 2012; Trost et al., 2011). Care should therefore be taken when making comparisons between studies that examine levels of PA in youth. For example, the cut points selected for use in the ALSPAC cohort (≥3600) are higher than the Evenson et al., (2008) cut points selected for use in the present study and other cut points frequently used across the child and adolescent PA literature (Trost et al., 2011). Conversely, the Evenson et al. (2008) cut points are more conservative than the age-specific cut points applied in most previous research investigating levels of PA engagement during youth sport (Guagliano et al., 2012; Leek et al., 2011; Machado-Rodrigues et al., 2012; Wickel & Eisenmann, 2007). The observations and comparisons made herein may therefore be somewhat a consequence of differing analytical decisions between study methodologies. Nevertheless, the superior validity and reliability of the Evenson et al., (2008) cut points over other independently validated cut-points for youth have been supported. Thus, relative to other cut-points, the application of the Evenson et al., (2008) cut-points in Studies 1 to 4 is likely to provide more valid and reliable estimates of PA engagement among youth sport participants than those reported previously in the literature.

A further important consideration of this thesis is the cross-sectional nature of the studies conducted. A cross-sectional design limits the extent to which we can make inferences regarding the direction of causality when examining relationships between PA and health (Study 2, Chapter 3) and the associations theorised by SDT (Studies 3 and 4, Chapters 4 and 5 respectively). For example, it cannot be ascertained whether higher levels of adiposity (e.g., BMI-for-age, BF%) are causative, rather than a consequence of lower levels of engagement in MVPA and VPA and higher ST. Similarly, a coaches' interpersonal behaviour towards their players may be affected by individual players' motivation regulation. Indeed, a recent study indicated adiposity may be a determinant of PA behaviour among youth, (Kwon, Janz, Burns, & Levy, 2011). However, longitudinal and experimental studies investigating the associations between PA, ST and health provide strong evidence for these associations occurring in the directions presented in Study 2 (Carson et al., 2013; Kimm et al., 2005; Mitchell et al., 2013; Moore et al., 2003; Must & Tybor, 2005). In addition, the relationships tested in Study 3 (Chapter 4) and Study 4 (Chapter 5) between perceptions of the social environment and motivation have been supported in PA intervention studies among adults and children (Duda et al., 2014; Edmunds, Ntoumanis, & Duda, 2008; Lonsdale et al., 2013b; Perlman, 2013). Still, additional experimental and longitudinal studies testing the hypothesised associations within various youth PA domains are required. This line of enquiry will enable conclusions to be drawn regarding the causal nature of such associations and allow the longer term consequences of autonomous and controlled motivation for levels of PA engagement to be ascertained. For example, studies examining the longitudinal associations between controlled motivation, drop out from youth sport and daily levels of engagement in MVPA and VPA are necessary in order to investigate the potentially deleterious consequences of this motivation regulation. Retaining samples across the lengths of time required to conduct longitudinal studies involving accelerometer-assessed PA engagement will likely present a number of difficulties. This, again, is where research seeking to determine factors related to accelerometer compliance will aid researchers in their attempts to answer important questions related to the correlates and consequences of engagement in MVPA, VPA and ST among youth.

In sum, whilst the studies contributing towards this thesis answer important questions pertaining to the role of youth sport as an opportunity for PA engagement and its value as a context for PA promotion, future studies in this area are needed. Specifically, studies which examine the associations reported within Studies 1 to 4 across different samples of youth sport participants (i.e., age, gender, sport, culture and ethnicity) are warranted to determine if findings can be generalised to the wider population of youth sport participants across the globe. Moreover, longitudinal studies are required to determine if interventions targeting the youth sport setting may be effective avenues for increasing levels of engagement in MVPA and reducing ST towards levels required to prevent overweight and obesity among youth sport participants. Specifically, to build upon the present research, examining associations between PA, ST and biomarkers of obesity linked diseases (e.g., cardiovascular disease and type 2 diabetes), in addition to testing the complete motivational sequence postulated by SDT (i.e., inclusion of BNS), would help to determine the application of PA interventions grounded in SDT towards producing clinically meaningful improvements in health outcomes related to obesity and associated diseases.

Conclusion

Existing research conducted in the youth sport domain has largely been limited to investigating PA levels during youth sport and the contribution of youth sport to daily levels of MVPA. The work contributing towards this thesis extended previous studies by examining patterns of engagement in PA (including youth sport PA) and ST across the week among youth sport footballers, determining associations with obesity related health outcomes. Moreover, the social-psychological factors related to PA engagement and ST among youth sport footballers were examined. Findings revealed some youth sport football participants may be at risk of engaging in PA behaviours associated with the development of overweight and obesity (i.e., low MVPA and VPA and high ST). Moreover, the social environment created within the youth sport football setting is likely a salient influence on young participants' levels of PA engagement and ST both within and outside the youth sport context. Whilst longitudinal studies are needed to examine these associations with respect to change, current findings highlight the need for PA promotion efforts targeting the youth sport setting, and support the application of interventions grounded in SDT towards increasing PA engagement (i.e., MVPA and VPA) and reducing ST among youth sport football participants. In sum, this thesis underlines the value of youth sport as a context through which PA interventions may contribute towards counteracting the obesity epidemic, highlighting the role of theoretically grounded interventions towards optimising the youth sport experience and promoting engagement in PA among children and adolescents active in this setting.

Adamo, K. B., Prince, S. A., Tricco, A. C., Connor-Gorber, S., & Tremblay, M. (2009). A comparison of indirect versus direct measures for assessing physical activity in the pediatric population: a systematic review. *Internationl Journal of Pediatric Obesity, 4*(1), 2-27.

Adie, J. W., Duda, J. L., & Ntoumanis, N. (2012). Perceived coach-autonomy support, basic need satisfaction and the well- and ill-being of elite youth soccer players: A longitudinal investigation. *Psychology of Sport and Exercise, 13*(1), 51-59.

Aelterman, N., Vansteenkiste, M., Van Keer, H., Van den Berghe, L., De Meyer, J., & aerens, L. (2012). Students' objectively measured physical activity levels and engagement as a function of between-class and between-student differences in motivation toward physical education. *Journal of Sport and Exercise Psychology, 34*(4), 457-480.

Ajzen, I. (1985) From intentions to actions: A theory of planned behavior. In J. Kuhl & J. Beckmann (Eds.) *Action-control: From cognition to behaviour* (pp.11-39). Heidelberg: Springer-Verlag.

Alderete, T., Gyllenhammer, L. E., Byrd-Williams, C. E., Spruijt-Metz, D., Goran, M. I., & Davis, J. N. (2012). Increasing Physical Activity Decreases Hepatic Fat and Metabolic Risk Factors. *Journal of Exercise Physiology Online, 15*(2), 40-54.

Alfano, C. M., Klesges, R. C., Murray, D. M., Beech, B. M., & McClanahan, B. S. (2002). History of Sport Participation in Relation to Obesity and Related Health Behaviors in Women. *Preventive Medicine, 34*(1), 82-89.

Alvarez, M. S., Balaguer, I., Castillo, I., & Duda, J. L. (2009). Coach autonomy support and quality of sport engagement in young soccer players. *The Spanish.Journal of Psychology, 12*(1), 138-148.

American Diabetes Association. (2000). Type 2 diabetes in children and adolescents. *Diabetes Care, 23*, 381-389.

Appleton, P.R., Ntoumanis, N., Quested., E.J & Duda, J.L. (2013). Development and validation of the multidimensional coach created motivational climate scale**.** *British Psychological Society, Division of Sport and Exercise Psychology Annual Conference.*

Arbuckle, J. L., & Wothke, W. (1999). *Amos 4.0 user's guide* Marketing Department, SPSS Incorporated.

Atkin, A. J., Ekelund , U., Møller, N. C., Froberg, K., Sardinha, L. B., Andersen, L. B. et al. (2013). Sedentary Time in Children: Influence of Accelerometer Processing on Health Relations. *Medicine & Science in Sports & Exercise, 45*(6).

Australian Bureau of Statistics. (2009). *Children's Participation in Cultural and Leisure Activities*.Retrived from: http://www.abs.gov.au/ausstats/abs@.nsf/Products/4901.0~Apr+2009~Main+Features~Organised+sport

Australian Government: Department for Health and Ageing. (2004). *Physical Activity Guidelines for Children (5-12 yrs)*. Retrived from: http://www.beactive.wa.gov.au/index.php?id=474

Balaguer, I., Gonz+ílez, L., Fabra, P., Castillo, I., Merc+®, J., & Duda, J. L. (2012). Coaches' interpersonal style, basic psychological needs and the well- and ill-being of young soccer players: A longitudinal analysis. *Journal of Sports Sciences*, 1-11.

Balyi, I., & Hamilton, A. (2004). Long-term athlete development:trainability in childhood and adolescence. *Olympic coach, 16*, 4-8.

Bandura. A. (1986). *Social foundations of thought and action: A social cognitive view.* Englewood Cliffs, NJ: Prentice Hall.

Baranowski, T., Dworkin, R. J., Cieslik, C. J., Hooks, P., Clearman, D. R., Ray, L. et al. (1984). Reliability and Validity of Self Report of Aerobic Activity: Family Health Project. *Research Quarterly for Exercise and Sport, 55*(4), 309-317.

Barreira, T. V., Staiano, A. E., & Katzmarzyk, P. T. (2013). Validity assessment of a portable bioimpedance scale to estimate body fat percentage in white and African-American children and adolescents. *Pediatric Obesity, 8*(2), e29-32.

Bartholomew, K. J., Ntoumanis, N., Ryan, R. M., & Thogersen-Ntoumani, C. (2011). Psychological need thwarting in the sport context: assessing the darker side of athletic experience. *Journal of Sport and Exercise Psychology., 33*(1), 75-102.

Bartholomew, K. J., Ntoumanis, N., & Thogersen-Ntoumani, C. (2010). The controlling interpersonal style in a coaching context: development and initial validation of a psychometric scale. *Journal of Sport and Exercise Psychology., 32*(2), 193-216. Retrieved from PM:20479478

Basterfield, L., Pearce, M. S., Adamson, A. J., Frary, J. K., Parkinson, K. N., Wright, C. M. et al. (2012). Physical Activity, Sedentary Behavior, and Adiposity in English Children. *American Journal of Preventive Medicine, 42*(5), 445-451.

Belecastro, A.N., Morrison, A.S., Hicks, E., & Matta, H. (2012). Cardiorespiratory and metabolic responses associated with children's physical activity during self-paced games. *Canadian Journal of Physiology and Pharmacology, 90*(9), 1269-1276.

Belton, S., O' Brien, W., Meegan, S., Woods, C., & Issartel, J. (2014). Youth-Physical Activity Towards Health: evidence and background to the development of the Y-PATH physical activity intervention for adolescents. *BMC.Public Health, 14*, 122.

Belton S., O'Brien, W., Wickel, E.E., & Issartel, J (2013). Patterns of non-compliance in adolescent field-based accelerometer research. *Journal of Physical Activity and Health, 10*(8), 1181-1185.

BeLue, R., Francis, L. A., Rollins, B., & Colaco, B. (2009). One Size Does Not Fit All: Identifying Risk Profiles for Overweight in Adolescent Population Subsets. *Journal of Adolescent Health, 45*(5), 517-524.

Bender, J. M., Brownson, R. C., Elliott, M. B., & Haire-Joshu, D. L. (2005). Children's Physical Activity: Using Accelerometers to Validate a Parent Proxy Record. *Medicine & Science in Sports & Exercise, 37*(8).

Berman, L. J., Weigensberg, M. J., & Spruijt-Metz, D. (2012). Physical activity is related to insulin sensitivity in children and adolescents, independent of adiposity: a review of the literature. *Diabetes/Metabolism Research and Reviews, 28*(5), 395-408.

Biddle, S. J., Gorely, T., Marshall, S. J., Murdey, I., & Cameron, N. (2004). Physical activity and sedentary behaviours in youth: issues and controversies. *The Journal of the Royal Society for the Promotion of Health, 124*(1), 29-33.

Biddle, S., Marshall, S., Gorely, T., & Cameron, N. (2009). Temporal and Environmental Patterns of Sedentary and Active Behaviors during Adolescents Leisure Time. *International Journal of Behavioral Medicine, 16*(3), 278-286.

Biddle, S. J. H., Gorely, T., Marshall, S. J., & Cameron, N. (2009). The prevalence of sedentary behavior and physical activity in leisure time: A study of Scottish adolescents using ecological momentary assessment. *Preventive Medicine, 48*(2), 151-155.

Biddle, S. J. H., Pearson, N., Ross, G. M., & Braithwaite, R. (2010). Tracking of sedentary behaviours of young people: A systematic review. *Preventive Medicine, 51*(5), 345-351.

Bitsori, M., Linardakis, M., Tabakaki, M., & Kafatos, A. (2009). Waist circumference as a screening tool for the identification of adolescents with the metabolic syndrome phenotype. *International Journal of Pediatric Obesity, 4*(4), 325-331.

Brener, N. D., Collins, J. L., Kann, L., Warren, C. W., & Williams, B. I. (1995). Reliability of the Youth Risk Behavior Survey Questionnaire. *American Journal of Epidemiology, 141*(6), 575-580.

British Medical Association, (2005). *Preventing Childhood Obesity*. Retrieved from: http://www.worldobesity.org/site_media/uploads/Preventing_childhood_obesity_2005.pdf.

Brockman, R., Fox, K.R., & Jago, R. (2011). What is the meaning and nature of active play for today's children in the UK. *International Journal of Behavioral Nutrition and Physical Activity, (8)*15.

Brockman, R., Jago, R., Fox, K. R., Thompson, J. L., Cartwright, K., & Page, A. S. (2009). "Get off the sofa and go and play": family and socioeconomic influences on the physical activity of 10-11 year old children. *BMC.Public Health, 9*, 253.

Brockman, R., Jago, R., & Fox, K. R. (2010). The contribution of active play to the physical activity of primary school children. *Preventive Medicine, 51*(2), 144-147.

Brunet, J., Burke, S. M., & Sabiston, C. M. (2013). The benefits of being self-determined in promoting physical activity and affective well-being among women recently treated for breast cancer. *Psycho-Oncology, 22*(10), 2245-2252.

Buchan, D. S., Ollis, S., Thomas, N. E., Buchanan, N., Cooper, S. M., Malina, R. M. et al. (2011). Physical activity interventions: effects of duration and intensity. *Scandinavian Journal of Medicine and Science in Sports, 21*(6), e341-e350. Retrieved from PM:21518010

Burke, V. (2006). Obesity in childhood and cardiovascular risk. *Clinical and Experimental Pharmacology and Physiology, 33*(9), 831-837.

Cain, K., Sallis, J. F., Conway, T. L., Van Dyck, D., & Calhoon, L. (2013). Using Accelerometers in Youth Physical Activity Studies: A Review of Methods. *Journal of Physical Activity and Health, 10*(3), 437-450.

Camhi, S. M., & Katzmarzyk, P. T. (2010). Tracking of cardiometabolic risk factor clustering from childhood to adulthood. *International Journal of Pediatric Obesity, 5*(2), 122-129.

Carroll, B., & Loumidis, J. (2001). Children's Perceived Competence and Enjoyment in Physical Education and Physical Activity Outside School. *European Physical Education Review, 7*(1), 24-43.

Carson, V., & Janssen, I. (2011). Volume, patterns, and types of sedentary behavior and cardio-metabolic health in children and adolescents: a cross-sectional study. *BMC Public Health, 11*(274).

Carson, V., Rinaldi, R. L., Torrance, B., Maximova, K., Ball, G. D. C., Majumdar, S. R. et al. (2014). Vigorous physical activity and longitudinal associations with cardiometabolic risk factors in youth. *International Journal of Obesity (2005), 38*(1), 16-20.

Caspersen CJ, Powell KE, Christensen GM. Physical activity, exercise and physical fitness: definitions and distinctions for health-related research. P*ublic Health Reports 1985*, *100*(2), 126-131.

Centers for Disease Control and Prevention. (2000). *Promoting Better Health for Young People through Physical Activity and Sports*. Retrieved from: http://usa.usembassy.de/etexts/sport/Promoting_better_health

Chan, D. K., & Hagger, M. S. (2012). Self-determined forms of motivation predict sport injury prevention and rehabilitation intentions. *Journal of Science and Medicine in Sport, 15*(5), 398-406.

Chaput, J. P., Lambert, M., Mathieu, M. E., Tremblay, M. S., O' Loughlin, J., & Tremblay, A. (2012). Physical activity vs. sedentary time: independent associations with adiposity in children. *Pediatric Obesity, 7*(3), 251-258.

Chatzisarantis, N. L. D., & Hagger, M. S. (2009). Effects of an intervention based on self-determination theory on self-reported leisure-time physical activity participation. *Psychology & Health, 24*(1), 29-48.

Chinapaw, M. J., Yildirim, M., Altenburg, T. M., Singh, A. S., Kovács, E., Molnár, D. et al. (2012). Objective and self-rated sedentary time and indicators of metabolic health in Dutch and Hungarian 10-12 year olds: the ENERGY-Project. *PLoS One, 7*(5), e36657.

Chinn, S., & Rona, R. J. (2001). Prevalence and trends in overweight abd obesity in three cross sectional studies of British children, 1974-94. *BMJ, 322*(24), 26.

Cleland, V., Dwyer, T., & Venn, A. (2012). Which domains of childhood physical activity predict physical activity in adulthood? A 20-year prospective tracking study. *British Journal of Sports Medicine, 46*(8), 595-602.

Cleland, V. J., Schmidt, M. D., Dwyer, T., & Venn, A. J. (2008). Television viewing and abdominal obesity in young adults: is the association mediated by food and beverage consumption during viewing time or reduced leisure-time physical activity? *The American Journal of Clinical Nutrition, 87*(5), 1148-1155.

Cole, T., Freeman, J., & Preece, M. (1995). Body mass index reference curves for the UK, 1990. *Archives of Disease in Childhood, 73*, 25-29.

Cole, T. J., Freeman, J. V., & Preece, M. A. (1998). British 1990 growth reference centiles for weight, height, body mass index and head circumference fitted by maximum penalized likelihood. *Statistics in Medicine, 17*(4), 407-429.

Cole, T. J., Bellizzi, M. C., Flegal, K. M., & Dietz, W. H. (2000). Establishing A Standard Definition For Child Overweight And Obesity Worldwide: International Survey. *BMJ: British Medical Journal, 320*(7244), 1240-1243.

Colley, R. C., Garriguet, D., Janssen, I., Wong, S. L., Saunders, T. J., Carson, V. et al. (2013). The association between accelerometer-measured patterns of sedentary time and health risk in children and youth: results from the Canadian Health Measures Survey. *BMC.Public Health, 13*, 200.

Collings, P. J., Wijndaele, K., Corder, K., Westgate, K., Ridgway, C. L., Dunn, V. et al. (2014). Levels and patterns of objectively-measured physical activity volume and intensity distribution in UK adolescents: the ROOTS study. *International Journal of Behavioral Nutrition and Physical Activity, 11*(23).

Commission of the European Communities. (2007). *White Paper on Sport*. Retrieved from: http://europa.eu/documentation/official-docs/white-papers/index_en.htm

Cox, A. E., Smith, A. L., & Williams, L. (2008). Change in physical education motivation and physical activity behavior during middle school. *Journal of Adolescent Health, 43*(5), 506-513.

Craig, R., Mindell, J., & Hirani, V. (2009). *Health Survey for England 2008:* Retrieved from: http://www.hscic.gov.uk/catalogue/PUB00430/heal-surv-phys-acti-fitn-eng-2008-rep-v2.pdf

Dabelea, D. (2013). The accelerating epidemic of childhood diabetes. *The Lancet, 373*(9680), 1999-2000.

Daly-Smith A, McKenna J, Radley D, Long J. The impact of additional weekdays of active commuting to school on children achieving a criterion of 300+ minutes of moderate-to-vigorous physical activity. *Health Education Journal 2011* 70(4), 428-34.

De Niet, J. E., & Naiman, D. I. (2011). Psychosocial aspects of childhood obesity. *Minerva Pediatrica, 63*(6), 491-505.

de Vries, S. I., Bakker, I., Hopman-Rock, M., Hirasing, R. A., & van Mechelen, W. (2006). Clinimetric review of motion sensors in children and adolescents. *Journal of Clinical Epidemiology, 59*(7), 670-680.

de Vries, S. I., Van Hirtum, H., Bakker, I., Hopman-Rock, M., Hirasing, R. A., & Van Mechelen, W., (2009). Validity and Reproducibility of Motion Sensors in Youth: A Systematic Update. *Medicine & Science in Sports & Exercise, 41*(4), 818-827.

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behaviour*. New York: Plenum.

Deci, E. L., & Ryan, R. M. (1987). The support of autonomy and the control of behavior. *Journal of Personality and Social Psychology, 53*(6), 1024-1037.

Deci, E. L., & Ryan, R. M. (2000). The 'what' and 'why' of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227-268.

Deci, E. L., & Ryan, R. M. (2008). Facilitating Optimal Motivation and Psychological Well-Being Across Life's Domains. *Canadian Psychology, 49*(1), 14-23.

Deci, E. L., Eghrari, H., Patrick, B. C., & Leone, D. R. (1994). Facilitating internalization: the self-determination theory perspective. *Journal of Personality, 62*(1), 119-142.

Dencker, M., & Andersen, L. B. (2008a). Health-related aspects of objectively measured daily physical activity in children. *Clinical Physiology and Functional Imaging, 28*(3), 133-144.

Dencker, M., Thorsson, O., Karlsson, M. K., Lindén, C., Wollmer, P., & Andersen, L. B. (2008b). Daily physical activity related to aerobic fitness and body fat in an urban sample of children. *Scandinavian Journal of Medicine & Science in Sports, 18*(6), 728-735.

Department of Health. (2011). UK physical activity guidelines. *Department of Health*. Retrieved from http://www.dh.gov.uk

Dietz, W. H. (1998). Health Consequences of Obesity in Youth: Childhood Predictors of Adult Disease. *Pediatrics, 101*(Supplement 2), 518-525.

Dishman, R. K., Motl, R. W., Saunders, R., Felton. G., ard, D.S., Dowda, M. et al. (2005). Enjoyment Mediates Effects of a School-Based Physical-Activity Intervention. *Medicine & Science in Sports & Exercise, 37*(3), 478-487.

Doehner, W., Clark, A., & Anker, S.D. (2010). The obesity paradox: weighing the benefit. *European Heart Journal, 31*(2), 146-148.

Dollman, J., Norton, K., & Norton, L. (2005). Evidence for secular trends in childrens physical activity behaviour. *British Journal of Sports Medicine, 39*(12), 892-897.

Dowda, M. (2001). Environmental influences, physical activity, and weight status in 8- to 16-year-olds. *Archives of Pediatrics & Adolescent Medicine, 155*(6), 711-717.

Duda, J.L. (1992). Motivation in sport settings: A goal perspective approach. In G.C. Roberts (Ed.), *Motivation in sport and exercise* (pp.57-91). Champaign, IL: Human Kinetics.

Duda, J. L., Quested, E., Haug, E., Samdal, O., Wold, B., Balaguer, I. et al. (2013). Promoting Adolescent health through an intervention aimed at improving the quality of their participation in Physical Activity (PAPA): Background to the project and main trial protocol. *International Journal of Sport and Exercise Psychology, 11*(4), 319-327.

Dudley, D. A., Okely, A. D., Cotton, W. G., Pearson, P., & Caputi, P. (2012). Physical activity levels and movement skill instruction in secondary school physical education. *Journal of Science and Medicine in Sport, 15*(3), 231-237.

Dunton, G. F., Whalen, C. K., Jamner, L. D., Henker, B., & Floro, J. N. (2005). Using ecologic momentary assessment to measure physical activity during adolescence. *American Journal of Preventive Medicine*, *29*(4), 281-287.

Dunton, G. F., Liao, Y., Intille, S. S., Spruijt-Metz, D., & Pentz, M. (2011). Investigating children's physical activity and sedentary behavior using ecological momentary assessment with mobile phones. *Obesity (Silver.Spring), 19*(6), 1205-1212.

Dunton, G.F., Kawabata, K., Intille, S., Wolch, J., & Pentz, M.A. (2012). Assessing the social and physical contexts of childrens leisure-time physical activity: an ecological momentary assessment study. *American Journal of Health Promotion, 26*(3), 135-142.

Edmunds, J., Ntoumanis, N., & Duda, J. L. (2008). Testing a self-determination theory-based teaching style intervention in the exercise domain. *European Journal of Social Psychology, 38*(2), 375-388.

Edwardson, C. L., & Gorely, T. (2010). Epoch Length and Its Effect on Physical Activity Intensity. *Medicine & Science in Sports & Exercise, 42*(5).

Ekelund, U., Anderssen, S. A., Froberg, K., Sardinha, L. B., Andersen, L. B., & Brage, S. (2007). Independent associations of physical activity and cardiorespiratory fitness with metabolic risk factors in children: the European youth heart study. *Diabetologia, 50*(9), 1832-1840.

Ekelund, U., Brage, S., Griffin, S. J., & Wareham, N. J. (2009). Objectively measured moderate- and vigorous-intensity physical activity but not sedentary time predicts insulin resistance in high-risk individuals. *Diabetes Care, 32*(6), 1081-1086.

Ekelund, U., Luan, J., Sherar, L. B., Esliger, D. W., Griew, P., & Cooper, A. (2012). Moderate to vigorous physical activity and sedentary time and cardiometabolic risk factors in children and adolescents. *JAMA:The Journal of the American Medical Association,, 307*(7), 704-712.

Emons, H. J., Groenenboom, D. C., Westerterp, K. R., & Saris, W. H. (1992). Comparison of heart rate monitoring combined with indirect calorimetry and the doubly labelled water (2H2(18)0) method for the measurement of energy expenditure in children. *European Journal of Applied Physiology Occupational Physiology, 65*(2), 99-103.

Epstein, L. H., Roemmich, J. N., Paluch, R. A., & Raynor, H. A. (2005). Physical activity as a substitute for sedentary behavior in youth. *Annals of Behavioral.Medicine, 29*(3), 200-209.

Eston, R. G., Rowlands, A. V., & Ingledew, D. K. (1998). Validity of heart rate, pedometry, and accelerometry for predicting the energy cost of children's activities. *Journal of Applied Physiology, 84*(1), 362-371.

Evenson, K. R., Catellier, D. J., Gill, K., Ondrak, K. S., & McMurray, R. G. (2008). Calibration of two objective measures of physical activity for children. *Journal of Sports Sciences, 24*(14), 1557-1565.

Fairclough, S. (2003). Physical activity, perceived competence and enjoyment during secondary school physical education. *The European Journal of Physical Education, 8*(1), 5-18.

Fairclough, S., & Stratton, G. (2005). 'Physical education makes you fit and healthy'. Physical education's contribution to young people's physical activity levels. *Health Education Research., 20*(1), 14-23.

Fan, X., Thompson, B., & Wang, L. (1999). Effect of sample size, estimation methods, and model specification on structural equation modeling fit indexes. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 56-83.

Field, A. E., Coakley, E. H., Must, A., Spadano, J. L., Laird, N., Dietz, W. H. et al. (2001). Impact of Overweight on the Risk of Developing Common Chronic Diseases During a 10-Year Period. *Archives of Internal Medicine, 161*(13), 1581-1586.

Fisher, A., Hill, C., Webber, L., Purslow, L., & Wardle, J. (2011). MVPA Is Associated with Lower Weight Gain in 8–10 Year Old Children: A Prospective Study with 1 Year Follow-Up. *PLoS ONE, 6*(4), e18576.

Fontaine, K. R., Redden, D. T., Wang, C., Westfall, A. O., & Allison, D. B. (2003). Years of Life Lost Due to Obesity. *JAMA: The Journal of the American Medical Association, 289*(2), 187-193.

Foresight. (2007). *Tackling Obesities: Future Choices - Project Report: Government Office for Science*.Retrieved from: http://www.bis.gov.uk/foresight/publications/reports

Fortier, M., Duda, J., Guerin, E., & Teixeira, P. (2012). Promoting physical activity: development and testing of self-determination theory-based interventions. *International Journal of Behavioral Nutrition and Physical Activity, (9)*20.

Foulds, H. J. A., Warburton, D. E. R., & Bredin, S. S. D. (2013). A systematic review of physical activity levels in Native American populations in Canada and the United States in the last 50 years. *Obesity Reviews, 14*(7), 593-603.

Freedson, P., Pober, D., & Janz, K. F. (2005). Calibration of accelerometer output for children. *Medicine and Science in Sports and Exercise, 37*(11 Suppl), S523-S530.

Gao, Z. (2008). Perceived competence and enjoyment in predicting students' physical activity and cardiorespiratory fitness. *Perceptual and Motor Skills, 107*(2), 365-372.

Gao, Z., Hannon, J. C., Newton, M., & Huang, C. (2011). Effects of curricular activity on students' situational motivation and physical activity levels. *Research Quarterly for Exercise and Sport, 82*(3), 536-544.

García Calvo, T., Cervelló, E., Jiménez, R., Iglesias, D., & Moreno Murcia, J. A. (2010). Using self-determination theory to explain sport persistence and dropout in adolescent athletes. *Spanish Journal of Psychology, 13*(2), 677-684.

Gaya, A. R., Alves, A., Aires, L., Martins, C. L., Ribeiro, J. C., & Mota, J. (2009). Association between time spent in sedentary, moderate to vigorous physical activity, body mass index, cardiorespiratory fitness and blood pressure. *Annals of Human Biology, 36*(4), 379-387.

Georgiades, E., Reilly, J. J., Stathopoulou, E., Livingston, A. M., & Pitsiladis, Y. P. (2003). BMI distribution changes in adolescent British girls. *Archives of Disease in Childhood, 88*(11), 978-979.

Gillis, L., Tomkinson, G., Olds, T., Moreira, C., Christie, C., Nigg, C. et al. (2013). Research priorities for child and adolescent physical activity and sedentary behaviours: an international perspective using a twin-panel Delphi procedure. *The International Journal of Behavioral Nutrition and Physical Activity, (10)*112.

Gillison, F. B., Standage, M., & Skevington, S. M. (2011). Motivation and body-related factors as discriminators of change in adolescents' exercise behavior profiles. *Journal of Adolescent Health, 48*(1), 44-51.

Gorely, T., Atkin, A.J., Biddle, S.J.H., Marshall, S.J. (2009). Family circumstance, sedentar behaviour and physical activity in adolescents living in England: Project STIL. *International Journal of Behavioral Nutrition and Physical Activity, (6),*33.

Gorely, T., Marshall, S., Biddle, S., & Cameron, N. (2007). Patterns of Sedentary Behaviour and Physical Activity Among Adolescents in the United Kingdom: Project STIL. *Journal of Behavioral Medicine, 30*(6), 521-531.

Grøntved, A., Ried-Larsen, M., Møller, N. C., Kristensen, P. L., Wedderkopp, N., Froberg, K. et al. (2014). Youth screen-time behaviour is associated with cardiovascular risk in young adulthood: the European Youth Heart Study. *European Journal of Preventive Cardiology, 21*(1), 49-56.

Guagliano, J. M., Rosenkranz, R. R., & Kolt, G. S. (2012). Girls' Physical Activity Levels during Organized Sports in Australia. *Medicine and Science in Sports and Exercise*.

Guinhouya, C. B., Hubert, H., Soubrier, S., Vilhelm, C., Lemdani, M., & Durocher, A. (2006). Moderate-to-vigorous physical activity among children: Discrepancies in accelerometry-based cut-off points. *Obesity, 14*(5), 774-777.

Gunnell, D. J., Frankel, S. J., Nanchahal, K., Peters, T. J., & vey Smith, G. (1998). Childhood obesity and adult cardiovascular mortality: a 57-y follow-up study based on the Boyd Orr cohort. *The American Journal of Clinical Nutrition, 67*(6), 1111-1118.

Gupta, N., Goel, K., Shah, P., & Misra, A. (2012). Childhood Obesity in Developing Countries: Epidemiology, Determinants, and Prevention. *Endocrine Reviews, 33*(1), 48-70.

Gutin, B., & Owen, S. (2011). The influence of physical activity on cardiometabolic biomarkers in youths: a review. *Pediatric Exercise Science, 23*(2), 169-185.

Hagger, M., Chatzisarantis, N. L., Hein, V., Soos, I., Karsai, I., Lintunen, T. et al. (2009). Teacher, peer and parent autonomy support in physical education and leisure-time physical activity: A transcontextual model of motiation in four nations. *Psychology and Health, 24*(6), 689-711.

Hamar, P., Biddle, S., Soós, I., Takács, B., & Huszár. (2010). The prevalence of sedentary behaviours and physical activity in Hungarian youth. *The European Journal of Public Health, 20*(1), 85-90.

Hancox, R. J., Milne, B. J., & Poulton, R. (2004). Association between child and adolescent television viewing and adult health: a longitudinal birth cohort study. *The Lancet, 364*(9430), 257-262.

Hardy, L. L., Dobbins, T., Booth, M. L., Denney-Wilson, E., & kely, A. (2006). Sedentary behaviours among Australian adolescents. *Australian and New Zealand Journal of Public Health, 30*(6), 534-540.

Hay, J., Maximova, K., & Durksen, A. (2012). Physical activity intensity and cardiometabolic risk in youth. *Archives of Pediatrics & Adolescent Medicine, 166*(11), 1022-1029.

Health and Social Care Information Centre. (2012). Health Survey for England, 2011: Health, social care and lifestyles. Summary of key findings., 1-21. Retrieved from www.ic.nhs.uk/pubs/hse11report

Henderson, M., Gray-Donald, K., Mathhieu, M., Barnett, T. A., Hanley, J. A., O'Loughlin, J. et al. (2012). How Are Physical Activity, Fitness, and Sedentary Behavior Associated With Insulin Sensitivity in Children? *Diabetes Care, 35*(6), 1272-1278.

Hill, J. O., Wyatt, H. R., & Peters, J. C. (2012). Energy Balance and Obesity. *Circulation, 126*(1), 126-132.

Hodge, K., & Lonsdale, C. (2011). Prosocial and antisocial behavior in sport: the role of coaching style, autonomous vs. controlled motivation, and moral disengagement. *Journal of Sport and Exercise Psychology, 33*(4), 527-547.

Hosking, J., Metcalf, B., Jeffery, A. N., Voss, L. D., & Wilkin, T. J. (2006). Validation of foot-to-foot bioelectrical impedance analysis with dual-energy X-ray absorbtiometry in the assessment of body composition in young children: the EarlyBird cohort. *The British Journal of Nutrition, 96*(6), 1163-1168.

Hsu, Y., Belcher, B. R., Ventura, E. E., Byrd-Williams, C. E., Weigensberg, M. J., Davis, J. N. et al. (2011). Physical Activity, Sedentary Behavior, and the Metabolic Syndrome in Minority Youth. *Medicine & Science in Sports & Exercise, 43*(12), 2307-2313.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1-55.

Huang, L.H., Liao, Y.L., & Hsu, C.H. (2012). Waist circumference is a better predictor than body mass index of insulin resistence in type 2 diabetes. *Obesity Research and Clinical Practice, 6*(4), e263-346

International Association for the Study of Obesity. (2012). *Change in % child overweight prevalence over time in selected countries around the globe*. Retrieved from http://www.iaso.org/resources/obesity-data-portal/resources/trends/

International Association for the Study of Obesity. (2014). *Prevalence % Overweight and Obesity by WHO Region by Gender and Age*. Retrieved from http://www.iaso.org/resources/obesity-data-portal/resources/tables/19/

Iso-Ahola, S. E. (1995). Intrapersonal and interpersonal factors in athletic performance*. *Scandinavian Journal of Medicine & Science in Sports, 5*(4), 191-199.

Jago, R., Davison, K. K., Brockman, R., Page, A. S., Thompson, J. L., & Fox, K. R. (2011a). Parenting styles, parenting practices, and physical activity in 10- to 11-year olds. *Preventive Medicine, 52*(1), 44-47.

Jago, R., Fox, K. R., Page, A. S., Brockman, R., & Thompson, J. L. (2010). Parent and child physical activity and sedentary time: do active parents foster active children? *BMC.Public Health, 10*, 194.

Jago, R., Macdonald-Wallis, K., Thompson, J. L., Page, A. S., Brockman, R., & Fox, K. R. (2011b). Better with a buddy: influence of best friends on children's physical activity. *Medicine and Science in Sports Exercise, 43*(2), 259-265.

Jago, R., & Baranowski, T. (2004). Non-curricular approaches for increasing physical activity in youth: a review. *Preventive Medicine, 39*(1), 157-163.

Jago, R., Davison, K. K., Thompson, J. L., Page, A. S., Brockman, R., & Fox, K. R. (2011c). Parental Sedentary Restriction, Maternal Parenting Style, and Television Viewing Among 10- to 11-Year-Olds. *Pediatrics, 128*(3), e572-e578

Jago, R., Wedderkopp, N., Kristensen, P. L., Moller, N. C., Andersen, L. B., Cooper, A. R. et al. (2008). Six-Year Change in Youth Physical Activity and Effect on Fasting Insulin and HOMA-IR. *American Journal of Preventive Medicine, 35*(6), 554-560.

Janssen, I. (2014). Active play: An important physical activity strategy in the fight against childhood obesity. *Canadian Journal of Public Health, 105*(1), e22-27.

Janssen, I., & Leblanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral.Nutrition and Physical Activity, (7)*40.

Jean, L. W., Karen E Peterson, David S Ludwig, Juhee, K., Arthur, S., & Steven, L. G. (2006). When children eat what they watch: impact of television viewing on dietary intake in youth. *Archives of Pediatrics and Adolescent Medicine, 160* (4), 436-442.

Jiménez-Pavon, D., Kelly, J., & Reilly, J. J. (2010). Associations between objectively measured habitual physical activity and adiposity in children and adolescents: Systematic review. *International Journal of Pediatric Obesity, 5*(1), 3-18.

Joesaar, H., Hein, V., & Hagger, M. S. (2012). Youth athletes' perception of autonomy support from the coach, peer motivational climate and intrinsic motivation in sport setting: One-year effects. *Psychology of Sport and Exercise, 13*(3), 257-262.

Kalaja, S., Jaakkola, T., Liukkonen, J., & Watt, A. (2010). The role of gender, enjoyment, perceived competence and fundamental movement skills as correlates of physical activity engagement of Finnish physical education students. *Scandinavian Sport Studies Forum, 1*, 69-87.

Katzmarzyk, P. T. (2010). Physical Activity, Sedentary Behavior, and Health: Paradigm Paralysis or Paradigm Shift? *Diabetes, 59*(11), 2717-2725.

Kim, Y., Beets, M. W., & Welk, G. J. (2012). Everything you wanted to know about selecting the "right" Actigraph accelerometer cut-points for youth, but...: A systematic review. *Journal of Science and Medicine in Sport, 15*(4), 311-321.

Kimm, S. Y., Glynn, N. W., Obarzanek, E., Kriska, A. M., Daniels, S. R., Barton, B. A. et al. (2005). Relation between the changes in physical activity and body-mass index during adolescence: a multicentre longitudinal study. *The Lancet, 366*(9482), 301-307.

King, A. C., Parkinson, K. N., Adamson, A. J., Murray, L., Besson, H., Reilly, J. J. et al. (2010). Correlates of objectively measured physical activity and sedentary behaviour in English children. *The European Journal of Public Health, 2*(4), 424-431.

Kins, E., Beyers, W., Soenens, B., & Vansteenkiste, M. (2009). Patterns of home leaving and subjective well-being in emerging adulthood: The role of motivational processes and parental autonomy support. *Developmental Psychology, 45*(5), 1416-1429.

Kjonniksen, L., Anderssen, N., & Wold, B. (2009). Organized youth sport as a predictor of physical activity in adulthood. *Scandinavian Journal of Medicine & Science in Sports, 19*(5), 646-654.

Klein, P. D., James, W. P., Wong, W. W., Irving, C. S., Murgatroyd, P. R., Cabrera, M. et al. (1984). Calorimetric validation of the doubly-labelled water method for determination of energy expenditure in man. *Human Nutrition. Clinical Nutrition, 38*(2), 95-106.

Klein, S., Allison, D. B., Heymsfield, S. B., Kelley, D. E., Leibel, R. L., Nonas, C. et al. (2007). Waist circumference and cardiometabolic risk: a consensus statement from Shaping America's Health: Association for Weight Management and Obesity Prevention; NAASO, The Obesity Society; the American Society for Nutrition; and the American Diabetes Association. *The American Journal of Clinical Nutrition, 85*(5), 1197-1202.

Kohl, H. W., Fulton, J. E., & Caspersen, C. J. (2000). Assessment of Physical Activity among Children and Adolescents: A Review and Synthesis. *Preventive Medicine, 31*(2), S54-S76.

Kopp, L. L., & Zimmer-Gembeck, M. J. (2011). Women's global self-determination, eating regulation, and body dissatisfaction: Exploring the role of autonomy support. *Eating Behaviors, 12*(3), 222-224.

Kozey-Keadle, S., Staudenmayer, J., Libertine, A., Mavilia, M., Lyden, K., Braun, B., & Freedson, P. (2013). Changes in Sedentary Time and Physical Activity in Response to an Exercise Training and/or Lifestyle Intervention. *Journal of Physical Activity and Health, (in press).*

Kunz, M. (2007). *265 million playing football*. In *FIFA Magazine, July issue* Retrieved from http://www.fifa.com/mm/document/fifafacts/bcoffsurv/emaga_9384_10704.pdf

Kwon, S., Janz, K. F., Burns, T. L., & Levy, S. M. (2011). Effects of Adiposity on Physical Activity in Childhood: Iowa Bone Development Study. *Medicine & Science in Sports & Exercise, 43*(3), 443-448.

Kwon, S., Burns, T. L., Levy, S. M., & Janz, K. F. Which Contributes More to Childhood Adiposity-High Levels of Sedentarism or Low Levels of Moderate-through-Vigorous Physical Activity? The Iowa Bone Development Study. *The Journal of Pediatrics 162*,(6), 1169-1174.

Laguna, M. a., Ruiz, J. R., Gallardo, C., García-Pastor, T., Lara, M. a. T., & Aznar, S. (2013). Obesity and physical activity patterns in children and adolescents. *Journal of Paediatrics and Child Health, 49*(11), 942-949.

Leblanc, A. G., & Janssen, I. (2010). Difference between self-reported and accelerometer measured moderate-to-vigorous physical activity in youth. *Pediatric Exercise Science, 22*(4), 523-534.

Leek, D., Carlson, J. A., Cain, K. L., Henrichon, S., Rosenberg, D., Patrick, K. et al. (2011). Physical activity during youth sports practices. *Archives of Pediatrics and Adolescent Medicine, 165*(4), 294-299.

Leger, L.A., Mercier, D., Gadoury, C., & Lambert, J. (1988). The multistage 20 metre shuttle run test for aerobic fitness. *Journal of Sport Sciences, 6(2),* 93 - 101.

Lemura, L. M., & Maziekas, M. T. (2002). Factors that alter body fat, body mass, and fat-free mass in pediatric obesity. *Medicine & Science in Sports & Exercise, 34*(3), 487-496.

Liu, N.Y., Plowman, S.S., & Looney, M.A. (1992). The reliability and validity of the 20-meter shuttle run test in American students 12 to 15 years old. *Research Quarterly for Exercise and Sport, 63*(4), 360-365.

Lobstein, T., Baur, L., & Uauy, R. (2004). Obesity in children and young people: a crisis in public health. *Obesity Reviews, 5 Suppl 1*, 4-104.

Long, M. W., Sobol, A. M., Cradock, A. L., Subramanian, S. V., Blendon, R. J., & Gortmaker, S. L. (2013). School-Day and Overall Physical Activity Among Youth. *American Journal of Preventive Medicine*, *45*(2), 150-157.

Lonsdale, C., Hodge, K., & Rose, E. A. (2008). The behavioral regulation in sport questionnaire (BRSQ): instrument development and initial validity evidence. *Journal of Sport and Exerise Psychology, 30*(3), 323-355.

Lonsdale, C., Rosenkranz, R. R., Peralta, L. R., Bennie, A., Fahey, P., & Lubans, D. R. (2013a). A systematic review and meta-analysis of interventions designed to increase moderate-to-vigorous physical activity in school physical education lessons. *Preventive Medicine*, *56*(2), 152-161.

Lonsdale, C., Rosenkranz, R. R., Sanders, T., Peralta, L. R., Bennie, A., Jackson, B. et al. (2013b). A cluster randomized controlled trial of strategies to increase adolescents' physical activity and motivation in physical education: Results of the Motivating Active Learning in Physical Education (MALP) trial. *Preventive Medicine*, *57*(5), 696-702.

Loprinzi, P. D., Smit, E., Cardinal, B. J., Crespo, C., Brodowicz, G., & Andersen, R. (2013). Valid and Invalid Accelerometry Data Among Children and Adolescents: Comparison Across Demographic, Behavioral, and Biological Variables. *American Journal of Health Promotion, 28*(3), 155-158.

Loucaides C.A, Jago, R., & Theophanous, M. (2011). Physical activity and sedentary behaviours in Greek-Cypriot children and adolescents: a cross-sectional study. *International Journal of Behavioral Nutrition and Physical Activity*, *(8)*90.

Lubans, D. R., Lonsdale, C., Plotnikoff, R. C., Smith, J., Dally, K., & Morgan, P. J. (2013). Development and evaluation of the Motivation to Limit Screen-time Questionnaire (MLSQ) for adolescents. *Preventive Medicine*, *57*(5), 561-566.

Lui, N. Y-S., Plowman, S.A., & Looney, M.A. (1992). The Reliability and Valdiity of the 20-Meter Shuttle Test in American Students 12 to 15 Years Old. *Research Quarterly for Exercise and Sport, 63*(4), 360-365.

Machado-Rodrigues, Am. M., Coelho e Silva, M. J., Mota, J., Santos, R. M., Cummin, S. P., & Malina, R. M. (2012). Physical Activity and Energy Expenditure in

Adolescent Male Sport Participants and Nonparticipants Aged 13 to 16 Years. *Journal of Physical Activity and Health, 9*(5), 626-633.

Macho, S., & Ledermann, T. (2011). Estimating, testing, and comparing specific effects in structural equation models: The phantom model approach. *Psychological Methods, 16*(1), 34-43.

Mageau, G. A., & Vallerand, R. J. (2003). The coach athlete relationship: a motivational model. *Journal of Sports Sciences, 21*(11), 883-904.

Maher, C., Olds, T., Mire, E., & Katzmarzyk, P. T. (2014). Reconsidering the sedentary behaviour paradigm. *PLoS ONE, 15*(9), e86403.

Mark, A. E., & Janssen, I. (2011). Influence of movement intensity and physical activity on adiposity in youth. *J ournal of Physical Activity and Health, 8*(2), 164-173.

Martinez-Gomez, D., Eisenmann, J. C., Healy, G. N., Gomez-Martinez, S., Diaz, L. E., Dunstan, D. W. et al. (2012a). Sedentary behaviors and emerging cardiometabolic biomarkers in adolescents. *Journal of Pediatrics, 160*(1), 104-110.

Martinez-Gomez, D., Eisenmann, J. C., Tucker, J., Heelan, K. A., & Welk, G. J. (2011). Associations between moderate-to-vigorous physical activity and central body fat in 3-8-year-old children. *International Journal of Pediatric Obesity, 6*(2-2), e611-e614.

Martinez-Gomez, D., Gomez-Martinez, S., Ruiz, J. R., Diaz, L. E., Ortega, F. B., Widhalm, K. et al. (2012b). Objectively-measured and self-reported physical activity and fitness in relation to inflammatory markers in European adolescents: the HELENA Study. *Atherosclerosis, 221*(1), 260-267.

Martinez-Gomez, D., Gomez-Martinez, S., Ruiz, J. R., Ortega, F. B., Marcos, A., & Veiga, O. L. (2012c). Video game playing time and cardiometabolic risk in adolescents: the AFINOS study. *Medicina.Clínica.(Barc.), 139*(7), 290-292.

Martinez-Gomez, D., Ortega, F. B., Ruiz, J. R., Vicente-Rodriguez, G., Veiga, O. L., Widhalm, K. et al. (2011). Excessive sedentary time and low cardiorespiratory fitness in European adolescents: the HELENA study. *Archives of Disease in Childhood, 96*(3), 240-246.

Martinez-Gomez, D., Ruiz, J. R., Ortega, F. B., Veiga, O. L., Moliner-Urdiales, D., Mauro, B. et al. (2010). Recommended Levels of Physical Activity to Avoid an Excess of Body Fat in European Adolescents: The HELENA Study. *American Journal of Preventive Medicine*, *39*(3), 203-211.

Mâsse, L. C., Fuemmeler, B. F., Anderson, C. B., Matthews, C. E., Trost, S. G., Catellier, D. J. et al. (2005). Accelerometer Data Reduction: A Comparison of Four Reduction Algorithms on Select Outcome Variables. *Medicine & Science in Sports & Exercise, 37*(11 Suppl), S544-S554.

Mathew, N. J., & Narang, I. (2013). Sleeping too Close Together: Obesity and Obstructive Sleep Apnea in Childhood and adolescence. *Paediatric Respiratory Physiology, (in press).*

Matthews, C. E., Chen, K. Y., Freedson, P. S., Buchowski, M. S., Beech, B. M., Pate, R. R. et al. (2008). Amount of time spent in sedentary behaviors in the United States, 2003-2004. *American Journal of Epidemiology*, *167*(7), 875-881.

Mattocks, C., Leary, S., Ness, A., Deere, K., Saunders, J., Tilling, K. et al. (2007). Calibration of an accelerometer during free-living activities in children. *International Journal of Pediatric Obesity, 2*(4), 218-226.

May, A. L., Kuklina, E. V., & Yoon, P. W. (2012). Prevalence of Cardiovascular Disease Risk Factors Among US Adolescents, 1999–2008. *Pediatrics, 129*(6), 1035-1041.

Maynard, L. M., Wisemandle, W., Roche, A. F., Chumlea, W., Guo, S. S., & Siervogel, R. M. (2001). Childhood Body Composition in Relation to Body Mass Index. *Pediatrics, 107*(2), 344-350.

McCarthy, H., Ellis, S., & Cole, T. (2003). Central overweight and obesity in British youth aged 11-16: crossectional surveys of waist circumference. *British Medical Journal, 326*, 624.

McNamara, E., Hudson, Z., & Taylor, S. J. C. (2010). Measuring activity levels of young people: the validity of pedometers. *British Medical Bulletin, 95*(1), 121-137.

Melkevik, O., Torsheim, T., Iannotti, R. J., & Wold, B. (2010). Is spending time in screen-based sedentary behaviors associated with less physical activity: a cross national investigation. *International Journal of Behavioral .Nutrition and Physical Activity, (7)*46.

Meyer, U., Roth, R., Zahner, L., Gerber, M., Puder, J. J., Hebestreit, H. et al. (2012). Contribution of physical education to overall physical activity. *Scandinavian Journal of Medicine & Science in Sports, 23*(5), 600-606.

Mitchell, J. A., Mattocks, C., Ness, A. R., Leary, S. D., Pate, R. R., Dowda, M. et al. (2009). Sedentary behavior and obesity in a large cohort of children. *Obesity (Silver.Spring), 17*(8), 1596-1602.

Mitchell, J. A., Pate, R. R., Beets, M. W., & Nader, P. R. (2013, print). Time spent in sedentary behavior and changes in childhood BMI: a longitudinal study from ages 9 to 15 years. *International Journal of Obesity, 37*(1), 54-60.

Mitchell, M. S., Gaul, C. A., Naylor, P. J., & Panagiotopoulos C. (2014). Habitual moderate-to-vigorous physical activity is inversely associated with insulin resistance in Canadian first nations youth. *Pediatric Exercise Science, 22*(2), 254-265.

Moore, L. L., Gao, D., Bradlee, M. L., Cupples, L. A., Sundarajan-Ramamurti, A., Proctor, M. H. et al. (2003). Does early physical activity predict body fat change throughout childhood? *Prev.Med, 37*(1), 10-17.

Mouratidis, A., Lens, W., & Vansteenkiste, M. (2010). Feedback makes a difference: The motivating role of communicating in an autonomy-supporting way. *Journal of Sport and Exercise Psychology, 32*, 619-637.

Must, A., & Tybor, D. J. (2005). Physical activity and sedentary behavior: a review of longitudinal studies of weight and adiposity in youth. *International Journal of Obesity (Lond), 29 Suppl 2*, S84-S96.

Nader, P. R., Bradley, R. H., Houts, R. M., McRitchie, S. L., & O'Brien, M. (2008). Moderate-to-vigorous physical activity from ages 9 to 15 years. *JAMA: Journal of the American Medical Association, 300*(3), 295-305.

Nathan, B. M., & Moran, A. (2008). Metabolic complications of obesity in childhood and adolescence: more than just diabetes. *Current Opinion in Endocrinology, Diabetes, and Obesity*, *15*(1), 21-29.

National Council of Youth Sports. (2008). *Report on Trends and Participation in Organized Youth Sports*. Retrieved from: http://www.ncys.org/publications/2008-sports-participation-study.php

National Obesity Observatory Data Briefings, (2014). Retrieved from www.noo.org.uk

Nelson, M. C., Neumark-Stzainer, D., Hannan, P. J., Sirard, J. R., & Story, M. (2006). Longitudinal and Secular Trends in Physical Activity and Sedentary Behavior During Adolescence. *Pediatrics, 118*(6), e1627-e1634.

Nelson, T. F., Stovitz, S. D., Thomas, M., LaVoi, N. M., Bauer, K. W., & Neumark-Sztainer, D. (2011). Do youth sports prevent pediatric obesity? A systematic review and commentary. *Current Sports Medicine Reports., 10*(6), 360-370.

Ness, A., Leary, S., Mattocks, C., Blair, S. N., Reilly, J. J., Wells, J. et al. (2007). Objectively measured physical activity and fat mass in a large cohort of children. *PLoSMed, 4*(3), e97.

Ng, J. Y. Y., Ntoumanis, N., Thøgersen-Ntoumani, C., Deci, E. L., Ryan, R. M., Duda, J. L. et al. (2012). Self-Determination Theory Applied to Health Contexts: A Meta-Analysis. *Perspectives on Psychological Science, 7*(4), 325-340.

Ng, J. Y. Y., Ntoumanis, N., & Thøgersen-Ntoumani, C. (2013). Autonomy support and control in weight management: What important others do and say matters. *British Journal of Health Psychology,(in press).*

Nicholls (1984). Achievement motivation: Conceptions of ability, subjective experience, task choice and performance. *Psychological review, 91*(3), 328-346.

Nilsson, A., Andersen, L. B., Ommundsen, Y., Froberg, K., Sardinha, L. B., Piehl-Aulin, K. et al. (2009a). Correlates of objectively assessed physical activity and sedentary time in children: a cross-sectional study (The European Youth Heart Study). *BMC.Public Health, 9*, 322.

Nilsson, A., Anderssen, S. A., Andersen, L. B., Froberg, K., Riddoch, C., Sardinha, L. B. et al. (2009b). Between- and within-day variability in physical activity and inactivity in 9- and 15-year-old European children. *Scandinavian Journal of Medicine and Science in Sports, 19*(1), 10-18.

NSW Department of Health. (2009). *NSW Government Plan for Preventing Overweight and Obesity in Children, Young People & their Families 2009 - 2011*. Retrieved from http://www0.health.nsw.gov.au/pubs/2009/pdf/obesity_action_plan.pdf

Office for National Statistics. (2012). 2011 Census: Key Statistics for local authorities in England and Wales. Retrieved from: http://www.ons.gov.uk/ons/rel/census/2011-census/key-statistics-for-local-authorities-in-england-and-wales/index.html

Olds, T., Tomkinson, G., Leger, L., & Cazorla, G. (2006). Worldwide variation in the performance of children and adolescents: An analysis of 109 studies of the 20-m shuttle run test in 37 countries. *Journal of Sport Sciences, 24*(10), 1025-1038.

Oreopoulos, A., McAlister, F.A., Kalantar-Zadeh, K., Padwal, R., Ezekowitz, J.A., & Sharma, A.M. et al. (2009). The relationship between body mass index, treatment, and mortality in patients with established coronary artery disease: a report from APPROACH. *European Heart Journal*, *30*(21), 2584-2592.

O'Rourke, D. J., Smith, R. E., Smoll, F. L., & Cumming, S. P. (2012). Parent-Initiated Motivational Climate, Self-Esteem, and Autonomous Motivation in Young Athletes: Testing Propositions from Achievement Goal and Self-Determination Theories. *Child Development Research, Article ID 393914*, 1-9.

Overseas Development Institute. (2014). *Future diets*. Retrieved from: http://www.odi.org.uk/future-diets.

Owen, K. B., Astell-Burt, T., & Lonsdale, C. (2013). The Relationship Between Self-Determined Motivation and Physical Activity in Adolescent Boys. *Journal of Adolescent Health, 53*(3), 420-422.

Pate, R. R., Mitchell, J. A., Byun, W., & Dowda, M. (2011). Sedentary behaviour in youth. *British Journal of Sports Medicine, 45*(11), 906-913.

Pate, R. R., & O'Neill, J. R. (2011). Youth sports programs: contribution to physical activity. *Archives of Pediatrics and Adolescent Medicine, 165*(4), 369-370.

Pelletier, L. G., Fortier, M. S., Vallerand, R. J., & Brière, N. M. (2001). Associations Among Perceived Autonomy Support, Forms of Self-Regulation, and Persistence: A Prospective Study. *Motivation and Emotion, 25* (4), 279-306.

Perlman, D. J. (2013). The influence of the social context on students in- class physical activity. *Journal of Teaching in Physical Education*, *32*(1), 46-60.

Physical Activity Guidelines Advisory Committee. (2008). *Physical Activity Guidelines Advisory Committee Report, 2008.* Washington, DC: US Department of Health and Human Services. Retrieved from: http://www.health.gov/paguidelines/committeereport.aspx

Pietrobelli, A., Andreoli, A., Cervelli, V., Carbonelli, M. G., Peroni, D. G., & De Lorenzo, A. (2003). Predicting fat-free mass in children using bioimpedance analysis. *Acta Diabetologica*, *40*(Suppl 1), S212-S215.

Plasqui, G., & Westerterp, K. R. (2007). Physical activity assessment with accelerometers: an evaluation against doubly labeled water. *Obesity (Silver.Spring)*, *15*(10), 2371-2379.

Poyrazoglu, S., Bas, F., & Darendeliler, F. (2014). Metablic syndrome in young people. *Current Opinion in Endocrinology, Diabetes, and Obesity*, *21*(1), 56-63.

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40*(3), 879-891.

Prentice-Dunn, H., & Prentice-Dunn, S. (2011). Physical activity, sedentary behavior, and childhood obesity: A review of cross-sectional studies. *Psychology, Health & Medicine*, *17*(3), 255-273.

Public Health Canada.(2002). *Family guide to physical activity for youth 10-14 years of age.* Ottawa, Canada. Retrieved from: http://www.bcchildrens.ca/NR/rdonlyres/F5DF4B98-7307-4FB8-AF70-2259F0F1B4F8/38077/FamilyGuideYouth.pdf

Public Health England. (2014). *Trends in child (aged 2-15 years) obesity prevalence (HSE)*. Retrieved from www.noo.org.uk/NOO_about_obesity/child_obesity/UK_prevalence

Puhl, J., Greaves, K. A., Hoyt, M., & Baranowski, T. (1990). Children's Activity Rating Scale (CARS): description and calibration. *Research Quarterly for Exercise & Sport*, *61*(1), 26-36.

Pulgaron, E. R. (2013). Childhood obesity: a review of increased risk for physical and psychological comorbidities. *Clinical Therapy, 35*(1), A18-A32.

Puyau, M. R., Adolph, A. L., Vohra, F. A., & Butte, N. F. (2002). Validation and calibration of physical activity monitors in children. *Obeitys Research., 10*(3), 150-157.

Quested, E., & Duda, J. L. (2011). Perceived autonomy support, motivation regulations and the self-evaluative tendencies of student dancers. *Journal of Dance Medicine & Science, 15*(1), 3-14.

Quested, E., Ntoumanis, N., Viladrich, C., Haug, E., Ommundsen, Y., Van Hoye, A. et al. (2013). Intentions to drop-out of youth soccer: A test of the basic needs theory among European youth from five countries. *International Journal of Sport and Exercise Psychology, 11*(4), 395-407.

Recio-Rodriguez, J.I., Gomez-Marcos, M.A., Patino-Alonso, M.C., Agudo-Conde, C., Rodriguez-Sanchez, E., & Garcia-Ortiz, L. (2012). Abdominal obesity vs general obesity for identifying arterial stiffness, subclinical atherosclerosis and wave reflection in healthy, diabetics and hypertensive. *BMC Cardiovascualr disorders, 12,* 3.

Reilly, J. J. (2006a). Obesity in childhood and adolescence: evidence based clinical and public health perspectives. *Postgraduate Medical Journal, 82*(969), 429-437.

Reilly, J. J. (2006b). Tackling the obesity epidemic: new approaches. *Arch Dis Child, 91*(9), 724-726.

Reilly, J. J. (2010). Assessment of obesity in children and adolescents: synthesis of recent systematic reviews and clinical guidelines. *Journal of Human Nutrition and Dietetics., 23*(3), 205-211.

Reilly, J. J., & Kelly, J. (2011). Long-term impact of overweight and obesity in childhood and adolescence on morbidity and premature mortality in adulthood: systematic review. *International Journal of Obesity (Lond), 35*(7), 891-898.

Reilly, J. J., & McDowell, Z. C. (2003). Physical activity interventions in the prevention and treatment of paediatric obesity: systematic review and critical appraisal. *Proc.Nutr Soc, 62*(3), 611-619.

Reilly, J. J., Methven, E., McDowell, Z. C., Hacking, B., Alexander, D., Stewart, L. et al. (2003). Health consequences of obesity. *Arch Dis Child, 88*(9), 748-752.

Reilly, J. J. (2007). Childhood Obesity: An Overview. *Children & Society, 21*(5), 390-396.

Reilly, J. J. (2012). Evidence-Based Obesity Prevention in Childhood and Adolescence: Critique of Recent Etiological Studies, Preventive Interventions, and Policies. *Advances in Nutrition: An International Review Journal, 3*(4), 636S-641S.

Reinboth, M., Duda, J. L., & Ntoumanis, N. (2004). Dimensions of coaching behavior, need satisfaction, and the psychological and physical welfare of young athletes. *Motivation and Emotion, 28*(3), 297-313.

Rich, C., Griffiths, L. J., & Dezateux, C. (2012). Seasonal variation in accelerometer-determined sedentary behaviour and physical activity in children: a review. *International Journal of Behavioral Nutrition and Physical Activity,(9)*49.

Riddoch, C. J., Leary, S. D., Ness, A. R., Blair, S. N., Deere, K., Mattocks, C. et al. (2009). Prospective associations between objective measures of physical activity and fat mass in 12-14 year old children: the Avon Longitudinal Study of Parents and Children (ALSPAC). *British Medical Journal, 339,* b4544.

Riddoch, C. J., Mattocks, C., Deere, K., Saunders, J., Kirkby, J., Tilling, K. et al. (2007). Objective measurement of levels and patterns of physical activity. *Archives of Disease in Childhood, 92*(11), 963-969.

Ridgers, N. D., Salmon, J., Parrish, A. M., Stanley, R. M., & Okely, A. D. (2012a). Physical activity during school recess: a systematic review. *Am J Prev.Med, 43*(3), 320-328.

Ridgers, N.D., Stratton, G., & Fairclough, S.J. (2006). Physical activity levels of children during school playtime. *Sports Medicine, 36*(4), 359 - 371.

Ridgers, N. D., Timperio, A., Cerin, E., & Salmon, J. (2014). Compensation of Physical activity and Sedentary Time in Primary School Children. *Medicine and Science in Sports and Exercise, 31(in press).*

Ridgers, N. D., Timperio, A., Crawford, D., & Salmon, J. (2012b). Five-year changes in school recess and lunchtime and the contribution to children's daily physical activity. *Br J Sports Med, 46*(10), 741-746.

Ried-Larsen, M., Grøntved, A., Froberg, K., Ekelund, U., & Andersen, L. B. (2013). Physical activity intensity and subclinical atherosclerosis in Danish adolescents: The European Youth Heart Study. *Scandinavian Journal of Medicine & Science in Sports, 23*(3), e168-e177.

Ried-Larsen, M., Grøntved, A., Møller, N. C., Larsen, K. T., Froberg, K., & Andersen, L. B. (2013). Associations between objectively measured physical activity intensity in childhood and measures of subclinical cardiovascular disease in adolescence: prospective observations from the European Youth Heart Study. *British Journal of Sports Medicine*, *(in press).*

Rizzo, N. S., Ruiz, J. R., Hurtig-Wennlöf, A., Ortega, F. B., & Sjöström, M. (2007). Relationship of Physical Activity, Fitness, and Fatness with Clustered Metabolic Risk in Children and Adolescents: The European Youth Heart Study. *The Journal of Pediatrics, 150*(4), 388-394.

Roberts, G.C. (1982). Achievement and motivation in sport. In R.Terjung (Ed). *Exercise and Sport Science Reviews:* (Vol. 10.) Philadelphia, Franklin Institute Press.

Roberts, G.C. (1997). Future research directions in understanding the motivation of children in sport: A goal orientation perspective. In R. Lidor & M. Bar-Eli (Eds.), *Innovations in sport psychology: Lonking theory and practice. Proceedings of the IX World Congress on Sport Psychology: Part II* (pp.576-580). Netanya, Israel: Ministry of Education, Culture and Sport.

Roemmich, J. N., Lambiase Ms, M. J., McCarthy, T. F., Feda, D. M., & Kozlowski, K. F. (2012). Autonomy supportive environments and mastery as basic factors to motivate physical activity in children: a controlled laboratory study. *International Journal of Behavioral Nutrition and Physical Activity, (9)*16.

Roemmich, J. N., & Rogol, A. D. (1995). Physiology of growth and development. It's relationship to performance in the young athlete. *Clinics in Sports Medicine, 14*(3), 483-502.

Rokholm, B., Baker, J. L., & Sorensen, T. I. (2010). The levelling off of he obesity epidemic since the year 1999: a review of evidence and perspectives. *Obesity Reviews, 11*, 835-846.

Romero-Corral, A., Montori, V.M., Somers, V.K., Korinek, J., Thomas, R.J., Allison, T.G., & Mookadam, F. et al., (2006). Association of body weight with total mortality and with cardiovascular events in coronary heart disease: a systematic review of cohort studies. *The Lancert, 368*(9536), 666-678.

Rosenkilde, M., Auerbach, P., Reichkendler, M.H., Ploug, T., Stallknecht, B.M., Sjodin, A. (2012). Body fat loss and compensatory mechanisms in response to different doses of aerobic exercise - a randomized control trial in overweight sedentary males. *American Journal of Physiology. Regulatory,integrative, and comparative physiology, 303*(6), R579-579.

Rouse, P. C., Ntoumanis, N., Duda, J. L., Jolly, K., & Williams, G. C. (2011). In the beginning: Role of autonomy support on the motivation, mental health and intentions of participants entering an exercise referral scheme. *Psychology & Health, 26*(6), 729-749.

Rudolf, M. C. J. (2004). The obese child. *Archives of disease in childhood - Education & practice edition, 89*(3), ep57-ep62.

Ruiz, J. R., Ortega, F. B., Warnberg, J., & Sjostrom, M. (2007, online). Associations of low-grade inflammation with physical activity, fitness and fatness in prepubertal children; the European Youth Heart Study. *International Journal of Obesity, 31*(10), 1545-1551.

Ruiz, J. R., Rizzo, N. S., Hurtig-Wennlöf, A., Ortega, F. B., Wärnberg, J., & Sjöström, M. (2006). Relations of total physical activity and intensity to fitness and fatness in children: the European Youth Heart Study. *The American Journal of Clinical Nutrition, 84*(2), 299-303.

Ryan, R. M. (1995). Psychological needs and the facilitation of integrative processes. *Journal of Personality, 63*(3), 397-427.

Ryan, R. M., & Connell, J. P. (1989). Perceived locus of causality and internalization: Examining reasons for acting in two domains. *Journal of Personality and Social Psychology, 57*(5), 749-761.

Ryan, R. M., & Deci, E. L. (2000a). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68-78.

Ryan, R. M., & Deci, E. L. (2000b). The Darker and Brighter Sides of Human Existence: Basic Psychological Needs as a Unifying Concept. *Psychological Inquiry, 11*(4), 319-338.

Sacheck, J. M., Nelson, T., Ficker, L., Kafka, T., Kuder, J., & Economos, C. D. (2011). Physical activity during soccer and its contribution to physical activity recommendations in normal weight and overweight children. *Pediatric Exercise Science, 23*(2), 281-292.

Sallis, J. F. (2000). Age-related decline in physical activity: a synthesis of human and animal studies. *Medicine & Science in Sports & Exercise, 32*(9), 1598-1600.

Sallis, J. F., & Saelens, B. E. (2000). Assessment of physical activity by self-report: status, limitations, and future directions. *Research Quarterly for Exercise and Sport, 71*(2 Suppl), S1-14.

Santos, R., Mota, J., Okely, A. D., Pratt, M., Moreira, C., Coelho-e-Silva, M. J. et al. (2013). The independent associations of sedentary behaviour and physical activity on cardiorespiratory fitness. *British Journal of Sports Medicine, (in press).*

Sardinha, L. B., Andersen, L. B., Anderssen, S. A., Quiterio, A. L., Ornelas, R., Froberg, K. et al. (2008). Objectively measured time spent sedentary is associated with insulin resistance independent of overall and central body fat in 9- to 10-year-old Portuguese children. *Diabetes Care, 31*(3), 569-575.

Saunders, T. (2011). Potential Contributors to the Canadian Pediatric Obesity Epidemic. *ISRN Pediatrics, 2011, Article ID 917684*, 10 pages.

Saunders, M.J., Blevins, J.E., Broeder, C.E. (1998). Effects of hydration changes on bioelectrical impedence in endurance trained individuals. *Medicine and Science in Sports and Exercise, 30*(6), 885-892.

Schenkeveld, L., Magro, M., Oemrawsingh, R.M., Lenzen, M., de Jaegere, P., & van Geuns, R-J et al. (2012). The influence of optimal medical treatment on the “obesity paradox,” body mass index and long-term mortality in patients treated with percutaneous coronary intervention: a prospective cohort study. *BMJ Open, 2,* e000535

Sebire, S. J., Jago, R., Fox, K. R., Edwards, M. J., & Thompson, J. L. (2013). Testing a self-determination theory model of children's physical activity motivation: a cross-sectional study. *The International Journal of Behavioral Nutrition and Physical Activity, (10)*111.

Sebire, S. J., Standage, M., & Vansteenkiste, M. (2011). Predicting objectively assessed physical activity from the content and regulation of exercise goals: evidence for a mediational model. *Journal of Sport and Exercise.Psychology., 33*(2), 175-197.

Sebire, S. J., Jago, R., Gorely, T., Hoyos Cillero, I., & Biddle, S. J. H. (2011). "If there wasn't the technology then I would probably be out everyday": A qualitative study of children's strategies to reduce their screen viewing. *Preventive Medicine, 53*(4-5), 303-308.

Sedentary Behaviour Research Network. (2012). Letter to the Editor: Standardized use of the terms 'sedentary' and 'sedentary behaviours'. *Applied Physiology, Nutrition, and Metabolism, 37*(3), 540-542.

Seligman, M. E. P. (1975). *Helplessness*. San Franciso: Freeman.

Shrout, P. E., & Bolger, N. (2002). Mediation in experimental and nonexperimental studies: New procedures and recommendations. *Psychological Methods, 7*(4), 422-445.

Silva, P., Sousa, M., Aires, L., Seabra, A., Ribeiro, J., Welk, G. et al. (2010). Physical activity patterns in Portuguese adolescents: The contribution of extracurricular sports. *European Physical Education Review, 16*(2), 171-181.

Singh, A. S., Mulder, C., Twisk, J. W. R., van Mechelen, W., & Chinapaw, M. J. M. (2008). Tracking of childhood overweight into adulthood: a systematic review of the literature. *Obesity Reviews, 9*(5), 474-488.

Sirard, J. R., & Pate, R. R. (2001). Physical activity assessment in children and adolescents. *Sports Medicine, 31*(6), 439-454.

Sisson, S. B., Church, T. S., Martin, C. K., Tudor-Locke, C., Smith, S. R., Bouchard, C. et al. (2009). Profiles of sedentary behavior in children and adolescents: The US National Health and Nutrition Examination Survey, 2001-2006. *International Journal of Pediatric Obesity, 4*(4), 353-359.

Song, M., Carroll, D. D., & Fulton, J. E. (2013). Meeting the 2008 Physical Activity Guidelines for Americans Among U.S. Youth. *American Journal of Preventive Medicine, 44*(3), 216-222.

Srinivasan, S. R., Myers, L., & Berenson, G. S. (2002). Predictability of Childhood Adiposity and Insulin for Developing Insulin Resistance Syndrome (Syndrome X) in Young Adulthood: The Bogalusa Heart Study. *Diabetes, 51*(1), 204-209.

Standage, M., Gillison, F. B., Ntoumanis, N., & Treasure, D. C. (2012). Predicting students' physical activity and health-related well-being: a prospective cross-domain investigation of motivation across school physical education and exercise settings. *Journal of Sport and Exercise.Psychology., 34*(1), 37-60.

Standage, M., Sebire, S. J., & Loney, T. (2008). Does exercise motivation predict engagement in objectively assessed bouts of moderate-intensity exercise? A self-determination theory perspective. *Journal of Sport and Exercise Psychology, 30*(4), 337-352.

Steele, R. M., van Sluijs, E. M., Cassidy, A., Griffin, S. J., & Ekelund, U. (2009). Targeting sedentary time or moderate- and vigorous-intensity activity: independent relations with adiposity in a population-based sample of 10-y-old British children. *American Journal of Clinical Nutrition, 90*(5), 1185-1192.

Steele, R. M., van Sluijs, E. M., Sharp, S. J., Landsbaugh, J. R., Ekelund, U., & Griffin, S. J. (2010). An investigation of patterns of children's sedentary and vigorous physical activity throughout the week. *International Journal of Behavioral.Nutrition and Physical Activity, (7)*88.

Stellino, M. B., & Sinclair, C. D. (2013). Psychological predictors of children' s recess physical activity motivation and behavior. *Research Quarterly for Exercise and Sport, 84*(2), 167-176.

Strauss, R. S. (2000). Childhood obesity and self-esteem. *Pediatrics, 105*(1), e15.

Strong, W. B., Malina, R. M., Blimkie, C. J. R., Daniels, S. R., Dishman, R. K., Gutin, B. et al. (2005). Evidence Based Physical Activity for School-age Youth. *The Journal of Pediatrics, 146*(6), 732-737.

Tannehill, D., MacPhail, A., Walsh, J., & Woods, C. (2013). What young people say about physical activity: the Children's Sport Participation and Physical Activity (CSPPA) study. *Sport, Education and Society,* 1-21.

Taylor, I. M., Ntoumanis, N., Standage, M., & Spray, C. M. (2010). Motivational predictors of physical education students' effort, exercise intentions, and leisure-time physical activity: a multilevel linear growth analysis. *Journal of Sport and Exercise Psychology, 32*(1), 99-120.

Teixeira, P., Carraca, E., Markland, D., Silva, M., & Ryan, R. (2012). Exercise, physical activity, and self-determination theory: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity, (9)*78.

Telama, R., Yang, X., Leskinen, E., Kankaanpää, A., Hirvensalo, M., Tammelin, T. et al. (2013). Tracking of Physical Activity from Early Childhood through Youth into Adulthood. *Medicine & Science in Sports & Exercise, (in press).*

Telama, R., Yang, X., Viikari, J., Valimaki, I., Wanne, O., & Raitakari, O. (2005). Physical activity from childhood to adulthood: a 21-year tracking study. *American Journal of Preventive.Medicine, 28*(3), 267-273.

Tessier, D., Smith., N., Tzioumakis, Y., Quested, E., Sarrazin, P., Papaioannou, A., Digelidis, N., & Duda, J.L. (2013). Comparing the objective motivational climate created by grassroots soccer coaches in England, Greece and France. *International Journal of Sport and Exercise Psychology 11*(4), 365-383.

Thompson, J. L., Jago, R., Brockman, R., Cartwright, K., Page, A. S., & Fox, K. R. (2010). Physically active families - de-bunking the myth? A qualitative study of family participation in physical activity. *Child Care Health Dev., 36*(2), 265-274.

Trayers, T., Cooper, A. R., Riddoch, C. J., Ness, A. R., Fox, K. R., Deem, R. et al. (2006). Do children from an inner city British school meet the recommended levels of physical activity? Results from a cross sectional survey using objective measurements of physical activity. *Archives of Disease in Childhood, 91*(2), 175-176.

Tremblay, M. S., Leblanc, A. G., Kho, M. E., Saunders, T. J., Larouche, R., Colley, R. C. et al. (2011). Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *The International Journal of Behavioral Nutrition and Physical Activity, 21*(8), 98.

Trilk, J. L., Ortaglia, A., Blair, S. N., Bottai, M., Church, T. S., & Pate, R. R. (2013). Cardiorespiratory Fitness, Waist Circumference, and Alanine Aminotransferase in Youth. *Medicine & Science in Sports & Exercise, 45*(4), 722-727.

Troiano, R. P., Berrigan, D., Dodd, K. W., Masse, L. C., Tilert, T., & McDowell, M. (2008). Physical Activity in the United States Measured by Accelerometer. *Medicine & Science in Sports & Exercise, 40*(1), 181-188.

Trost, S. G. (2001). Objective measurement of physical activity in youth: current issues, future directions. *Exercise and Sport Science Reviews, 29*(1), 32-36.

Trost, S. G., Loprinzi, P. D., Moore, R., & Pfeiffer, K. A. (2011). Comparison of accelerometer cut points for predicting activity intensity in youth. *Medicine and Science in Sports and Exerc., 43*(7), 1360-1368.

Trost, S. G., Pate, R. R., Freedson, P. S., Sallis, J. F., & Taylor, W. C. (2000). Using objective physical activity measures with youth: how many days of monitoring are needed? *Medicine and Science in Sports and Exercise., 32*(2), 426-431.

Trost, S. G., Ward, D. S., Moorehead, S. M., Watson, P. D., Riner, W., & Burke, J. R. (1998). Validity of the computer science and applications (CSA) activity monitor in children. *Medicine and Science in Sports and Exercise., 30*(4), 629-633.

Trost, S. G. (2007). State of the Art Reviews: Measurement of Physical Activity in Children and Adolescents. *American Journal of Lifestyle Medicine, 1*(4), 299-314.

Trudeau, F., Laurencelle, L., & Shephard, R. J. (2004). Tracking of physical activity from childhood to adulthood. *Medicine and Science in Sports and Exercise., 36*(11), 1937-1943.

UK Statistics Authority. (2013). *Taking Part - Statistical Release* Department for Culture, Media and Sport. Retrieved from: www.gov.uk/government/uploads/system/uploads/attachment_data/file/191967/Taking_Part_2011Q4_12Q3_Supplementary_Child_Report.pdf

US Department of Health and Human Services. (2013). Physical activity guidelines for Americans. Retrieved from http://www.health.gov/PAguidelines/guidelines/chapter3.aspx.

Vallerand, R. J. (1997). Toward a hierarchical model of intrinsic and extrinsic motivation. In M.P. Zanna (Ed.), *Advances in experimental social psychology* (pp. 271-360). New York: Academic Press.

Van Hoye, A. l., Fenton, S., Krommidas, C., Heuzé, J.-P., Quested, E., Papaioannou, A. et al. (2013). Physical activity and sedentary behaviours among grassroots football players: A comparison across three European countries. *International Journal of Sport and Exercise Psychology, 11*(4), 341-350.

Vansteenkiste, M., Mouratidis, A., & Lens, W. (2010). Detaching reasons from aims: fair play and well-being in soccer as a function of pursuing performance-approach goals for autonomous or controlling reasons. *Journal of Sport and Exercise Psychology, 32*(2), 217-242.

Vierling, K. K., Standage, M., & Treasure, D. C. (2007). Predicting attitudes and physical activity in an "at risk" minority youth sample: A test of self-determination theory. *Psychology of Sport and Exercise, 8*(5), 795-817.

Viladrich, C., Appleton, P. R., Quested, E., Duda, J. L., Alcaraz, S., Heuzé, J.-P. et al. (2013). Measurement invariance of the Behavioural Regulation in Sport Questionnaire when completed by young athletes across five European countries. *International Journal of Sport and Exercise Psychology,11*(4), 384-394.

Wang, Y., & Lobstein, T. (2006). Worldwide trends in childhood overweight and obesity. *International Journal of Pediatric Obesity, 1*(1), 11-25.

Wareham, N. J., van Sluijs, E. M., & Ekelund, U. (2005). Physical activity and obesity prevention: a review of the current evidence. *The Proceedings of the Nutrition Society, 64*(2), 229-247.

Weiss, M. R. (2000). *Motivating kids in physical activity* (Series 3).Retrieved from: https://www.presidentschallenge.org/informed/digest/docs/200009digest.pdf

Welk, G. J., Corbin, C. B., & Dale, D. (2000). Measurement issues in the assessment of physical activity in children. *Reearch Quarterly for Exercise and Sport, 71*(2 Suppl), S59-S73.

Weston, A. T., Petosa, R., & Pate, R. R. (1997). Validation of an instrument for measurement of physical activity in youth. *Medicine and Science in Sports & Exercise, 29*(1), 138-143.

White, S. A., Duda, J. L., & Hart, S. (1992). An exploratory examination of the Parent-initiated Motivational Climate Questionnaire. *Perceptual and Motor Skills, 75*(3 Pt 1), 875-880.

White, S. A., Kavussanu, M., & Guest, S. M. (1998). Goal Orientations and Perceptions of the Motivational Climate Created by Significant Others. *European Journal of Physical Education, 3*(2), 212-228.

Wickel, E. E., & Eisenmann, J. C. (2007). Contribution of youth sport to total daily physical activity among 6- to 12-yr-old boys. *Medicine and Science in Sports and Exercise., 39*(9), 1493-1500.

Wight, V. R., Price, J., Bianchi, S. M., & Hunt, B. R. (2009). The time use of teenagers. *Social Science Research, 38*(4), 792-809.

Williams, G. C., Grow, V. M., Freedman, Z. R., Ryan, R. M., & Deci, E. L. (1996). Motivational predictors of weight loss and weight-loss maintenance. *Journal of Personality and Social Psychology, 70*(1), 115-126.

Womens Sports Foundation. (2008). *Go Out and Play: Youth Sports in America*. Retrieved from: http://www.womenssportsfoundation.org/home/research/articles-and-reports/mental-and-physical-health/go-out-and-play

Woods, C. B., Tannehill, D., Quinlan, A., Moyna, N., & Walsh, J. (2010). *The Children's Sport Participation and Physical Activity Study (CSPPA). Research report No. 1*. School of Health and Human Performance, Dublin City University and the Irish Sports Council . Retrieved from: https://www4.dcu.ie/shhp/downloads/CSPPA.pdf.

World Health Organisation. (1995). *Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee* (854), 1-452.

World Health Organisation. (1998). *Obesity. preventing and managing the global epidemic*. Retrieved from: http://whqlibdoc.who.int/hq/1998/WHO_NUT_NCD_98.1_(p1-158).pdf

World Health Organisation. (2011). *Global Strategy on Diet, Physical Activity and Health: Physical Activity and Young People*. Retrieved from http://www.who.int/dietphysicalactivity/factsheet_young_people/en/

World Health Organisation. (2013). *Obesity and overweight: Fact sheet N°311*. Retrieved from http://www.who.int/mediacentre/factsheets/fs311/en/

Wyatt, S. B., Winters, K. P., & Dubbert, P. M. (2006). Overweight and Obesity: Prevalence, Consequences, and Causes of a Growing Public Health Problem. *The American Journal of the Medical Sciences, 331*(4), 166-174.

Yang, X., Telama, R., Hirvensalo, M., Viikari, J. S., & Raitakari, O. T. (2009). Sustained participation in youth sport decreases metabolic syndrome in adulthood. *International Journal of Obesity (Lond), 33*(11), 1219-1226.

Zaninotto, P., Wardle, H., Stamatakis, E., Mindell, J., & Head, J. (2006). *Health Survey for England: Forecasting Obesity to 2010*. Retrieved from: http://www.sportni.net/NR/rdonlyres/7FEF403C-063D-42B6-89FF-A666522BC5DD/0/Forecasting_Obesity_in_2010.pdf.

APPENDIX 1: Information sheets and consent forms

APPENDIX 2: Materials to aid with cleaning/interpretation of accelerometer data

Physical activity diary
Accelerometer wear time log

APPENDIX 3: Materials for Chapters 4 and 5

Questionnaires

APPENDIX 1

INFORMATION SHEETS AND CONSENT FORMS

Parent or Guardian information Sheet

Part 1

Study Title:
Physical Activity in Children and Adolescents

- Thank you for taking the time to read this information sheet. We would like to invite your child to be part of this research study. In order for him/her to take part we need your consent as well as the assent of your child. If there is any further information that you would like then please do not hesitate to contact us.

- Your child's participation in this study is entirely voluntary.

- Before you decide whether or not you would like your child to take part it is important you understand why the research is being done and what it will involve for him/her. Please read the following information carefully and discuss it with your child. Please ask us if there is anything else you would like to know.

- Part 1 tells you what the study is about and what will be asked of your child if they decide to take part.

- Part 2 gives you more detailed information about the way the study will be run.

Please take time to decide if you wish to consent for your child to take part.

1. Why are we doing this research?

The aim of this study is to investigate physical activity levels of young people who play football and determine whether this is related to their levels of health and fitness.

2. Why has my child been chosen?

Your child has been approached because he/she is between 10-16 years old. The study began in June 2010 and will include up to 150 young people. Your child is being asked to take part in this study for 1 week.

3. Does he/she have to take part?

No, his/her participation is purely voluntary and he/she is free to withdraw at any stage without reason or consequences. If you wish to withdraw your child at any time without giving reason you are free to do so. Unfortunately if your child has a history of chronic illness such as severe asthma, he/she will not be able to take part.

4. What will happen to him/her if they decide to take part?

Your child will be part of the study for 1 week. If he/she would like to stop taking part at any time he/she may do so without giving a reason.

5. What will he/she have to do?

Researchers from the University of Birmingham will visit a training session. If your son/daughter decides to take part and you give your consent for them to do so, he/she will be asked to carry out a simple fitness test, have measurements of their height, weight and bodyfat percentage taken and wear an activity monitor for one week. These procedures are explained in more detail below. Should you wish, you will be able to join your child whilst they take part in the study. We may ask that he/she arrives before their training session or match with yourself and/or a signed parent/guardian consent form. This is so they can undergo the procedures before or at the start of their football session (in terms of matches we will try to test him/her beforehand or afterwards so they would not have to miss any of the game).

The procedures which will be carried out are outlined below:

Screening and Participation

Before we carry out any of the tests your child will be checked to make sure he/she is eligible to take part in the study. The researcher will ask him/her about any past or current illnesses.

The researcher will then carry out the following assessments:

- Measurements of his/her height, weight, waist circumference and body composition.

In the final part of the study your child will be asked to carry out a simple exercise test wearing a physical activity measurement device the GT3X accelerometer. It is small device worn on an elasticated strap around the hip under the clothes. The GT3X will be fitted by the researcher. A picture of the GT3X is shown below.

GT3X

Following this your child will be asked to wear the GT3X for 7 days and we will visit the training session next week to collect it. The GT3X is small and light and designed to be worn for 5-10 days so it should not feel uncomfortable. However, if it does begin to feel uncomfortable at any time your child may remove it and make a note of the date and time it was removed/replaced.

The fitness test is the final procedure we will ask your child to carry out and following this they will be free to leave and begin their training session or match. The fitness test he/she will be asked to undertake is the 20 metre shuttle run test (more commonly known as the 'bleep test') During the test your child will be asked to run between 20 sets of cones, 20 metres apart, at a set pace which is determined by an audio-CD. This CD beeps at specific time intervals and as the test progresses the time between beeps becomes increasingly shorter. The aim is to be able to complete one shuttle (i.e., 20 metres) and make it to the opposite set of cones at the same time the next beep is played. Once you miss 2 beeps in a row the test finishes. If you have any further questions regarding this fitness test please do not hesitate to ask. Your child's coach will be present during this test.

Things to take home:

Your child will be given a questionnaire pack to take home. This will include a physical activity diary in which we will ask him/her to record the activities they undertake during the 7 days they are participating in the study. There will also be a questionnaire which assess the amount of physical activity he/she undertakes during the week and his/her feelings towards taking part in sport and active games.

The above procedures should only take around 25 minutes in total but he/she will be in the study for 7 days whilst wearing the GT3X. You are also welcome to be present for some/all of the procedures should you wish.

6. What are the possible disadvantages and risks of taking part?

There are no known risks to taking part. During the exercise your child may feel tired and out of breath. However, he/she may stop at any time .

7. What are the potential benefits of taking part?

We will be able to give your child feedback on some aspects of his/her general health (body composition, BMI). In addition once your child has worn the accelerometers for seven days we will be able to give him/her information and feedback on their physical activity/fitness levels. It may also be useful for your child to mention taking part in a research study in his or her portfolio. .

8. What if there is a problem?

Detailed information about this is given in part 2.

9. Will the personal data collected from my child during the study be kept confidential?

Yes. All information about him/her taking part in the study will be kept confidential. More information regarding confidentiality may be found in part 2.

10. Contact for further information

If you require further information, please feel free to contact the people below and ask any questions you wish.

Investigators name: *Researchers name:*

[redacted] [redacted]

[redacted] [redacted]

[redacted] [redacted]

[redacted] [redacted]

[redacted] [redacted]

[redacted] [redacted]

[redacted]

You may also wish to contact the Patient Advice and Liaison Service at Birmingham Children's Hospital who will be able to give you more information about how this type of research is carried out.

PALS Officer: Carmel Cremins-Jones
Email: carmel.cremins-jones@bch.nhs.uk

Equality and Diversity/ PALS Officer: Safia Datoo
Email: safia.datoo@bch.nhs.uk

Tel: 0121 333 8403
Tel: 0121 333 8611
Text: 07771 996 221
Visit: The PALS Office is next to the Welcome Desk at Main Reception

Thankyou for reading so far. If you are interested to find out more, please go to part 2 before making any decision.

Part 2

11. What happens if new information about the study becomes available?

Sometimes new information comes along about the exercise that is being studied whilst a study is still happening and this may affect your willingness for your child to continue to participate in the study. If this happens your study researcher will discuss with you and your child whether or not they want to continue in the study and if you are happy for them to. If you decide to withdraw him/her from the study, you may do so without giving reason. If you decide to continue in the study, you and your child may be asked to sign an updated assent/consent form containing the new information.

Also, on receiving new information your study researcher might consider it to be in your best interests to withdraw your child from the study. Your researcher will explain the reasons if this should occur.

12. What will happen if he/she does not want to carry on with the study?

Your child's participation in the study is voluntary and he/she may withdraw at any time without a reason. You may also wish to make sure your child fully understands this before he/she decides whether or not to take part in the study.

13. What if there is a problem?

Complaints:

If you have a concern about any aspect of this study, you should contact the researcher or Chief Investigator (contact details above). They will do their best to answer any questions you may have. If you are still unhappy and wish to make a formal complaint, you can do this using the University of Birmingham complaints procedure. The researcher will be able to inform you on how to do this,

Harm: If your child has an accident such as a fall, while undertaking the exercise tests, The University or Birmingham has in force a Public Liability Policy and/or Clinical Trials and the activities here are included within that coverage.

. We will make sure he/she is closely supervised while undergoing the procedures. You are also free to join them whilst they take part should you wish to do so.

14. Will anyone else know he/she is taking part in this study?

Yes. If you and your child have given your consent to take part in this study, any of his/her medical records may be looked at by members of the research team to check the information collected for the study. Also, people from the regulatory authorities (such as the Department of Health) may look at his/her medical notes to check that the study is being carried out properly.

His/her data will be identified by a subject number. Any questionnaires, physical information and information about his/her physical activity will be identified in the same way. None of their personal details will be used in any presentations or publications as required by local/regional/national regulations. The information collected during the study is confidential.

15. What will happen to the results of the research study?
Once the study is complete, the results will be published and a final report written. You or your child may contact your study doctor/researcher if you would like to get copies of any information that is published. Your child will not be identified in any reports or publications.

16. Who is organizing and funding the research?
The University of Birmingham funds the researcher (Sally Fenton) who will be carrying out this study as part of her work for her postgraduate degree.

17. Who has reviewed this study?
This study has been reviewed by the School of Sports and Exercise Sciences projects committee, and by a Birmingham Research Ethics Committee.

The study will be run in accordance with all suitable guidelines aimed at ensuring proper conduct and safety of anyone taking part, including the Guidelines on Good Clinical Practice and the Declaration of Helsinki.

18. What happens now if my child decides to take part?
For your child to take part in this study it is essential we have both your child’s assent and your consent. Please return the slip overleaf if you wish to give your permission for him/her to take part. If you have any concerns/questions regarding this research/investigation please contact us (details in part 1). You are welcome to join your child whilst they take part and should you wish to withdraw your consent for his/her

participation in the study at any point you may do so. On providing consent for him/her to take part in this project, you and your child are agreeing to the anonymised results of the study being used for scientific purposes and with the results potentially being published in a scientific journal. The results will be published anonymously. Our analysis will use ID codes to ensure this. You may give your consent before hand, or if you prefer, on the day we are visiting the training sessions. We will ask that you are present when we obtain your child's assent and they are recruited to the study. If you and/or your child would like to meet the researcher Sally Fenton and discuss the study further before deciding whether or not to assent/consent, this can be arranged.

Thankyou for taking the time to read this information sheet

Birmingham Children's Hospital NHS
NHS Foundation Trust

PARENT OR GUARDIAN CONSENT FORM

The Relationship of Lifestyle Physical Activity and Pulse Wave Velocity in Children and Adolescents

Name of Researcher:

Parent/Guardian in the boxes below please initial all statements you agree with. If you do not agree and do not wish for your child to take part in this study please do not initial the box.

1. I confirm I have read and understood the study information sheet.

2. Somebody else has explained this study to me

3. I fully understand the purpose of this study.

4. I have had the opportunity to discuss the study and ask any questions.

5. I am satisfied with the explanations both myself and my child have been given.

6. I understand that my child's participation in the study is my choice and I may withdraw him/her from the study at any time without reason and without my medical care being affected.

7. I am happy for my child to take part in the study and know that I will get a copy of this signed form and information sheet to take home.

8. I understand that the relevant sections of my child's medical notes and data collected during the study may be looked at by individuals from regulatory authorities of from the NHS trust where it is

relevant to him/her taking part in this research. I give permission for these individuals to have access to my his/her records.

Parent

I .... have read the study information sheet. I understand the purpose and design of the study. I hereby give permission for my child to take part in the above project, if he/she wishes to do so, with the knowledge that he/she may withdraw at any time without giving a reason.

Signature .... **Date** ....

Name (print) ....

Person taking consent

I confirm that I have explained the nature of the study to the participant and their parent/guardian in terms that they understand, outlining both benefits and risks. I confirm that he/she has given consent freely to partake in this study.

Signature .... **Date** ....

Name (print) ....

Participant Information Sheet

Part 1

1. **Study Title:**

Physical Activity in Children and Adolescents

2. **An invitation to take part**

- Thank you for taking the time to read this information sheet. We are asking if you would agree to take part in a research study. We are also asking your parent or guardian to agree for you to take part in this study.

- Your taking part in this study is entirely voluntary

- Before you decide if you want to take part, it is important that you understand why we are doing this research and what it will involve for you. Please read the following information carefully and discuss it with your family and friends if you want to. Please ask us if there is anything else you would like to know.

- Part 1 tells you what the study is about and what will happen to you if you take part.

- Part 2 gives you more detailed information about the way that the study will be run.

Please take time to decide if you want to take part.

3. **Why are we doing this research?**

The aim of this study is to find out about physical activity levels of young people who play football and whether the amount of physical activity you do is related to your health. This will help Doctors and Scientists learn more about how physical activity can help keep you healthy as you get older.

4. Why have I been chosen?

You have been invited to take part because you are aged between 10-16 years. This study started in June 2010 and will include up to 150 young people. You are being asked to take part in this study for 1 week.

5. Do I have to take part?

No. It is up to you to decide whether or not you take part. It is important to understand that taking part in this study is voluntary and you are free to withdraw at any time without giving a reason and without any consequences.

Before any tests are carried out, your study researcher will explain the tests that will be done in this study and you are asked to read this information sheet thoroughly. If wish to take part and are happy with the explanations, you will be asked to sign and date the assent form. A copy of this information sheet will be signed, dated and given to you to keep. Please show this information to your parent(s) or guardian(s) and they must also consent (agree) before you can take part.

6. What will happen to me if I agree to take part?

You will be in the study for one week, but if you would like to stop taking part at any time, you may, without anything happening to the quality of your healthcare.

7. What will I have to do?

Researchers from the University of Birmingham will visit a training session. If you decide you would like to take part in the project and your parent/guardian says it is ok for you to do so, the researcher s will ask you to carry out a simple fitness test, take measurements of your height, weight and body fat percentage, and ask you to wear an activity monitor for 1 week. More information about this is described below. You may be asked to arrive before your training session or match so you can take part in the study before you go and play football.

Screening and participation

Before we carry out any of the tests you will be checked to make sure you are ok to take part in the study. The researcher will ask you about any past or current illnesses you may have.

The nurse or researcher (Sally Fenton) will then measure your weight, height, waist circumference and body composition.

-In the last part of the study we will ask you to wear a small gadget called a GT3X accelerometer. This measures your movements during the day. The GT3X is small and light and is worn on an elastic strap around your waist underneath your clothes. The GT3X is shown below.

GT3X

We will ask you to wear the GT3X for 7 days (this includes a day which you have a football match) and then we will collect it back from you at your training session the following week. It is important that you do not play/tamper with the GT3X or give it to anyone else to wear as this will affect the results of our study. The GT3X is small and light and designed to be worn for between 5-10 days so should not feel uncomfortable. However, if it does begin to feel uncomfortable you may take it off at any time and make a note of the date and time you removed/replaced it.

The final thing we will ask you to do is a fitness test. The test we will ask you to do is called the 20 Meter Shuttle Run test. This test is also called the bleep test and you may have already been asked to do it at school. During the test you will be asked to run in a straight line between 2 sets of cones that are 20 metres apart. We will ask you to run at a set pace which is determined by bleeps on an audio-CD. The CD beeps at time intervals and the beeps get faster and faster the better you do and the further into the test you get. The aim is to be able to run from one set of cones to the next, at the same time the next beep is played. Once you miss 2 beeps in a row or you feel like you can not run anymore the test finishes. If you have any questions about this fitness test please ask the researchers. Your coach will also be present during this test and your parent's can be there to if you would like.

Things to take home:
You will be given a questionnaire pack to take home with you. This will include a physical activity diary. In this diary we will ask you to record any activities you have done for the 7 days you are taking part in the study. There will also be a questionnaire which asks you about the amount of physical activity you do during the week and your motivations and feelings about taking part in sport and active games.

After all of this, you will be free to leave and join your training session and we will collect your GT3X and questionnaires a week later.

8. What will I be asked to do?

During the study you will need to follow your study researcher's instructions and you must not take part in any other research studies.

9. What are the other possible disadvantages and risks of taking part?

There are no known risks to taking part. You will be asked to exercise for 8 minutes and this may make you feel a little tired and out of breath but you are able to stop when you want to.

10. What are the potential benefits of taking part?

If you take part in this study we will be able to tell you how much exercise and physical activity you do and how many calories you burn up. If you would like, we can also give you some information on your level of fitness, your BMI and how much fat and muscle is in your body.

11. What if there is a problem?

Detailed information about this is given in part 2.

12. Will personal information which is collected during the study be kept confidential?

Yes. All of the information about your taking part in this study will be kept confidential. More information about this may be found in part 2.

13. Contact for further information

If you would like to know more about the study and are interested in taking part please feel free to contact us and ask any questions you wish.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

You may also wish to contact the Patient Advice and Liaison Service at Birmingham Children's Hospital who will be able to give you more information about how this type of research is carried out.

PALS Officer: Carmel Cremins-Jones

[redacted]

[redacted]

[redacted]

Visit: The PALS Office is next to the Welcome Desk at Main Reception

Thankyou for reading so far. If you are interested to find out more, please go to part 2 before making any decision.

Part 2

14. What happens if new information about the study comes along?

Sometimes new information comes along about the exercise that is being studied whilst a study is still happening and this may affect your decision on whether to carry on taking part. If this happens your study researcher (Sally Fenton) will talk to you about whether or not you want to continue in the study. If you decide you no longer want to take part, that is ok. If you decide to continue in the study, you may be asked to sign an updated assent form which will contain the new information and your parent(s) or guardian(s) may also be requested to sign an updated consent form.

On receiving new information your study researcher might decide it is in your best interest to take you out of the study. They will explain the reasons and arrange for care if you need it. If the study is being stopped for any other reason, you will be told why.

15. What will happen if I don't want to carry on with the study?

It is important for you to understand that taking part in this study is voluntary and you are free to stop taking part at any time.

If you decide to do this you wil only need to inform the study researcher. You will not have to give a reason for this decision.

16. What if there is a problem?

Complaints: If you are worried about any part of this study, you should first talk to your parent(s) or guardian(s). You can then ask to speak to the study researcher who will do their best to answer any questions you have (see contact details in Part 1). If you are still unhappy and wish to complain formally, you can do this using the University of Birmingham complaints

procedure. The researcher will inform you of how to do this.

Harm: If you have an accident such as a fall, while carrying out the exercise tests, The University of Birmingham has in force a Public Liability Policy and the activities here are included within that coverage . We will make sure you are closely supervised whilst carrying out the tests. Your parent (s) or guardian (s) are also free to join you whilst you take part.

17. Will anyone else know I am taking part in this study?

Yes. If you have given your assent to take part in this study and if your parent(s)/guardian(s) have signed the consent form, any of your medical records may be looked at by the researchers to check the information collected for the study. Also, people from the regulatory authorities (such as the Department of Health) may look at your medical notes. This is to check that we are carrying out the study properly.

Your data will be identified by a subject number (this is a number you get if you join the study). Any questionnaires, physical information and information about your physical activity will be identified by this same number. None of your personal details (e.g. your name) will be used in any presentations and publications. The information collected during the study is confidential.

18. What will happen to the results of the research study?

Once the study is complete, the results will be published and a final report written. If you would like any copies of this information you should contact your study researcher. You will not be identified in any reports or publications.

19. Who is organising and funding the research?

The University of Birmingham funds the researcher (Sally Fenton) who will be carrying out this study as part of her work for her postgraduate degree.

20. Who has reviewed this study?

This study has been reviewed by the School of Sports and Exercise Sciences projects committee, and by a Birmingham Research Ethics Committee. These people make sure we are carrying out the study properly and carefully.

The study will be run in accordance with all suitable guidelines aimed at ensuring proper conduct and the safety of anyone taking part, including the Guidelines on Good Clinical Practice and the Declaration of Helsinki.

22. What do I do now if I decide I would like to take part?

If you decide you would like to take part in the study you or your parent/guardian will need to contact the researcher (Sally Fenton) or Chief Investigator (details above) and speak to them about the study. Before you can take part you will be asked to sign the assent (agreement) form which is attached to the back of this sheet. However, you can only take part if your parent(s) or guardian(s) also consent for you to take part in the study. You must both visit the researcher Sally Fenton to consent together. This can be done on the same day you are taking part in the study provided you have read this information leaflet, discussed the study with the researcher, asked any questions you may have, and have had at least 24 hours to decide if you would like to take part. A copy of your signed assent form and this information sheet will be given to you to keep.

Thankyou for taking the time to read this information sheet.

Birmingham Children's Hospital NHS
NHS Foundation Trust

CHILD AND YOUNG PERSON ASSENT FORM

Name of Researcher:

Child/young person (or if unable, parent on their behalf), in the boxes below please initial all the statements you agree with. If you do not agree with the statement and do not wish to take part in the study please do not initial the box.

1. I confirm I have read (or had read to you) the study information sheet.

2. Somebody else has explained this study to you.

3. I understand what this project is about.

4. I have asked all the questions I want to about the study.

5. I understand that taking part is my choice and it is ok for me to stop at any time without giving any reasons and without my medical care being affected.

6. I am happy to take part in the study and know that I will get a copy of this signed form and information sheet to take home.

7. I understand that the relevant sections of my medical notes and data collected during the study may be looked at by individuals from regulatory authorities of from the NHS trust where it is

relevant to my taking part in this research. I give permission for

these individuals to have access to my records.

If you do not agree with **any** of the statements or you **don't** want to take part, **don't** initial in the box!

If you <u>**do**</u> want to take part, please write your name and today's date

Your name ____________________________

Date ____________________________

YOUR PARENT OR GUARDIAN

Your parent or guardian must write their name here too if they are happy for you to do the study

___________________ _________________ __________________

Print name Date Signature

Optional Second signature

________________ _________________ __________________

Print name Date Signature

PERSON TAKING YOUR ASSENT

The person who explained this project to you needs to sign too:

____________________ __________________ ___________________

Print name Date Signature

YOUR STUDY DOCTOR (OR RESEARCHER)

____________________ __________________ ___________________

Print name Date Signature

IF APPLICABLE

If your child is **unable** to read and/or write, you, as their parent or guardian must write your child's name here. You must also write your name and sign to affirm that the study has been explained by the study doctor/nurse to your child and that your child is unable to sign the assent form.

____

Your child's name

____________________ __________________ ___________________

Print name Date Signature

Thank you for your help.

APPENDIX 2

MATERIALS TO AID WITH CLEANING/INTERPRETATION OF ACCELEROMETER DATA

In the table below each box asks you a question about different things you have done during the day both inside and outside of school. Please fill in the table before you go to bed every night. When you fill in the table start by writing the day of the week you are on in the “Week Day” column and try and remember the times you started and finished each activity we ask you about. The first line is an example day to show you how to fill in the table and what sort of information we would like you to record.

Week day	What time did you wake up?	What time did you go to bed?	How did you get to and from school?	What time were your lunch and break times today?	Did you play football today?	Did you have a PE lesson today? If you did what did you do?	Have you played any other sports today other than football?	Have you watched television or played video-games today?	If you have been anywhere else today apart from school how did you get there ?
Example: Monday	08:30	21:35	Car (8.20 – 8.35) Car (3.30 – 3.45)	10.15 – 10.30 12 – 1	At school : Lunch time (12.30 – 1) With your club : Training (6 – 7.30) Other (e.g. with friends) : After school (4 – 5)	Hockey (1.30 – 2.30)	Dance 10 :30-12 :30	8:30-9:30pm	Walked to the shop (3.45 – 4)
					At school : With your club : Other (e.g. with friends) :				
					At school : With your club : Other (e.g. with friends) :				

					At school : With your club : Other (e.g. with friends) :				
					At school : With your club : Other (e.g. with friends) :				
					At school : With your club : Other (e.g. with friends) :				
					At school : With your club : Other (e.g. with friends) :				

MATERIALS FOR CHAPTERS 4 (STUDY 3) AND 5 (STUDY 4)

Questionnaires assessing perceptions of the autonomy supportive and controlling facets of the social environment (Bartholomew et al., 2010; Williams et al., 2006; Quested, 2013), section A) and motivation regulations (BRSQ; Lonsdale et al., 2008, section B).