Title  The Role of the TGfU Pedagogical Approach in Promoting Physical Activity Levels During Physical Education Lessons and Beyond

Name  Lindsey Rachel Smith

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The Role of the TGfU Pedagogical Approach in Promoting Physical Activity Levels During Physical Education Lessons and Beyond

Lindsey Rachel Smith

‘A thesis submitted to the University of Bedfordshire, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.’

October 2010
In memory of L. V. Smith
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This thesis is dedicated to my Grandad who sadly passed away before I was accepted onto the PhD programme. I know you would be proud.
Abstract

The study was designed to initially determine levels of moderate-to-vigorous physical activity (MVPA) occurring during physical education in 11-12 year olds using appropriate objective methods. Subsequently, the potential of a pedagogical method; 'teaching games for understanding' to increase PA levels and self determined motivation during PE lessons, and habitual physical activity during leisure time was examined.

The most reliable and valid PA measurement tool for the chosen age group was the RT3 ® triaxial accelerometer. PA levels during PE lessons fell short of the recommended 50% (20 minute) criterion, with children accumulating 16.4 ± 2.3 minutes (44.9 ± 5.6%) of mean MVPA during lesson time. Seven day habitual activity monitoring revealed that time spent in MVPA on a PE day was significantly higher (P <0.05) than on a weekend day. This study also highlighted that on non PE days the lack of PE-related activity was not compensated by engagement in other activity.

An investigation into the effects of a 12 week TGfU pedagogical strategy on MVPA and elements of Self Determination Theory during PE lessons revealed that boys assigned to the intervention displayed significantly higher (P <0.01) levels of MVPA, and significantly higher levels of autonomy (P < 0.05) post-intervention versus the control group. In addition, a non significant
trend for an increase in habitual PA for boys assigned to the intervention lessons was revealed. No significant differences were displayed in the constructs of the TPB pre-post intervention and no significant benefits of TGfU were noted for girls.

The reported increases in MVPA and levels of autonomy during PE lessons in boys using a TGfU approach are novel and promising. However it is suggested that future research incorporates such strategies in a health-promoting PE environment in addition to the traditional skills-based activities. This may have potential in enhancing MVPA during PE in girls and boys, and may promote greater transference to habitual physical activity levels. The potential for self determined environments positively impacting upon motivation and intentions to be physically active both during and outside of PE lessons warrants further exploration but over longer time periods.

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<td>BMI</td>
<td>Body Mass Index</td>
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<td>CI</td>
<td>Confidence Interval</td>
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<td>CO₂</td>
<td>Carbon Dioxide</td>
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<td>CRB</td>
<td>Criminal Records Bureau</td>
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<td>DfES/QCA</td>
<td>Department for Education and Skills / Qualifications and Curriculum Authority</td>
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<td>DoH</td>
<td>Department of Health</td>
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<td>EE</td>
<td>Energy Expenditure</td>
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<td>FSM</td>
<td>Free School Meal Eligibility</td>
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<td>HR</td>
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<td>Health Survey for England</td>
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<td>Middle School Physical Activity and Nutrition</td>
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<td>MANOVA</td>
<td>Multivariate Analysis of Variance</td>
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<td>METs</td>
<td>Metabolic Equivalents</td>
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<td>MPA</td>
<td>Moderate Physical Activity</td>
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<td>Moderate to Vigorous Physical Activity</td>
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<td>NCPE</td>
<td>National Curriculum Physical Education</td>
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<td>O₂</td>
<td>Oxygen</td>
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<td>PA</td>
<td>Physical Activity</td>
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<td>PBC</td>
<td>Perceived Behavioural Control</td>
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<td>PCT</td>
<td>Primary Care Trust</td>
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<td>PE</td>
<td>Physical Education</td>
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<td>Research Tracker 3</td>
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<td>SDT</td>
<td>Self Determination Theory</td>
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<tr>
<td>SPSS</td>
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<td>SOFIT</td>
<td>System for Observing Fitness Instruction Time</td>
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<td>SPARK</td>
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<td>UK</td>
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1.0 Introduction

Regular physical activity (PA) has been associated with a decreased incidence of type 2 diabetes, obesity, cardiovascular disease, cancer and osteoporosis in later life (Department of Health, 2003, NICE, 2009). An inactive lifestyle has been estimated to cause approximately 54,000 premature deaths every year (Department for Health, Media and Sport, 2002). In children, increasing PA levels has been shown to be positively associated with skeletal health and growth (DoH, 2003).

The current recommended level of moderate-vigorous physical activity (MVPA) is 60 minutes per day for children (NICE, 2009). However many children fail to meet these recommendations (NICE, 2009; United States Department for Health and Human services (USDHH), 2008). According to the Health Survey for England (2008) only 32% of boys and 24% of girls in the UK aged 2 -15 years old were classed as meeting the recommended PA targets. Similarly the US PA guidelines (2008) state that only 42% of children aged 6-11 years old meet the recommended 60 minutes MVPA per day. These studies were based on subjective measures suggesting the problem could be even larger (Sirard and Pate, 2001).

Due to the inactive lifestyle that has been demonstrated in young people (NICE, 2009, Lowry et al. 2009, HSE, 2008, USDHH, 2008) and its
association with chronic diseases (DoH, 2003), early intervention is necessary to combat the risk factors associated with chronic diseases. An objective assessment of PA levels and patterns in children is pivotal in order to accurately establish current PA levels and to aid the development of programmes to promote PA.

PA promotion within schools and in particular during physical education (PE) lessons has attracted much interest (Cale and Harris, 2006a, McKenzie, 2001). Importantly, the PE lesson has been highlighted as the most suitable place for the promotion of active, healthy lifestyles among young people (McKenzie 2001, Fairclough and Stratton, 2005b, Cale and Harris, 2006a).

The Association for PE (afPE) in the UK has a number of objectives; to ensure that children participate in two hours of high-quality PE per week and that the children are ‘actively moving’ for at least 50% of the lesson time (afPE, 2008). However the afPE offers no definition of ‘actively moving’ so therefore it is necessary to employ the similar targets from the US. The USA have set a target that 50% of the lesson time should be spent in MVPA to make a significant contribution to the recommended 60 minutes of MVPA per day (USDHH, 2000). It has been consistently shown that PE lessons typically fall short of the 50% MVPA target (McKenzie et al. 2006, McKenzie et al. 2000, Fairclough and Stratton, 2005b, Fairclough, 2003a).
Cale and Harris (2005) outlined that the time limitations on the PE lesson due to core subjects being made high priority for curriculum time make it difficult to allow adequate time to achieve high levels of MVPA during PE. Equally, the time allocation for other curriculum modules may impact negatively upon the amount of time spent in MVPA within the PE lesson (Cale and Harris, 2005). Therefore it is important to examine the influence of pedagogical interventions/instructional models which could potentially enhance PA levels without compromising lesson objectives.

Joyce and Weil (1980, p.1) define an instructional model as ‘a plan or pattern that can be used to shape curriculum’s (long term courses of studies), to design instructional materials, and to guide instruction in the classroom and other settings’. Teaching Games for Understanding (TGfU) is a type of sequential curriculum model developed to aid the teaching of games activities in a tactical context during PE (Bunker and Thorpe, 1986). Unlike traditional teaching methods this method starts with ‘a game and its rules which set the scene for tactical awareness and decision making, which leads onto more modification (conditioned games) and the cycle begins again’ (Bunker and Thorpe, 1986, p. 4). Students are typically more active during games activities than individual activities (McKenzie et al. 2006; Fairclough and Stratton, 2005a; Fairclough and Stratton, 2006a), and skill based lesson time is associated with less PA than games based lesson time (Yelling et al. 2000). It was therefore proposed that a tactical games based approach to learning
skills, which utilizes a small group approach and is focused more on process rather than outcome goals, may increase PE PA levels.

In addition, employing the TGfU curriculum model within the PE setting has been shown to enhance enjoyment and deliver intrinsic values (Butler, 2006). Student motivation during PE is a significant factor that can affect PA levels and willingness to participate in PE (Standage et al. 2005). The application of Self Determination Theory (SDT) (Deci and Ryan, 1985) within PE settings has been investigated to determine the effect self determined behaviour has on experiences in PE and how this potentially translates into continued participation in PA into adult life (Taylor and Ntoumanis, 2007; Standage et al. 2005; Wallhead and Ntoumanis, 2004; Ntoumanis, 2001).

A ‘chain of influence and links’ exist between constructs of SDT and intentions to be physically active (The Theory of Planned Behaviour (TPB)), (Ajzen, 1985) 'commencing with general motives to engage in PA (intrinsic motives), filtered by specific expectations (attitudes) and ending with behavioural intentions' (Hagger et al. 2002, p. 294). It has been found that PE teachers who create perceptions of autonomy support for students in PE had an impact on the level of autonomous leisure time activities and finally this impacted on attitudes and intentions (Hagger et al. 2009). There appears to be no research to date which has investigated the impact of the TGfU
curriculum model on levels of MVPA and SDT during PE and the impact upon leisure time activities and intentions to be physically active.

This thesis investigated using TGfU within the PE lesson context to establish potential physiological and psychological benefits of the curriculum model. Specifically the thesis focused on the role of TGfU in promoting levels of MVPA and creating a self determined environment. The influence of TGfU in the PE lesson context was then tracked to establish any potential impact on children’s intentions to be physically active and immediate habitual activity levels during leisure time.
1.1 Aims and Objectives

Study 1:
(a) Identify the re-test reliability of the following PA methods; RT3 (Research Tracker) Triaxial accelerometers, Bodymedia armband, and Actiheart.
(b) Assess the validity of the PA monitors by comparison with oxygen (O₂) consumption measures (Metalyser 3B) during standardised bouts of exercise.

Study 2:
(a) To accurately quantify PA levels during middle school PE lessons in the Bedfordshire area, to establish if current recommendations i.e. 50% of lesson time in activity of at least a moderate intensity, are met.

Study 3:
(a) To quantify activity levels during PE and quantify the contribution PE to the recommended 60 minutes MVPA per day in English middle school children.

Study 4:
(a) Assess the impact of a ‘TGfU’ approach on objectively assessed MVPA levels.
Study 5:
(a) To investigate the impact of the TGfU approach on objectively measured PA levels during PE.
(b) To investigate the impact of the TGfU approach on motivational levels; specifically on the constructs of SDT.

Study 6:
Part 1
(a) To investigate the impact of a TGfU approach on objectively assessed student PA levels during PE lessons
(b) To investigate the impact of TGfU on students' self-determination.

Part 2
(a) To investigate the impact of TGfU on children’s intentions to be physically active outside of school
(b) To investigate the impact of TGfU on objectively measured habitual activity levels.
Chapter 2 Review of Literature
2.0 Physical Activity – General

PA health benefits have been vastly researched (DoH, 2003; The Information Centre, 2009). Regular PA has been associated with a decreased incidence of type 2 diabetes, obesity, cardiovascular disease, cancer and osteoporosis in later life (DoH, 2003). An inactive lifestyle has been estimated to cause approximately 54,000 premature deaths every year (Department for Health, Media and Sport, 2002).

In 2007 24% of UK adults (over 16 years) were classed as obese with a body mass index (BMI) greater than 30kg/m² (The Information Centre, 2009). This figure produced in 2009 highlighted an increase in adult obesity levels of 15% from 1993 (The Information Centre, 2009). The Information Centre (2009) report that 13% and 16% of men and women respectively are classed as being at high risk of health problems as a result of obesity. In addition 21% and 23% of men and women respectively are classed as being at very high risk of health problems due to obesity (The Information Centre, 2009).

In terms of adult PA the Information Centre (2009) reported that PA levels amongst UK adults have increased from 32% men and 21% of women reporting meeting the 30 minutes on at least five days per week recommendation (CMO report, 2004) in 1997, to 40% of men and 28% of
women in 2006. However, the research figures from the Information Centre (2008) revealed that only 34% and 29% of men and women respectively had heard of the Chief Medical Officer’s PA recommendation. More positively, the Information Centre (2008) over two thirds of adults (69% men and 68% women) reported that they would like to participate in more PA.

2.1 Physical Activity Monitoring

Measuring PA subjectively has consistently been highlighted as problematic for both adults and children (Sirard and Pate, 2001; Rowlands, 2007; HSE, 2008; Prince et al. 2008). Sirard and Pate (2001) state that self reported PA measures are typically over reported and therefore can bias research studies. However, it is also important to acknowledge that self report measures and surveys also have their strengths (Van Sluijs et al. 2008). Subjective measurement is a very useful and cost effective tool when employed on a large population scale where is would not be possible to gain objective PA measurement for all members of the population (Sirard and Pate, 2001). Although these measures are suitable for measurement on an epidemiological scale they should be interpreted with caution due to the cognitive recall capability of young children (Sirard and Pate, 2001). Prince et al. (2008) conducted a review of literature that specifically focused upon different methods of direct PA measurement in comparison to self-report
measures in adults. The review concluded that research studies involving the comparison of direct and self-report measures were extremely varied and that self-reported PA was both over reported and under reported in comparison to direct PA measurement (Prince et al. 2008). Similarly, the problematic nature of using self-report measures in the pediatric population has also been highlighted (Adamo et al. 2009). For example, Corder et al. (2008) found that subjective measures overestimated PA by 72% when compared with objective measurements.

More specifically, Rowlands (2007) highlight the limited ability of the pediatric population to self-report PA as they haven’t developed the necessary cognitive recall skills. It has been acknowledged that survey methods such as PA recall questionnaires are a cost-effective method of measuring PA and can be appropriate for investigation on large numbers of participants (Sirard and Pate, 2001). However, these methods lack objectivity and the main limitations of these subjective measurements include ‘recall errors, deliberate misrepresentation and social desirability’ (Sirard and Pate, 2001, p. 448). In particular, Adamo et al. (2009) found that indirect measurements i.e. questionnaires in a pediatric population overestimated PA by 72% in comparison to direct measurements i.e. accelerometers.

More recently, the use of objective measurements i.e. accelerometers to determine PA levels in children has become more prevalent (Rowlands,
This equipment provides a more reliable measurement of PA in the pediatric population when recording not only the levels of PA but the duration, intensity and frequency of PA (Sirard and Pate, 2001). Several objective techniques for quantifying PA have been developed such as HR monitors, accelerometers i.e. RT3® triaxial accelerometers and HR and accelerometry combined monitors i.e. Actiheart and the Sensewear Bodymedia armband (Sirard and Pate, 2001). With PA promotion in the pediatric population becoming a public health priority it is critical that precise measures are used to accurately assess the intensity and frequency of PA (Trost, 2007; Sirard and Pate, 2001). Objective measurement has been shown to provide a more accurate record regarding the potential correlation between PA and chronic diseases (Sirard and Pate, 2001). In addition important information can be gained in understanding the potential dose-response relationships which exists (Trost, 2007; Rowlands, 2007; Sirard and Pate, 2001). However, caution must also be used when interpreting children’s PA measured by objective tools due to the sporadic nature of the pediatric populations activity (Rowlands and Eston, 2007) and the limitations with each objective PA monitoring tool (Trost, 2007). For example heart rate telemetry can provide inaccuracies due to increased heart rate form other variables such as stress rather than the actual participation in PA (Fairclough and Stratton, 2005b). In addition the use of accelerometry can also be problematic die to its inability to quantify isometric movements (Fairclough and Stratton, 2005b) and the discrepancies within the literature to establish intensity thresholds.
2.2 Physical Activity in Children

Obesity levels in children have risen since 1995; current levels show that 17% of boys and 16% of girls are classed as clinically obese, a rise of 11 and 12% respectively (The Information Centre, 2009). Regular PA in youth is associated with improved health and wellbeing and a lower risk of developing diseases such as type 2 diabetes and obesity in later life (Strong et al. 2005, Anderson et al. 2006, Janssen and Leblanc 2010). In addition the World Health Organisation (WHO, 2010) outline that a dose-response relationship exists between PA and improvements in cardiovascular health. More specifically, maintaining high amounts of PA starting in childhood can enable people to have a more favourable health profile in later life. The WHO (2010) also highlight that ‘more is better’ when it comes to PA levels and that higher volumes or intensities of exercise lead to greater benefits in metabolic health.

Current guidelines recommend that children should undertake a minimum of 60 minutes of at least moderate intensity PA each day (DoH, 2004; NICE 2009) and at least twice a week, this should include activities to improve bone health (body mass-bearing activities that produce high physical stresses on the bones, such as running and jumping), muscle strength and flexibility (DoH, 2004). More recently the WHO (2010) has also outlined that on three days per week PA should include activities such as weight bearing activities
to promote muscular strength and vigorous PA to improve cardiovascular risks and cardiorespiratory benefits. Although it is apparent that PA confers many health benefits, many children fail to meet the suggested recommendations of 60 minutes MVPA a day (DoH, CMO Report, 2004; Riddoch et al. 2007; Health Survey, 2008; The Information Centre, 2009).

According to the HSE, (2008), only 32% of boys and 24% of girls in the UK aged 2 -15 years were classed as meeting the recommended PA targets based on self reported measures and excluding time at school. However when school time is taken into consideration the Information Centre (2009) reported that 72% of boys and 63% girls aged 2-15 years old met the recommended levels of PA. Evidence suggests that children aged 9 may need as much as 120 minutes of MVPA per day and young people aged 15 may need 90 minutes per day, to reduce their risk of cardiovascular disease (Andersen et al. 2006). Similarly the US PA guidelines (2008) state that only 42% of children aged 6-11 years meet the recommended 60 minutes MVPA per day. However it should be noted that data collected from the HSE (2008); the Information Centre (2009) and the US PA guidelines (2008) used self reported measures so it is possible that the problem could be even larger as PA levels are typically over reported (Sirard and Pate, 2001; HSE, 2008).

Pate et al. (2002) conducted a study which objectively measured PA for 375 students from grades 1-12 (aged 6-19 years old) using uniaxial accelerometry
They found that 90% of the children recruited for the study met the daily recommendation of 60 minutes per day. In addition Trost et al. (2002a) conducted a study on young people of a similar age group in grades 1-12 (aged 6-19 years old) with the same uniaxial accelerometry (CSA 7164). On average it was found that children participated in 100 minutes of MVPA per day. However, Trost et al. (2002a) found that there was a significant inverse relationship between the amount of time spent in MVPA and an increase in age. The data shows that this age related decline in PA tends to occur between grades 4-6 and grades 7-9 age groups meaning that PA levels decline around the age of 11 and 12 years.

This age related decline has been reinforced by findings from a European study conducted by Riddoch et al. (2004). The study measured PA levels and PA patterns of children aged 9-15 years participating in the European Youth Heart Study (EYHS). 2185 children from Denmark, Portugal, Estonia and Norway had their PA levels objectively measured using CSA 7164 uniaxial accelerometers. It was found that boys were more active than girls at age 9 (192 ± 66 versus 160 ± 54 minutes) and at age 15 (99 ± 45 versus 73 ± 32 minutes). Riddoch et al. (2004) highlighted the age related decrease with 97.4% and 97.6% of boys and girls respectively aged 9 achieving the 60 minutes per day recommendation and only 81.9% of boys and 62% of girls achieving the same recommendation by the age of 15. Interestingly the study
found that across all four countries the levels of MVPA accumulated by children were remarkably similar and consistent (Riddoch et al. 2004).

Given the evidence suggesting the age related decline is more prominent after the age of 11 years (Trost et al. 2002a; Riddoch et al. 2004; The Information Centre, 2009), Riddoch et al. (2007) conducted a large-scale study in the UK (5595 children aged 11). The study incorporated objective measures of PA by using uniaxial accelerometers (CSA 7194). The data suggested that a large majority of children aged 11 years are not active enough. Only 2.5% (boys 5.1%, girls 0.4%) did more than 60 minutes of MVPA daily (the internationally recognised minimum recommendation for children) (Riddoch et al. 2007).

It is important to acknowledge, as previously mentioned, that PA monitoring using accelerometry can be varied due to the differences in the definition of activity thresholds. Riddoch et al. (2007) employed intensity thresholds that established 4 mets as the cut off for moderate intensity exercise. In comparison Trost (2002a) used 3 mets as the moderate intensity cut off point. This may explain the differences in the two studies i.e. Trost et al (2002a) found on average children participated in 100 minutes of MVPA daily in comparison to Riddoch et al. (2007) who found that only 2.5 % of girls and boys participated in 60 minutes of MVPA daily.
Due to this inactive lifestyle that has been demonstrated in a large proportion of young people (The Information Centre, 2009; US PA guidelines, 2008; HSE, 2008; Riddoch, 2007) and its association with chronic diseases (NICE, 2009), early intervention is necessary to combat the risk factors associated with chronic diseases (NICE, 2009). Therefore an assessment of PA levels in children is advantageous in order to accurately establish current PA levels and to assist with programmes that will ultimately increase PA levels particularly for children aged 11 years and upwards particularly when PA levels have been shown to decline significantly (Trost et al. 2002a; Riddoch et al. 2004; Riddoch et al. 2007; The Information Centre, 2009).

2.3 The Importance of the School Environment and PE Setting

Given the growing concerns regarding PA levels amongst children and the potential health consequences, the promotion of PA levels within the school and the PE lesson has attracted growing interest (Cale and Harris, 2006b). McKenzie and Lounsbery (2008) highlighted the importance of the school environment for the promotion of PA as children spend a significant proportion of their life (twelve years) in school. Importantly schools provide PA regardless of socio economic status (McKenzie and Lounsbery, 2008). It has been recommended (McKenzie and Lounsbery, 2008) that schools should
consider redesigning their environment to provide more opportunities to be physically active.

More specifically the PE lesson has been identified as the most suitable place for the promotion of active, healthy lifestyles among young people (Cale, 1996; McKenzie, 2001; Trost, 2004; Fairclough and Stratton, 2005b). There is a growing need for increases in PA during PE due to the fact that children are not accruing as much PA through daily living as their counterparts 50 years ago (McKenzie and Lounsbery, 2008). In addition several research studies explain that for some less physically active children PE can be the only time they can accumulate and take part in structured activity to contribute to daily MVPA levels (McKenzie, 2001; Fairclough and Stratton, 2005a; Jago et al. 2009). McKenzie and Lounsbery (2008) outline that children don’t compensate at home for activity lost if they do not participate in PE.

The Association for Physical Education (afPE) in the UK has a number of objectives; to ensure that children participate in two hours of high-quality PE per week and that the children are ‘actively moving’ for at least 50% of the lesson time (afPE, 2008). However the document offers no definition of ‘actively moving’ so therefore it is necessary to employ similar targets from the US. The USA have set a target that 50% of the lesson time should be spent in MVPA to make a significant contribution to the recommended 60 minutes of MVPA per day (USDHH, 2000). The USDHH (2000) has two
objectives in relation to PE; firstly to advocate daily PE and secondly the 50% target as previously mentioned. Trost (2004) reports that ‘physical education programs can best contribute to public health by providing frequent exposure to enjoyable and developmentally appropriate PA and by preparing students for a lifetime of regular PA’ (p. 328). However, as Fairclough and Stratton (2005b) outline, the UK targets for PE do not contain explicit MVPA targets but conclude that PE should be viewed as an ‘important vehicle in promoting health-related PA within broader national PA recommendations for young people’ (p.218). This seems a more realistic target based around the fact that the US 50% target is based upon daily PE whereas the afPE aspires to two hours of high quality PE per week in addition to PE, School Sport and Club Links (PESSCL) targets that young people should gain at least three extra hours from extra curricular and club activities outside of school. Due to the restrictions in duration and frequency of PE in the UK PE should be seen as a positive contributor to daily MVPA in combination with other school based PA and the 50% MVPA PE target should be viewed as a positive motivator (Fairclough and Stratton, 2005a).

The PE teacher has been identified as a key figure in this health related PA promotion (Cale, 1996). Cale (1996) suggests that PE teachers have a very strong influence over young people’s PA. The image of PA created by PE teachers is paramount to children’s attitude towards PA and ultimately this will impact directly upon levels of sports participation out of school (Cale, 1996).
Many studies have reiterated the importance of PE and the PE teacher by highlighting PE’s role in the promotion of lifetime PA (Trost, 2004; Green, 2004; Corbin, 2002; Kirk, 2005). McKenzie and Lounsbery (2008) explain that there is a need for better quality data on what is and is not happening in PE.

2.4 Physical Education Curriculum

The present National Curriculum for PE aspires to provide two hours of high quality PE lessons a week (QCA, 2008). One of the curriculum aims outlined (QCA, 2008) is aimed at helping young people to become ‘confident individuals who are able to live safe, healthy and fulfilling lives’ (p. 189). This policy is ultimately directed at PE’s contribution towards lifelong activity. If children can discover what they like to do within the PE lesson they can make informed choices about lifelong PA (QCA, 2008). In addition if PE can develop a child’s competence and confidence then they are more likely to take part in PA and understand the importance and value of a healthy active lifestyle (QCA, 2008). One of the key concepts of the PE curriculum is healthy active lifestyles and understanding that PA ‘contributes towards the healthy functioning of the body’ (QCA, 2008, p.3). Another health based focus of the curriculum is explained within the key processes of PE. PE is used to encourage young people to make informed choices about healthy active lifestyles and their involvement with PA (QCA, 2008). Ultimately this emphasizes the role of PE as a key provider of the knowledge and promotion
of young people achieving a healthy active lifestyle. This key process supports the governments role within PE to aspire for the two hours of high quality PE per week and the government’s ‘Physical Education and Sport Strategy for Young People’ (PESSYP) (2008) for young people to accrue an additional three hours of PA beyond the school day.

In 2008 the Department for Children, Schools and Families (DCSF) introduced the five hour offer through PESSYP. The document outlines the importance of PE in achieving the Chief Medical Officer’s (2004) recommendation of an hour of daily MVPA. The commitment and aim is to deliver five hours of high quality sport and PE per week. The DCSF (2008) outline the positive increase in the number of children taking part in two hours of high quality PE and sport per week rising from 25% in 2002 to 90% in 2008, which is a positive contributor to the five hour commitment. The DCSF (2008) outlines the contribution of PE within the five hour target and the responsibility of the wider authorities and health providers such as the Primary Care Trusts (PCTs) to reaching national goals such as reducing childhood obesity.

The DCSF (2008) acknowledge that the five hour target is ambitious but is also an achievable goal. This is helped by the lottery and government funding of £2.4 billion over the period of 2003-2011. This investment was put in place
to realize the aims and ambitions of the PESSYP strategy. The aspirations are as follows (DCSF, 2008);

- ‘By the end of the academic year 2010-2011, 40% of young people to take part in five hours of PE and sport per week’.
- ‘By the end of the academic year 2012-2013, 60% of young people to take part in five hours a week PE and sport.
- ‘By the end of the academic year 2010-2011, 80% of 5-16 year olds in every school sport partnership to take part in three hours a week of PE and sport organized by schools.

The DCSF (2008) emphasise the responsibility of schools to provide at least three hours of the five hour target. Two of these hours will come from high quality PE and the other hour should be provided on the school site beyond school hours. The assumption is that community and clubs will provide the additional two hours to complete the target.

Quick et al. (2009) conducted the PE and Sport Survey 2008/2009 across 21,164 schools in the UK to establish whether targets from the government are being achieved or improving. The survey revealed that over years 1-13 50% of young people were achieving three hours of high quality PE and out of hours school sport per week. As previously mentioned self reported measures can mean that PA levels may be over reported (Sirard and Pate, 2001; HSE, 2008). The results revealed a 12% decrease in participation in
these three hours from year 6 to year 7 and, thereafter, a decrease each year in the percentage of young people meeting the three hours. The data reveals that only 29% of children in year 7 are participating in out of school hours activity emphasizing the importance of PE as the only opportunity some young people get to participate in organized sport and achieve activity towards daily recommendations of MVPA (Quick et al. 2009).

2.5 Current Physical Activity Levels in Physical Education

The general consensus throughout studies conducted in the UK and US is that typically PE lessons fall short of the 50% MVPA target (Fairclough, 2003a; Trost, 2004; McKenzie et al. 2000; Yelling et al. 2000; McKenzie et al. 2006; Fairclough and Stratton, 2005b). Trost (2004) conducted a public health analysis in relation to the USDHH (2000) recommendations for PE and concluded that PE had failed to meet public health goals namely the ‘proportion of children and adolescents exposed to daily PE and the amount of PA provided by an average PE lesson’ (p. 325). This was echoed in the UK with Fairclough and Stratton (2005b) reviewing PA levels during middle and high school PE. They concluded that overall levels of MVPA displayed during 40 PE studies ranged from 27% to 47%, falling short of the recommendations, it is important to remember that this study was conducted six years ago and therefore these figures may be subject to change.
Fairclough (2003a) studied key stage three PE lessons in the UK and found mean total PA time (moderate intensity) measured by heart rate (HR) telemetry to equate to only 19 minutes. This is equivalent to 39.7% of the total lesson time being spent in moderate PA (Fairclough, 2003a). Another UK study using HR telemetry was conducted by Yelling, Penney & Swaine (2000). They found that PE lessons do not always ensure that pupils are engaged in appropriate activity levels. Results from this research showed activity levels in PE measured over a six week period (11-12 year olds) accrued on average, only 20% of MVPA during the lessons.

Similarly in a US context McKenzie et al. (2000) recorded baseline measures of PA during PE lessons in preparation for a four year intervention study aiming to target PA levels and nutritional habits. Twenty four middle schools (grades 4-6) were recruited into the study. Again an observational analysis called SOFIT (System for Observing Fitness Instruction Time) was used during the study to record PA levels within the lesson. Overall it was found that 48.4% of the lesson was spent in MVPA, equating to 16.6 minutes. Although this is closer to the 50% MVPA target it still falls short of the recommendations. However it is important to recognise that the results from the study showed that only a small proportion, 14.6% (5 minutes), of the lesson time was spent in VPA which is the intensity likely to enhance cardio respiratory fitness (Armstrong and Welsman, 1997). This study was different to UK studies in the fact that schools recruited in the US study engaged in
daily PE. Students accumulated 25 minutes of VPA through PE on average per week which is about half of the weekly recommendation of VPA (USDHH, 2000). Students accumulated 83 minutes of MVPA weekly through PE which is extremely low in comparison to the 60 minutes per day criterion (USDHH, 2000). McKenzie et al. (2000) concluded that PE can contribute to public health targets but that it should be used in conjunction with PA outside of school. However McKenzie et al. (2000) reiterates that PE 'is a critical setting for promoting health related PA' (p. 258).

These results were later reinforced by a study by McKenzie et al. (2006) which reported baseline measures from a later intervention study called Trial of Activity for Adolescent Girls (TAAG). Data was collected using the SOFIT observational tool to quantify PA levels. This study only reported results from girls PE, however the data was collected in 36 schools from diverse geographical areas and population. Enrolment totalled 1027 students with 47% of the students being non-white and 34% receiving FSM. It was found that girls PE lessons fell short of recommended targets and that only 37.9% of the PE lesson was spent in activity of at least a moderate intensity. This translated to 13.9 minutes of MVPA; substantially less than the daily recommendations of 60 minutes of activity (USDHH, 2000). Across all schools it was found the average amount of VPA accrued by the girls in the study was 4.8 minutes (13.1%) per lesson. Again VPA accrued within PE totaled 17 minutes per week which is less than one third of the
recommendation in the US outlined by USDHH (2000). However McKenzie et al. (2006) emphasise that ‘although these 36 schools provided limited amounts of PA during classes, school PE remains a critical place for promoting health related PA’ (p. 1235).

Quantifying levels of PA during PE lessons is problematic (Fairclough and Stratton, 2005b). Fairclough and Stratton, (2005b) assessed 40 studies that assessed PA levels during PE, the overall standard deviation of 40 studies was found to be 14.2% and in addition to this overall MVPA was found to range from 27 to 47% of the lesson spent in MVPA. The first problem comes from the choice of instrument to measure MVPA during PE. HR telemetry techniques are regularly employed to assess MVPA, however these studies should be approached with caution due to the measurement being affected by emotional stress affecting the results (Fairclough and Stratton, 2005b). In addition HR has been shown to be lower in boys than girls when assessing activity of the same intensity making comparison problematic if HR reserve has not been incorporated (Stratton, 1996).

Accelerometry studies can also be problematic (Fairclough and Stratton, 2005b; Jago et al. 2009). Accelerometers are not affected by emotional stress but detect no movement when the lower limb is in motion but the hip is stationary. Accelerometers do not detect isometric activity again proving problematic (Fairclough and Stratton, 2005b). Studies that quantify MVPA
during PE can also be skewed by the type of activities that boys and girls take part in; girls may take part in more activities that do not require as much body mass loading as invasion games such as movement activities and therefore the opportunities for the accumulation of MVPA may be less frequent (Fairclough and Stratton, 2005b; Jago et al. 2009).

In addition to methodological issues PE studies are also simply affected by the type of school recruited for the study. ‘Comparing PA levels across studies is problematic because of the contextual diversity that exists in different types of schools’ (Fairclough and Stratton, 2005b, p. 218). This contextual diversity can include types of activity, time allocation for PE to occur and instructional methods used at the school.

Cale and Harris (2005) outline that the time limitations on the PE lesson due to core subjects being made high priority for curriculum time make it difficult to allow adequate time to achieve high levels of MVPA during PE. Equally, the time allocation for lesson objectives and other curriculum modules may impact negatively upon the amount of time spent in MVPA within the PE lesson at different schools. Therefore it is important to look at such interactions and to examine the role of pedagogical interventions which may enhance PA levels without compromising lesson objectives.
2.6 Interventions in the Physical Education Lesson to Increase Physical Activity

A review of PE intervention studies was conducted by Fairclough and Stratton (2005b). They highlight that all of the intervention studies reviewed that had aimed to increase PA levels were successful. Overall intervention studies using HR measures accumulated on average 47.9 ± 10.6% MVPA in comparison to non-intervention studies that accumulated 37.9 ± 14.6% MVPA. It is important to note that a majority of the intervention studies assessed were focused upon fitness and high intensity activity promotion and did not take into account the wider educational focus of PE (Fairclough and Stratton, 2005b).

Hastie and Trost (2002) investigated the use of a pedagogical intervention to increase levels of MVPA within the PE lesson. They used a student centered approach similar to the TGfU model called Sport Education (Metzler, 2005). They investigated whether implementing pedagogical strategies based on the sport education model can increase levels of MVPA within the PE lesson. Nineteen boys (grade 7) participated in a sport education unit for 22 lessons consisting of 50 minutes per lesson. It was found in the study that on average students engaged in MVPA for 60% of the lesson time, 10% above the US recommended target. Importantly there were no significant differences in the activity levels of high versus lower skilled performers, which means that
regardless of ability students can potentially accumulate high levels of activity during PE. Hastie and Trost (2002, p. 71) conclude by stating ‘sport education with its focus on small sided teams, substantive time allocated to game play and a competitive game ethic can provide situations where students can reach high levels of activity.’ However the students selected the sport in which they participated, which potentially enhanced motivation levels and ultimately may have promoted increased levels of PA. This is a major flaw of the study due to its impact on motivation, enjoyment and ultimately effort. Another major flaw of the study was the absence of a baseline assessment of activity levels of the participants involved. This is crucial as this particular group of participants may have had high levels of activity during the lesson regardless of the intervention.

Baquet et al. (2002) conducted an intervention during PE lessons to look at the effect of intensified PE lessons on adolescents aged 11-16 years old. 345 children with a mean age of 13.1 years were recruited to the study. Students were assigned to one of three groups; experimental high intensity jumping group (HIJG), experimental high intensity running group (HIRG) or control condition. HR monitoring was used to assess activity levels. Two PE lessons per week were monitored over a ten week period. The control group took part in standard PE lessons with the experimental groups taking part in one intervention lesson and one standard PE lesson. The two experimental groups did not significantly differ in levels of PA however both experimental
groups were found to elicit significantly ($p < .001$) higher HR than the control group. Baquet et al. (2002) concluded that ‘the intensified sessions proposed in the present study, if performed regularly over a period of time, may result in improvements in aerobic fitness’ (p. 287). However the practicality of this intensified lesson in the curriculum and within lesson objectives is debatable due to the focus on fitness rather than adhering to national curriculum learning objectives.

Sallis et al. (1997) implemented and investigated the effects of a two year health related PE programme (Sport, Play and Active Recreation for Kids, SPARK) in seven elementary schools (aged 9-10 years). Each school was assigned to one of three conditions; control, teacher lead health related PE intervention or specialist led health related PE programme. It was found that students were significantly ($P < .001$) more active in the specialist and teacher lead lessons in comparison to the control group. In addition girls assigned to the specialist lead condition displayed significantly ($P < 0.001$) higher levels of abdominal strength and respiratory endurance in comparison to girls in the control condition. In addition the effects of SPARK were followed up and extended to middle schools to assess the impact of such an intervention in older children.

McKenzie et al. (2004) evaluated the outcomes of a two year middle school intervention (Middle School Physical Activity and Nutrition; M-SPAN) leading
on from the SPARK intervention. The study was conducted across 24 middle schools (approximately 25,000 students) that were randomly assigned to intervention (n = 12) or control (n = 12) across Southern California. On average across the schools 45% of the students recruited were non white and 39% were receiving free or low cost meals. Schools were offered $1000 to participate in the study. Intervention lessons were accompanied with professional development training sessions aimed at promoting health related PE and in addition provided materials for teaching. SOFIT was used to quantify levels of PA during the study. Data were collected at baseline, year 1 and year 2 of the intervention. The study observed a total of 1849 lessons (430 baseline, 711 year one and 708 year 2 intervention). Student enjoyment questionnaires and teacher assessment questionnaires were incorporated into the study. McKenzie et al. (2004) found a significant increase (p = 0.02) in time spent in MVPA. Effect sizes were reported as large for boys (d = 0.98) and moderate for girls (d = 0.68). The effect of the intervention was cumulative and by year 2 girls in the intervention condition were participating in the same levels of MVPA as boys in the control condition. Teachers appeared to need time to feel comfortable with the intervention techniques and a departure with ‘traditional’ teaching methods. Enjoyment during PE was not significantly increased with the intervention. From baseline to year 2 the intervention schools increased MVPA by 18% compared to 3% in the control schools, this equated to approximately 2.6 minutes per lesson for the intervention schools. McKenzie et al. (2004) revealed that this extra 2.6
minutes totaled 13 minutes per week and over a 36 week period would provide 7.8 hours of PA which is the equivalent to 7lb of body mass. McKenzie et al. (2004) acknowledge the limited change in MVPA which leads onto the need for further development of interventions within PE. It is important to note that when girls PE lessons were analysed they revealed no significant differences between intervention and baseline suggesting that new intervention designs for girls need to be developed using different motivational or instructional strategies (McKenzie et al. 2004).

Verstraete, Cardon, DeClercq and Bourdeaudhuij (2007) assessed the impact of a two year health related intervention based on the previous work of McKenzie et al. (2004) and the SPARK health related PE intervention. Teachers in the study were given the SPARK manual which consisted of specifically designed lessons. In addition training sessions with specialist SPARK staff were implemented to ensure the health related intervention was successful. Sixteen elementary schools were randomly assigned to a control (n = 8) or intervention (n = 8) group. SOFIT and RT3 ® triaxial accelerometers were employed to assess differences in MVPA. Pre and post measures were taken over the two year period. There were no significant differences in MVPA using the objective accelerometer assessment, however, SOFIT analyses revealed significant differences pre-post intervention lessons 42% to 56% MVPA respectively. It is important to note that this was the first study to objectively assess the effects of a health related intervention
(Verstraete et al. 2007), however, the study used 1 minute epochs which can underestimate MVPA as it averages the activity counts over one minute therefore losing intense, short, sporadic outbursts of activity (Rowlands et al. 2004).

Fairclough and Stratton (2005b) developed an intervention using an intervention design aimed at instructional techniques in PE to improve girls PA levels. The study used an experimental design with two classes of mixed ability girls aged 11-12 randomly assigned to the control (n = 14) or experimental group (n = 12). Both classes took part in a six week unit of gymnastics with the same lesson objectives. A female and male teacher taught the control and experimental classes respectively. The experimental teacher was told to incorporate an added objective of increasing MVPA using teaching approach techniques such as organization of groups and space, teaching approaches, lesson pace, teacher positioning, ‘active’ learning and making the lesson fun (Fairclough and Stratton, 2005b). MVPA was quantified using the observational tool SOFIT and objectively using HR monitors (50% HR reserve threshold). Intrinsic motivation and perceived competence were also monitored to ensure the added objective of increasing PA levels did not negatively impact upon motivation as previously reported by Fairclough (2003b). The study reported that MVPA was significantly increased by the intervention (18.5% INT versus 13.5% CON, p = 0.047), and that motivation was similar throughout the study showing that there was no
negative effect on motivation (Fairclough and Stratton, 2005b). However of particular concern was the data showing that MVPA targets were well below the 50% criteria.

Most recently a study by Jago et al. (2009) looked at the effects of two pilot interventions during middle school PE. Two pilot studies were implemented over a two year period on 6th grade students (aged 11-12). Both studies monitored HR levels to establish MVPA levels and children were given $5 each time they wore the HR monitor. The first pilot study looked at the effects on MVPA of an activity based PE intervention. 56 instruction cards were devised and a ‘master PE’ teacher at each school attended a five day training course which they would disseminate to other teachers at the school. 585 students agreed to take part in the study with five randomly selected students wearing HR monitors each lesson (students were not selected more than 8 times to wear the HR monitor). It was found that on average 58.7% (19 minutes) of class time was spent with a HR above 140 bpm (Jago et al. 2009). Interestingly it was found that during the study there was a cumulative effect of the intervention similar to that displayed by McKenzie et al. (2004). During week one the average HR for the intervention were calculated at 144 bpm whereas by week seven of the intervention HR were reaching 150 bpm. Jago et al. (2009) explain that ‘changes to middle school PE can be made, but changes may take time to ‘bed in’ while the teachers learn and implement the new classroom management methods’ (p. 177).
In the second pilot study Jago et al. (2009) conducted a curriculum based intervention. This intervention was built upon the activity based study but curriculum requirements were incorporated into the study. The aim of the study was to increase MVPA levels by reducing changing time and more time spent modelling the lessons with a ‘master PE’ teacher. The same ‘master PE’ teacher delivered the training programme to other teachers in the study. The same methodology was used in terms of measuring PA by HR. The difference in this pilot study students were characterised by BMI category (normal BMI < 85\textsuperscript{th} percentile or overbody mass BMI > 85\textsuperscript{th} percentile). 46% of the students recruited were classified as overbody mass (Jago et al. 2009). The intervention successfully increased HR and this was cumulative over the study (week one average HR 140 bpm and by week 8 HR averaged 146 bpm). Interestingly there were no differences between ethnicity and BMI groups by activity levels meaning that practically PE interventions can be effective in enhancing levels of MVPA regardless of body mass and ethnicity. Jago et al. (2009) conclude by stating that the ‘study shows that it is possible to deliver PE lessons that meet state curriculum requirements while also ensuring that students obtain a substantial amount of health enhancing activity’ (p. 180) and that more instructional and motivational methods should be piloted and implemented to increase the amount of activity whilst staying within the curriculum requirements.
As Fairclough and Stratton (2005b) summarise in their review of PE studies, intervention studies that have been conducted prior to 2005 have not accounted for the wider educational focus of PE. Intervention studies have tended to focus upon fitness protocols and high intensity activity and therefore Fairclough and Stratton (2005b) and Jago et al. (2009) recommended that intervention studies should take into consideration existing subject matter and aims of PE in addition to fitness focus elements. They also outline that interventions involving pedagogical teaching approaches and class content are much more favorable than purely fitness focused interventions.
2.7 Pedagogical Intervention: Teaching Games for Understanding

The ‘TGfU’ approach was developed by Bunker and Thorpe (1982). Bunker and Thorpe (1986) highlighted that most school leavers obtain little game understanding during traditionally taught lessons and as a result possess inflexible techniques and poor decision making skills. ‘Traditional’ approach lessons have been characterised by ‘direct instruction, and a lesson format divided into an introductory activity, a skills phase focusing on developing and improving skill technique and a game’ (Blomqvist et al, 2001, p. 140). This has been reinforced recently by the identification of students across the PE curriculum having problems linking the skill drills used in the traditional teaching approach to a game situation as a result of poor game understanding (Mitchell, Oslin and Griffin, 2006). Games’ understanding is ‘a player’s ability to solve tactical problems by selecting appropriate solutions in different situations and by selecting arguments for these solutions’ (Blomqvist and Luhtanen, 2000, p. 325). In other words it is the student having the ability to apply skills and knowledge of the activity in a games situation in order to play the game effectively. A student who cannot play the game effectively is often frustrated by traditional skill drills as the skills they have learnt ‘deteriorate in a games situation and they tend to feel that their participation is aimless and their contribution is irrelevant’ (Mitchell et al. 2006, p.24).
TGfU is a sequential curriculum model developed to aid the teaching of games activities in a tactical context during the PE lesson (Bunker and Thorpe, 1986). As Metzler (2000) explains TGfU is an instructional model that is used to develop a learner’s capability to play games. Limitations are placed on a game situation in order to teach skills and recognise when skills should be used in a games context the sequential aspects of the model are critical. Unlike traditional teaching methods, as previously defined, the TGfU approach begins with a conditioned game which leads the student into a tactical awareness and decision making setting (Bunker and Thorpe, 1986). It then progresses onto a ‘question and answer’ section that asks leading questions to develop the learner’s understanding of how and when to use the skill and emphasise the tactical decisions that may need to be made in certain situations. The skill is then extracted from the game and practiced and finally the students are directed back into a conditioned game (Mitchell et al. 2006). The TGfU approach was developed after the traditional teaching approach had been recognised as problematic for students particularly in terms of students being able to transfer the skills into a games context (Bunker and Thorpe, 1986). This is reinforced by Mitchell et al. (2006, p. 8) who explained that the ‘traditional’ skills based approach to teaching can lead students to ask questions such as ‘why are we doing this?’ and ‘when can we play a game?’ It has been highlighted by Bunker and Thorpe (1986, p. 1) that students have difficulties transferring skills learnt into games activities as the ‘PE Curriculum present problems of ‘what to do?’ and ‘when to do it?’ and not
just ‘how it is done?’. Mitchell et al (2006, p. 8) point out that ‘many physical educators teach both the skills and tactics of the game but have problems linking the two’. As a result of this students tend to lose the context of the skill and become frustrated during game play (Mitchell et al. 2006).

Bunker and Thorpe (1986) explain that games activities are different to other activities in the way that they produce questions for the performer such as ‘what to do?’ and ‘when to do it?’ rather than just how to perform the activity. This is also highlighted by Blomqvist and Luhtanen (2000, p. 325) ‘Traditional approaches produce skillful players who are not always able to use their skills in the game because the skills were learned in isolation from a games context.’ A TGfU approach to teaching games activities emphasises tactical decisions that will occur during a game and as a result students will find that games can be fun and interesting (Bunker and Thorpe, 1986). ‘A tactical approach provides an exciting alternative through which students can learn to play games’ (Mitchell et al. 2006, p.8).

Importantly research has been conducted on teachers responses to actually teaching the games for understanding approach. TGfU teaching is very different to the traditional approach that most teachers have been employing for years and therefore its implementation is critical to the success of its introduction into the curriculum. Butler (1996) interviewed a group of ten teachers with a combined teaching career of 137 years. The teachers
participated in two activities. Activity I - teachers used a traditional technical approach of teaching. Activity II - teachers conducted TGfU sessions following training sessions. The teachers were then interviewed for an hour after the testing sessions had been completed. During activity I it was found that teachers spent most time giving directions which resulted in low student contribution scores. The students also had limited time in practising the skills. In activity II more student understanding was experienced through problem solving along with more interaction time between the students and teachers. Most importantly the focus changed in the TGfU lessons from executing skills to understanding tactics. During the interviews the teachers were asked if they had any concerns with the TGfU approach. The main concerns focused around the fact that the technical (traditional) model gave more control over the children and the children needed to have knowledge of the skills involved with the game prior to the TGfU approach. The teachers were also asked how TGfU could be best implemented to teachers that had not used the approach before. The main responses involved teaching TGfU to a small group of teachers, having video footage of one class to enhance understanding, practical sessions not lecture style and providing research that shows TGfU works for reassurance and reasoning for employing the approach. Overall the teachers felt an integrated approach would be best with clear aims and support given throughout (Butler, 1996).
One of the main arguments against using the TGfU model in PE, is its potentially detrimental effect on the development of technical skills (Allison and Thorpe, 1997). Technical skills are the fundamental skills required for specific games i.e. how to perform an overhead clear in badminton. However there have been a number of research studies conducted using the TGfU model that find that there are minimal detrimental effects on skill development (Allison and Thorpe, 1997).

Allison and Thorpe (1997) compared the effectiveness of a skill based approach to learning to that of a ‘games for understanding’ approach. They focused on pupil enjoyment, skill development and tactical understanding. Two groups of children (40 year 9 boys and 56 year 8 girls) were involved in the study which consisted of a 3 week pre-test, 6 x 1 hour teaching sessions and then a 3 week post-test. The two groups were randomly split into two (TGfU and control; four groups in total). Post lesson questionnaires were employed to establish pupil enjoyment and recognised skill tests pre and post teaching sessions. The study found that % skill improvement was ‘as good as if not better in the games for understanding classes’ in comparison to the control PE lessons (Allison and Thorpe, 1997, p. 11). It was also found that children in the games for understanding groups enhanced their understanding of the game i.e. when to pass/shoot/dribble. Interestingly the teachers felt they had more time to observe the pupils in the lesson and felt the pupils were involved in more planning and evaluating in comparison to the
traditional skill based lesson. The lower skilled pupils in the study reported higher levels of perceived ability which could have potentially led to the increase in enjoyment levels recorded during the TGfU lessons (Allison and Thorpe, 1997).

Very little research has been conducted specifically on the effects of different curriculum models or teaching approaches on MVPA levels. Research has shown that games based activity during the PE lesson can produce elevated levels of PA in comparison to skill dominated lessons (Yelling et al. 2000). Yelling et al. (2000) found that during a six lesson unit of netball 55% of a skills based lesson and 42% of a games dominated lesson were spent with HR below 50% HR reserve, showing that skills based lessons may produce lower HR and ultimately lower levels of MVPA. Hence the TGfU approach has the potential to promote increased time spent in MVPA during PE lessons.

Most recently Van Acker, Carreiro da Costa, Bourdeaudhuij, Cardon and Haerens (2010) showed that a modified game form similar to TGfU impacted positively on MVPA for both boys and girls. The study was conducted on 221 students across Portugal and Belgium (113 boys, 108 girls). The intervention was based around an ‘invasion games competence model’ developed at Ghent University. The model consisted of three content blocks; 2 versus 1 games situation, 3 versus 2 game situation and 3 versus 3 game with the
around 10% of the lesson allocated to demo’s (Van Acker et al. 2010). The activity chosen was a game called ‘korfball’. Korfball is the only game that has rules set out especially to incorporate boys and girls, to make the game a fair contest (Van Acker et al. 2010). HR monitors were used to assess PA levels, however, this objective assessment was only conducted during one lesson meaning no lesson-lesson changes were monitored (Van Acker et al. 2010). Interestingly the study found that both boys and girls displayed levels of PA over the 50% criterion using this modified game form. In particular it was found that girls had significantly higher levels of MVPA in comparison to the boys. However, this increase for girls could be due to the issues surrounding HR monitoring i.e. girls have a slower HR recovery and it has been demonstrated physiologically that girls have a higher HR than boys (Van Acker et al. 2010).

Due to the fact that children are typically more active during games activities than individual activities (McKenzie et al. 2006 and Fairclough, 2003a), and given that it has been found that skill based lesson time is associated with less PA than games based lesson time (Yelling et al. 2000) it is proposed that a tactical games based approach to learning skills will increase PA levels within the PE lesson without compromising lesson objectives or discriminating against lower skilled students. It has also been highlighted that research focusing on different curriculum models has been extremely limited and has been mainly focused on their effectiveness (in terms of implementation of the
model and its effect on the students) rather than whether the models promote PA in the PE lesson. In addition, most of these studies have shown a lack of control and external validity i.e. students are able to select the activity used and small sample sizes are employed. Van Acker et al. (2010) lends further support for modified games by stating ‘using modified games forms has the potential to achieve PA goals’ (p. 169). Therefore it has been recommended that the effect of different curriculum models on MVPA levels be investigated more robustly (Van Acker et al. 2010; Yelling et al. 2000; Hastie and Trost, 2002).

It has been suggested that if the students’ enjoyment levels are increased during PE this can have a significant impact upon motivation levels (Griffin et al. 1995). In 2002, Kirk and MacPhail produced a paper which proposed revisions to the Bunker and Thorpe model. They suggested that a ‘situated learning perspective’ (‘active engagement of individuals with their environment’ (Kirk and MacPhail, 2002, p. 183)) needed to be incorporated into the model due to the fact that TGfU is an instructional model, ‘a coherent framework held by the teacher and communicated to the pupils’ (Metzler, 2000, p. 1). The revised model places more emphasis on the learners’ perspective and on skill development. This is further reinforced by Gubacs-Collins (2007, p. 107) who has highlighted the importance of this ‘situated learning perspective’ and explains that this perspective has shown that ‘when people find their learning experiences to be meaningful and authentic,
motivation is enhanced’. For example in the TGfU model skills are learnt in a games context which allows the skill to become more meaningful and authentic (as it is being learned in the correct context) and ultimately this may have a positive impact upon motivation levels.

2.8 Motivational Factors Influencing Physical Activity Levels During Physical Education – Self Determination Theory

Student motivation during PE has been highlighted as a significant factor that can affect levels of PA and willingness to participate in PE (Standage et al. 2005). SDT in particular has been directly researched within the PE lesson (Taylor and Ntoumanis, 2007, Standage et al. 2005, Wallhead and Ntoumanis, 2004). SDT is based upon three innate psychological needs; competence, autonomy and relatedness which when satisfied yields enhanced self motivation and mental health’ (Ryan and Deci, 2000, p. 68). SDT directly impacts on intrinsic motivation as it relies upon the three innate needs (autonomy, competence and relatedness) (Ryan and Deci, 2000). Intrinsic motivation has been described as the principal source for an individual’s ability to make life enjoyable and continue vitality throughout life (Ryan and Deci, 2000). If the three innate needs of SDT are disrupted and the student becomes extrinsically motivated, students tend to show less interest in the activity and ultimately put in less effort towards achieving (Ryan
and Deci, 2000). If students are intrinsically motivated they will show ‘interest in an activity and experience enjoyment and feelings of competence and control’ (Wallhead and Ntoumanis, 2004 p. 4). Ryan and Deci (2000) outline that SDT is also affected by the environment created. By using different curriculum models during PE the environment created can be manipulated.

Standage et al. (2005) tested the influence of SDT in PE, using questionnaires examining the different constructs of SDT. They outlined that an ‘intrinsically motivated student would participate in PE because of feelings of satisfaction and pleasure that arise directly from the various activities embraced by the PE curriculum’ (Standage et al. 2005, p. 412). The study found that when the students perceived the environment in a context that supported autonomy, competence and relatedness their overall need satisfaction was consequently higher (Standage et al. 2005). This means that when a self determined environment is created, overall the intrinsic motivation of the student will be higher influencing how satisfied the student will be and ultimately the student will have a greater overall participation and effort during PE.

Similarly Taylor and Ntoumanis (2007) further investigated the relationship between teaching strategies and self determination in PE. The study examined data from 1083 (399 boys, 371 girls) British PE students (aged 11-16 years) and 51 PE teachers. The aim of the study was to look at teachers
reported use of three motivational strategies; autonomy support, involvement and structure and teachers perceptions of average class self determination and compare these findings to the student’s perceptions of self determination. The data from the study show that teachers’ perceptions of class self determination did predict their use of the three motivational strategies (Taylor and Ntoumanis, 2007). In addition the study also revealed that student perceptions of the level of autonomy support, structure and involvement provided by the PE teacher positively predicted their degree of self determination. However the teachers self determination level was not related to student self determination which may be problematic for interventions due to interventions being aimed at teachers but outcomes are aimed at students (Taylor and Ntoumanis, 2007). In a practical sense this means that the PE class could exhibit high levels of self determination but the PE teacher may have low self determination, and vice versa. Taylor and Ntoumanis (2007) conclude by stating that more studies need to be conducted to highlight the relationships between student and teacher motivational regulations.

Wallhead and Ntoumanis (2004) investigated the use of a pedagogy based intervention on SDT. The research focussed on how a Sport Education Model used during PE lessons affect the students’ motivation levels. The Sport Education Model focuses on small sided games activities where the children are affiliated to teams and take responsibility for roles and organisation. The Sport Education Model embraces key factors from traditional sport settings. It
also has similar components to the TGfU approach in particular encouraging students to develop their own learning and ultimately to be intrinsically motivated. Wallhead and Ntoumanis (2004, p. 6) outline the sport education model as an encouragement for students ‘to fulfil other sport related roles such as referee, team coach, captain and serving on a sports management board or as part of a duty team’. The research was conducted using two classes of boys (n = 25, n = 26). One class was taught a unit (8 weeks) of basketball using the sport education model and the other class was taught using the traditional approach. Pre and post intervention questionnaires were completed by all participants in relation to enjoyment levels, perceived effort, perceive competence and intrinsic motivation. Wallhead and Ntoumanis (2004) found that participants in the sport education class displayed significantly higher levels of enjoyment and perceived effort pre-post intervention. The traditional class experienced no gains in enjoyment, perceived competence or perceived effort and intrinsic motivation. The students reported that during the sport education directed sessions they felt they learnt more and were more involved in the lesson (Wallhead and Ntoumanis, 2004). Overall, it was shown that when the students displayed perceived autonomy a positive effect was found on student motivation meaning practically that basing lessons on the sport education model enables students to understand the game and ultimately will feel more competent in sporting activities (Wallhead and Ntoumanis, 2004). High levels of perceived
autonomy also makes the students feel more competent during PE lesson activities (Wallhead and Ntoumanis, 2004).

Most recently Lonsdale et al. (2009) conducted the first study that looked at students self determined behaviour and the effect on objectively measured PA. This study focussed on the relationship between self determined behaviour and PA behaviour during structured PE lessons and free choice periods. The study recruited 528 Hong Kong students (n = 296 girls, n = 232 boys) with a mean age of 15.8 years. From a baseline situational motivation scale questionnaire measuring self determined behaviour, students were placed either in either a low self determination group or a high self determination group (significant difference between groups, \( P < 0.01 \)). Students were monitored over 18 lessons and wore a pedometer to objectively measure PA levels. Lessons were split into two parts; 20 minutes structured PE and 20 minutes free choice period. Across both parts of the lesson students that were classed as high in self determination had significantly higher (\( p < 0.01 \)) step counts than the low self determined group (Lonsdale et al. 2009). The results show that students who were more self determined took part in significantly greater amounts of activity than students who have low levels of self determination (Lonsdale et al. (2009). This is the first study to actually look at this multidisciplinary relationship and therefore more research is warranted.
Fairclough and Stratton (2005a) highlight the need for more investigation into the relationship between MVPA and motivation. They explain that this relationship has seldom been investigated and that the area of research is of ‘importance because PA levels might be linked to effort and perceived competence, which are predictive of intrinsic motivation’ (p. 227). This is further reinforced by Fairclough and Stratton (2005b) that ‘multidisciplinary methods can yield rich sources of information, which may better inform the development of strategies to engage students in health enhancing activity during PE’ (p. 456). Most recently Jago et al. (2009) highlighted the need for more effective instructional and motivational research that increases the amount of PA students engage in during PE. Lonsdale et al. (2009) also support this by stating that future research is needed in which the PE environment is manipulated in order to create a self determined environment and ultimately the effect of this type of intervention on objectively measured PA.

2.9 Teaching Games for Understanding and Self Determination Theory

Using the TGfU curriculum model has been shown to enhance enjoyment and deliver intrinsic values (Butler, 2006). Alternatively if a lesson is only taught in a technical traditional manner, learners will lose intrinsic experiences (Butler, 2006). In particular Butler (2006) highlights that TGfU promotes elements
such as small group work which will directly impact upon relatedness which is a direct determinant of self determination. TGfU also promotes individual improvement recognition, individual progression and the use of skill in a game situation which will all positively impact upon the determinants of SDT (competence, relatedness and autonomy). Alternatively if a lesson is only taught in a technical traditional sense it has been found that learners will lose intrinsic experiences (Butler, 2006).

Mandigo et al. (2008) recently conducted research on the effect of autonomy supportive games lessons on children’s motivational levels. TGfU is congruent with autonomy supportive games as both focus on student centered learning environments and humanistic theories (Mandigo et al. 2008). Mandigo et al. (2008) highlighted that ‘children’s participation in PE and involvement of PA outside of schools remains problematic’ (p.408). They also point out that there has been no structured intervention to investigate the impact of using autonomy supportive games (in particular TGfU) on motivational levels. Mandigo et al. (2008) also highlight the lack of such interventions investigating possible differences associated with sex and in motivation across different games categories. The Mandigo et al. (2008) study was conducted using 12 primary schools (37 classes) grade 4-7 (8-12 years old). The study focused on four different types of games activities; target, striking/fielding, net/wall and invasion games. The lessons were taught using a TGfU autonomy supportive approach by teachers who had received
training on autonomy supportive methods of teaching and had attended at least one course on TGfU (Mandigo et al. 2008). The study found that ‘humanistic approaches (i.e. TGfU) can be an effective way to foster intrinsic motivation’ (Mandigo et al. 2008). The students who took part in the study experienced high levels of motivation as a result of the intervention. In particular girls displayed significantly higher levels of optimal challenge, enjoyment and autonomy support ($P < 0.05$) in comparison to boys. Boys displayed significantly higher ($P < 0.05$) levels of perceived competence in comparison to girls. Invasion games were found to be the type of activity that produced the lowest motivation, 42% of the students reported finding the invasion games boring suggesting that the students did not find the invasion game lessons challenging enough due to prior participation in similar activities. In addition the results show significantly lower levels ($P < 0.05$) of enjoyment during invasion games in comparison to the other games activities. Mandigo et al. (2008) highlight that invasion games are the most complex type of game and therefore the lesson could have potentially been developmentally inappropriate for the students. Overall across all types of games activities it was found that 61% and 54% of girls and boys respectively, responded positively to the intervention by indicating on the questionnaire that it was ‘fun’. Importantly no baseline measures were taken meaning that although most participants responded positively after the intervention they may have already been positively motivated by PE. Due to
the differences found across sex and activities Mandigo et al. (2008, p. 420) suggest that ‘a richer understanding of the root causes of these differences (gender, activity) is still needed’. They also suggest that future research needs to focus on autonomy supportive games but with observational analysis (SOFIT) to help gain the relationship between individual, environment and task and its effect on motivation. According to Mandigo et al. (2008) such research in this autonomy supportive domain is long overdue.

To date, research has mainly focused on how the TGfU model has been shown to work in terms of enhancing teacher experience, student understanding, and skill development during the PE lesson. There is a lack of research into the potential impact of a TGfU session on participation and PA levels within and outside of the PE lesson. This lack of research of the contribution of PE to PA goals is further reinforced by Yelling, Penney and Swaine (2000, p.59) ‘There is a huge need to acknowledge the contribution that PE makes to PA goals’. As Talbot (2008, p. 7) states ‘serial data on participation is rarely used to inform strategy for PE’.
2.10 Teaching Games for Understanding, Self Determination Theory, the Theory of Planned Behaviour and Physical Activity Outside of School

If children’s enjoyment levels and aspects of SDT are satisfied during PE lessons children will be more likely to carry on PA behaviour into adulthood (Greenwood-Parr and Oslin, 1998). Fairclough et al. (2002) outlined that one of the primary goals of PE is to promote lifelong PA. It is imperative that studies that investigate behaviour and attitudes to PA are considered in order to create interventions for reducing inactive lifestyles of school students and these behaviours that they take into adulthood (Rikard et al. 2006). More specifically it has been highlighted that this may occur from student centered learning approaches rather than the traditional skill based approach to teaching (Greenwood-Parr and Oslin, 1998, Rikard et al. 2006, Kirk, 2005).

TGfU has been shown to promote the aspects of SDT (Mandigo et al. 2008) and therefore there is the potential of transference between using the TGfU approach and the enhancement of PA intentions through the TPB (Ajzen, 1985).

The TPB outlines that ‘PA behaviour and intentions can change through attitudes, subjective norms or perceptions of control and/or a combination of these three variables’ (Chatzisarantis and Hagger. 2005, p. 471). Intentions towards PA are based upon how the individual evaluates the activity
(attitude), if significant others around them exert social pressure (subjective norm) and if the individual believes they will be successful (perceived behavioural control) (Armitage, 2005). Most of the research surrounding the TPB has been focused upon adults and very few studies have actually focused upon children’s PA intentions (Hagger et al. 2001).

Blue (2007) investigated health behaviour change using the TPB model. They investigated the role of the perceived risk of diabetes on intentions to be physically active and to eat a healthy diet. A convenience sample of 106 adults took part in the study. Blue (2007) found that subjective norm and perceived behavioural control had a direct influence on intentions to be physically active ($P < 0.05$). More specifically it was found that perceived behavioural control explained the majority of the variance in intentions to be physically active. In addition it was found PA intentions were not associated with attitude. Blue (2007) explains that a limitation of the TPB is that it does not take into account the economical or environmental barriers that may exist for participants meaning that the scope of the model may be limited. Overall Blue (2007) concluded that perceived behavioural control and social influence are the most important factors for the promotion of PA. It is important to remember that the study measured PA subjectively in an adult population which as previously mentioned can be typically over reported (Sirard and Pate, 2001).
Hagger et al. (2001) investigated the antecedents of children’s PA intentions and behaviours. Hagger et al. (2001) outlined that children’s determinants of PA change in comparison to adults and therefore the study aimed to test the validity of the determinants of behaviour in children. The study was split into two parts. In study one 431, children aged 12-14 years were recruited, all participants completed the TPB questionnaire followed by a PA recall questionnaire a week later. In study two, 154 children completed the TPB questionnaire and were re assessed five weeks later. Interestingly in study 1 it was found that subjective norms had no contribution to PA intentions which suggests that children make their own choices and decisions towards PA (Hagger et al. 2001). In study 2 it was found that children’s immediate attitudes influence their decision to participate in PA rather than attitudes from a previous time point. Previous attitudes and behaviour do exert an influence but this is not as great as the direct impact of current attitudes. Hagger et al. (2001) suggest that due to these results interventions should focus on attitudes to enhance PA. The study did show ‘evidence in support of the construct and predictive validity of children’s PA intentions, attitude and perceived behavioural control’ (Hagger et al. 2001, p.405). Interestingly Hagger et al. (2001) conclude that children tend to perform activities based upon enjoyment and other intrinsic factors that the TPB does not measure. This suggests that the TPB is limited and these other factors need to be incorporated.
Hagger et al. (2002) investigated how SDT affects intentions to be physically active. As previously mentioned the TPB has been shown to be highly influenced by attitude (Hagger et al. 2001) and ultimately may be influenced by enjoyment and intrinsic motives. SDT incorporates these factors and may be used to explain why intentions are formed based upon general motives from SDT. Participants (n = 1088, aged 12-14 years) were recruited into the study. The TPB and SDT questionnaire was completed by each student. It was found that attitude and perceived behavioural control exerted a significant influence upon intentions. In line with results from Hagger et al. (2001) subjective norms exerted no significant influence upon intentions. Intrinsic motives from SDT theory were found to be a strong predictor of attitude, subjective norms and perceived behavioural control. These general intrinsic motives are useful sources of information when assessing children’s attitudes and ultimately control of PA in the future. The results of the study show a chain of influence and links between constructs of SDT and the TPB ‘commencing with general motives to engage in PA (intrinsic motives), filtered by specific expectations (attitudes) and ending with behavioural intentions’ (Hagger et al. 2002, p. 294). The results also indicate that when perceived behavioural control mediates intrinsic motives this ultimately affects intentions through the relationship between competence and relatedness. In practical terms this means that when children have a high control over what PA they participate in, they will have a high estimate of competence, therefore perceived behavioural control is necessary to influence children’s PA
intentions. Hagger et al. (2002) concluded by explaining that competence is a key area for interventions to impact on intentions via constructs of SDT. Competence is also of importance within the PE curriculum. One of the curriculum aims (QCA, 2008) is to ‘help young people become confident citizens who have the knowledge and ability to live healthy lives’. Within this aim, competence is highlighted as key area; the QCA (2008) outline that if a child develops competence through PE they will be more likely to continue PA outside of school and into adulthood.

Similarly Chatzisarantis, Hagger and Smith (2007) investigated the influence of perceived autonomy support (part of SDT model) on PA within the TPB. Chatzisarantis et al. (2007) specifically outline perceived autonomy as the ‘extent to which individuals perceive that significant others encourage choice and participation in decision making’. The research was conducted on 171 participants from two age groups (13.9 ± 0.6 and 18.9 ± 2.6 years old). PA levels were measured using self report methods. Self report methods are outlined as a limitation of the study as PA levels can be typically over reported (Chatzisarantis et al. 2007; Sirard and Pate, 2001). It was found that perceived autonomy influenced intentions directly through attitude not via subjective norms or perceived behavioural control. Importantly this study found that perceived autonomy was the only construct to predict intentions to be physically active when the effects of past behaviour were controlled.
Most recently Hagger et al. (2009) studied the effect of teacher, peer and parent autonomy support in PE and then on leisure time activity. The study used a trans contextual model incorporating SDT, motivation and the TPB. The model theoretical background is based around the PE teacher promoting autonomy support to influence self determined behaviour and ultimately how this self determined behaviour can enhance leisure time activity. This is of importance because ‘such evidence is useful for intervention design as it provides a rationale for promoting autonomous motivation in a context where a captive audience exists i.e. PE that will have an influence on motivation in another context where access is limited i.e. leisure time activity’ (Hagger et al. 2009, p. 690). The study was conducted across four nations; UK, Estonia, Finland and Hungary. The study reported support for this trans contextual model and that the effects of perceived autonomy support during PE influenced autonomous motivation in leisure time and ultimately influenced intentions to be physically active (Hagger et al. 2009). This study is particularly important in terms of PE because it implies that the PE teacher can have a very important role in the promotion of PA outside of school through techniques used within PE. This transfer of motivation from one context to another is extremely important to develop interventions in PE to promote PA outside of school. This will ultimately impact on the effectiveness on one of PE’s aims; to promote lifelong PA. Hagger et al. (2009) highlight the lack of studies investigating how motivational factors during PE are translated into PA participation outside of school. In addition Chatzisarantis and Hagger
(2005) highlight the need for more studies to use the TPB to develop and facilitate interventions as there are very few studies that have used the TPB based interventions to study how PE can influence PA participation outside of school and lifelong PA.

2.11 Importance of Lifelong Activity through Teaching Games for Understanding

It has been widely accepted that one of the primary goals of PE is to promote lifelong PA (Bailey et al. 2009; Seghers et al. 2009; Trudeau and Shepherd, 2008; Fairclough et al. 2002). The national curriculum for PE also states one of the aims of PE is to help young people become ‘confident individuals who are able to live safe, healthy and fulfilling lives’ (QCA, 2008, p. 189). This policy is ultimately directed at PE’s aim towards lifelong activity for young people. In addition to this statement Bailey et al (2009) state that there is ‘suggestive evidence of a distinctive role of PE and school sport in the acquisition and development of childrens movement skills and physical competence’ (p. 1). The International council of sport science and PE claim that PE plays an important role in the development of mind and body, understanding the aerobic and anaerobic fitness for health, increases self confidence and has a positive influence on social and cognitive development.
The PE lesson has been highlighted as the key setting for influencing positive attitudes towards PA (McKenzie, 2001, Fairclough et al. 2002, Kirk, 2005). If children have an enjoyable experience and feel more competent during PE they are more likely to carry this behaviour on into adulthood (Greenwood-Parr and Oslin, 1998). It is imperative that studies that investigate behaviour and attitudes to PA and are considered in order to provide a solution to reducing inactive lifestyles of school students and the behaviours that they take into adulthood (Rikard et al. 2006). More specifically it has been highlighted that this may occur from student centered learning approaches rather than the traditional skill based approach to teaching (Greenwood-Parr and Oslin, 1998, Rikard et al. 2006, Kirk, 2005).

As outlined previously TGfU is a student centered approach to learning which has a direct positive influence upon motivation levels (Mandigo et al. 2008). Interestingly Rikard et al. (2006) conducted a study on high school student attitudes to PE and worryingly 82% of the participants in the study answered negatively to the question ‘do you participate in any activities out of school due to being introduced to it in your PE lesson?’ This is particularly concerning as lifelong trends and intentions are more likely to occur from activities viewed as positive and that others around them view as positive.

Rikard et al. (2006) also highlighted from their study that the negative attitudes demonstrated show a certain amount of unrest with old ‘traditional’
teaching methods. Similarly Kirk (2005) explains that secondary school PE lessons taught in a traditional manner have had limited effects in the transfer of participation in later life. Competence has also been highlighted as an important factor for lifelong participation (Kirk, 2005). If children perceive their own competence to be low especially in comparison to others then lifelong intentions to be physically active will be low due to a negative impact on their motivation levels (Kirk, 2005). The QCA (2008) outline in the national curriculum the importance of competence for young people so they have the confidence to lead healthy and fulfilling lives. Fairclough et al. (2002) outlined that further investigation is required into the effect of teaching approaches on the promotion of lifelong PA. Kirk (2005) supported this by explaining that in order for PE to affect a child’s lifelong participation in PA a development of modified PA interventions that create a task orientated (i.e. TGfU) environment particularly in the school setting is required. Kirk (2005) also suggests that children aged 8-14 years should learn to play through conditioned games (TGfU) rather than a technical approach (skills prior to a game). McKenzie and Lounsbery (2008) explain that school PE is the ‘pill not taken’ and that the numerous barriers that surrounds PE such as limited curriculum time, low subject status within the national curriculum has hindered PE from achieving its aim of PA promotion. It has also been noted that PE has muddled aims due to numerous other goals of PE such as motor skill, emotional and cognitive development (McKenzie and Lounsbery, 2008).
Lonsdale et al. (2009) explain the importance of research investigating different instructional models to enhance motivation in the PE lesson and promote lifelong activity, ‘promoting self determined motivation may be an effective means by which to ensure that PE programs increase PA levels, foster self initiated PA behaviours and enhance adolescents health’ (p. 73). The use of effective instructional methods combined with motivational methods is key to the promotion of lifelong activity through PE (Hagger et al. 2009; Jago et al. 2009; Fairclough and Stratton 2005b). As McKenzie and Lounsbery (2008) conclude ‘PE should be an enjoyable experience during which students learn generalisable movement skills that will transfer into diverse activities, sports and games offered at school, in the community and later in life’ (p.222).
Chapter 3 Methodology
3.0 Introduction

This chapter outlines the equipment and testing procedures used during the studies.

This thesis will focus on children aged 11-12 years old (year 7). The specified age group was employed due to the literature suggesting that after the age of 11 there is an age related decline in PA levels and participation in school sport (Quick et al. 2009). To illustrate this the PE and Sport Survey (2009) outline the number of children taking part in a cumulative total of three hours of PA from PE and out of school sport was 65 % of pupils in year 6 and only 53 % in year 7 with a year-year decrease thereafter i.e. year 8 – 50 %, year 9 – 44 %. In addition the Department for Health (2007) outlines an age related decline in PA levels after the age of 11 years old for boys and girls.

3.1 Anthropometric Measurements

Anthropometric techniques used were consistent throughout the studies. All measurements were taken in allocated spaces at the schools involved in the studies.

3.1.1 Height

Each child was asked to remove their footwear prior to height measurements. Height was taken using a portable Leicester height stadiometer. Measurements were taken to the nearest 0.1 cm.
3.1.2 Body Mass

Each subject was asked to remove footwear before any mass measurement was taken. Body mass was measured using the Tanita bioelectrical impedance Scales (BC-418MA segmental body composition analysis – bioelectrical impedance analyser). The Tanita scales takes into account clothing mass and measures body mass to the nearest 0.1 kg.

3.2 Objective Physical Activity Measurement

3.2.1 RT3 ® Triaxial Accelerometry

The RT3 ® triaxial accelerometer is a small, lightbody mass triaxial accelerometer which stores activity data for up to 21 days. The device is non invasive and is worn on the waistband of the child’s clothing. The sensor in the RT3 ® is an accelerometer which is sensitive along three orthogonal axes (X, Y, Z), representing vertical, anteroposterior and mediolateral motion, respectively. Triaxial accelerometers are thought to be better suited for measuring children’s PA, as they may be more sensitive to children’s movements, in activities such as climbing (Ott et al. 2000) and they are capable of providing estimates of the amount of moderate, hard and very hard activity carried out by individuals. The acceleration is measured periodically, converted to a digital representation and processed to obtain an ‘activity count’.
3.2.2 RT3 ® Triaxial Accelerometry During Physical Education Classes

A one second epoch was used during PE lessons in order to minimise underestimation of any short bouts of high intensity exercise which may occur with longer duration epochs (Rowlands, 2007). RT3 ® devices were collected in at the end of each lesson and downloaded using the Stayhealthy RT3 ® software (version 1.0.7). Lesson start and end time was recorded each lesson so that the RT3 ® data could be cut to these particular times for each lesson. RT3 activity counts were converted to metabolic equivalents using the Rowlands et al. (2004) cut off points (Table 3.0), and frequencies were then calculated to establish time spent in MVPA. Activity thresholds (counts/min) were as follows; sedentary <288 (<1.5 METs), light 288-969 (1.5 METs), moderate 970-2332 (3 METs) and vigorous >2333 (6 METs) activity (Rowlands et al. 2004). The RT3 activity counts have been successfully validated in a laboratory setting against O₂ uptake relative to body mass (R= 0.87, p <0.01 level) (Rowlands et al. 2004).

Table 3.0 Accelerometer cut off points (Rowlands et al. 2004)

<table>
<thead>
<tr>
<th>Activity Level</th>
<th>Accelerometer (counts·min⁻¹)</th>
<th>METs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedentary</td>
<td>&lt;288</td>
<td>&lt; 1.5</td>
</tr>
<tr>
<td>Light</td>
<td>288-969</td>
<td>1.5</td>
</tr>
<tr>
<td>Moderate</td>
<td>970-2332</td>
<td>3</td>
</tr>
<tr>
<td>Vigorous</td>
<td>&gt;2333</td>
<td>6</td>
</tr>
</tbody>
</table>
The accelerometer cut off points (Rowlands et al. 2004) were employed over other studies i.e Treuth et al (2004) as the population sample and methodology used were more in line with the protocols used within the thesis. Treuth et al. (2004) used uniaxial accelerometers to establish accelerometry cut off points. Treuth et al (2004) recruited 74 girls aged 13-14 years old for the study. Treuth et al (2004) established that activity counts for moderate PA were between 3000-5200 which was established as 4 mets. This is in contrast with the Rowlands et al (2004) study that employed boys aged 9.5 ± 0.8 years into the study. Rowlands et al. (2004) used the RT3 triaxial accelerometer which was the model available at the University. The sample in this study was a closer age range to the specified sample to be used within the thesis (see methodology section 3.8) and these cut off points were therefore used in data analysis. It is important to note the difference between cut off points i.e. 4 mets (3000-52000 MPA (Treuth et al. 2004) and 970-2332 (3 mets) MPA (Rowlands et al. 2004) between studies. These differences in moderate intensity threshold should be considered when interpreting the results of each study although Rowlands et al (2004) cut off points were successfully validated against oxygen uptake for the RT3 triaxial accelerometer.
3.2.3 RT3 ® Triaxial Accelerometry During Seven Day Habitual Activity Monitoring

One minute epochs were used based on RT3 ® triaxial accelerometry memory for seven day collection of data. Prior to RT3 ® recoding, the PA diary was taken into consideration (see methodology section 3.4.2). Times marked as swimming or any other PA where the child took off the RT3 ® triaxial accelerometer were coded as moderate PA in the analysis (3 METs).

In order to accurately understand habitual activity and quantify typical PA patterns, five week days and two weekend days were monitored. This period of time is recommended as it provides a reliable estimate of PA in this age group (Trost et al. 2000; Baquet et al. 2007). RT3 ® devices were collected from the school at the end of the seven day period and the data was downloaded using the Stayhealthy RT3 ® software (version 1.0.7). For inclusion in the analysis, each child was required to have produced counts for at least 600 minutes per weekday and 480 minutes per weekend day (Trost 2000; Rowlands et al. 2008). Children who did not achieve 600 minutes of wear time on at least three separate days and both weekend days with the RT3 ® device were excluded from the analysis (Rowlands et al. 2008; Trost, 2000).
3.2.4 Actiheart

The Actiheart is a single-piece combined HR and movement monitor, and was clipped on via two standard electrocardiogram (ECG) electrodes on the chest of the child. The child was asked to place the electrodes on themselves for child protection purposes, after a demonstration of where the electrodes should be placed. The Actiheart is capable of measuring acceleration, HR and HR variability. The Actiheart utilises software which is able to calculate PA intensity and energy expenditure (EE). The Actiheart is set at 15 second epoch intervals.

3.2.5 Sensewear BodyMedia Armband

The bodymedia armband is a small piece of equipment worn on the upper arm. Through the measurement of various body functions — HR, sweat, heat, galvanic skin response and 2-dimensional accelerometry, the monitor estimates total EE, distance travelled, time rested, duration and levels of activity, steps taken and duration of sleep. The children placed the non invasive monitor on their upper arm prior to testing and attached the monitor using a velcro strap.
3.3 Online Gas Analyser

3.3.1 Metalyser 3B ®

The cortex Metalyser 3B ® is a portable cardiopulmonary exercise system which has the ability to measure total EE of the activity (by measuring expired O₂ and carbon dioxide (CO₂) concentrations) and HR. Indirect calorimetry is a criterion measure for PA, because it measures EE which is a physiologic measure closely associated with PA. The children wore the Metalyser 3B ® portable system around their chest with a specially designed strap to keep the monitor in place during exercise. Children breathed through a Hans Rudolph mask which was fitted prior to testing and attached to the metamax sample line. The Metalyser 3B ® system was calibrated prior to testing, using the Hans Rudolph 3 litre syringe and bags of known O₂ and CO₂ concentrations (16.00 % O₂, 4.00 % CO₂).

3.4 Subjective Observation of Physical Activity Monitoring

3.4.1 System for Observing Fitness Instruction Time

SOFIT is described as ‘a momentary time sampling and interval recording system designed specifically to quantify factors believed to promote health-related PA’ (McKenzie and Sallis, 1991, p.196). SOFIT is split into three phases (McKenzie and Sallis, 1991). The first phase involves the observation of the child’s activity levels. The activity level is coded against numbers 1-5.
all of which have been validated using HR monitors (McKenzie and Sallis, 1991). Student Activity levels are coded as follows; 1 = lying down, 2 = sitting, 3 = standing, 4 = walking and 5 = very active. The second coding phase involves coding the context of the lesson. Lesson context codes are as follows; M = general content (transition, break, management), P = knowledge content (physical fitness), K = general knowledge (rules, strategy, social behaviour, technique), F = motor content fitness, S = skill practice and G = game play. The final phase involves the coding of teacher behaviour; P = promotes fitness, D = demonstrates fitness, I = instructs generally, M = manages, O = observes, T = off task. All codes are taken from McKenzie and Sallis (1991, p.204). Observations of each variable were recorded every 20 seconds. Four randomly selected children in each lesson were observed as per the SOFIT training manual (McKenzie, 1998).

3.4.2 Physical Activity Diary

The PA diary was completed by each child to monitor times when the RT3 ® triaxial accelerometer was taken off i.e. for bedtimes and times when the child was in contact with water. The PA diaries were incorporated into the RT3 ® analysis (see methodology section 3.4.2).
3.5 Teaching Games for Understanding

3.5.1 Training Course

Teachers were recruited to take part in the TGfU intervention from a TGfU evening training course held by Paul Sammon at the University of Bedfordshire. The evening course (duration: 4 hours) consisted of a lecture outlining the components of TGfU and the theoretical concepts. In addition to this, the lecture was followed up with a practical component which included a demonstration of how a TGfU should be organised and conducted. Teachers were allocated to small groups to practice a lesson taught using a TGfU framework. Teachers were then invited to ask questions about implementing TGfU at the end of the course and were given a brief overview of the research study. Any teachers who were interested in taking part in the study were directed to leave their contact details and advised that they would receive an email outlining further details of the research study.

3.5.2 Lesson Planning

Two consultations (approximately 60 minutes) took place between the teacher and researcher to discuss and plan the TGfU lessons. Session 1: This consultation involved a discussion of the TGfU approach (using current literature and a DVD supplied with the literature; Mitchell et al. 2006) to illustrate the purpose of TGfU and how it should be taught. This involved an
explanation of TGfU and a discussion of how it is different to a ‘traditional’ skill based approach to teaching. The teacher was encouraged to ask any questions with regards to the TGfU approach and its implementation. Session 1 also consisted of producing potential ideas for the teacher in the TGfU sessions. These ideas were based around the lesson objectives outlined by the teacher i.e. whether attacking or defensive focus. Following session 1 the investigator produced preliminary lesson plans based on the lesson plans outlined by Mitchell et al. (2006) which were then finalized with the teacher in session 2.

3.6 Self Determination Theory Questionnaire

The constructs included in SDT were assessed using the questionnaire developed by Standage et al. (2005). Standage et al. (2005) outline that all measures for the questionnaire reached the acceptable internal reliability criterion of 0.70. Confirmatory factor analyses were also conducted on the questionnaire providing positive outcomes. Alpha coefficients were calculated for each study and were based on the 0.70 alpha criterions set by Nunnally and Bernstein (1994). Self determination was assessed by measuring 12 variables on a Likert scale ranging from 1 = strongly disagree to 7 = strongly agree. Need support was assessed by measuring three variables: autonomy support measured on a 15 item scale (e.g. we feel understood by our teacher), competence support - 4 items (e.g. the PE teacher helps us to
improve), and relatedness support – 5 items (e.g. the PE teacher supports us). Need satisfaction was assessed by measuring three variables: autonomy – 6 items (e.g. I have some choice of what I want to do), competence – 5 items (e.g. I think I am pretty good at PE), relatedness – 6 items (e.g. with the other students in this PE class I feel supported). Motivation was assessed across the continuum of self determination by measuring 5 variables: Amotivation – 4 items (e.g. I take part in this PE class but I don’t see why we should have PE), external regulation – 4 items (e.g. I take part in this PE class because that’s the rule), introjected regulation – 4 items (e.g. I take part in this PE class because I would feel bad about myself if I didn’t), identified regulation – 4 items (e.g. I take part in this PE class because it is important for me to do well in PE), intrinsic motivation – 4 items (e.g. I take part in this PE class because PE is exciting). Positive and negative affect was assessed on a 9 item scale (e.g. in this PE class I feel happy). The questionnaire was completed during registration time to cause minimal disruption to other school activities.

3.7 The Theory of Planned Behaviour Questionnaire

The TPB assessment questions were developed from Conner and Norman (2005). The TPB was assessed by measuring 4 variables on a Likert scale ranging from 1 = strongly disagree to 7 = strongly agree. Intentions to be physically active - three items (e.g. ‘I intend to be physically active for 60
minutes at a time (this could be split into 3 exercise sessions of 20 minutes), at least 5 times a week for the next fortnight’). Perceived behavioural control - 4 items (e.g. 'how much control do you have over whether you participate in PA for at least 60 minutes per day (this could be split into 3 exercise sessions of twenty minutes) on five days per week over the next fortnight’). Attitude – 5 items measured by responding to the question ‘If I am physically active for at least 60 minutes at a time (this could be split into 3 exercise sessions of twenty minutes), at least 5 times a week for the next fortnight it would be ‘bad’–‘good’, ‘harmful’-‘beneficial’, ‘unpleasant’-‘pleasant’, ‘unenjoyable’-‘enjoyable’ and ‘foolish’-‘wise’. Subjective norms (injunctive and descriptive) – 4 items (e.g. 'Most people who are important to me think I should/should not take regular PA over the next fortnight’).
Chapter 4: Study One: Reliability and validity of several physical activity instruments to assess physical activity in school-children.
4.0 Introduction

An inactive lifestyle is a recognised risk factor for coronary artery disease, type 2 diabetes mellitus, hypertension and obesity (NICE, 2009). The World Health Organisation (WHO, 2010) explicitly outline the that higher levels of PA have been found to be associated with more favorable health benefits such as reduced body fatness, improved cardiovascular disease profiles and enhanced bone health. The importance of promoting PA in childhood has received widespread attention on the basis that PA behaviour tracks from childhood to adulthood (Malina, 2001). Activity guidelines suggest that children should engage in 60 minutes of MVPA each day (WHO, 2010; NICE, 2009; DoH, 2004). Although there is empirical data that indicates that many children are achieving this target (Riddoch et al. 2004), concern remains that a large proportion of children are insufficiently active in order to gain subsequent health benefits (Biddle et al. 2004; Andersen et al. 2006). The high prevalence of an inactive lifestyle in the young and associated chronic disease risk factors, suggests that early prevention programmes may be critical to reduce the rate of chronic disease. Accurate assessment of PA in children is necessary to identify current levels of activity and to assess the effectiveness of intervention programmes designed to increase PA (Rowlands and Eston, 2007).
PA levels have traditionally been quantified using questionnaires and surveys (Van Sluijs et al. 2008). Both subjective and objective measurements have their strengths and weaknesses (Sirard and Pate, 2001). Subjective measurement is useful and cost effective as a PA measurement tool for a large sample size where it is not possible to obtain objective measurement and can indicate the levels of PA for large populations (Sirard and Pate, 2001). Although these measures are suitable for measurement on an epidemiological scale they should be interpreted with caution due to the cognitive recall capability of young children (Sirard and Pate, 2001). For example Corder et al. (2008) found that subjective measures overestimated PA by 72% when compared with objective measurements. Objective measurement of PA has been identified as becoming the ‘gold standard’ (Naylor and MacKay, 2009). However, caution must also be used when interpreting children’s PA measured by objective tools due to the sporadic nature of the pediatric populations activity (Rowlands and Eston, 2007) and the limitations with each objective PA monitoring tool (Trost, 2007).

Heart rate telemetry has been established as a valid tool for PA monitoring but can be prone to recording an elevated high rate due to stress rather than PA. Triaxial accelerometers have become more prevalent over past decade and used more frequently within research studies (Rowlands et al. 2004; Rowlands and Eston, 2007; Rowlands, 2007). It should be recognised that triaxial accelerometers have associated limitations due to the device relying
on movement from the hip and as a result isometric movements are not incorporated (Fairclough and Stratton, 2005b). To overcome such limitations combined movement sensors that incorporate heart rate telemetry and accelerometry were introduced i.e. sensewear bodymedia armband and the Actiheart. These devices have been researched recently with mixed outcomes of their effectiveness across different pediatric populations (Barriera et al. 2009; Arvidsson et al. 2007; Dominy et al. 2005; Corder et al. 2005; Brage et al. 2003). As Trost explains ‘not one single method can be described as optimal in all situations’ (p. 10) and therefore more research needs to be conducted to establish accurate and valid measurements for specific populations.

In order to quantify children’s PA, valid and reliable measures are needed (Rowlands et al. 1999). Trost (2007) highlight the importance of being able to accurately quantify children’s PA due to the promotion of PA becoming a public health priority. Based on the definition of PA as any bodily movement resulting in EE, direct observation of the individual’s movement should be used as the gold standard for PA research. The doubly labelled water technique and indirect calorimetry can also be considered criterion measures for PA research, because they measure EE, a physiological consequence closely associated with PA. However, doubly labelled water provides no information on the patterns or nature of activity (Speakman et al. 1998; Ainslie et al. 2003).
Devices such as accelerometers and combined movement monitors (combination of acceleration and heart rate telemetry) have become increasingly popular as measurement tools for PA (Rowlands and Eston, 2007). These devices reduce the subjectivity inherent in survey methods (Rowlands and Eston, 2007). Triaxial and uniaxial accelerometers, and combined movement monitors can be used to assess PA as acceleration (bodily movement), or number of steps respectively. They may also provide an estimate of EE associated with bodily movement (Matthews and Freedson, 1995). Triaxial accelerometers measure acceleration in three directions (x, y, z) whereas uniaxial accelerometers detect bodily acceleration in the vertical direction (z) only. It has been found that using triaxial accelerometers is a more accurate way of estimating EE (Corder et al. 2008; Eston et al. 1998) and they are capable of providing estimates of the amount of moderate, hard and very hard activity carried out by individuals.

Studies have demonstrated the utility of combined HR and movement measurement to improve precision of PA EE and PA intensity (Rennie et al. 2000; Strath et al. 2001; Strath et al. 2002; Brage et al. 2003). Consequently the Actiheart (Cambridge Neurotechnology Ltd, Papworth, UK) was designed to combine HR and a movement sensor. This equipment has been shown to be the most valid for estimating PA EE in children during treadmill walking and running compared to movement sensing or HR monitoring alone (Corder
et al. 2005). In addition an alternative combined HR and movement sensor; the Sensewear Pro Bodymedia Armband has also been developed (Dorminy et al. 2008). The SenseWear Pro Armband measures various body functions - HR, sweat, heat, galvanic skin response and 2-dimensional accelerometry, the monitor estimates total EE (Dorminy et al. 2008). PA has traditionally been measured with surveys and recall instruments. These techniques must be used cautiously in a paediatric population that typically has difficulty recalling such information (Trost et al. 2000).

Very few studies have investigated the reliability and validity of PA monitors in schoolchildren (Rowlands et al. 2007; Eston et al. 1998) and limitations highlighted (Corder et al. 2008; Trost, 2007; Rowlands, 2007) with different types of PA monitors make it difficult to establish the correct instrument to use with specific pediatric populations (Trost, 2007). It is of great importance to accurately establish PA levels of schoolchildren to enable further studies to investigate the dose-response relationship between PA and health and to determine the effectiveness of intervention programmes designed to improve PA (Trost, 2007).

Therefore the purpose of this study was to identify the re-test reliability of the following PA methods to quantify activity of the specified 11-12 year old age group that will be used throughout the thesis; RT3 ® triaxial accelerometers, Bodymedia armband, and Actiheart, and their validity by comparison with O₂
consumption measures (as measured using Metalyser 3B, a mobile $O_2$ consumption analyser) during standardised bouts of exercise.

4.1 Methodology

Subjects and Settings
Twenty 11-12 year olds (boy and girls) were selected from one Bedfordshire Middle School. Written parental consent and an adapted PAR-Q questionnaire were obtained before the study commenced. Children were excluded from the study if they were identified as having chronic medical conditions such as cardiopulmonary disease, heart disease, asthma (not controllable with medication) or any other condition or physical disability that could interfere with the walking and stepping test.

Instruments
The study received ethical approval from the University of Bedfordshire Ethics Committee. Body mass, body composition and stature were measured using Tanita Bioelectrical Impedance Scales (BC-418MA segmental body composition analysis – bioelectrical impedance analyser) and a portable Leicester height stand (see methodology 3.1).

Physical Activity Monitors
RT3 ® Triaxial Accelerometer
The RT3 ® triaxial accelerometer is a small, lightbody mass triaxial accelerometer which stores activity data for up to 21 days. The RT3 ® was set to record at one second epochs (see methodology 3.2.1).

**Actiheart**

The Actiheart is a single-piece combined HR and movement monitor, for further details see methodology 3.2.4.

**Bodymedia Armband**

The bodymedia armband is a combined device which includes two dimensional accelerometry and various body responses such as skin temperature. For further details see methodology 3.2.5.

**Metalyser 3B ®**

The Metalyser is a portable cardiopulmonary exercise system which is used to estimate total EE (by measuring expired O₂ and CO₂ concentrations) and HR (see methodology 3.3.1).

**Design**

Children recruited to the study undertook 3 exercise sessions [9 minutes of PA in total (walking on a treadmill for 6 minutes at two different speeds and undertaking a step test for 3 minutes) in each session)]. Treadmill speeds of 3kph and 5kph were included to assess low and moderate intensity. The step
test was included to investigate vertical movements as well as horizontal movement validations and reliability. The protocol was completed in a designated room in the school whilst wearing the PA monitors (accelerometer, Bodymedia armband, Actiheart) and the Metalyser at the same time. The exercise sessions were repeated on 3 consecutive days to establish test-retest reliability with the children assigned a time slot which they attended on each of the three days. Children were asked to fast for 12 hours prior to testing time so that the energy expenditure of children was not influenced by thermal effects of food consumption.

**Familiarisation Session**

Participants took part in a familiarisation session prior to the testing days. Children had the opportunity to ask questions and be familiarised with the treadmill with the speeds chosen for the protocol (3 and 5kph) and the step test protocols (15cm high, 30 steps/per minute on metronome). Children were encouraged to continue the exercise until they felt comfortable and were competent in using the equipment. The children were also familiarised with the Metamax and were allowed to practice wearing the mask whilst walking on the treadmill. During the familiarisation session the researcher asked the children if they would still like to participate in the study. During the familiarisation session one child found wearing the gas analyser mask uncomfortable and withdrew from the study.
Procedures

Children were grouped in pairs (so that the children felt at ease) with the assistance of the PE Teacher at the school and given a time allocation spot (30 minutes) for the testing procedure. All measurements were taken and all equipment fitted and removed in the presence of at least 2 researchers (all Criminal Record Bureau (CRB) checked).

According to time allocation when the child entered the testing room, the RT3® triaxial accelerometer placed upon the waistband of their shorts, the Bodymedia armband was placed around the tricep, the Actiheart attached to the chest (using 2 electrode pads), and had the Metalyser mask fitted (with harness over shoulders containing $O_2$ and $CO_2$ analysers). The testing protocol then began. The children arrived in pairs at the designated time slots and therefore one child was allocated the treadmill protocols first (3 minutes at 3kph followed immediately by 3 minutes at 5kph) and the other child the step test (stepping up and down using a standard gym bench (height of 15 cm) which requires children to place the feet on and off the bench according to the beat of a metronome, 30 steps per minute). Children completed the exercise protocol at the same time slot on three consecutive days.

Data Analyses

Shapiro Wilk tests revealed data was normally distributed. Confidence intervals (CI) and coefficient of variation analyses were used to establish test-
retest reliability of the PA monitors. The agreement between PA monitors were assessed using correlation analyses and Bland and Altman (1986) statistical measures of agreement. Regression analyses namely Pearson and Spearman rho were used to establish the relationship between the metabolic expenditure of the PA monitors (RT3 ® triaxial accelerometer, Bodymedia Armband ® and Actiheart ®), over three exercise modalities (slow treadmill, fast treadmill and step) against the gold standard of the online gas analyser (metalayer 3B ®). The Bland and Altman analysis incorporates a calculation of mean bias (mean of differences between the modalities) and limits of agreement (± 2 SD from the mean bias). Data was analysed using statistical package for the social sciences (SPSS) version 17.
4.2 Results

Reliability

The mean and 95 % CI for the four activity monitors across the three exercise protocols (3 and 5kph treadmill and step exercise) are represented in figure 4.0 and expressed as Kcal/min. EE (kcal.min) outputs for the three PA monitors display similar means across the slow and stepping protocols in addition to the CI overlapping suggesting they are likely to contain the true value of the mean (Field, 2009). The fast treadmill protocol displays variations in the means of the four activity monitors however, all CI overlap apart from the RT3 fast treadmill modality suggesting that the means can plausibly come from the same population (Field, 2009).

The coefficient of variation (CV%) shows that the RT3 ® triaxial accelerometer displays the highest reliability due to its low CV% of 4.00, 8.37 and 5.16% for slow, fast and stepping protocols respectively (table 4.0). Expressed as a coefficient of variation the RT3 ® triaxial accelerometers display the lowest % variation values. A small % coefficient of variation represents a smaller dispersion of the data around the mean and therefore smaller variation for test-retest data representing higher reliability of the PA tool. The coefficient of variation displays large % variation for both the Actiheart and Bodymedia armband devices (table 4.0). This suggests a large
variation in data and that the test-retest reliability of these monitors produces a high dispersion of the data across the three days.

Table 4.0. Coefficient of variation (CV %) for Accelerometer, Actiheart and Bodymedia during various activities; slow, fast, stepping (kcal.min; mean±SD)

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Slow</th>
<th>Fast</th>
<th>Stepping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accelerometer</td>
<td>4.00±2.97</td>
<td>8.37±7.85</td>
<td>5.16±4.13</td>
</tr>
<tr>
<td>Actiheart</td>
<td>17.11±24.26</td>
<td>10.97±11.18</td>
<td>21.66±21.71</td>
</tr>
<tr>
<td>Bodymedia</td>
<td>18.8±13.69</td>
<td>15.21±14.42</td>
<td>27.54±15.64</td>
</tr>
</tbody>
</table>
Figure 4.0. Means and 95% CI of EE measured by accelerometer, Actiheart, Metalyzer and Bodymedia during three different modes of activity, slow walking, fast walking and stepping.

**Validity**

All PA monitors were validated against $O_2$ uptake as measured by the online gas analyser; the metalyser.

**RT3 ® Triaxial Accelerometer**

Regression analyses were used to establish the relationship between the metabolic expenditure of two PA monitors (metalyzer 3B ® and RT3 ® triaxial accelerometer), the results of this regression analysis can be found in figures 4.1-4.3 for slow, fast and step protocols respectively.
Figure 4.1. Regression analysis between the metalyser 3B and RT3 ® triaxial accelerometer in the slow treadmill exercise.

Figure 4.2. Regression analysis between the metalyser 3B and RT3 ® triaxial accelerometer in the fast treadmill exercise.
Figure 4.3. Regression analysis between the metalyser 3B and RT3 ® triaxial accelerometer in the step exercise.

A Pearson correlation analysis was employed to establish the relationship between the two pieces of equipment. The Pearson correlation (table 4.1) revealed a significant correlation between the RT3 ® triaxial accelerometer and the metalyser for the three protocols ($P < 0.01$). Although a correlation coefficient was used to establish the relationship between the variables, the correlation coefficient does not necessarily mean that the two variables agree. The $r$ value measures the strength of the relationship not the level of agreement (Bland and Altman, 1986).
Table 4.1. Pearson Correlation analyses to compare the RT3 ® triaxial accelerometer and metalyser 3B from the three exercise protocols.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Pearson</th>
<th>Spearman rho</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow walking</td>
<td>20</td>
<td>.419*</td>
<td>.430**</td>
</tr>
<tr>
<td>Fast Walking</td>
<td>20</td>
<td>.301</td>
<td>.275</td>
</tr>
<tr>
<td>Step</td>
<td>20</td>
<td>.618**</td>
<td>.636**</td>
</tr>
</tbody>
</table>

Notes. *correlation is significant at $P < 0.05$ **correlation is significant at $P < 0.01$.

Therefore a Bland and Altman plot was used in order to establish the limits of agreement between the two PA monitors (figure 4.4).
Figure 4.4. Bland-Altman plots of RT3 ® triaxial accelerometer EE minus Metalyser 3B ® EE (y axis) against average of RT3 ® triaxial accelerometer and Metalyser 3B ® for the slow walking (3kph), fast walking (5kph) and step protocols. The horizontal lines represent the 95% limits of agreement and the mean difference.

The Bland-Altman Plot (figure 4.4) shows the plot of RT3 ® triaxial accelerometer EE minus Metalyser 3B ® EE (y axis) against average of RT3 ® accelerometer and Metalyser 3B ® for the three exercise protocols. The mean bias (expressed as the mean difference between EE between the Metalyser 3B ® and RT3 ®) was -.43 (-2.17 to .94 CI), -1.54 (-4.6 to .41 CI) and -.34 kcal.min (-2.08 to 1.22 CI) for slow, fast walking and stepping respectively. The lower and upper confidence interval limits represent the 95% spread in agreement in the population from which the sample was derived. This means that 95% of the population would fall between these CI.
The RT3 ® triaxial accelerometer tends to underestimate EE on average by -0.43 kcal.min, -1.54 kcal.min and -0.34 kcal.min for slow, fast and stepping respectively in comparison to the Metalyser 3B ®.

**Actiheart ®**

Regression analyses were used to establish the relationship between the metabolic expenditure of two PA monitors (metalyser 3B ® and Actiheart ®), the results of this regression analysis can be found in figures 4.5 - 4.7 for slow, fast and step protocols respectively.

![Regression analysis between the metalyser 3B and Actiheart in the slow treadmill exercise.](image)

\[ r^2 \text{ linear} = 0.008 \]

Figure 4.5. Regression analysis between the metalyser 3B and Actiheart in the slow treadmill exercise.
Figure 4.6. Regression analysis between the metalyser 3B and Actiheart in the fast treadmill exercise.

Figure 4.7. Regression analysis between the metalyser 3B and Actiheart in the step exercise.
Pearson correlation analyses (table 4.2) revealed a significant correlation between the Actiheart and the metalyser for the three protocols ($P < 0.01$). A Bland and Altman plot was then employed (figure 4.8).

**Table 4.2. Pearson Correlation analyses to compare the Actiheart ® and metalyser 3B from the three exercise protocols.**

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Pearson</th>
<th>Spearman rho</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow walking</td>
<td>20</td>
<td>.087</td>
<td>.022</td>
</tr>
<tr>
<td>Fast Walking</td>
<td>20</td>
<td>.139</td>
<td>.170</td>
</tr>
<tr>
<td>Step</td>
<td>20</td>
<td>.307*</td>
<td>.306*</td>
</tr>
</tbody>
</table>

Notes. *correlation is significant at $P < 0.05$. 
Figure 4.8. Bland-Altman plot of Actiheart ® EE minus Metalyser 3B ® EE (y axis) against average of Actiheart ® and Metalyser 3B ® for the slow walking (3kph), fast walking (5kph) and step protocols. The horizontal lines represent the 95% limits of agreement and the mean difference.

The Bland-Altman Plot (figure 4.8) shows the plot of Actiheart versus metalyser. The mean bias (expressed as the mean difference between in kcal.min by metalyser and Actiheart) was -.09 (-2.86 to .2.68 CI), .04 (-2.50 to 2.58 CI) and .00 kcal.min (-3.06 to 3.06 CI) for slow, fast and stepping respectively. It is apparent from the fast walking protocol (figure 4.8) that there is a systematic trend in the data. The trend shows that as metabolic activity increases the Actiheart becomes less valid against the metalyser.

**Bodymedia Armband ®**
Regression analyses were used to establish the relationship between the metabolic expenditure of two PA monitors (metalyser 3B ® and Bodymedia armband ®), the results of this regression analysis can be found in figures 4.9 - 4.11 for slow, fast and step protocols respectively.

Figure 4.9. Regression analysis between the metalyser 3B and Bodymedia Armband in the slow treadmill exercise.
Figure 4.10. Regression analysis between the metalyser 3B and Bodymedia Armband in the fast treadmill exercise.

\[ r^2 \text{ linear} = 0.311 \]

Figure 4.11. Regression analysis between the metalyser 3B and Bodymedia Armband in the step exercise.

\[ r^2 \text{ linear} = 0.055 \]
Pearson correlation analyses (table 4.3) revealed no significant correlations between the Bodymedia Armband and the metalyser for the three protocols. A Bland and Altman plot was then employed (figure 4.12).

Table 4.3. Pearson Correlation analyses to compare the Bodymedia Armband® and metalyser 3B from the three exercise protocols.

<table>
<thead>
<tr>
<th>Protocol</th>
<th>N</th>
<th>Pearson</th>
<th>Spearman rho</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow walking</td>
<td>20</td>
<td>-.011</td>
<td>-.099</td>
</tr>
<tr>
<td>Fast Walking</td>
<td>20</td>
<td>-.558**</td>
<td>-.461*</td>
</tr>
<tr>
<td>Step</td>
<td>20</td>
<td>-.235</td>
<td>-.187</td>
</tr>
</tbody>
</table>

Notes. *correlation is significant at $P < 0.05$ **correlation is significant at $P < 0.01$. 
Figure 4.12. Bland-Altman plot of Bodymedia Armband ® EE minus Metalyser 3B ® EE (y axis) against average of Bodymedia Armband ® and Metalyser 3B ® for the slow walking (3kph), fast walking (5kph) and step protocols. The horizontal lines represent the 95% limits of agreement and the mean difference.

The Bland-Altman Plot (figure 4.12) shows the plot of Bodymedia Armband versus metalyser. The mean bias (expressed as the mean difference between
in kcal.min by metalyser and Bodymedia) was -.59 (-2.94 to 1.77 CI), -.48 (-3.70 to 2.74 CI) and .08 kcal.min (-3.23 to 3.39 CI) for slow, fast and stepping respectively. Over a one hour period on the slow treadmill protocol EE would be underestimated by 35.4 kcal.

4.3 Discussion

The aim of this study was to identify the re-test reliability of the following PA methods; RT3 ® triaxial accelerometers, Bodymedia armband, and Actiheart, and their validity by comparison with O₂ consumption measures (as measured using the Metalyser 3B, a mobile O₂ consumption analyser) during standardised bouts of exercise. Three different exercise modalities were used to reflect the type of movements that may be observed during PE lessons particularly the vertical movements represented by the step exercise. This study is only one of very few that have actually conducted reliability and validity assessments in school settings under controlled conditions with schoolchildren.

The RT3 ® triaxial accelerometer was found to be the most reliable measure of EE over a three day test-retest protocol. Reliability was measured by the coefficient of variation and is the ratio of the standard deviation to the mean (Cohen, Cohen, West and Aitken, 2003). The coefficient of variation values indicated that the RT3 had the smallest variation in data when repeated over
three consecutive days and therefore was the most reliable PA monitor. The Actiheart protocol displayed large variations across all three exercise modalities as reflected by large coefficient of variation values; 17.11 ± 24.26%, 10.97 ± 11.18%, 21.66 ± 21.71% for slow, fast walking and step respectively. The Bodymedia armband was found to be the least reliable of all three PA monitors. For example the step protocol for the bodymedia armband displayed a coefficient of variation value of 27.54 ± 15.64%.

Of all three PA monitors, the RT3 ® triaxial accelerometer was found to have the lowest limits of agreement. It can be seen that the fast treadmill protocol displayed the largest range between the intervals of 5.01 kcal.min. Practically this means that 95% of the population would display kcal.min values within 5.01 kcal.min of each other. In addition the step and slow walking protocols displayed that 95% of the population would fall within 3.11 and 3.30 kcal.min for slow walking and step respectively. The DoH (2004) recommended that children are engaged in sixty minutes of activity per day. In practical terms the RT3 ® triaxial accelerometer was found to typically underestimate EE by 0.43 kcal.min during the slow treadmill protocol. Over a one hour period this means the RT3 ® triaxial accelerometer would underestimate EE by up to 25.8 kcal. Rowlands et al. (2004) also found that the RT3 ® triaxial accelerometer was a valid tool when compared to O₂ uptake in boys (9.5 ± 0.8 years old). However, Rowlands et al. (2004) only used a small sample of boys (n = 19) in their study. In addition Ott et al. (2000) investigated the use
of uniaxial and triaxial accelerometers to measure children’s ‘free play’ activity. Ott et al. (2000) found that the triaxial accelerometers were significantly correlated to a predicted MET level and HR monitoring amongst children aged 9-11 years old. The study sample size was twenty eight students limiting the generalisation of the findings. Trost (2007) conducted a review article of PA measurement in children and concluded that the majority of the studies reviewed found a strong positive correlation between EE and accelerometry.

Corder et al. (2008) outline that the ‘limitations concerning the accurate measurement of PA are often amplified in young people due to the cognitive, physiological and biomechanical changes that occur during natural growth’ (p. 22). The main limitations surrounding accelerometry are the issues with epoch length as a result of memory capacity (Rowlands and Eston, 2007). One minute epochs have been found to significantly underestimate PA levels (Rowlands and Eston, 2007). Accelerometers set to collect data at one minute epoch average the vector magnitude over the one minute period to one value. This results in an underestimation of PA during that minute because it will ‘smooth out’ a ten second short burst of activity, hence the vigorous activity will be lost if the majority of the minute period is not spent in high intensity activity (Rowlands and Eston, 2007). The RT3 ® triaxial accelerometer has a memory capacity to collect 1 second epoch data for a period of up to nine hours. Corder et al. (2008) recommends an epoch length
as short as possible to gain a more accurate measure of short duration high intensity activities.

The Sensewear Pro Bodymedia Armband was found to be the least reliable and valid measurement of PA in the study. The 95% limits of agreement of the Bland and Altman (1986) analysis revealed limits of -2.94 to 1.77, -3.70 to 2.74 and -3.23 to 3.39 for slow, fast and stepping respectively. The widest limits of agreements were found in the fast treadmill and step exercise modalities. It was found that during the step exercise the difference in the CI were displayed as 6.62 kcal.min (-3.23, 3.39). This is an extremely wide range and practically means that one participant could have an EE of 1.00 kcal.min and another 7.62 kcal.min, this is the difference between resting and jogging (Puyau, Adolph, Vohra, Zakeri and Butte, 2004) and therefore is not clinically acceptable. Dorminy et al. (2008) investigated the validity of the Sensewear Pro Bodymedia Armband in African American children aged 11 years old. It was found that the Bodymedia Armband significantly (P<0.05) underestimated energy cost with increased PA levels across activities incorporated into the study which included treadmill exercise.

Similarly a research study was conducted by Arvidsson et al. (2007) to validate the Bodymedia Armband against breath by breath $O_2$ analysis in children aged 11-13 years old. The study used varying treadmill protocols to validate EE from the online gas analyser and the Bodymedia Armband.
Arvidsson et al. (2007) concluded that the Bodymedia Armband underestimated energy cost at varying treadmill speeds including the speeds of 3 and 5 kph as used in the present study. It was found that this underestimation of EE increased with an increased PA intensity (Arvidsson et al. 2007). At the treadmill speed of 10 kph it was found that the sensewear armband underestimated EE by 11.1 kJ.min in comparison to the treadmill speed of 4.0 kph that displayed a smaller underestimation of 1.2 kJ.min. However it is important to remember that the children used in each study consisted of a small sample size (n = 20) and specific age groups and therefore Dorminy et al. (2008) recommended more research on varying age groups and different activities.

The Actiheart was developed by Cambridge Neurotechnology Ltd (Papworth, UK) to help eradicate the limitations associated with using single PA monitors in children (Rowlands and Eston, 2007). It has been concluded by many researchers that there are limitations to using individual PA monitors and therefore a combination of methods may provide more accurate measurement (Rowlands and Eston, 2007). In the present study the Actiheart provided 95% limits of agreement of -2.86 to .2.68, -2.50 to 2.58 and -3.06 to 3.06 for slow, fast and stepping respectively which were wider than those observed for the RT3 ® triaxial accelerometry. This is not consistent with previous research (Corder et al. 2005; Brage et al. 2005) that has found that the Actiheart is more valid and reliable than accelerometry alone. Corder et
al. (2005) conducted a study investigating the validity of the Actiheart against indirect calorimetry and HR and accelerometer monitoring alone. The study was conducted on 39 children (aged 13.2 ± 0.3 years old) over a progressive treadmill exercise and found that the Actiheart combined movement sensor was the most valid piece of equipment in comparison to HR and accelerometry monitoring alone. Again this piece of research was conducted on specific age groups and there is a need to conduct more research on broader age ranges across different schools and regions (Corder et al. 2005). The research was also treadmill specific which does not necessarily reflect children’s ‘free play’ movements (Ott et al. 2000). In comparison, Barriera et al. (2009) conducted a validation study of the Actiheart monitor involving participants aged 21.8 ± 3.6 years old. The study employed treadmill exercise and ‘free living’ conditions. The Actiheart only underestimated EE at the highest workload of the treadmill which was 9.6 kph. This speed would be unlikely to reflect the majority of ‘free time’ PA in children. However, an interesting finding of the study was that during ‘free living’ activity a significant difference (t (33) = 3.0, p = 0.05) was found between polar HR monitor and HR recorded by the Actiheart (Barreira et al. 2009). In practical terms this study demonstrated that the Actiheart over estimated HR and this ultimately impacted upon the EE observed (Barreira et al. 2009). This is in line with the present study that represents a systematic trend in the data for the Actiheart in the fast walking protocol; as the metabolic activity increases the Actiheart becomes less valid against the metalyser.
The Actiheart has been reported as having a high validity and reliability as a combined (accelerometer and HR) PA monitor compared to single PA measures (Corder et al. 2005; Brage et al. 2005). More recently it has been found that the Actiheart was only accurate at lower intensities of exercise (Barreira et al. 2009). Barreira et al. (2009) reported at an intensity of 9.6 kph there was a significant difference ($P < 0.01$) between measured caloric expenditure and the Actiheart. However this study was conducted on an adult age group. The general consensus for children’s studies is that the Actiheart is a very reliable and accurate predictor of PA (Trost, 2007; Corder et al. 2005). The present study did not reflect these findings. This could be due to the fact that this study was conducted on twenty children from one school across three exercise modalities.

The Actiheart has been shown consistently to be valid and reliable as a PA monitor for children (Trost, 2007). It is important to note that the cost of the Actiheart is very expensive and therefore may not be practical for use in large scale studies (Rowlands and Eston, 2007). In comparison the Bodymedia armband has displayed varying results in terms of its validity and reliability (Dorminy et al. 2008). The general consensus from the research states that more investigative work needs to be conducted on the reliability and validity of the Bodymedia armband (Dorminy et al. 2008; Arvidsson et al. 2007). The use of accelerometry has increased dramatically within research studies since
2001 (Corder et al. 2008; Trost, 2007; Rowlands and Eston, 2007). RT3 ® triaxial accelerometry have consistently been found to be valid and reliable measures of PA in children (Trost, 2007; Rowlands et al. 2004; Ott et al. 2000). Rowlands (2007) concludes that accelerometry directly measures movement which is important when assessing the relationship between health and activity. Importantly, accelerometers are non invasive, easy to use and research has shown that there is little reactive behaviour when children wear them (Rowlands, 2007).

It is important to acknowledge several limitations of this study. Firstly the small sample size of school children in one Bedfordshire middle school in addition to the restricted age group (11-12 years old) means that the results of the present study cannot be generalized to the population. However, the current literature does highlight the varying results of validation and reliability of PA tools across different age groups which is why it was important to establish tests for the chosen age group for the thesis. It is also important to acknowledge that this data was not collected in an actual PE lesson where the equipment will be used. However the movements and protocols used were in line with movements that may are likely to occur during PE lessons.
Future studies should investigate the reliability and validity of PA monitors across a larger sample size across numerous schools and extend the research over various age groups.

4.4 Conclusion

In conclusion, the RT3 ® triaxial accelerometer was found to be the most reliable and valid monitor for assessing PA levels in children aged 11-12 years who will form the subject group for this thesis. It was particularly important to research PA monitors in the age group utilised within the thesis as it has been highlighted that the sporadic nature of children’s PA makes it difficult to accurately assess (Corder et al. 2008; Rowlands and Eston, 2007). The limitations associated with all types of PA monitors when quantifying children’s activity also make it necessary to conduct research (Rowlands and Eston, 2007).
Chapter 5: Study 2: Physical Activity Levels During Middle School Physical Education
5.0 Study Map

Summary of Objectives and Findings

<table>
<thead>
<tr>
<th>Study</th>
<th>Objectives</th>
<th>Key findings</th>
</tr>
</thead>
</table>
| Study 1: Reliability and validity of several physical activity monitors to assess physical activity in school children. | • To identify the re-test reliability of the following physical activity methods; RT3 Triaxial accelerometers, Bodysmedia armband, and Actiheart.  
• To assess the validity of the physical activity monitors by comparison with oxygen consumption measure (Metalyser 3B) during standardised bouts of exercise. | • The RT3 ® triaxial accelerometer was found to be the most valid and reliable physical activity monitor for use in school children aged 11-12 years old. |

5.1 Introduction

Regular PA in youth is associated with improved health and wellbeing and a lower risk of developing diseases such as type 2 diabetes and obesity (Strong et al. 2005, Anderson et al. 2006, Janssen & Leblanc 2010). Current guidelines recommend that children should undertake a minimum of 60 minutes of MVPA each day (DoH, 2004; NICE 2009) and at least twice a week, this should include activities to improve bone health (body mass-bearing activities that produce high physical stresses on the bones, such as running and jumping), muscle strength and flexibility (DoH 2004). Evidence suggests that a large proportion of children are not active enough (Riddoch et al 2007, NICE, 2009).
Given the growing concerns regarding low PA levels amongst children and the potential associated health consequences (HSE, 2008; WHO, 2010), PA levels within schools and in particular during PE lessons has been a focus of attention (Fairclough et al 2008; Cale and Harris, 2006b; NICE, 2009; Jago et al. 2009). Considering that PE lessons are one of the only opportunities that some children have to take part in sport, it is important that the delivery of these lessons is of a high quality to help instigate high levels of PA (McKenzie, 2001; Fairclough and Stratton, 2005a). The Healthy People 2010 target (USDHHS, 2000) for students to engage in MVPA for at least 50% of PE class time is typically not met in the US or UK (McKenzie et al. 2006, McKenzie et al. 2000, Fairclough and Stratton, 2005a, Fairclough, 2003a).

McKenzie et al. (2006) conducted a time course study in the US to investigate girls’ activity levels and lesson contexts (indoor or outdoor environment) in middle school PE and reported low levels of PA during PE. 431 PE lessons were observed and it was found that outdoor and indoor activity provided 33.7% and 45.7% of MVPA respectively per lesson. In addition it was found that 26% and 37.5% of a lesson on average was spent on management and sitting time, respectively (McKenzie et al. 2006).

In the UK PE context Yelling, Penney and Swaine (2000) found that PE lessons do not always take full advantage of ensuring that pupils are engaged in appropriate activity levels. Results from this research showed that only
20% of PE lesson time was spent in MVPA. Similarly Fairclough (2003a) found that pupils engaged in PA of at least a moderate intensity for 39.7% of PE lesson time again falling short of the recommendation that pupils should be active for 50% of lesson time. The study found that in a games activity moderate physical activity (MPA, classed as > 75% of HRR) was achieved for 45.6% of the lesson time but only for 14.3% during dance. The study also found that activity levels were significantly different according to sex. Of all the lessons observed boys were found to have spent 45.8% of the time in MPA whereas girls spent 12% lower time in MPA.

In addition Fairclough and Stratton (2005a) quantified PE lessons in five high schools over a twelve week period and found that on average students engaged in MVPA for 34.3% of the lesson time which equated to 17.5 minutes. It was found that levels of MVPA were highest during team game activities (43.2% MVPA) and lowest during movement activities (22.2% MVPA).

It is evident from previous research (McKenzie et al. 2006; Fairclough and Stratton, 2005a; Fairclough, 2003a) that PE lessons do fall short of the recommended 50% MVPA target (USDHH, 2000). However the contextual diversity of schools means that there are large amounts of variance between schools (Fairclough and Stratton, 2005b; Jago et al. 2009).
Therefore the purpose of this study was to accurately quantify PA levels during middle school PE lessons in the Bedfordshire area and to establish if current recommendations i.e. 50% of lesson time in activity of at least a moderate intensity, are met.

5.2 Methodology

Subject and Settings
Fifty three students (25 girls and 28 boys, aged 11-12 years old) from three co-educational state middle schools in Bedfordshire, England participated in the study. One year 7 class (aged 11-12 years) was selected from each school; one boys’ class, one girls’ class and one co educational class. Due to restrictions within the school to specifically choose whether the classes were co-educational or single sex lessons the methodology was established by which class arrangement the school used i.e. single sex or co-educational. Written parental consent was obtained before the study commenced. PE was taught in mixed sex groups at one school and single sex lessons in two schools, with the exception of games activities where the students were placed in single sex groups. The co educational lessons were taught by a female teacher. In the single sex lessons the boys and girls were taught by a male and female teacher PE respectively. All data collection took place over one full school term at each school.
Instruments

The study received ethical approval from the University of Bedfordshire Ethics Committee. Body mass and stature was measured using Tanita bioelectrical impedance Scales (BC-418MA) and a portable Leicester height stand, respectively (see methodology section 3.1). PA levels were measured using triaxial accelerometry (Stayhealthy RT3 ®) as this was found to be the most valid and reliable measure of PA for this age group (chapter 4). The accelerometer detects movement across three axes (x, y and z), and the accelerations of such movements are recorded by the device and converted into activity counts. Information on the RT3 ® triaxial accelerometer device used in this study can be found in methodology section 3.2.1.

Physical Education Monitoring

During PE monitoring students were asked to place the RT3 ® triaxial accelerometer device on their waistband whilst changing into their PE kit. Each RT3 ® triaxial accelerometer was placed in a small bag which stated the individual student’s name and distributed before the student entered the PE changing rooms. RT3 ® triaxial accelerometry information during PE lessons can be found in methodology chapter 3.2.2.

Design

In total forty four lessons were monitored over a full school term. This was split into two six week blocks of activity (15 co-educational lessons, 30 single
sex lessons). Due to restrictions within the schools some PE lessons were cancelled due to other curriculum activities, external sports activities and school trips. These activities covered a variety of activities including movement (e.g. dance), individual (e.g. athletics) and team games (e.g. football, hockey, netball) (Table 5.0). Activities during PE were grouped into activity areas that share similar characteristics for statistical analysis (Fairclough and Stratton, 2005a); movement (e.g. dance), individual (e.g. athletics), invasion games (e.g. football, hockey, rugby) (Table 5.0).

Table 5.0  Number and type of PE lessons monitored

<table>
<thead>
<tr>
<th>PE Activity</th>
<th>No of Lessons</th>
<th>Boys</th>
<th>Girls</th>
<th>Co-Educational</th>
<th>All Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team Games</td>
<td>15</td>
<td>14</td>
<td>0</td>
<td>9</td>
<td>29</td>
</tr>
<tr>
<td>Individual Activities</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Movement</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>14</td>
<td>15</td>
<td></td>
<td>44</td>
</tr>
</tbody>
</table>

Data Analyses

Preliminary Shapiro-Wilk tests and Levene’s test were employed to establish if the parametric assumptions were met. MVPA PE data violated the
assumptions of a parametric test (Shapiro-Wilk and Levene’s). Therefore the MVPA PE data was analysed using a non parametric test for one way ANOVA; the Kruskal-Wallis test. Post-hoc Mann-Whitney U-tests were employed to assess differences between activities. The significance level was set at $P < 0.05/k$ for the post hoc test which was calculated as acceptable after bonferroni correction had been employed to control for type 1 error. Shapiro Wilk and Levene’s tests revealed that PE VPA data met the parametric assumptions. VPA data was analysed using a between groups one way ANOVA with bonferroni post hoc tests to reduce the risk of type I error. All data was analysed using SPSS version 17.0 (SPSS, Chicago, IL).

5.3 Results

The average duration of all the PE lessons was 35.8 ± 1.4 minutes. In total the overall contribution of PE lessons across all activities was 16.4 ± 2.3 (MVPA) and 9.3 ± 2.1 (VPA) minutes, this translated to 44.9 ± 5.6 (%MVPA) and 25.6 ± 4.8 of lesson time (%VPA, a full list of activity % and minutes can be found in table 5.1). MVPA levels were significantly different between activities ($H (2) = 23.02, P < 0.05$). Team games provided 51.3 ± 5.0% (MVPA) ($P < 0.0167$, figure 5.0) of lesson time in comparison to movement activities which contributed 37.7 ± 6.9% (MVPA). Movement activity was the lowest contributor to lesson time spent in MVPA with a total contribution of 37.7 ± 6.9% ($P < 0.0125$, figure 5.0) equating to 13.7 ± 3.4 minutes.
Figure 5.0 Mean (± SD) MVPA of different activities during PE. **Team Games > movement activities $(Z (2) = -4.9, P < 0.0167)$. *Individual activity > movement activity $(Z (2) = -2.5, P < 0.0167)$. Dashed horizontal line represents the 50% USDHH (2000) criterion.

Table 5.1 Mean (±SD) MVPA and VPA minutes and % spent in different activities.

<table>
<thead>
<tr>
<th>Activity</th>
<th>$N$</th>
<th>MVPA (minutes)</th>
<th>VPA (minutes)</th>
<th>MVPA (%)</th>
<th>VPA (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team Games</td>
<td>53</td>
<td>18.40 ± 5.78</td>
<td>10.51 ± 2.04</td>
<td>51.26 ± 5.01</td>
<td>30.64 ± 6.35</td>
</tr>
<tr>
<td>Individual</td>
<td>25</td>
<td>18.04 ± 3.41</td>
<td>10.50 ± 2.90</td>
<td>46.05 ± 8.25</td>
<td>26.9 ± 6.8</td>
</tr>
<tr>
<td>Movement</td>
<td>25</td>
<td>13.77 ± 3.41</td>
<td>6.90 ± 2.10</td>
<td>37.66 ± 6.93</td>
<td>19.2 ± 5.8</td>
</tr>
</tbody>
</table>
A between groups one way ANOVA revealed a significant difference in VPA between the activities (F (2, 87) = 9.34, p < 0.05). Bonferroni post hoc tests revealed team games (30.64 ± 6.35 %) and individual activity (26.9 ± 6.8 %) were significantly higher (p < 0.05) providers of VPA in comparison to movement activities (19.2 ± 5.8 %) (Table 5.1).

5.4 Discussion

This study used objective measures (RT3 ® triaxial accelerometers) to quantify PA levels during middle school PE lessons in the Bedfordshire area. The data was considered in relation to the USDHH (2000) criterion that 50%
of lesson time should be spent in activity of at least a moderate intensity to contribute to the recommended daily levels of activity. It is important to note that in addition to the 50% criterion, the USDHH (2000) document also outlines that being active for at least half of PE class time on at least half of the school days would provide a substantial portion of the PA time to contribute to the recommended 60 minutes MVPA per day. However, PE in the UK aspires to two hours of PE per week in comparison to the US who aspire to PE occurring daily so this target must be approached with caution.

Data revealed that children in the study spent an average of 44.9 ± 5.6% of the PE lesson engaged in MVPA which translated to 16.4 ± 2.3 minutes. A large proportion of activities in the study fell short of the USDHH (2000) 50% (20 minute) criterion. These results are in line with previous study findings (McKenzie et al. 2000; Fairclough, 2003a; Fairclough and Stratton, 2005a; McKenzie et al. 2006) that PE lessons fall short of the 50% (20 minutes) criterion (USDHH, 2000). These findings are significant since for some less physically active children PE can be the only time that they can accumulate and take part in structured activity to contribute to daily MVPA levels (McKenzie, 2001; Fairclough and Stratton, 2005a; Jago et al. 2009).

The study found that team games provided the most opportunity for % of lesson time spent in MVPA (51.26 ± 5.01% in comparison to individual; 46.05 ± 8.25%, and movement activities; 19.2 ± 5.8%). However due to the
restricted lesson length of team game activities because of factors such as; change time, cleaning boots and shower time, individual activities were longer in length (34.8 ± 5.1 and 37.1 ± 5.2 minutes for team games and individual activities respectively). This resulted in the accumulation of similar minutes of lesson time spent in MVPA, 18.40 ± 5.78 and 18.04 ± 3.41 minutes of MVPA for team games and individual activities respectively still falling short of the 20 minute criterion (USDHH, 2000).

Team games and individual activities were found to contribute significantly higher amounts of MVPA and VPA (P < 0.05) in comparison to movement activities. This is similar to previous research findings (Fairclough and Stratton, 2005b; Fairclough, 2003a) that team games and individual activities were the highest contributors to MVPA levels. Team game and individual activities included numerous running and sprinting bouts which require whole body exercise lending explanation for these higher levels of MVPA. Fairclough and Stratton (2005a) outline the reason for this larger contribution of VPA being the requirement of team games to sustain large muscle groups engaged in PA for large proportions of time and hence its impact on the heart to beat faster to satisfy O₂ demand. The lowest levels of activity were found in movement activities i.e. dance (P < 0.0167). This is also in line with previous research (Fairclough and Stratton, 2005b; Fairclough, 2003a) which found movement activities to be the lowest contributor to MVPA and VPA levels. Movement activities tend to ‘emphasise aesthetic appreciation and motor skill
development’ (Fairclough and Stratton, 2005c, p.455) and therefore the opportunities for MVPA may be decreased. However it should also be noted that movement and gymnastic activities are essential to satisfy the DoH (2004) criteria that at least twice a week children should participate in body mass-bearing activities to improve bone health, muscle strength and flexibility in addition to daily activity targets.

An interesting finding of this study was the contribution of PE to the amount of time spent in VPA. Overall PE provided almost ten minutes (9.3 ± 2.1 minutes) of VPA which is a third of the contribution to potentially enhancing cardiorespiratory fitness (Armstrong and Welsman, 1997). These findings were higher than previous studies reporting amounts of VPA during PE as 4.5 and 3.3 minutes (Fairclough and Stratton, 2005a). Baquet et al. (2002) designed a specific intervention to enhance cardiorespiratory fitness during PE lessons but with questionable education value (Fairclough and Stratton, 2005a). It is promising that PE lessons in the study accumulated almost ten minutes of VPA, which potentially increases cardio respiratory fitness (Armstrong and Welsman, 1997) without compromising educational value. It also promising considering that PE lessons were not purposely intensified. In addition Ruiz, Rizzo, Hurtig-Wennlof, Ortega, Wanberg and Sjostrom (2006) found that in children aged 9-10 years old lower body fat was significantly ($P < 0.05$) associated with higher levels of VPA. Ruiz et al. (2006) suggest that
higher levels of VPA may have a greater impact on reducing obesity than MPA.

Quantifying levels of PA during PE lessons is problematic (Fairclough and Stratton, 2005b; Jago et al. 2009). In a review of literature conducted by Fairclough and Stratton (2005b) the overall standard deviation of 40 studies that assessed PA levels during PE was 14.2% which highlights the large differences in PA levels during PE between schools caused by variations in PE specific contextual factors such as lesson objectives, content and teaching styles. In addition to this overall MVPA was found to range from 27 to 47% of the lesson spent in MVPA (Fairclough and Stratton, 2005b). The first problem comes from the choice of instrument to measure MVPA however these studies should be approached with caution due to the measurement being affected by emotional stress (Fairclough and Stratton, 2005b). Secondly HR has been shown to be lower in boys than girls when assessing activity of the same intensity making comparison problematic if HR reserve has not been incorporated (Stratton, 1996).

Accelerometry studies can also be problematic (Fairclough and Stratton, 2005b). Accelerometers are not affected by emotional stress but cannot detect movement when the lower limb is in motion but the hip is stationary, or detect isometric activity, proving problematic (Fairclough and Stratton,
Studies that quantify MVPA during PE can also be skewed by the type of activities that boys and girls take part in; girls may take part in more activities that do not require as much body mass loading as invasion games such as movement activities and therefore the opportunities for the accumulation of MVPA may be less frequent during such activities (Fairclough and Stratton, 2005a). It should also be acknowledged that there are differences in reported MVPA levels when using accelerometry due to ambiguous cut off points used within the literature (Trost et al. 2002; Treuth et al. 2004; Rowlands et al.2004; Riddoch et al. 2007). For example Treuth et al (2004) and Riddoch et al. (2007) employed moderate intensity cut off points of 4 mets in contrast to Rowlands et al. (2004) and Trost et al. (2002) who established moderate intensity accelerometer cut off points of 3 mets.

PE studies are also affected by the type of school recruited for the study. ‘Comparing PA levels across studies is problematic because of the contextual diversity that exists in different types of schools’ (Fairclough and Stratton, 2005b, p. 218). This contextual diversity can include types of activity, time allocation for PE to occur and instructional methods used at the school. However, the data from the study displayed small standard deviations for % MVPA (table 5.1 and figure 5.0) which suggests the schools used in the study were similar in terms of PE contextual factors.
Limitations and delimitations within this study should be acknowledged when drawing conclusions from the findings. A major delimitation of this study is associated with the structure of PE within each different school. Firstly the schools used within the study taught PE lessons in different ways specific to the school policy i.e. whether they taught students in single sex or coeducational classes. This could affect results of the study in terms of PA levels displayed during single sex vs. co-educational lessons and therefore should be inferred with caution. In addition different teachers taught at different schools and therefore the teaching style of the teacher could have directly impacted on these findings in terms of levels of PA. The sample size of the study was relatively small and the schools observed were all within the Bedfordshire region. However, a major strength of this study is the use of objective measurement for each child during every lesson that was observed over a full term. Previous studies have used short time periods and taken a random sample of objective measurements.

5.5 Conclusion

In conclusion a large proportion of activities in the study fell short of the 50% criterion (USDHH, 2000) which is in line with previous studies. However, it is important to recognise PE’s potential to promote health enhancing activity particularly in light of the contribution of VPA displayed in the study. The study showed the variation of activity across the activities undertaken during
PE. Team games were found to be the largest provider of MVPA and VPA closely followed by individual activities. Although movement activities made the smallest contribution to MVPA it is an important activity to help meet the targets set out by the DoH (2004) for children to be involved with body mass bearing activities at least twice a week to promote bone health. Overall PE lessons contributed almost a third to the recommended daily amount of PA which demonstrates the importance of PE for young people. There is clearly potential for PE to meet and exceed the USDHH (2000) targets. However due to the infrequency of PE it is important for PE to be combined with activity outside of the PE lesson for young people to meet the daily PA targets as outlined in the PESSYP ‘five hour offer’.
Chapter 6: Study 3: Does Physical Education make a significant contribution to the recommended 60 minutes of moderate-vigorous physical activity (MVPA) per day?
6.0 Study Map

Summary of study objectives and findings

<table>
<thead>
<tr>
<th>Study</th>
<th>Objectives and Key Findings</th>
</tr>
</thead>
</table>
| Study 1: Reliability and validity of several physical activity monitors to assess physical activity in school children. | Objectives:  
- To identify the re-test reliability of the following physical activity methods; RT3 Triaxial accelerometers, Bodymedia armband, and Actiheart.  
- To assess the validity of the physical activity monitors by comparison with oxygen consumption measure (Metalyser 3B) during standardised bouts of exercise.

Key findings:  
- The RT3 ® triaxial accelerometer was found to be the most valid and reliable physical activity monitor for use in school children aged 11-12 years old. |
| Study 2: Physical activity levels during middle school physical education. | Objectives:  
- To accurately quantify physical activity levels during middle school physical education lessons in the Bedfordshire area, to establish if current recommendations i.e. 50% of lesson time in activity of at least a moderate intensity, are met.

Key findings:  
- On average during PE lessons students spent 44.9 ± 5.6 % of the PE lesson engaged in MVPA which translated to 16.4 ± 2.3 minutes which fell short of the USDHH (2000) 50 % (20 minute) target. |

6.1 Introduction

Regular PA in youth is associated with improved health and wellbeing and a lower risk of developing diseases such as type 2 diabetes and obesity (Strong et al. 2005, Anderson et al. 2006, Janssen & Leblanc 2010; WHO, 2010). Current guidelines recommend that children should undertake a minimum of
60 minutes of MVPA each day in order to achieve the associated health benefits related to PA i.e. to maintain a favourable cardiovascular risk profile and lower risk of diabetes and rates of morbidity in later life (DoH, 2004; NICE 2009; WHO, 201) but evidence suggests that a large proportion of children are not active enough (Information Centre, 2009; Riddoch et al. 2007; HSE, 2008; US PA Guidelines, 2008). Currently, daily PA levels for children vary according to different methods employed (Corder et al. 2008). The Information Centre (2009) reported that 72% of boys and 63% girls in the UK aged 2-15 years old met the recommended levels of PA. Similarly the US PA guidelines (2008) state that only 42% of children aged 6-11 years met the recommended 60 minutes MVPA per day. However it should be noted that data collected from the HSE (2008); the Information Centre (2009) and the US PA guidelines (2008) used self reported measures so it is possible that the problem could be even larger as PA levels are typically underreported (Sirard and Pate, 2001; HSE 2008), for example, Riddoch et al. (2007) reported objective measurement of PA and found that only 2.5 % of boys and girls aged 11 years old are participating in the recommended daily PA levels.

The school setting and in particular the PE lesson has been highlighted as the place to reach most young people to promote a healthy active lifestyle and in addition children spend most of their young lives in school settings (McKenzie and Lounsbery, 2008). It is widely accepted that one of PE’s primary aims is the promotion of lifelong activity (Bailey et al. 2009; Seghers
et al. 2009). The PE lesson is one of the only opportunities that some children have to take part in organised sport (Seghers et al. 2009) and the PE lesson and school environment has been highlighted as the key settings for the promotion of lifelong PA (Seghers et al. 2009; McKenzie and Lounsbery, 2008). It has also been shown that if PE did not occur at school children do not compensate for the lack of PA (McKenzie and Lounsbery, 2008).

The Association for PE (afPE) in the UK has a number of objectives; to ensure that children participate in two hours of high-quality PE per week and that the children are ‘actively moving’ for at least 50% of the lesson time (afPE, 2008). However the document offers no definition of ‘actively moving’ so therefore it is necessary to employ the similar targets from the US. The USA have set a target that 50% of the lesson time should be spent in MVPA to make a significant contribution to the recommended 60 minutes of MVPA per day (USDHH, 2000). However it has been shown that this target is typically not met in the US or UK (McKenzie et al. 2006, McKenzie et al. 2000, Fairclough and Stratton, 2005b, Fairclough, 2003a). In addition to the afPE aspiration, the PESSCL (2008) strategy outlines a ‘five hour target’ for young people. In addition to the two hours of PE at least three hours should come from extra curricular and out of school activities (PESSCL, 2008). It is clear from the literature that PE and the school environment is essential in providing a key role in young people achieving the daily activity recommendation.
There is a lack of literature outlining the contribution of PE activities to children’s recommended PA levels and more specifically no studies have used triaxial accelerometry to establish PA levels during PE in comparison to habitual PA levels. There is also evidence to suggest that children do not compensate for activity lost on a non PE day with other PA activities (Fairclough and Stratton, 2005b). Therefore the purpose of this study was to quantify activity levels of middle school children during PE and leisure time using triaxial accelerometry and then to compare activity on a PE day versus non-PE day to the recommended 60 minutes of MVPA per day.

6.2 Method

Participants and Settings

One intact class of 25 Year 7 students (14 girls and 11 Boys; aged 11-12 years) from one middle school in Bedfordshire, England participated in the study. One child did not wish to take part in the study after week 3 and was therefore excluded from the study (n=24). The middle school has 424 boys and girls enrolled from the ages of 9-13 years old. The school consisted of students from a predominately white origin (98.3%) with a below average score for FSM eligibility (4.3%). Written parental consent was obtained before the study commenced and the study received ethical approval from the University Ethics Committee. The school followed the six activity areas set out in the National Curriculum for Physical Education (NCPE) (i.e. dance,
gymnastics, outdoor activities, games and swimming; DfES/QCA, 1999). PE was taught in mixed sex groups, with the exception of games activities where the students were placed in single sex groups. The co-educational lessons were taught by a female teacher. During single sex lessons girls were taught by the same female teacher as the co-educational lessons and boys taught by a male teacher. The students participated in PE twice weekly over a ten week period between February and May 2008. In addition to PE observation, students took part in repeated seven day habitual PA measurements.

**Instruments**

Body mass and stature were measured using Tanita bioelectrical impedance Scales (BC-418MA) and a portable Leicester height stand, respectively (see methodology section 3.1). PA was measured using triaxial accelerometry (Stayhealthy RT3 ®) (see methodology 3.2.1).

**Physical Education Monitoring**

During PE monitoring students were asked to place the RT3 ® triaxial accelerometer device on their waistband whilst changing into their PE kit. Each RT3 ® triaxial accelerometer was placed in a small bag which stated the individual student's name and distributed before the student entered the PE changing rooms. RT3 ® triaxial accelerometer information can be found in methodology section 3.2.2.
Habitual Seven Day Monitoring

During habitual daily activity monitoring students were asked to take away and wear the small RT3 ® triaxial device for a seven day period. Students were also asked to keep a PA diary (see methodology section 3.4.2). RT3 ® triaxial devices were collected from the school at the end of the seven day period. Further details of habitual RT3 ® triaxial accelerometry cut off points can be found in methodology section 3.2.3.

Design

In total twenty lessons were monitored over a ten week period. This was split into two five week blocks of activity. Activities during PE were grouped into activity areas that share similar characteristics for statistical analysis (Fairclough and Stratton, 2005a); movement (e.g. dance), individual (e.g. athletics), invasion games (e.g. football and hockey), fitness activities (e.g. circuit) (Table 6.0). Habitual activity data was collected one week prior to the study and one week after the study.

Table 6.0 Number and type of PE lessons

<table>
<thead>
<tr>
<th>Activity</th>
<th>No of Lessons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invasion</td>
<td>5</td>
</tr>
<tr>
<td>Individual</td>
<td>9</td>
</tr>
<tr>
<td>Fitness</td>
<td>2</td>
</tr>
<tr>
<td>Movement</td>
<td>6</td>
</tr>
</tbody>
</table>
Data Analyses

Activity counts from the RT3 © triaxial accelerometer for both the PE lesson and seven day habitual activity monitoring were converted into PA intensities using the Rowlands et al. (2004) accelerometer cut off points (see methodology 3.2).

Physical Education Monitoring Data Analyses

Preliminary Shapiro-Wilk tests and Levene’s test were employed to establish if the parametric assumptions were met. PE data violated the assumptions of a parametric test (Shapiro-Wilk and Levene’s). Therefore the PE data was analysed using a non parametric test for repeated measures one way ANOVA; the Friedman test. Post-hoc Wilcoxon signed rank test were employed to reveal differences between groups. The significance level was set at $P < 0.05/k$ for the post hoc test which was calculated as acceptable after bonferroni correction had been employed to control for type 1 error.

Habitual Seven Day Monitoring Data Analyses

Inclusion criteria for seven day habitual activity data can be found in methodology section 3.2.3. Reasons for non wear time were due to technical errors, illness, incomplete data or the child forgetting to wear the RT3 © triaxial device. Shapiro – Wilk tests revealed that data was normally
distributed for both MVPA and VPA. A repeated measures ANOVA was used to calculate differences between MVPA and VPA for seven day habitual activity. Post hoc tests determined the differences between groups. The Bonferroni correction was used to control for type 1 error and the significance alpha employed was $P < 0.05$. All data was analysed using SPSS version 17.0 (SPSS, Chicago, IL).
6.3 Results

PE Lesson Monitoring

The average duration of all the PE lessons was 34.6 ± 3.2 minutes. Overall across all activities PE contributed 16.1 ± 5.3 minutes (45.8 ± 13.6% MVPA), a full list of activity % and minutes can be found in table 6.1. Team games contributed the greatest to MVPA compared to all other activities. For example team games provided 58.9 ± 18.2% (MVPA) \( (P < 0.0125, \text{figure 6.0}) \) of lesson time in comparison to fitness activities which contributed 40.5 ± 5.8% (MVPA). Movement activity was the lowest contributor to lesson time spent in MVPA with a total contribution of 37.7 ± 6.9% \( (P < 0.0125, \text{figure 6.0}) \) equating to 13.7 ± 2.5 minutes.
Figure 6.0 Mean (± SD) MVPA of different activities during PE. ***Team Games > movement activities \((p < 0.0125)\) and fitness activity \((P < 0.0125)\) **Individual activity > fitness activity \((P < 0.0125)\) and movement activity \((P < 0.0125)\). *Fitness activity > movement activity \((P < 0.0125)\). The dashed horizontal line represents the 50% USDHH (2000) criterion.
Figure 6.1 Mean (± SD) VPA minutes of different activities during PE. **Team Games > fitness activities ($Z \ (3) = -3.23, P < 0.0125$) and movement activity ($Z \ (3) = -3.7, P < 0.0125$) *Individual activity > movement activity ($Z \ (3) = -4.2, P < 0.0125$) and fitness activity ($Z \ (3) = -3.6, P < 0.0125$).

Table 6.1 Mean (± SD) MVPA and VPA minutes and % time spent in different activities.

<table>
<thead>
<tr>
<th>Activity</th>
<th>$n$</th>
<th>MVPA (minutes)</th>
<th>VPA (minutes)</th>
<th>MVPA (%)</th>
<th>VPA (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team Games</td>
<td>24</td>
<td>19.8 ± 7.5</td>
<td>12.1 ± 6.7</td>
<td>58.9 ±18.2</td>
<td>38.4 ± 20.9</td>
</tr>
<tr>
<td>Individual</td>
<td>24</td>
<td>18.0 ± 3.4</td>
<td>10.5 ± 2.9</td>
<td>46.1 ± 8.2</td>
<td>26.9 ± 6.8</td>
</tr>
<tr>
<td>Movement</td>
<td>24</td>
<td>13.7 ± 2.5</td>
<td>6.9 ± 2.1</td>
<td>37.7 ± 6.9</td>
<td>19.2 ± 5.8</td>
</tr>
<tr>
<td>Fitness</td>
<td>24</td>
<td>12.6 ± 1.9</td>
<td>7.2 ± 1.7</td>
<td>40.5 ± 5.8</td>
<td>22.9 ± 5.1</td>
</tr>
</tbody>
</table>
Minutes of VPA were significantly different between activities ($X^2 (3) = 29.4$, $P < .05$) (Figure 6.1). Team games were the largest contributor of VPA in minutes ($12.1 \pm 6.7$) (table 6.1) and contributed significantly ($P < 0.0125$) more minutes than movement activities ($6.9 \pm 2.1$) and fitness activities ($10.5 \pm 2.9$). Individual activities contributed significantly ($P < 0.0125$) more VPA minutes than movement and fitness activities.

**Habitual Activity Monitoring**

On average habitual activity on a non PE day totalled $86.6 \pm 32.6$ minutes spent in activity of at least a moderate intensity (Table 6.3). Activity on a weekday that students took part in a PE lesson totalled $99.1 \pm 34.8$ minutes. PE lesson activity was included in the habitual activity data. PE day activity was greater than non PE weekdays by $12.4$ minutes. Weekend activity accumulated the least minutes spent in MVPA; $50.2 \pm 37.9$ minutes. Repeated measures ANOVA revealed that time spent in activity of at least a moderate intensity was significantly different between conditions, $F(2, 30) = 13.3$, $P < 0.05$. MVPA on a PE day was significantly ($P < 0.05$) higher than on a weekend day ($P = 0.001$). Similarly, non PE days provided significantly ($P < 0.05$) more MVPA than weekend days ($P = 0.016$). Time spent in VPA (minutes) was significantly different between conditions (figure 6.3) $F(2, 30 = 7.47$, $P < 0.05$). PE days provided significantly ($P < 0.05$) more VPA minutes than weekend days and was the highest contributor to VPA ($28.3 \pm 12.2$ minutes) (table 6.4).
Figure 6.3 Mean (± SD) MVPA (minutes) contribution of PE to 7 day habitual activity. The dashed horizontal line represents the recommendation of 60 minutes daily activity set out by the DoH (2004). *PE Day > weekend day ($P < 0.05$). *Non PE Day > weekend day ($P < 0.05$). No significant difference between PE day and non PE day MVPA.

Table 6.3 Mean physical activity levels (± SD) (minutes) during 7 day habitual PA monitoring.

<table>
<thead>
<tr>
<th></th>
<th>$n$</th>
<th>MVPA (minutes)</th>
<th>VPA (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE Day</td>
<td>18</td>
<td>99.1 ± 34.8</td>
<td>28.3 ± 12.2</td>
</tr>
<tr>
<td>Non PE Day</td>
<td>18</td>
<td>86.6 ± 32.6</td>
<td>19.9 ± 12.3</td>
</tr>
<tr>
<td>Weekend</td>
<td>18</td>
<td>50.2 ± 37.9</td>
<td>12.3 ± 14.6</td>
</tr>
</tbody>
</table>
6.4 Discussion

The study aim was to quantify PE’s contribution to the recommended 60 minutes MVPA per day (DoH, 2004) in one middle school. Across all lessons, PE contributed on average 16.1 ± 5.3 minutes of MVPA to daily PA levels, which equated to a percentage lesson time of 45.8 ± 13.6%. This fall shorts of the USDHH (2000) 50 % MVPA. The USDHH (2000) document also outlines that being active for at least half of PE class time on at least half of the school days would provide a substantial portion of the PA time to contribute to the recommended 60 minutes MVPA per day. As previously mentioned, it is important to note that one of the aims of PE in the UK is to provide two hours
of PE per week so this target must be approached with caution due to the shorter frequency of lessons in the UK in comparison to the US.

The Chief Medical Officer’s recommendation is for children and young people to do a minimum of 60 minutes MVPA daily. Children in the present study exceeded the recommendations on a PE day, and non PE weekday; 99.1 ± 34.8 and 86.6 ± 32.6 minutes respectively. Children did not, however, meet the recommendations on weekend days (50.2 ± 37.9 minutes). These findings were in line with the findings of Rowlands et al. (2008) who found that in children aged 9-10 years old weekday activity was more frequent and longer in duration in comparison to weekdays. Rowlands et al. (2008) suggested that weekend days provided no structure to PA and that this had a detrimental effect on PA levels over the weekend.

These findings were unexpectedly high in comparison to other studies that have objectively measured PA using RT3 triaxial accelerometry (Riddoch et al. 2007). Riddoch et al. (2007) found that girls and boys aged 11-12 years only took part in 25 and 16 minutes of MVPA per day respectively. It should be acknowledged that Riddoch et al. (2007) employed accelerometry cut off points higher than those employed in the present study. As previously mentioned in study 3, measuring PA with accelerometry can be problematic due to discrepancies of cut off points used within the literature (Trost et al. 2002; Treuth et al. 2004). Riddoch et al. (2007) employed cut off points using
a moderate intensity threshold of 4 mets in comparison to the present study that employed a 3 met threshold for moderate intensity activity based on Rowlands et al. (2004) cut off points. The difference in intensity thresholds may account for the higher levels of MVPA displayed within the present study. These discrepancies are further highlighted by results displayed within the literature i.e. Trost et al (2002) reported average MVPA levels of 100 minutes in 12-13 year olds using the 3 mets cut off points versus Riddoch et al. (2007). It is also important to note that the socio economic status of the school (4.3% FSE) used in the study was high in comparison to the national average FSE of 12.1% (DfES, 2005). The NICE guidelines (2009) outline that the number of children participating in sports and exercise on at least one day increased with income levels suggesting that children from higher income families participate in more PA on a daily basis.

Levels of MVPA during PE were similar, however, to the findings in previous studies (Fairclough and Stratton, 2005a; Fairclough, 2003a). The study found that MVPA accrued during PE did not meet the USDHH, (2000) 50% of lesson time spent in activity of at least a moderate intensity criterion. It is apparent from the data that there is a large variation in MVPA between the different types of activity monitored during the PE lessons. This is in line with previous studies who have also found large variations between activities (Fairclough and Stratton, 2005b). When converted to minutes team game activities were found to make the largest contribution to MVPA (19.7 ± 3.1
minutes). Team game activities included numerous running and sprinting
bouts which require whole body exercise lending explanation for these higher
levels of MVPA. Team games were also found to make the largest
contribution to VPA (12.1 ± 6.7 minutes) in comparison to other activities,
which is similar to previous research findings (Fairclough and Stratton, 2005a;
Fairclough, 2003a). Fairclough and Stratton (2005a) outline the reason for
this larger contribution of VPA as the requirement of team games to use
larger proportions of muscle mass and hence its impact on the heart to beat
faster to satisfy O$_2$ demand. This may have significance in relation to the
promotion of cardiovascular health (Armstrong and Welsman, 1997).

The lowest levels of activity in the present study were found in movement
activities i.e. dance ($P < 0.0125$) which could be due to the fact that
movement activities tend to 'emphasise aesthetic appreciation and motor skill
development' (Fairclough and Stratton, 2005c, p.455). This is also in line with
previous research that reported low levels of activity (Fairclough and Stratton,
2005a; Fairclough, 2003b). However it should also be noted that movement
and gymnastic activities are essential to satisfy the DoH’s (2004) criteria that
at least twice a week children should participate in body mass-bearing
activities to improve bone health, muscle strength and flexibility in addition to
achieving the 60 minutes daily activity.
Another important confounding variable to discuss in relation to the high levels of daily PA is ethnicity of the students. Children from ethnic groups including Indian, Pakistani, Bangladeshi and Chinese tend to display lower levels of PA in comparison to white children (NICE, 2009). The school used in the study was predominately white children (98.3%) which may also lend some explanation to the high PA levels displayed. It is important to acknowledge socio economic status as a delimitation of this study and that the school used within the study may not be a true representation of the population.

The recommendation of achieving 60 minutes MVPA per day may not improve health enhancing cardiovascular fitness and in addition evidence suggests that children aged 9 may in fact need 120 minutes per day and young people aged 15 may need 90 minutes per day, to reduce their risk of cardiovascular disease (Andersen et al. 2006). The findings from the present study found that days on which children participate in PE accumulates the most amount of time spent in MVPA (99.1 ± 34.8 minutes) and is closest to these recommendations which may reduce the risk of cardiovascular diseases. It is also an interesting finding that VPA accumulated on a day that children participate in PE has a greater contribution to daily activity than a normal non PE day and a weekend day. The average contribution of PE to VPA was 9.2 ± 4.4 minutes. Although this seems a small contribution, VPA accumulated through PE enhanced VPA to over thirty minutes. It has been
found that 20-30 minutes of high intensity exercise 3-5 times per week is necessary for cardiorespiratory gains (Armstrong and Welsman, 1997). Importantly is has been found that it is not the amount of activity a child participates in but the intensity of the exercise that is important for health benefits (Ruiz et al. 2006). The study showed that VPA accumulated on a day that included PE was higher than a non PE day and significantly higher than a weekend day (P < 0.05). This highlights the importance of PE to young people’s health. The study demonstrated that on a PE day 28.3 ± 12.2 minutes of VPA were accumulated in comparison to a non PE day which only accrued 19.9 ± 12.3 minutes. It has been found that children achieving > 40 minutes of VPA per day displayed higher levels of cardiovascular fitness in comparison to other children who only took part in < 18 minutes per day (Ruiz et al. 2006). With the aspiration for children to take part in two hours of PE per week (QCA, 2008) this potentially means that PE twinned with habitual activity could provide enough VPA for health enhancing activity twice a week.

Fairclough & Stratton (2007) argue that PE classes are not the only option for providing PA opportunities, with active commuting, recess, extra-curricular sport and recreation all being associated with the school setting. This therefore not only highlights PE’s potential to accumulate high levels of MVPA but also emphasises the fact that learning through involvement in PA is what makes PE superior to other subjects (Fairclough, 2003a). It also shows the importance of schools as the “key environments for promoting health-
enhancing PA as children spend ~40-45% of their waking hours there” (Fairclough, Stratton and Butcher, 2008, p. 576). In response to the views of Fairclough and Stratton (2007), Yelling, Penney and Swaine (2000) also believe that PE is the only subject within the National Curriculum which considers actively promoting children’s physical development and well-being, as well as providing the knowledge, skills and understanding to encourage active lifestyles beyond compulsory schooling (Fairclough and Stratton, 2006b). The Physical Education Association of the United Kingdom (PEA UK) are in agreement stating that “PE allows young people to be physically active and to learn through being active” (Yelling, Penney and Swaine, 2000, p. 46). Enhancing the awareness of the physical, social and mental health benefits acquired through PA, making links between inactive lifestyles and chronic disease risk factors, improving attitudes regarding exercise and sport and highlighting activity possibilities in the community are all ways in which lead to PE promoting PA (Fairclough, 2003b).

The findings of this study could have been affected by the delimiting factor that games activities were taught in single sex lessons which could affect the amount of PA during each lesson. In addition six children were excluded from the seven day habitual activity due to their data not meeting the criteria set out to be included in seven day monitoring i.e. non compliance and insufficient wear time, which may have impacted upon results due to the relatively small sample size. Due to age restrictions and sample size the
findings cannot be generalized to the population. This is highlighted by results displayed within the studies i.e. Trost et al (2002) reported average MVPA levels of 100 minutes in 12-13 year olds using the 3 mets cut off points versus Riddoch et al. (2007)

6.5 Conclusion

The results show that on average during the week children in this study achieved the 60 minutes MVPA per day target which potentially reduces the risk of cardiovascular disease (Andersen et al. 2006). However, this was not the case for weekend activity which fell short of the DoH (2004) recommendation and is in line with previous research that found on weekend days activity is not as long in duration (Rowlands et al. 2008). It is also important to remember the children in this study were from a high socio economic area which potentially impacts on PA levels. It was also apparent from the results that PE lessons fall short of the USDHH (2000) 50% criterion and therefore suggests the importance of a PE intervention to increase PA levels within PE without compromising lesson objectives. PE was also found to be of importance in terms of the unique contribution it makes to levels of VPA which increases cardiorespiratory fitness (Ruiz et al. 2006; Armstrong and Welsman, 1997). Due to the infrequency of PE and the aspiration in the UK for two hours of PE per week PE will not contribute everyday but can make a significant impact on days when PE is conducted. The study also
highlighted that on non PE days the activity lost (both MVPA and VPA) from not participating in PE was not compensated for which was in line with the findings of Fairclough and Stratton, (2005b). Further research needs to focus on an intervention such as TGfU to maximise the contribution of PE to the recommended target of MVPA per day. Research also needs to investigate the effectiveness of PE to the adherence of PA outside of school into adulthood.
Chapter 7: Study 4: Pilot Study to Assess the Influence of a TGfU Approach on Physical Activity Levels Monitored During Physical Education Lessons
### 7.0 Study Map

Summary of objectives and findings.

<table>
<thead>
<tr>
<th>Study</th>
<th>Objectives and Key Findings</th>
</tr>
</thead>
</table>
| Study 1: Reliability and validity of several physical activity monitors to assess physical activity in school children. | **Objectives:**  
- To identify the re-test reliability of the following physical activity methods; RT3 Triaxial accelerometers, Bodymedia armband, and Actiheart.  
- To assess the validity of the physical activity monitors by comparison with oxygen consumption measure (Metalyser 3B) during standardised bouts of exercise.  

**Key findings:**  
- The RT3 ® triaxial accelerometer was found to be the most valid and reliable physical activity monitor for use in school children aged 11-12 years old. |

| Study 2: Physical activity levels during middle school physical education. | **Objectives:**  
- To accurately quantify physical activity levels during middle school physical education lessons in the Bedfordshire area, to establish if current recommendations i.e. 50% of lesson time in activity of at least a moderate intensity, are met.  

**Key findings:**  
- On average during PE lessons students spent 44.9 ± 5.6 % of the PE lesson engaged in MVPA which translated to 16.4 ± 2.3 minutes which fell short of the USDHH (2000) 50 % (20 minute) target. |
7.1 Introduction

The TGfU model was developed in the 1980’s by Bunker and Thorpe (1982) in response to school leavers relatively little understanding of game play (Bunker and Thorpe, 1986). TGfU is based on a modified games approach (Mitchell et al. 2006). The model aims to teach skills in a game situation which will ultimately bridge the gap between skill practice and transferring the skill into a game situation (Mitchell et al. 2006). It has been found that forms of conditioned games and game play can provide more MVPA than skill based activity (Yelling et al. 2000; Van Acker et al. 2010).
Research has mainly focused on how the TGfU model has been shown to be effective in relation to teacher experience, student understanding, skill development and low ability students (Butler, 1996; Allison and Thorpe, 1997). TGfU has not been researched in relation to objectively quantifying its impact upon MVPA levels during PE lessons and it has been recommended that the effects of different curriculum models on MVPA levels be investigated (Yelling et al. 2000, Hastie and Trost, 2002), particularly given the growing concerns surrounding low levels of PA measured during PE (McKenzie et al. 2006, McKenzie et al. 2000, Fairclough and Stratton, 2005a, Fairclough, 2003a).

Therefore the aim of this pilot study was to assess the impact of a TGfU approach during PE on objectively assessed MVPA levels using RT3 ® triaxial accelerometry.

7.2 Methodology

Participants and Settings

One class of 23 Year 7 students (13 girls and 10 Boys; aged 11-12 years) from one middle school in Bedfordshire, England participated in the study. The middle school had 424 boys and girls enrolled from the ages of 9-13 years old. The school consisted of students from a predominately white origin (98.3%) with a below average score for FSM eligibility (4.3%). Written
parental consent was obtained before the study commenced and the study received ethical approval from the University Ethics Committee. The school followed the six activity areas set out in the NCPE (i.e. dance, gymnastics, outdoor activities, games and swimming; DfES/QCA, 1999). PE was taught in co-educational lessons by a female teacher.

**Instruments**

Body mass and stature were measured using Tanita bioelectrical impedance Scales (BC-418MA) and a portable Leicester height stand, respectively (see methodology 3.1). Physical activity was measured using RT3 ® triaxial accelerometry (see methodology section 3.2.1 for full details).

**Physical Education Monitoring**

During PE monitoring students were asked to place the RT3 ® triaxial device on their waistband having changed into their PE kit. Each RT3 ® triaxial accelerometer was placed in a small bag which stated the individual student’s name and distributed before the student entered the PE changing rooms. The RT3 ® triaxial accelerometer was set to record one second epochs (methodology section 3.2.2). Lesson times were recorded (start and finish) so that the data could be cropped before analysis. RT3 ® triaxial devices were collected in at the end of each lesson and downloaded using the Stayhealthy RT3 ® software (version 1.0.7).
Design

In total four rounders lessons were monitored over a four week period and were split into two control and two intervention lessons. Two control lessons were monitored over the first two weeks. After this time the consultations were set up with the class teacher to plan the TGfU lessons (methodology section 3.5.2). The teacher had not implemented TGfU prior to this study.

Data Analyses

Preliminary normality Shapiro Wilk tests were employed to establish if the parametric assumptions were met. All data met the assumptions of a parametric test. Data was analysed using a paired samples t test to assess differences in MVPA and VPA levels between groups (control versus intervention). All data was analysed using SPSS version 17.0 (SPSS, Chicago, IL).

7.3 Results

The average duration of all the PE lessons was 40.8 ± 3.1 minutes. During control lessons average lesson time spent in MVPA was 40.7 ± 11.3%, which translated to 16.4 ± 5.9 minutes. The intervention lessons provided significantly higher (t (19) = -3.9, P < 0.01) levels of % MVPA (52.7 ± 15.8% or 21.0 ± 6.5 minutes) (figure 7.0). On average the intervention lesson
accrued almost five minutes more MVPA in comparison to the control lessons. Intervention lessons also provided significantly higher ($t(19) = -2.8, P < 0.01$) levels of VPA in comparison to the control condition, 30.8 ± 13.9 and 24.3 ± 8.2% respectively (figure 7.0). This translated to 12.3 ± 5.7 VPA minutes in the intervention lesson and 9.8 ± 4.1 VPA minutes for the control lessons.

![Figure 7.0 Mean (±SD) % MVPA and VPA between conditions (CON vs. INT).](image)

*INT MVPA > CON MVPA ($t(19) = -3.9, P < 0.01$). *INT VPA > CON VPA ($t(19) = -2.8, P < 0.01$). The dashed horizontal line represents the 50% MVPA criterion for PE set out by the USDHH (2000).

### 7.4 Discussion

The purpose of the present pilot study was to assess the impact of a TGfU approach on MVPA levels during PE lessons. The study showed significant
increases in both MVPA and VPA ($P < 0.01$) in the intervention lesson compared to the control lesson. This finding is in line with previous research studies that has found that game play is typically associated with more activity than skill based sessions (Yelling et al. 2000). TGfU is a sequential model that practices skills in a games context using conditioned games, therefore increasing the amount of time spent in game play (Mitchell et al. 2006). The increases in MVPA displayed in the intervention lesson meant that these lessons exceeded the 50% USDHH (2000) criterion.

Previous research has also shown that other forms of modified games have a positive impact upon activity levels (Van Acker et al. 2010). Van Acker et al. (2010) displayed increases in MVPA across schools in Belgium and Portugal as a result of using a modified games concept developed at Ghent University called the ‘Invasion Games Competence Model’. It was found that during co-educational mixed ability groups the intervention lessons accrued 65.5% MVPA; exceeding the 50% target. This reinforces the current study findings that children accumulated greater MVPA ($52.7 \pm 15.8\%$) after implementation of the intervention in comparison to baseline ($40.7 \pm 11.3\%$).

Interestingly on average the intervention lessons accrued almost three minutes more VPA than the control lesson which is potentially health enhancing activity (Armstrong and Welsman, 1997). In addition to these three minutes it was found that the intervention lessons increased minutes spent in
MVPA by five minutes. Although these increases seem small in comparison to the 60 minute daily target (DoH, 2004), PE has been identified as the only time some children take part in organized PA (McKenzie and Lounsbery, 2008). This outlines the importance of PE in promoting PA levels within the lessons whilst taking into consideration the wider educational focus of PE which has lacked in some previous studies (Fairclough, 2005b).

Whilst the present study was intended as a pilot study to provide direction for future research the limitations of the study must be acknowledged. The small sample size and the restriction of the study to one Bedfordshire middle school does not make the study a true representation of the population. In addition the same teacher taught both the control and intervention lessons within the study and therefore there is a potential for data contamination with aspects of TGfU filtering into the control lessons. A major strength of the study is the impact of TGfU on activity levels during PE after lesson-lesson objective PA monitoring.

7.5 Conclusion

This pilot study highlighted the potential for the TGfU intervention to increase PA levels above the 50% criterion (USDHH, 2000) without comprising lesson objectives set within the national curriculum. It also indicates that the 50% criterion is an achievable target in the aim for PE lessons to significantly
contribute to the daily PA levels. Many studies have outlined the need for PE based interventions to incorporate a multidisciplinary approach to looking at the effectiveness of different instructional models used during PE (Jago et al. 2009; Mandigo et al. 2008; Seghers et al. 2007). Lubans and Sylva (2006) argue that interventions are most effective when they influence the underlying factors of PA behaviours. TGfU has previously been shown to impact positively on intrinsic motives (Butler, 2006) which have been linked to the promotion of PA behaviours (Lonsdale et al. 2009). In order to fully understand the potential of TGfU to contribute to one of the primary aims of PE; the promotion of active healthy lifestyles (Bailey et al. 2009), future research needs to investigate the motivational climate created by TGfU along with pupils’ motivation and perceptions of the environment created. In addition a larger sample size needs to be incorporated across numerous schools into the future research to ensure the findings are more applicable to the population.
Chapter 8: Study 5: Preliminary Studies: The Influence of a TGfU Approach on Physical Activity Levels and Motivational Responses During Physical Education Lessons.
## 8.0 Study Map

### Summary of findings and objectives.

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<thead>
<tr>
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**Key findings:**  
- The RT3 ® triaxial accelerometer was found to be the most valid and reliable physical activity monitor for use in school children aged 11-12 years old. |
| **Study 2:** Physical activity levels during middle school physical education. | **Objectives:**  
- To accurately quantify physical activity levels during middle school physical education lessons in the Bedfordshire area, to establish if current recommendations i.e. 50% of lesson time in activity of at least a moderate intensity, are met.  

**Key findings:**  
- On average during PE lessons students spent 44.9 ± 5.6 % of the PE lesson engaged in MVPA which translated to 16.4 ± 2.3 minutes which fell short of the USDHH (2000) 50 % (20 minute) target. |
8.1 Introduction

The TGfU approach is a sequential curriculum model and was developed by Bunker and Thorpe (1982). Bunker and Thorpe (1986) highlight that most...
school leavers obtain little game understanding during traditionally taught
lessons and as a result possess inflexible techniques and poor decision
making skills (Mitchell, Oslin and Griffin, 2006; Blomqvist and Luhtanen,
2000). Research has shown that games based activity during the PE lesson
can produce elevated levels of PA in comparison to skill dominated lessons
(McKenzie et al. 2006; Fairclough, 2003a; Yelling et al. 2000). TGfU employs
small sided games which have been shown to increase MVPA levels
(McMurray et al. 2009). TGfU places limitations on a game situation in order
to teach skills and recognise when skills should be used in a games context
(Bunker and Thorpe, 1986) and this approach has been highlighted as a
more enjoyable alternative to traditional teaching methods (Mitchell et al.
2006). If student enjoyment levels are increased during PE then this may
positively impact upon motivation levels (Ryan and Deci, 2000).

Student motivation during PE has been highlighted as an important factor that
can influence levels of PA and willingness to participate during PE (Standage
et al. 2005). The application of SDT is of particular relevance to the PE
setting (Taylor and Ntoumanis, 2007, Standage et al. 2005, Wallhead and
Ntoumanis, 2004). Intrinsic motivation has been described as the principal
source of an individual's ability to make life enjoyable and continue vitality
throughout life (Ryan and Deci, 2000). If students are intrinsically motivated
they will show 'interest in an activity and experience enjoyment and feelings
of competence and control' (Wallhead and Ntoumanis, 2004 p. 4). Ryan and
Deci (2000) outline that SDT is also affected by the environment created. By using different curriculum models during PE the motivational environment can be manipulated.

The TGfU curriculum model has been shown to enhance enjoyment and deliver intrinsic values (Butler, 2006). Alternatively if a lesson is only taught in a technical traditional sense it has been found that learners may lose intrinsic experiences (Butler, 2006). A different curriculum model called the Sport Education Model (Seidentop, 1994) has been shown to enhance motivation levels during PE (Wallhead and Ntoumanis, 2004) due to its similarity with the TGfU approach in terms of the potential for students to develop their own learning. However, the TGfU approach has the potential to further enhance PA levels in comparison to the Sport Education Model since it does not focus solely on roles and responsibilities but focuses on skill development through practising the skill in a games context. The TGfU approach was developed after the traditional teaching approach had been recognised as problematic, particularly in terms of students being able to transfer the skills into a games context. TGfU may help bridge the ‘gap’ between practising the skill and having the ability to use the skill in a game situation (Bunker and Thorpe, 1986). In particular Butler (2006) highlights that TGfU promotes elements such as small group work which could directly impact upon relatedness; a direct determinant of self determination. TGfU also promotes individual improvement recognition, individual progression and the use of skill in a game
situation which should all positively impact upon the determinants of SDT (competence, relatedness and autonomy).

Fairclough and Stratton (2005a) highlight the need for more investigation into the relationship between motivation and MVPA. They explain that this relationship has seldom been investigated and that the area of research is of ‘importance because PA levels might be linked to effort and perceived competence, which are predictive of intrinsic motivation’ (p. 227). This is further reinforced by Fairclough and Stratton (2005b) who state that ‘multidisciplinary methods can yield rich sources of information, which may better inform the development of strategies to engage students in health enhancing activity during PE’ (p. 456). Most recently Jago et al. (2009) highlighted the need for more effective instructional and motivational interventions that increase the amount of PA students engage in during PE. This is further reinforced by Lonsdale et al. (2009) who state that future research is needed specifically on the effect of manipulating the PE lesson to create a more self determined environment and objectively measured PA levels.

Therefore the purpose of this study was to assess the impact of the TGfU approach on both self determined motivational levels during PE and objectively measured PA levels.
8.2 Methodology

Subject and Settings

Seventy students (40 girls and 30 boys) from three co-educational state middle schools in Bedfordshire, England participated in the study. Socio economic status of the three schools, as represented by FSM eligibility were very different. School ‘A’, school ‘B’ and school ‘C’ had FSM of 60.9, 9.0 and 21.5% respectively (DfES, 2005). Students currently enrolled at each school totalled 319, 597 and 750 for school A, B and C. Ethnicity of students at school ‘A’ was as follows; 2% white, 50% Pakistani, 40% other ethnic groups. School ‘B’ had an ethnic background of 72.7% white, 3.4% black origin, 3.9% Indian, 1.5 % Pakistani, 9.7% other minority ethnic group. School ‘C’ consisted of 76% white, 2.3% black origin, 12.3% Indian, 0.8% Pakistani, 8.3% other minority ethnic group. Nineteen students (n = 4 girls, n = 15 boys) from one year 7 co educational class (11-12 years) at school ‘A’ participated in the study. Nineteen students (n = 19 girls) from one year 7 single sex class (11-12 years) at school ‘B’ participated in the study. A total of two coeducational classes participated in the study from school ‘C’; each class was randomly selected to be taught using the pedagogical intervention (n = 16, n = 8 girls, n = 8 boys) of TGfU and one class selected for the ‘traditional’ teaching approach (n = 16, n = 7 boys, n = 9 girls). One male teacher taught all lessons at school ‘A’. One female teacher taught all lessons at school ‘B’ One male and one female teacher taught the control and intervention classes
respectively at school ‘C’. Written parental consent was obtained before the study commenced.

**Instruments**

The study received ethical approval from the University of Bedfordshire Ethics Committee. Body mass and stature were measured using Tanita bioelectrical impedance Scales (BC-418MA) and a portable Leicester height stand, respectively (see methodology 3.1). PA was measured using triaxial accelerometry (Stayhealthy RT3 ®) (methodology 3.2.1).

**System for Observing Fitness Instruction Time (SOFIT) – Physical Education Lessons**

The observational tool SOFIT was used in all PE lessons to assess lesson contextual information. All researchers were trained to use the SOFIT protocol based on the McKenzie and Sallis (1991) guidelines. SOFIT was conducted as outlined in methodology section 3.4.1.
Physical Education Monitoring

During PE monitoring each student was asked to place the RT3 ® triaxial device on their waistband whilst changing into their PE kit. Each RT3 ® triaxial accelerometer was placed in a small bag which stated the individual student’s name and distributed before the student entered the PE changing rooms. The RT3 ® triaxial accelerometer was set at one second epoch data collection during PE (see methodology 3.2.2).

Self Determination Assessment

The constructs included in SDT were assessed pre and post intervention using the questionnaire developed by Standage et al. (2005) suitable for 11-2 year old children. Alpha coefficients were shown to range between 0.80 and 0.96 (Standage et al. 2005) and were based on the 0.70 alpha criterions set by Nunnally and Bernstein (1994). Self determination was assessed by measuring 12 variables on a Likert scale ranging from 1 = strongly disagree to 7 = strongly agree (see methodology 3.6).

Design

The teachers used within the study across the three schools had attended a University based TGfU training course (see methodology section 3.5.1). Teachers were not aware, however, of the specific aims of the study. Lesson plans for the control lessons were obtained prior to the study. The TGfU lessons were based around the instructional model set out by Metzler (2000).
To ensure that the TGfU approach and structure was implemented correctly SOFIT analyses were employed to help ensure that Metzler's benchmarks were properly implemented. For example Metzler (2000) states that a 'record and frequency of teachers instructional interactions' should be kept. SOFIT analyses have the capacity to record these as outlined by Metzler (2000). In addition lesson plans were obtained (appendix A-C) to confirm that a TGfU approach was implemented in the intervention lessons (another satisfaction of Metzler’s benchmarks). Lesson structure i.e. co-educational or single sex lessons were determined by the school recruited in the study dependent on the individual school policy.

School ‘A’
In total four hockey lessons were monitored (2 x control, 2 intervention). Prior to data collection, a meeting was held with the teacher to plan the two lessons using the TGfU approach (see methodology section 3.5.2) (appendix A).

School ‘B’
In total six football lessons were monitored over a 6 week period (3 x intervention, 3 control, alternate weeks). Prior to data collection a meeting was held with the teacher to plan the TGfU lessons (see methodology section 3.5.2) (appendix B).
School ‘C’
A total of twelve hockey lessons were observed over a six week period. Due to weather conditions and the school closing, data was collected during three weeks reducing the number of lessons to three. A meeting was held with the intervention teacher prior to data collection to plan the TGfU lessons (see methodology section 3.5.2) (appendix C). Male and female teachers taught the same units of work and employed similar lesson objectives but adapted their delivery according to whether the session was traditional (control) or used the TGfU approach.

Data Analyses
Physical Education Lesson Monitoring
Activity counts from the RT3 ® triaxial accelerometer for the PE lessons were converted into PA intensities using the Rowlands et al. (2004b) accelerometer cut off points (see methodology 3.2.2). Levenes tests were employed to establish if the parametric assumptions were met. MVPA and VPA PE data for all schools met the assumptions of a parametric test. Therefore the MVPA and VPA PE data for school ‘A’ and school ‘B’ were analysed using paired t tests. School ‘C’ data was analysed using an independent samples t test as control and intervention lessons employed different classes of students. All data was analysed using SPSS version 17.0 (SPSS, Chicago, IL).
System for Observing Fitness Instruction Time – Physical Education Lessons

SOFIT was analysed using the methods outlined in the McKenzie and Sallis (1991) SOFIT training manual (see methodology 3.4.1). Paired sample t tests were employed for school ‘A’ and school ‘B’ to establish any significant differences between conditions in lesson contexts. Independent sample t tests were employed for school ‘C’.

Self Determination Theory

Cronbach’s alpha levels were calculated for all scales to assess internal consistency of the measures. Cronbach’s alpha levels greater than 0.70 were classed as acceptable (Kline, 1998). Repeated measures MANOVA was employed to assess any differences in self determination constructs between groups for school ‘C’. Although school ‘C’ and school ‘B’ data initially violated the assumptions necessary to perform a MANOVA, the robustness of the MANOVA was preserved once significant univariate (± 2.5 standard deviations, Field, 2009) outliers were removed. School ‘A’ met all parametric assumptions. Version 17.0 of SPSS (SPSS Inc, Chicago, IL) was used for all statistical analyses and the alpha level was set at p < 0.05.

8.2 Results

Physical Education Monitoring
The average duration of all PE lessons was 36.09 ± 3.14 minutes (control) and 38.79 ± 2.32 minutes (intervention). A full list of activity % and minutes for each school and between each condition can be found in table 8.0.
Table 8.0 Mean (± SD) MVPA and VPA minutes and MVPA as a % of lesson time across the three schools and between conditions

<table>
<thead>
<tr>
<th>Activity</th>
<th>Condition</th>
<th>n</th>
<th>MVPA (minutes)</th>
<th>VPA (minutes)</th>
<th>MVPA (%)</th>
<th>VPA (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>'A' Hockey</td>
<td>CON</td>
<td>19</td>
<td>22.76±4.90</td>
<td>13.49±4.46</td>
<td>62.56±13.49</td>
<td>37.09±12.27</td>
</tr>
<tr>
<td></td>
<td>INT</td>
<td></td>
<td>20.68±4.93</td>
<td>11.92±5.02</td>
<td>49.75±11.64</td>
<td>27.83±10.5</td>
</tr>
<tr>
<td>'B' Football</td>
<td>CON</td>
<td>19</td>
<td>20.17±4.48</td>
<td>11.62±4.45</td>
<td>51.99±11.52</td>
<td>29.95±11.45</td>
</tr>
<tr>
<td></td>
<td>INT</td>
<td></td>
<td>22.11±4.39</td>
<td>14.00±3.84</td>
<td>58.79±11.69</td>
<td>37.25±10.20</td>
</tr>
<tr>
<td>'C' Hockey</td>
<td>CON</td>
<td>16</td>
<td>10.25±3.40</td>
<td>4.18±2.96</td>
<td>31.89±9.82</td>
<td>15.40±7.03</td>
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<tr>
<td></td>
<td>INT</td>
<td></td>
<td>18.49±7.10</td>
<td>10.67±6.13</td>
<td>47.08±18.19</td>
<td>27.19±15.47</td>
</tr>
</tbody>
</table>

Figure 8.0 Mean (± SD) MVPA and VPA (% of lesson time) levels between conditions (CON vs INT). **CON MVPA > INT MVPA (t (18) = 12.80, P < 0.05). *CON VPA > INT VPA (t (18) = 6.47, P < 0.05).
A paired t test revealed significantly higher levels of % MVPA and VPA in the control condition, $t(18) = 12.80, P < 0.05$ and $t(18) = 6.47, P < 0.05$ for MVPA and VPA respectively versus the intervention condition (figure 8.0). The control condition on average provided $62.56 \pm 13.49\%$ MVPA which translated to $22.76 \pm 4.90$ minutes of lesson time. Intervention lessons displayed $49.75 \pm 11.64\%$ MVPA ($20.68 \pm 4.93$ MVPA minutes). The control lessons provided $37.09 \pm 12.27\%$ VPA ($13.49 \pm 4.46$ minutes) in comparison to the intervention which totalled $27.83 \pm 10.5\%$ ($11.92 \pm 5.02$ minutes).

For school ‘A’ there were no significant ($P > 0.05$) differences between conditions for any of the activity or contexts measured using SOFIT (table 8.1).
<table>
<thead>
<tr>
<th>Category</th>
<th>Mean ± SD</th>
<th>t</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVPA</td>
<td>40.4 ± 10.4</td>
<td>-2.11</td>
<td>.28</td>
</tr>
<tr>
<td>VPA</td>
<td>8.2 ± 6.2</td>
<td>-6.04</td>
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<tr>
<td>Management</td>
<td>22.7 ± 6.6</td>
<td>.60</td>
<td>.66</td>
</tr>
<tr>
<td>General Knowledge</td>
<td>18.9 ± 3.9</td>
<td>-.69</td>
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<tr>
<td>Physical Fitness</td>
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<td>0</td>
<td>0</td>
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<td>Fitness Activity</td>
<td>8.2 ± 4.9</td>
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<td>.52</td>
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<td>Skill Practice</td>
<td>20.3 ± 1.9</td>
<td>3.4</td>
<td>.18</td>
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<tr>
<td>Game Play</td>
<td>28.5 ± 2.9</td>
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<tr>
<td>Promotes Fitness</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Demonstrates</td>
<td>3.7 ± 1.2</td>
<td>-1.14</td>
<td>.46</td>
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<tr>
<td>Fitness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Instruction</td>
<td>58.6 ± 2.5</td>
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<td>.12</td>
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<td>Manages</td>
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<td>Observes</td>
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</table>
Figure 8.1 Mean (±SD) % MVPA and VPA between conditions (CON vs INT).

**INT MVPA > CON MVPA (t (18) = -3.89, P < 0.05).*INT VPA > CON VPA (t (18) =-3.99, P < 0.05).

A paired t test revealed that % MVPA and VPA in the INT condition were significantly higher than the CON condition (t (18) = -3.89, P < 0.05 for MVPA and t (18) =-3.99, P < 0.05 for VPA. The intervention lessons provided 58.79 ± 11.69% (22.11 ± 4.39 minutes) and 37.25 ± 10.20% (14.00 ± 3.84 minutes) for MVPA and VPA respectively (figure 8.1).

SOFIT analyses revealed that % of lesson time spent in game play was significantly (P < 0.05) higher in the intervention condition. Although non significant the SOFIT analyses revealed that % of lesson time spent in skill practice was higher in the control condition (25.5 ± 13.4%) in comparison to the intervention lesson (9.9 ± 9.1%) (table 8.2).
Table 8.2 % Mean (± SD) of SOFIT analyses by condition school ‘B’

<table>
<thead>
<tr>
<th>Category</th>
<th>Mean ± SD</th>
<th>CON</th>
<th>INT</th>
<th>t</th>
<th>Sig</th>
</tr>
</thead>
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<td>28.1 ± 4.3</td>
<td>41.8 ± 5.9</td>
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<tr>
<td>VPA</td>
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<td>11.9 ± 3.2</td>
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<td>.36</td>
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</tr>
<tr>
<td>Management</td>
<td>32.1 ± 22.8</td>
<td>22.1 ± 5.7</td>
<td>.66</td>
<td>.58</td>
<td></td>
</tr>
<tr>
<td>General Knowledge</td>
<td>28.8 ± 15.3</td>
<td>23.6 ± 7.8</td>
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<td>0</td>
<td>0</td>
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<tr>
<td>Fitness Activity</td>
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<td>.06</td>
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</tr>
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<td>Skill Practice</td>
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<td>9.9 ± 9.1</td>
<td>1.39</td>
<td>.30</td>
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<td>Game Play</td>
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<td>44.7 ± 16.9</td>
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<td>0</td>
<td>0</td>
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<tr>
<td>Promotes Fitness</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Demonstrates</td>
<td>12.4 ± 7.6</td>
<td>5.1 ± 4.4</td>
<td>1.15</td>
<td>.37</td>
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<tr>
<td>Fitness</td>
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<td></td>
</tr>
<tr>
<td>General Instruction</td>
<td>38.6 ± 6.2</td>
<td>44.4 ± 0.3</td>
<td>-1.60</td>
<td>.25</td>
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<tr>
<td>Manages</td>
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<td>11.7 ± 8.0</td>
<td>3.82</td>
<td>.06</td>
<td></td>
</tr>
<tr>
<td>Observes</td>
<td>26.9 ± 9.7</td>
<td>39.1 ± 11.1</td>
<td>-3.19</td>
<td>.08</td>
<td></td>
</tr>
<tr>
<td>Other Task</td>
<td>1.8 ± 1.6</td>
<td>0</td>
<td>8.00</td>
<td>.02*</td>
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</tbody>
</table>

Notes *P < 0.05
**INT MVPA > CON MVPA** (t (30) = -2.94, P < 0.05).

*INT VPA > CON VPA* (t (30) = -2.77, P < 0.05).

An independent t test revealed a significant difference (t (30) = -2.94, P < 0.05) in % MVPA between the conditions (47.08 ± 18.19% and 31.89 ± 9.82% for intervention and control respectively). A significant difference was also found in % VPA (INT > CON, t (30) = -2.77, P < 0.05).

At school ‘C’ the SOFIT analyses revealed a significant increase (P < 0.05) in the amount of time spent in management in the control condition compared to the intervention lesson (45.8 ± 9.4 and 31.3 ± 3.5% for control and intervention lessons respectively). Time spent in game play was higher in the
intervention condition (29.5 ± 14.3%) in comparison to the control condition (16.9 ± 21.8%).

Table 8.3 % Mean (± SD) of SOFIT analyses by condition school ‘C’

<table>
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<tr>
<th>Mean ± SD</th>
<th>CON</th>
<th>INT</th>
<th>t</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
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<td>MVPA</td>
<td>21.5 ± 5.7</td>
<td>33.9 ± 10.2</td>
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<td>.09</td>
</tr>
<tr>
<td>VPA</td>
<td>4.1 ± 5.4</td>
<td>10.9 ± 9.6</td>
<td>-1.23</td>
<td>.28</td>
</tr>
<tr>
<td>Management</td>
<td>45.8 ± 9.4</td>
<td>31.3 ± 3.5</td>
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<td>.05*</td>
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<td>General Knowledge</td>
<td>12.2 ± 4.40</td>
<td>10.4 ± 6.2</td>
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<td>Physical Fitness</td>
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<td>0</td>
</tr>
<tr>
<td>Fitness Activity</td>
<td>3.4 ± 2.8</td>
<td>2.5 ± 4.1</td>
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<td>.76</td>
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<tr>
<td>Skill Practice</td>
<td>15.9 ± 15.3</td>
<td>26.6 ± 18.8</td>
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<td>.44</td>
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<tr>
<td>Game Play</td>
<td>16.9 ± 21.8</td>
<td>29.5 ± 14.3</td>
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</tr>
<tr>
<td>Demonstrates</td>
<td>3.2 ± 2.6</td>
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<td>2.08</td>
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<td>Fitness</td>
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<tr>
<td>General Instruction</td>
<td>32.5 ± 10.6</td>
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<td>Manages</td>
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<td>26.2 ± 2.1</td>
<td>.86</td>
<td>.43</td>
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<tr>
<td>Observes</td>
<td>31.5 ± 7.2</td>
<td>23.9 ± 5.6</td>
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<td>Other Task</td>
<td>1.7 ± 2.2</td>
<td>8.9 ± 6.2</td>
<td>-2.21</td>
<td>.08</td>
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</table>

Notes *P < 0.05
Self Determination Theory

Internal Consistency

All constructs attained the set internal reliability criterion of $\alpha = 0.70$ (Nunnally and Bernstein, 1994) apart from ‘competence’ at school ‘C’ (table 8.4). Competence at baseline and intervention attained an alpha level of 0.61 and 0.59 respectively and was thus disregarded from subsequent analysis.
Table 8.4 Descriptive statistics and internal reliability for each construct of SDT pre- and post- PE lessons for each school

<table>
<thead>
<tr>
<th>Constructs of SDT</th>
<th>Alpha</th>
<th>School ‘A’</th>
<th>School ‘B’</th>
<th>School ‘C’</th>
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<td>.94</td>
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<td>2. Competence Support</td>
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<td>.89</td>
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<td>3. Relatedness Support</td>
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<td>.93</td>
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<td>.70</td>
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<td>.91</td>
<td>.94</td>
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<td>.87</td>
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<tr>
<td>8. External Regulation</td>
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<td>.92</td>
<td>.89</td>
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<td>9. Introjected Regulation</td>
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<td>.78</td>
<td>.79</td>
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<td>10. Identified Regulation</td>
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<td>.91</td>
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</tr>
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<td>13. Positive/Negative Affect</td>
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<td>.79</td>
<td>.77</td>
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<td>4. Autonomy</td>
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<td>7. Amotivation</td>
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<td>8. External Regulation</td>
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<td>13. Enjoyment</td>
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<td>.94</td>
<td>.94</td>
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</table>
School ‘A’ Multivariate Analysis of Variance

Repeated measures analysis of variance (ANOVA) revealed no significant changes in SDT constructs as a result of the intervention ($F = 0.77, P > 0.05$) (table 8.5).
Table 8.5 SDT constructs one way ANOVA for school ‘A’ pre-post intervention

<table>
<thead>
<tr>
<th>Measure</th>
<th>(I) time</th>
<th>(J) time</th>
<th>Mean Difference (I-J)</th>
<th>Sig.</th>
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</table>
School ‘B’ Multivariate Analysis of Variance

Analyses revealed no significant differences in constructs of SDT pre-post intervention (table 8.6).

Table 8.6 SDT constructs pairwise comparisons for school ‘B’ pre-post intervention

<table>
<thead>
<tr>
<th>Measure</th>
<th>(I) time</th>
<th>(J) time</th>
<th>Mean Difference (I-J)</th>
<th>Sig.</th>
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<td>.08</td>
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School ‘C’

Multivariate Analysis of Variance

At baseline pre intervention, there were no significant differences in SDT constructs \((P < 0.05)\) between groups for school ‘C’. Competence is disregarded at school ‘C’ due to its low internal consistency pre and post intervention (table 8.4). Analyses revealed a significant increase in amotivation \((p = 0.03)\) and a significant decrease in competence support \((p = 0.03)\) (table 8.7). In addition it was found that students in the control and intervention lessons pre-post displayed significant decreases in identified motivation \((P < 0.05)\).
Table 8.7 SDT constructs pairwise comparisons for School ‘C’, Pre- to Post-Intervention

<table>
<thead>
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<th>Sig</th>
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* significant at \( P < 0.05 \)
8.4 Discussion

Middle school PE lessons typically fall short of the 50% USDHH (2000) criterion (McKenzie et al. 2006; Fairclough and Stratton, 2005a; Trost, 2004; Fairclough, 2003a; McKenzie et al. 2000; Yelling et al. 2000). Student motivation during PE has been highlighted as a significant factor that can affect levels of PA and willingness to participate in PE (Standage et al. 2005). It is therefore important to study the influence of self determined behaviours on PA levels during PE to establish factors that affect students’ PE involvement (Lonsdale et al. 2009). The purpose of this study was to assess the impact of the TGfU approach on levels of self determined behaviour during PE and objectively measured PA levels.

Students in school ‘C’ displayed significantly higher levels of objectively measured MVPA and VPA (t (30) = -2.94, $P < 0.05$ MVPA and t (30) = -2.77, $P < 0.05$ for VPA) during the TGfU intervention in comparison to the control lessons. However, the observational SOFIT PA assessment did not highlight any significant differences in any of the schools used in the study. Fairclough and Stratton (2005c) have outlined that SOFIT may provide different results to objectively measured PA due to the different dimensions of activity that each methods measures i.e. RT3 = movement and SOFIT = behaviour. It has been suggested that utilising SOFIT with an objective measure (even though they are not in agreement) is still useful as it provides important lesson information.
which can help to link lesson contextual factors and PA levels together (Scruggs et al. 2005; Fairclough and Stratton, 2005c).

The higher levels of objectively measured PA were not mirrored by higher levels of self determined behaviour measured by SDT questionnaire as previous studies have found (Lonsdale, 2009). Interestingly at school ‘C’ amotivation; the least self determined form of behaviour (Ryan and Deci, 2000), had significantly increased ($P < 0.05$) and competence support had significantly decreased pre-post intervention. Practically this implies that the increase in activity levels may have had a detrimental effect on the motivation of the students. This is a similar finding to a previous study conducted by Fairclough (2003b) who found a decrease in motivation as a result of an increase in the intensity of the lesson. Fairclough (2003b) investigated PA levels, perceived competence and enjoyment during high school PE. Seventy three students (mean age 13.1 years old) took part in the study from 5 high schools. It was found that students with high MVPA scores enjoyed PE significantly less than the students with the low MVPA scores. This suggests that when students are ‘pushed hard’ that they may not enjoy PE (Fairclough, 2003b). It is important to remember that this study was conducted on high school students whereas the students in the present study attended middle school (aged 11-12 years old).
Students at school 'C' participated in hockey. The type of activity undertaken can influence motivation as girls and boys tend to favour different activities, with girls favouring individual activities such as dance and gymnastics (Fairclough and Stratton, 2005c). Fairclough (2003b) found that girls demonstrated a negative correlation between MVPA and enjoyment suggesting that as MVPA increased, enjoyment levels decreased. It was also found that girls displayed greater levels of enjoyment during individual activities in comparison to games activities which was mirrored by a 22.9% decrease in the time spent in MVPA during individual activities (Fairclough, 2003b). In addition, serious behavioural issues were observed at school 'C' throughout the duration of the intervention lessons with senior members of staff present to supervise behaviour. SOFIT analyses revealed a significant ($P < 0.05$) increase in management time during the control lessons as a result of these behavioural issues. This resulted in three children being removed from the class in addition to children being told to run laps of the pitch as 'punishment'. This in itself may have been detrimental to the motivation of the students that behaved during the lesson but ironically may have impacted positively upon the children’s levels of MVPA. Therefore the significant ($P < 0.05$) increases displayed in MVPA may have been even higher than might have been expected during the intervention lessons.

MVPA and VPA levels were significantly higher in the intervention lessons at school 'B' ($t (18) = -3.89$, $P < 0.05$ for MVPA and $t (18) = -3.99$, $P < 0.05$ for
VPA). SOFIT analyses revealed a significantly higher ($P < 0.05$) amount of time spent in game play during the intervention lesson. This was expected as TGfU lessons utilise a conditioned game to practise skills (Mitchell et al. 2006). This finding was in line with previous research that has found that game situations produce significantly higher levels of MVPA in comparison to skill play (Van Acker et al. 2010; Yelling et al. 2000). No significant changes in self determined behaviour were found from baseline to post intervention. This is a positive outcome from the study as it shows that children were engaged in significantly ($P < 0.05$) more MVPA and VPA but that this increase in activity had no detrimental effect on motivation as Fairclough (2003b) had previously reported. This finding suggests that using the TGfU model may create a more self determined environment. Previous literature (Lonsdale et al. 2009) has shown that creating a more self determined environment can significantly increase PA levels. It may be in this study that the time period may have been too short to observe changes in self determined behaviour as a result of the intervention. Armitage (2005) concluded that it takes 5 weeks to change exercise behaviours, however, it is important to note that this research was conducted on adults and their gym attendance. The students at school ‘B’ were only subjected to the intervention for three weeks because this study was intended to be preliminary studies to assess the impact of TGfU.
A surprising result occurred within school ‘A’. The control sessions elicited significantly ($P < 0.05$) higher levels of MVPA and VPA in comparison to the intervention condition. This was reflected by a large amount of time spent in game play in both the control (28.5 ± 2.9%) and TGfU lessons (29.4 ± 4.9%) as observed using SOFIT. It has previously been shown that game play situations are more active than skill based activity (Yelling et al. 2000) and it was expected that given that TGfU is more games focused that PA levels would be increased. However, as McKenzie et al. (2004) explain the teacher can take time to adjust to implementing new teaching methods. School ‘A’ data showed no significant changes in self determined behaviour as a result of the intervention. This could be due to several factors. Firstly the study at school ‘A’ was the shortest of the three studies due to teacher illness and school closure (due to severe weather conditions) and was therefore reduced to 4 weeks (4 lessons) and consequently only two of the lessons were taught using TGfU. Interventions normally produce cumulative effects (McKenzie et al. 2004) and it has been highlighted that it can take time for teachers to become comfortable with a new ‘style’ of teaching. Therefore the amount of time the intervention is implemented for is a very important factor (McKenzie et al. 2004; Jago et al. 2009).

A positive outcome of the intervention was the amount of potentially health enhancing VPA activity (Armstrong and Welsman, 1997) that students in the TGfU session at school ‘B’ and school ‘C’ accumulated. Overall objectively
measured VPA during the intervention lessons totalled 14.00 ± 3.84 and
10.67 ± 6.13 minutes at school B and C respectively, which is over a third of
the weekly recommendation to enhance cardiorespiratory fitness (Armstrong
and Welsman, 1997). These were significantly higher ($P < 0.05$) than the
control lessons at each school by 3.4 and 6.4 minutes for school B and C
respectively. This result was very promising considering TGfU takes into
account the wider educational focus of PE. Some previous studies have been
specifically designed to intensify health enhancing PA and have not
considered the wider learning objectives of PE (Baquet et al. 2002).

Although this study was a preliminary investigation into the effect of TGfU on
self determined motivation and MVPA levels it is important to recognise
limitations and delimitations of the present study. Firstly the short intervention
period reflects upon the longevity of the findings and the question still remains
whether longer intervention periods would produce significant changes in
determinants of SDT. Only three schools with children aged 11-12 years old
were recruited in this study meaning that it is not possible to generalise the
findings to the population.

8.5 Conclusion

In conclusion this is the first study that has researched the potential of TGfU
to increase PA using objective measures whilst examining any changes in
self determined motivation. The study showed the positive impact of the TGfU intervention in promoting activity levels within the PE lesson. Although no significant changes were found in self determined behaviour it may be that the intervention needs to be undertaken for longer in order to display these effects. Creating a self determined environment may be an effective way of promoting PA within PE lessons and encouraging students to engage in self determined PA behaviours and intentions to be physically active outside of PE (Hagger et al. 2009; Hagger, 2001;). In particular it has been demonstrated that constructs of SDT can influence intentions directly through the TPB (Hagger et al. 2009). Future research needs to investigate the effect of the TGfU intervention over a longer duration in PE lessons and examine if any changes in self determined behaviour during PE result in PA promotion outside of the lesson.
9.0 Study Map

Summary of findings and objectives

<table>
<thead>
<tr>
<th>Study</th>
<th>Objectives and Key Findings</th>
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| Study 1: Reliability and validity of several physical activity monitors to assess physical activity in school children. | Objectives:  
• To identify the re-test reliability of the following physical activity methods; RT3 Triaxial accelerometers, Bodymedia armband, and Actileert.  
• To assess the validity of the physical activity monitors by comparison with oxygen consumption measure (Metalyser 3B) during standardised bouts of exercise.  

Key findings:  
• The RT3 ® triaxial accelerometer was found to be the most valid and reliable physical activity monitor for use in school children aged 11-12 years old. |
| Study 2: Physical activity levels during middle school physical education. | Objectives:  
• To accurately quantify physical activity levels during middle school physical education lessons in the Bedfordshire area, to establish if current recommendations i.e. 50% of lesson time in activity of at least a moderate intensity, are met.  

Key findings:  
• On average during PE lessons students spent 44.9 ± 5.6 % of the PE lesson engaged in MVPA which translated to 16.4 ± 2.3 minutes which fell short of the USDHH (2000) 50 % (20 minute) target. |
Study 3: Does physical education significantly contribute to the recommended 60 minutes moderate-vigorous physical activity per day?

Objectives:
- To quantify activity levels during PE and quantify the contribution PE to the recommended 60 minutes MVPA per day in English middle school children.

Key Findings
- PE lessons fell short of the 50% (20 minute) criterion (USDHH, 2000).
- Children in the study achieved the daily recommendation of 60 minutes MVPA per day (DoH, 2004) during weekday activity; however, at the weekend it was shown that children did not achieve the daily recommendation.
- PE was also found to be of importance in terms of the unique contribution it makes to levels of VPA which potentially increases cardio respiratory fitness.
- This study highlighted the need to focus on an intervention or approach to maximise the contribution of PE to the recommended target of MVPA per day.

Study 4: Pilot Study to Assess the Influence of a TGfU Approach on Physical Activity Levels Monitored During Physical Education Lessons

Objectives:
- Assess the impact of a ‘Teaching Games for Understanding’ approach on objectively assessed MVPA levels.

Key Findings
- This pilot study highlighted the potential for the TGfU intervention to increase PA levels above the 50% criterion (USDHH, 2000) without comprising lesson objectives set within the national curriculum.
- Importantly the study also indicated that the 50% criterion is an achievable target in the aim for PE lessons to significantly contribute to the daily PA levels.
9.1 Introduction

The general consensus surrounding activity levels during PE is that lessons fall short of the USDHH (2000) criterion that, 50% of the lesson should be spent in activity of at least a moderate intensity (McKenzie et al. 2006; Fairclough and Stratton, 2005b; Fairclough, 2003a; McKenzie et al. 2000). This was also reinforced in chapter 5 of this thesis which demonstrated that on average PE lessons in the Bedfordshire area fell short of the USDHH (2000) target. Cale and Harris (2005) suggest that the limited curriculum time allocated to PE classes compared to higher priority subjects such as mathematics, science and English make it difficult for physical educators to
provide adequate time for students to achieve high levels of MVPA during PE. Intervention studies have been shown to typically increase MVPA during PE by 18% (McKenzie and Lounsbery, 2008) and exceed the 50% target suggesting that the USDHH (2000) target is achievable. It has long been accepted and agreed that one of PE’s primary aims is the promotion of lifelong physically active lifestyles (Bailey et al. 2009). It is therefore relevant to examine how pedagogical strategies, and in particular the use of instructional models, in PE, can influence PA levels within the context of planned learning objectives.

Joyce and Weil (1980) define an instructional model as ‘a plan or pattern that can be used to shape curriculums (long term courses of studies), to design instructional materials, and to guide instruction in the classroom and other settings’ (p. 1). Metzler (2001) outlines seven instructional models that are used within the curriculum: direct instruction, personalised system, cooperative learning, sport education, peer teaching, inquiry teaching and the tactical games model. Blomqvist et al. (2001) state that ‘traditional’ teaching approaches in PE have been characterised by ‘direct instruction, and a lesson format divided into an introductory activity, a skills phase focusing on developing and improving skill technique and a game’ (p. 140). Bunker and Thorpe (1986) highlighted that most students obtain little game understanding during PE lessons taught using traditional approaches and as a result possess inflexible techniques and poor decision making skills. This was
reinforced recently by the identification of students across the PE curriculum having problems linking skill drills used in traditional teaching approaches to game situations, and is thought to be a consequence of poor game understanding (Mitchell, Oslin and Griffin, 2006). TGfU is a sequential curriculum model developed to aid the teaching of games activities in a tactical context during PE (Bunker and Thorpe, 1986). As Metzler (2000) explains TGfU is an instructional model used to develop learners’ capabilities to play games. Limitations are placed on a game situation in order to teach skills and recognise when skills should be used in a games. Unlike traditional teaching methods, TGfU starts with a game and set boundaries which set the scene for tactical awareness and decision making. This game situation is subject to additional modification (conditioned games) (Bunker and Thorpe, 1986).

The type of PE activity may also influence class-time PA levels. Students are typically more active during games activities than individual activities (McKenzie et al. 2006; Fairclough and Stratton, 2005c; Fairclough and Stratton, 2006a), and skill based lesson time is associated with less PA than games based lesson time (Yelling et al. 2000). It is therefore proposed that a tactical games based approach to learning skills, which utilizes a small group approach and is focused on process rather than outcome goals, may increase PA levels during PE. It is anticipated that such an approach would not compromise overall lesson objectives or discriminate against lower skilled
students (Allison and Thorpe, 1997). Research into the influence of PE curriculum models on PA has been limited in this context, focusing mainly on effectiveness, in terms of implementation and student affect, rather than PA promotion (Allison and Thorpe, 1997; Brooker et al. 2000; Butler, 2005; Wright et al. 2005). In addition, most of these studies have shown a lack of control and external validity (e.g. students self selecting activities, small sample sizes). Therefore, it was recommended that the effect of different curriculum models on MVPA levels be investigated more robustly (Yelling et al. 2000; Hastie and Trost, 2002).

Student motivation during PE is a significant factor that can affect PA levels and willingness to participate in PE and activity outside PE (Standage et al. 2005) and the application of SDT has been investigated in this context. More specifically, the effect of self determined behaviour on experiences in PE and how this potentially translates into continued participation in PA outside of PE has been investigated (Taylor and Ntoumanis, 2007; Standage et al. 2005; Wallhead and Ntoumanis, 2004; Ntoumanis, 2001). SDT is based upon three innate psychological needs; ‘competence, autonomy and relatedness which when satisfied yield enhanced self motivation and mental health’ (Ryan and Deci, 2000, p. 68). If the three innate needs are satisfied, the individual becomes self determined and this positively impacts upon intrinsic motivation (Ryan and Deci, 2000). Intrinsic motivation has been described as the principal source of an individual’s ability to make life enjoyable and continue
vitality throughout life (Ryan and Deci, 2000). If the three innate needs of SDT are unfulfilled, students become extrinsically motivated, and they then tend to show less interest in the activity and ultimately put in less effort towards achieving (Ryan and Deci, 2000). Ryan and Deci (2000) outline that intrinsic motivation is also affected by the environment created. The PE environment may be manipulated by using different curriculum models. Standage et al. (2005) found that when students perceived the PE environment to support autonomy, competence and relatedness, their overall need satisfaction was consequently higher. Thus, when a self-determining environment is created, students’ intrinsic motivation and satisfaction may be enhanced, thus predicting greater overall participation and effort during PE (Standage et al. 2005).

If lessons are only taught in a traditional technical manner, learners may lose intrinsic experiences (Butler, 2006). Employing the TGfU curriculum model within the PE setting has been shown to enhance enjoyment and deliver intrinsic values (Butler, 2006). Classrooms that students perceive to be more autonomy supportive lead to enhanced self determined behaviour (Reeve, 2002). Reeve and Jang (2006) investigated what teachers say and do to support autonomy which can ultimately lead to an increase in intrinsic motivation. Reeve and Jang (2006) found that teachers behaviours such as listening, giving student the opportunities to talk, praising signs of improvement and encouraging student effort were all positively correlated
with significant in autonomous motivation. TGfU has been recognised as allowing teachers more time to offer praise and encouraging signs of improvement (Butler, 2006). In addition TGfU asks leading questions which incorporate progress enabling hints and encourages students to form a discussion (Butler, 2006). These specific components of TGfU are all factors that Reeve and Jang (2006) highlight as autonomy supportive behaviours which have been found to impact positively on components of intrinsic motivation. These intrinsic values promoted by self determined behaviour have also been shown to impact positively on intentions to be physically active outside of school through Ajzen’s (1985) TPB (Hagger et al. 2009).

Chatzisarantis and Hagger (2005) outline that ‘PA behaviour and intentions can be modified by attitudes, subjective norms or perceptions of control and/or a combination of these three variables’ (p. 471). Intentions in relation to being physically active are based upon how the individual views the activity (attitude), if significant others around them exert social pressure (subjective norm) and if the individual believes they will be successful (perceived behavioural control) (Armitage, 2005). Most of the research surrounding the TPB and PA intentions has been focused upon adults with very few studies involving children (Hagger et al. 2001).

Hagger et al. (2001) investigated the antecedents of children’s PA intentions and behaviours. Hagger et al. (2001) outlined that children’s determinants of
PA are different in comparison to adults and therefore the study aimed to test the validity of the determinants of behaviour in children. The study was split into two parts. In study one 431 children aged 12-14 years were recruited and completed the TPB questionnaire followed by a PA recall questionnaire a week later. In study two 154 children aged 12-14 years completed the TPB questionnaire and were reassessed five weeks later. Interestingly in study 1 it was found that subjective norms made no contribution to PA intentions which suggests that children appear to make their own choices and decisions regarding PA (Hagger et al. 2001). In study 2 it was found that children’s immediate attitudes influence their decision to participate in PA rather than attitudes from a previous time point. Previous attitudes and behaviour do exert an influence but this is not as great as the direct impact of current attitudes (Hagger et al. 2001). Hagger et al. (2001) suggest, in light of their findings, that interventions should focus on attitudes to enhance PA. However, it should be noted that Martin et al. (2005) found that subjective norms and perceived behavioural control significantly predicted intentions. Interestingly Hagger et al. (2001) conclude that children tend to perform activities based upon enjoyment and other intrinsic factors that the TPB theory does not measure. This suggests that the TPB is limited in this context and that other factors may need to be incorporated.

Hagger et al. (2002) investigated how constructs of SDT affect intentions to be physically active. As previously mentioned the TPB has been shown to be
highly influenced by attitude (Hagger et al. 2001) and ultimately may be
influenced by enjoyment and intrinsic motives. SDT incorporates these factors
and may be used to explain why intentions are formed based upon general
motives from SDT. Children (n=1088) aged 12-14 years were recruited into
the study. The TPB and SDT questionnaire were completed by each student.
It was found that attitude and perceived behavioural control exerted a
significant influence upon intentions to be physically active. In line with results
from Hagger et al. (2001) subjective norms exerted no significant influence
upon intentions. Intrinsic motives from SDT theory were found to be a strong
predictor of attitude, subjective norms and perceived behavioural control. The
results of the study show a chain of influence and links between constructs of
SDT and the TPB ‘commencing with general motives to engage in PA
(intrinsic motives), filtered by specific expectations (attitudes) and ending with
behavioural intentions’ (Hagger et al. 2002, p. 294). The results also indicate
that when perceived behavioural control mediates intrinsic motives this
ultimately affects intentions through the relationship between competence
and relatedness. In practical terms this means that when children perceive
that they have a high level of control over the PA they participate in, they will
have a high estimate of competence, implying that perceived behavioural
control is necessary to positively influence children’s PA intentions. Hagger et
al. (2002) concluded by explaining that competence (through SDT) is the key
area for intervention as this will directly impact on intentions.
TGfU has been highlighted to impact directly on constructs of SDT (Mandigo et al. 2008) therefore TGfU may influence PA intentions through the key area of competence within SDT. Hagger et al. (2009) provided more evidence for the link between constructs of SDT particularly autonomy supportive environments created by the PE teacher. The study entitled ‘Teacher, peer and parent autonomy support in PE and leisure time PA’ found support for the Trans – Contextual model (Hagger et al. 2009) which incorporates the TPB, SDT and the hierarchical model of motivation. It was found that PE teachers who created perceptions of autonomy support for students had a positive impact on the level of autonomous leisure time and also on attitudes and intentions to carry out the desired behaviour (Hagger et al. 2009). More specifically Hagger et al. (2009) found that autonomous motivation in leisure time was significantly (P < 0.05) related to autonomous motivation during PE. Hagger et al. (2009) highlight the importance of this finding for the PE curriculum and the promotion of PA outside of school and, in particular, the transference of motivation from one context to another.

Mandigo et al. (2008) point out that there has been no structured intervention to investigate the impact of using autonomy supportive games (in particular TGfU) on motivational levels. Mandigo et al. (2008, p. 420) also highlight the lack of such interventions investigating possible differences associated with sex and in motivation across different games categories and as such suggest
that ‘a richer understanding of the root causes of these differences (gender, activity) is still needed’.

Limited research is available examining the potential of the TGfU model to enhance students’ PE PA, enjoyment, and intrinsic motivation levels (Mandigo et al. 2008). No study to date has investigated either the effects of the TGfU approach on children’s immediate PA levels or their intentions to be physically active in leisure time. In an attempt to enhance the evidence base in this area, this study aimed to assess the impact of a TGfU approach on (a) objectively assessed student PA levels during PE lessons, (b) students’ self-determination (c) children’s intentions to be physically active outside of school and (d) objectively measured habitual activity levels.

9.2 Methods

Participants

This study was conducted in two co-educational state middle schools in Bedfordshire, England. Schools were matched as closely as possible in terms of socio-economic status to the national average. Socio economic status of the two schools, as represented by FSM eligibility was similar (9% and 12% FSM) and close to the national average of 12.1% (DfES, 2005). Comparable numbers of students (597 and 675) were currently enrolled at each school. Ethnicity at each school was also broadly matched. Ethnicity of students at
school one was as follows; 72.7% white, 3.4% black origin, 3.9% Indian, 1.5% Pakistani, 9.7% other minority ethnic group. School two had an ethnic background of 84.6% white, 3.6% black origin, 4% Indian, 0.4% Pakistani, 7% other minority ethnic group. Classes from the schools were randomly selected from the Year seven age group. All research procedures received approval from the University Research Committee, head teachers and PE teachers from the schools involved. Informed consent was obtained from parents of the children involved in the study prior to data collection.

**Organisation of Classes**

A total of 4 classes participated in the study; two ‘all girl’ classes in school D (n = 31), and two ‘all boys’ classes in school E (n = 51). At each school one class was randomly selected to be taught using the pedagogical intervention of TGfU and one class selected for the ‘traditional’ teaching approach (control) (school D ‘all girls’ n = 17 CON, n = 13 INT, school E ‘all boys’ n = 19 CON, n = 23 INT).

Prior to data collection, a meeting was held with the teachers selected to plan lessons using the TGfU approach (see methodology 3.5.2). Both intervention teachers had experience of the concepts surrounding TGfU and had attended a University based TGfU training course (see methodology 3.5.1). Teachers were not aware, however, of the specific aims of the study.
Two female teachers were recruited in school D, one to teach the control class and one to teach the intervention class. Similarly, at school E, two male teachers were recruited to teach the control and intervention classes. Different teachers taught the control and intervention classes to avoid contamination of the data (i.e. aspects of TGfU filtering into the control sessions). The TGfU lessons were assessed using the observational tool SOFIT to ensure that the lessons followed the correct TGfU structure outlined by Metzler (2000) i.e. conditioned game, skill practice, question and answer and back into a conditioned game. Lesson plans for the TGfU sessions were obtained for both school ‘D’ and school ‘E’ (appendix D and E respectively). In addition teacher assessments (student attainment levels) were also obtained pre-post intervention to ensure that learning objectives were achieved and skills developed regardless to condition i.e. that TGfU was not detrimental to skill development. The weekly control and intervention sessions ran in parallel at each school with lesson objectives being matched within and between schools. Observations took place over a twelve week period, involving one lesson per week for each class, and two different activities (2 x 6 week blocks). The activities were netball (activity 1) and football (activity 2) for girls and rugby (activity 1) and football (activity 2) for boys. Male and female teachers taught the same units of work and lesson objectives but adapted their delivery according to whether the session was traditional (control) or used the TGfU approach. In addition to this all children recruited to the study wore RT3 ® triaxial accelerometers for one week at baseline.
(prior to any TGfU intervention in the PE lesson) and one week post intervention.

**Measures and Procedures**

**RT3 ® Triaxial Accelerometry – Physical Education Lessons**

PA levels during each lesson were measured using RT3 ® triaxial accelerometers (methodology 3.2.1). Lesson start and end time was recorded for each lesson so that the RT3 ® triaxial accelerometer data could be cut to these particular times for each lesson. The children were asked to clip the RT3 ® triaxial accelerometer onto their waistband in the changing rooms prior to each PE lesson. See methodology 3.2.2.

**System for Observing Fitness Instruction Time (SOFIT) – Physical Education Lessons**

The observational tool SOFIT was used in all PE lessons to assess lesson contextual information. All researchers were trained to use the SOFIT protocol based on the McKenzie and Sallis (1991) guidelines. SOFIT was conducted as outlined in methodology section 3.3.1.

**Teacher Assessment**
Attainment targets pre and post intervention were obtained from the teacher to ensure the students developed their skill during both the control and TGfU lessons. This also ensured that TGfU was not detrimental to lower skilled students and all students progressed regardless of which condition they were assigned to.

**RT3 ® Triaxial Accelerometry – 7 Day Habitual Activity**

Children were issued with an RT3 ® triaxial accelerometer and a seven day diary (see methodology 3.3.2) on seven day habitual monitoring weeks. A familiarisation session was held to ensure the children wore the equipment correctly and to reinforce the fact that the RT3 ® triaxial accelerometer was not allowed in contact with water and to provide explanations regarding how to complete the diary. RT3 ® triaxial accelerometers and diaries were taken into participating schools by the researcher during break times for the children to collect and return during testing weeks. The researcher also enforced the no contact with water policy when distributing the equipment. One minute epochs were used based on RT3 ® triaxial accelerometry memory for seven day collection of data (see methodology 3.2.3).

**Self Determination Assessment**

Self determination in PE was assessed pre and post intervention using the questionnaire developed by Standage et al (2005). Alpha coefficients were shown to range between 0.80 and 0.96 (Standage et al. 2005) and were
based on the 0.70 alpha criterions set (Nunnally and Bernstein, 1994). Self
determination was assessed by measuring 12 variables on a Likert scale
ranging from 1 = strongly disagree to 7 = strongly agree (see methodology
section 3.6).

The Theory of Planned Behaviour Assessment
The TPB assessment questions were developed from Conner and Norman
(2005). TPB was assessed by measuring 4 variables on a Likert scale
ranging from 1 = strongly disagree to 7 = strongly agree (see methodology
3.7).
Data Analyses

System for Observing Fitness Instruction Time – Physical Education Lessons

SOFIT was analysed using the methods outlined in the McKenzie and Sallis (1991) SOFIT training manual (see methodology 3.4.1). Independent sample t tests were employed to establish any significant differences between conditions in lesson contexts for girls and boys.

Teacher Assessments

Teacher assessments were analysed using a Likert scale procedure. Attainment levels ranged from 3-5. Each level had three stages i.e. 3a = can do all of the skills in this level, 3b = can do many of the skills in this level and 3c = can do some of the skills in this level. Therefore there were 9 levels in total i.e. 3c, 3b, 3a, 4c, 4b, 4a, 5c, 5b, 5a. These levels were then converted to a Likert Scale from 1-9 i.e. 1 = 3c and 9 = 5a. The data was split by gender, activity and condition and paired sample t tests were run to ensure attainment levels had significantly increased pre-post intervention.

RT3 ® Triaxial Accelerometry – Physical Education Lessons

RT3 ® triaxial accelerometer data for each child was downloaded after each lesson. RT3 ® triaxial accelerometer data that did not contain any data were excluded from the study i.e. if the child had forgotten to put the device on. Percentage time spent in MVPA overall for boys versus girls, and percentage
time according to condition and activity type was calculated. A repeated measures ANOVA was employed to assess sex differences in PA levels across the two conditions (control vs. intervention). Procedures for checking violations of assumptions were conducted and all assumptions were met.

**Comparative Analyses - RT3 ® Triaxial Accelerometry and System for Observing Fitness Instruction Time**

Levels of agreement between SOFIT and RT3 ® triaxial accelerometry MVPA across the PE lessons were assessed using Bland and Altman (1986) statistical measures of agreement. Regression analyses namely Pearson and Spearman rho were used to establish the relationship between the MVPA calculated from accelerometry and SOFIT methods. The Bland and Altman analysis incorporates a calculation of mean bias (mean of differences between the modalities) and limits of agreement (± 2 SD from the mean bias).

**RT3 ® Triaxial Accelerometry – Seven Day Habitual Activity**

A 2 (time; pre and post) x 2 (condition; control and intervention) between groups one way ANOVA was employed to assess any differences in time spent in MVPA from the seven day habitual PA monitoring separately for girls and boys. This analysis was carried out for weekdays and weekend days. All assumptions for the seven day habitual activity were met.
Self Determination Theory
Cronbach’s alpha levels were calculated for all scales to assess internal reliability of the questionnaire. Cronbach’s alpha levels greater than 0.70 were classed as acceptable (Kline, 1998).

A sex x time x condition repeated measures MANOVA was employed to assess any differences in self determination between groups. Although the data initially violated the assumptions necessary to perform a MANOVA, the robustness of the MANOVA was preserved once significant univariate (± 2.5 standard deviations, Field, 2009) and multivariate outliers (Mahalonobis distance, Tabachnick and Fidell, 2007) were removed.

The Theory of Planned Behaviour
Internal reliability of scales were calculated using Cronbach’s alpha levels. Cronbach’s alpha levels greater than 0.70 were classed as acceptable (Kline, 1998). Prior to statistical analysis normality tests of the data were conducted. Grimm and Yarnold (2003) explain that an additional assumption must be met when conducting the repeated measures MANOVA, namely sphericity. The normal assumption in MANOVA of independence is not required for repeated measures MANOVA design (Hair, Anderson, Tatham and Black, 1998). The data should be randomly sampled and based on interval data (Field, 2009). The data should display normality (Field, 2009). Field (2009) also states the final assumption of MANOVA as homogeneity of covariance matrices. The
univariate assumption was met by the Levene’s test that is the ‘variances in each group are roughly equal’ (Field, 2009, p. 603).

In MANOVA it needs to be assumed that the univariate assumption is true for each dependent variable but ‘also that the correlation between any two dependent variables is the same in all groups’ (Field, 2009, p. 603). The above assumptions are not met and there is a presence of outliers. Tabachnick & Fidell (2007, p. 330) state that ‘one of the more serious limitations of MANOVA is its sensitivity to outliers, especially worrying is that an outlier can produce a type I or a type II error’. In addition, ‘it is highly recommended that a test for outliers accompany any use of MANOVA’ (Tabachnick and Fidell, 2007, p.330). Univariate and multivariate outliers must be screened for and either transformed or removed (Tabachnick and Fidell, 2007).

Univariate outliers in the analysis were screened for by calculating z scores in SPSS for each dependent variable and using a ‘cut off’ point of ± 2.5 standard deviations based on sample size (Tabachnick and Fidell, 2007). Subsequently, 18 univariate outliers were removed from the analysis. Multivariate outliers were removed using Mahalanobis distance (Tabachnick and Fidell, 2007). Mahalonobis distance is a multidimensional version of a z score. It measures the distance from the multidimensional mean of a distribution. A chi square value is calculated based on the number of
variables included in the calculation (Tabachnick and Fidell, 2007). If the case displays a value of 0.001 or less the case is considered to be a multivariate outlier and needs to be removed. No multivariate outliers were present in this data.

A repeated measures mixed design multivariate ANOVA was employed to assess any differences in the TPB variables according to sex, time (pre and post) and condition. A one way ANOVA was employed to assess any differences in condition between boys and girls. Version 17.0 of SPSS (SPSS Inc, Chicago, IL) was used for all statistical analyses.

9.3 Results

9.3.1 Analysis 1 – Physical Education Lessons

General

Forty eight lessons were observed in total over a 12 week period, 24 lessons at each school (school D - 12 lessons control, 12 lessons intervention, school E - 12 lessons control, 12 lesson intervention), taught by 4 PE specialists (2 men, 2 women). Lesson length in school D was 36.06 ± 2.17 minutes versus 38.23 ± 1.84 minutes for control and intervention lessons respectively. In school E lesson length was 36.27 ± 2.87 minutes versus 36.38 ± 1.66 minutes for control and intervention lessons respectively. All lessons took place outdoors.
Student Physical Activity Levels

A total of 82 students from the two classes at each school were recruited into the study (n = 31 girls and n = 51 boys); age range 11-12 years old (girls mean = 11.4, SD = 0.5, boys mean = 11.22, SD = 0.4). Table 9.0 displays the descriptive statistics for mean percentage of time spent in MVPA for boys and girls and according to condition.

Table 9.0 Overall % MVPA (Mean ± SD) according to condition, gender and activity

<table>
<thead>
<tr>
<th></th>
<th>% MVPA (Mean ± SD)</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls ACT1</td>
<td>CON Netball</td>
<td>46.21 ± 4.39</td>
<td>18.35</td>
</tr>
<tr>
<td></td>
<td>INT Netball</td>
<td>39.59 ± 3.94</td>
<td></td>
</tr>
<tr>
<td>ACT2</td>
<td>CON Football</td>
<td>50.87 ± 5.77</td>
<td>1.520</td>
</tr>
<tr>
<td></td>
<td>INT Football</td>
<td>53.9 ± 7.72</td>
<td></td>
</tr>
<tr>
<td>Boys ACT1</td>
<td>CON Rugby</td>
<td>41.24 ± 7.24</td>
<td>47.14</td>
</tr>
<tr>
<td></td>
<td>INT Rugby</td>
<td>54.78 ± 4.45</td>
<td></td>
</tr>
<tr>
<td>ACT2</td>
<td>CON Football +</td>
<td>59.31 ± 6.95</td>
<td>10.35</td>
</tr>
<tr>
<td></td>
<td>68.72 ± 6.85</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Significant differences between % time of lesson spent in MVPA by activity and condition * P < 0.01, **P < 0.001

Girls’ MVPA during the control sessions for activity 1 was significantly (F = 18.35, P < 0.001, d = 1.59) greater than during activity 1 in the intervention session (table 9.0, figure 9.0), but there was no difference between activity 2
and control ($P = .228, d = 0.44$) (figure 9.0). There were more consistent results for boys. During activity 1, boys in the intervention session displayed significantly ($F = 47.14, P < 0.001, d = 2.25$) higher levels of MVPA in comparison to the control group. Similar results were found in activity 2 with the intervention group displaying significantly ($F = 10.35, P < 0.01, d = 1.36$) higher MVPA levels than the control group (figure 9.0). The largest effect sizes were displayed during MVPA in activity 1 for both boys (intervention versus control, $d = 2.25$) and girls (control versus intervention, $d = 1.59$).

<table>
<thead>
<tr>
<th>Activity</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rugby</td>
<td>INT</td>
<td>CON</td>
</tr>
<tr>
<td>Football</td>
<td>INT</td>
<td>CON</td>
</tr>
<tr>
<td>Netball</td>
<td>CON</td>
<td>INT</td>
</tr>
</tbody>
</table>

Figure 9.0 Mean (± SD) MVPA of each activity for boys and girls in control and intervention sessions. *MVPA Boys INT Rugby > than boys CON Rugby ($P < 0.01$). *MVPA Boys INT Football > than boys CON Football ($P < 0.01$). *MVPA Girls CON Netball > than girls INT Netball ($P < 0.01$).
System for Observing Fitness Instruction Time Analyses

Table 9.1 and table 9.2 represent the average percentages of lesson time spent in MVPA and VPA and in different lesson contexts for girls and boys respectively over the 12 week study. SOFIT showed significantly higher levels of MVPA on average for boys in the intervention lesson ($P < 0.01$) in comparison to activity in the control condition (table 9.2). Management, gameplay and observations were significantly ($P < 0.05$) higher in the intervention lessons (Table 9.2). In addition it was found that demonstration of fitness, skill play and general knowledge were significantly higher ($P < 0.05$) in the control lesson for boys. During the girls lessons SOFIT highlighted that there were significantly ($P < 0.05$) higher levels of management and fitness activity in the control lesson (Table 9.1). In addition general knowledge time was significantly ($P < 0.05$) higher in the intervention lessons.
Table 9.1 % Mean (± SD) of girls SOFIT analyses by condition

<table>
<thead>
<tr>
<th></th>
<th>CON</th>
<th>INT</th>
<th>t</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVPA</td>
<td>39.8 ± 15.7</td>
<td>44.9 ± 16.2</td>
<td>-1.04</td>
<td>.32</td>
</tr>
<tr>
<td>VPA</td>
<td>13.5 ± 9.0</td>
<td>18.5 ± 6.5</td>
<td>-1.24</td>
<td>.24</td>
</tr>
<tr>
<td>Management</td>
<td>20.0 ± 7.2</td>
<td>13.6 ± 5.3</td>
<td>4.27</td>
<td>.00**</td>
</tr>
<tr>
<td>General Knowledge</td>
<td>19.5 ± 6.7</td>
<td>28.7 ± 12.2</td>
<td>-2.50</td>
<td>.02*</td>
</tr>
<tr>
<td>Physical Fitness</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fitness Activity</td>
<td>8.9 ± 3.7</td>
<td>4.3 ± 2.5</td>
<td>4.05</td>
<td>.00**</td>
</tr>
<tr>
<td>Skill Practice</td>
<td>17.6 ± 7.5</td>
<td>15.3 ± 5.5</td>
<td>1.44</td>
<td>.17</td>
</tr>
<tr>
<td>Game Play</td>
<td>24.0 ± 10.6</td>
<td>27.1 ± 10.6</td>
<td>-1.20</td>
<td>.25</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Promotes Fitness</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Demonstrates</td>
<td>7.6 ±3.3</td>
<td>7.7 ± 3.6</td>
<td>.08</td>
<td>.94</td>
</tr>
<tr>
<td>Fitness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Instruction</td>
<td>32.6 ± 17.3</td>
<td>38.3 ± 14.2</td>
<td>-.33</td>
<td>.74</td>
</tr>
<tr>
<td>Manages</td>
<td>21.1 ± 8.4</td>
<td>9.6 ± 3.4</td>
<td>7.00</td>
<td>.00**</td>
</tr>
<tr>
<td>Observes</td>
<td>31.1 ± 21.4</td>
<td>34.9 ± 13.4</td>
<td>-.67</td>
<td>.52</td>
</tr>
<tr>
<td>Other Task</td>
<td>1.6 ± 2.2</td>
<td>1.36 ± 3.1</td>
<td>.01</td>
<td>.99</td>
</tr>
</tbody>
</table>

Notes * P < 0.05 **P < 0.01
Table 9.2 % Mean (± SD) of boys SOFIT analyses by condition

<table>
<thead>
<tr>
<th></th>
<th>CON</th>
<th>INT</th>
<th>t</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVPA</td>
<td>34.1 ± 16.4</td>
<td>50.4 ± 15.6</td>
<td>-3.32</td>
<td>.00**</td>
</tr>
<tr>
<td>VPA</td>
<td>16.8 ± 8.6</td>
<td>19.8 ± 7.4</td>
<td>-0.92</td>
<td>.37</td>
</tr>
<tr>
<td>Management</td>
<td>11.9 ± 4.3</td>
<td>16.1 ± 5.7</td>
<td>-2.82</td>
<td>.01**</td>
</tr>
<tr>
<td>General Knowledge</td>
<td>31.6 ± 13.1</td>
<td>18.8 ± 7.7</td>
<td>2.61</td>
<td>.02*</td>
</tr>
<tr>
<td>Physical Fitness</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fitness Activity</td>
<td>3.5 ± 1.3</td>
<td>2.6 ± 2.5</td>
<td>0.97</td>
<td>.34</td>
</tr>
<tr>
<td>Skill Practice</td>
<td>28.5 ± 13.3</td>
<td>12.8 ± 8.1</td>
<td>2.91</td>
<td>.00**</td>
</tr>
<tr>
<td>Game Play</td>
<td>21.2 ± 17.9</td>
<td>43.6 ± 15.5</td>
<td>-3.61</td>
<td>.00**</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Promotes Fitness</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Demonstrates</td>
<td>13.9 ± 10.3</td>
<td>4.9 ± 4.4</td>
<td>2.20</td>
<td>.04*</td>
</tr>
<tr>
<td>Fitness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Instruction</td>
<td>60.7 ± 23.1</td>
<td>49.7 ± 18.9</td>
<td>1.73</td>
<td>.10</td>
</tr>
<tr>
<td>Manages</td>
<td>11.1 ± 4.4</td>
<td>14.5 ± 6.6</td>
<td>-1.43</td>
<td>.17</td>
</tr>
<tr>
<td>Observes</td>
<td>7.0 ± 4.4</td>
<td>22.7 ± 16.9</td>
<td>-2.10</td>
<td>.05*</td>
</tr>
<tr>
<td>Other Task</td>
<td>1.6 ± 1.5</td>
<td>2.0 ± 2.5</td>
<td>-0.31</td>
<td>.75</td>
</tr>
</tbody>
</table>

Notes *P < 0.05 **P < 0.01
Comparative Analyses - RT3 ® Triaxial Accelerometry and System for Observing Fitness Instruction Time

Regression analyses were used to establish the relationship between the % MVPA levels recorded from the RT3 ® triaxial accelerometer PA monitor and the SOFIT observational tool. The results of this regression analysis can be found in figure 9.1.

![Regression Analysis](image)

\[ R^2 \text{ Linear} = 0.437 \]

Figure 9.1. Regression analysis to evaluate the relationship between SOFIT and RT3 ® triaxial accelerometry
Pearson correlation analyses (table 9.3) revealed a significant correlation between the RT3 ® triaxial accelerometer and the SOFIT protocol ($P < 0.01$). Although a correlation coefficient was used to establish the relationship between the variables, the correlation coefficient does not necessarily mean that the two variables agree. The $r$ value measures the strength of the relationship not the level of agreement (Bland and Altman, 1986). Therefore a Bland and Altman plot was used in order to establish the limits of agreement between the two PA monitors (figure 9.2).

**Table 9.3 Comparative analyses to compare the RT3 ® triaxial accelerometer and SOFIT MVPA**

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Pearson</th>
<th>Spearman rho</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>31</td>
<td>.661*</td>
<td>.482*</td>
</tr>
</tbody>
</table>

Notes. *correlation is significant at $P < 0.01$
Figure 9.2 Bland-Altman plot of RT3 ® triaxial accelerometer % MVPA minus SOFIT % MVPA (y axis) against average of RT3 ® triaxial accelerometer and SOFIT. The horizontal lines represent the 95% limits of agreement and the mean difference.

The Bland-Altman Plot (figure 9.2) shows the plot of MVPA recorded by RT3 ® triaxial accelerometry minus MVPA recorded by SOFIT (y axis) against the average of RT3 ® triaxial accelerometer and SOFIT across PE lessons. The mean bias (expressed as the mean difference between % MVPA by RT3 and SOFIT) was 4.97 (-14.6 to 24.5 CI). The lower and upper confidence interval
limits represent the 95% spread in agreement in the population from which the sample was derived. Therefore the SOFIT protocol tends to overestimate MVPA on average by 4.97%.

**Self Determination Theory**

**Internal Consistency**

All constructs attained the set internal reliability criterion of \( \alpha = 0.70 \) (Nunnally and Bernstein, 1994) apart from ‘competence’ (table 9.4). Competence at baseline and intervention attained an alpha level of 0.49 and 0.5 respectively and was thus disregarded from subsequent analysis.
Table 9.4 Descriptive statistics and internal reliability for each construct of SDT pre- and post- PE lessons

<table>
<thead>
<tr>
<th>Constructs of SDT</th>
<th>Mean</th>
<th>Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Autonomy Support</td>
<td>5.16</td>
<td>.74</td>
</tr>
<tr>
<td>2. Competence Support</td>
<td>6.01</td>
<td>.84</td>
</tr>
<tr>
<td>3. Relatedness Support</td>
<td>5.74</td>
<td>.86</td>
</tr>
<tr>
<td>4. Autonomy</td>
<td>4.66</td>
<td>.71</td>
</tr>
<tr>
<td>5. Competence</td>
<td>4.76</td>
<td>.49</td>
</tr>
<tr>
<td>6. Relatedness</td>
<td>5.32</td>
<td>.93</td>
</tr>
<tr>
<td>7. Amotivation</td>
<td>2.60</td>
<td>.83</td>
</tr>
<tr>
<td>8. External Regulation</td>
<td>4.45</td>
<td>.85</td>
</tr>
<tr>
<td>9. Introjected Regulation</td>
<td>4.83</td>
<td>.79</td>
</tr>
<tr>
<td>10. Identified Regulation</td>
<td>5.90</td>
<td>.75</td>
</tr>
<tr>
<td>11. Intrinsic Motivation</td>
<td>5.76</td>
<td>.86</td>
</tr>
<tr>
<td>12. Enjoyment</td>
<td>3.92</td>
<td>.83</td>
</tr>
<tr>
<td>13. Positive/Negative Affect</td>
<td>4.64</td>
<td>.54</td>
</tr>
</tbody>
</table>

Multivariate Analysis of Variance

At baseline pre intervention, there were no significant differences in SDT constructs ($P < 0.05$) within matched sex groups. At baseline boys displayed significantly higher autonomy support, competence support and relatedness support in comparison to girls ($P < 0.05$). There was also a non-significant
trend for greater intrinsic motivation at baseline in boys versus girls ($P = .071$). Overall across both time points (pre-post 12 week intervention) boys displayed significantly higher levels of intrinsic motivation ($P = 0.002$), autonomy support ($P = .006$), relatedness support ($P = .007$), autonomy ($P = .010$) and relatedness ($P = .021$) in comparison to girls (Table 9.5).

**Between Groups One Way Analysis of Variance - Sex Effects**

Between groups ANOVA revealed a significant increase in autonomy in boys as a result of the 12 week intervention versus control ($F = 7.67$, $P < 0.01$, $d = 0.84$ Table 9.5), but not in other SDT constructs. There were no significant changes in SDT constructs in girls as a result of the TGfU condition (Table 9.5).
Table 9.5 SDT constructs one way ANOVA for boys and girls post

<table>
<thead>
<tr>
<th>SDT Construct</th>
<th>Gender</th>
<th>Condition</th>
<th>Mean</th>
<th>F</th>
<th>Sig</th>
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<td>INT</td>
<td>5.61</td>
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</tr>
<tr>
<td></td>
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<td>CON</td>
<td>4.37</td>
<td>0.01</td>
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<td>INT</td>
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<td>Boys</td>
<td>CON</td>
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<td>1.85</td>
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<td>CON</td>
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<td>7.67</td>
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<td>5.25</td>
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<td>CON</td>
<td>3.92</td>
<td>0.19</td>
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<td>0.74</td>
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<td>CON</td>
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<td></td>
<td>Girls</td>
<td>CON</td>
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Amotivation

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<td>CON</td>
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<td>5.8</td>
<td>-9.1</td>
</tr>
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<td>5.5</td>
<td>-5.2</td>
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Enjoyment

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<th>Sig</th>
</tr>
</thead>
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<td>.980</td>
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<td>INT</td>
<td>4.63</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>ACT1</td>
<td>CON</td>
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<td>0.08</td>
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Positive/Negative Affect

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<th>t</th>
<th>Sig</th>
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</thead>
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<td>CON</td>
<td>4.01</td>
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<td>4.11</td>
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<td></td>
</tr>
<tr>
<td>Girls</td>
<td>ACT1</td>
<td>CON</td>
<td>3.56</td>
<td>0.76</td>
<td>.395</td>
</tr>
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<td></td>
<td>INT</td>
<td>3.76</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* significant at \( P < 0.01 \)

Teacher Assessments

Paired t tests revealed that all activities for boys and girls across the intervention and control conditions saw significant increases in attainment levels as assessed by PE teachers (table 9.6).

Table 9.6 Mean (± SD) of attainment levels achieved pre-post intervention by activity, gender and condition.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Mean Pre</th>
<th>Mean Post</th>
<th>t</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>ACT1</td>
<td>CON</td>
<td>4.5</td>
<td>4.7</td>
<td>-2.2</td>
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<td>.000**</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>ACT1</td>
<td>CON</td>
<td>4.8</td>
<td>6.0</td>
<td>-10.4</td>
</tr>
</tbody>
</table>

Significant differences between % time of lesson spent in MVPA by activity and condition * \( P < 0.05 \), ** \( P < 0.01 \)
9.3.2 Analysis 2 – Seven Day Habitual Activity and the Theory of Planned Behaviour

Student Seven Day Habitual Physical Activity Levels

Table 9.7 and 9.8 display average MVPA in minutes for seven day habitual activity per condition and by sex. The tables are also split by weekday (table 9.7) and weekend (table 9.8) activity. Interestingly the boys in the intervention group displayed higher levels of MVPA minutes for both the weekend (108.67 ± 33.08 to 162.83 ± 175.21) and weekday (124.1 ± .74 to 130.11 ± 32.55) days from baseline to post intervention. Minutes spent in MVPA were higher than the control boys post intervention (103.13 ± 42.42 weekday and 83.9 ± 93.45 weekend). This pattern is not seen in the girls’ data which displayed no increases for girls assigned to the TGfU condition.
Table 9.7 Boys and Girls Weekday MVPA levels (minutes) (mean ± SD) by condition

<table>
<thead>
<tr>
<th></th>
<th>Time</th>
<th>Condition</th>
<th>MVPA Minutes (Mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>Pre</td>
<td>CON</td>
<td>116.5 ± 15.79</td>
</tr>
<tr>
<td></td>
<td></td>
<td>INT</td>
<td>124.1 ± .74</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>121.05 ± 8.94</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>CON</td>
<td>103.13 ± 42.42</td>
</tr>
<tr>
<td></td>
<td></td>
<td>INT</td>
<td>130.11 ± 32.55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>113.25 ± 39.07</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>CON</td>
<td>106.95 ± 35.83</td>
</tr>
<tr>
<td></td>
<td></td>
<td>INT</td>
<td>127.1 ± 20.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>116.25 ± 30.54</td>
</tr>
<tr>
<td>Girls</td>
<td>Pre</td>
<td>CON</td>
<td>111.76 ± 30.64</td>
</tr>
<tr>
<td></td>
<td></td>
<td>INT</td>
<td>113.19 ± 25.18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>112.32 ± 28.03</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>CON</td>
<td>91.38 ± 27.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>INT</td>
<td>106.75 ± 82.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>98.47 ± 57.21</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>CON</td>
<td>104.96 ± 30.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td>INT</td>
<td>110.61 ± 52.96</td>
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<tr>
<td></td>
<td></td>
<td>Total</td>
<td>107.32 ± 40.76</td>
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</tbody>
</table>
Table 9.8 Boys and Girls Weekend MVPA levels in minutes (mean ± SD) by condition

<table>
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<tr>
<th>Time</th>
<th>Condition</th>
<th>MVPA Minutes (Mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>Pre</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CON</td>
<td>115 ± 36.77</td>
</tr>
<tr>
<td></td>
<td>INT</td>
<td>108.67 ± 33.08</td>
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<td></td>
<td>Total</td>
<td>111.2 ± 29.95</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CON</td>
<td>83.9 ± 93.45</td>
</tr>
<tr>
<td></td>
<td>INT</td>
<td>162.83 ± 75.21</td>
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<td></td>
<td>Total</td>
<td>113.5 ± 24.18</td>
</tr>
<tr>
<td></td>
<td>Total</td>
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</tr>
<tr>
<td></td>
<td>CON</td>
<td>92.79 ± 79.23</td>
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<td></td>
<td>INT</td>
<td>135.75 ± 116.55</td>
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<td></td>
<td>Total</td>
<td>112.62 ± 96.41</td>
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<tr>
<td>Girls</td>
<td>Pre</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CON</td>
<td>101.32 ± 56.46</td>
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<td></td>
<td>INT</td>
<td>81.14 ± 52.77</td>
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<td>Total</td>
<td>94.6 ± 54.79</td>
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<td>Post</td>
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<td></td>
<td>CON</td>
<td>87.72 ± 66.99</td>
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<td></td>
<td>INT</td>
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<td>92.53 ± 67.66</td>
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<td></td>
<td>Total</td>
<td>93.74 ± 59.56</td>
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</table>
Figure 9.3 Mean (±SD) MVPA in minutes by condition for boys weekday habitual activity. No significant differences.

Figure 9.4 Mean (±SD) MVPA in minutes by condition for boys weekend habitual activity. No significant differences.

Figure 9.3 and 9.4 represent weekday and weekend activity pre-post intervention respectively for boys. ANOVA revealed no significant differences pre-post intervention for minutes spent in MVPA.
Figure 9.5 Mean (±SD) MVPA in minutes by condition for girls weekday habitual activity. No significant differences.

Figure 9.6 Mean (±SD) MVPA in minutes by condition for girls weekend habitual activity. No significant differences.
Figure 9.5 shows the mean and standard deviation for each condition pre-post intervention for girls for weekday activity. Figure 9.6 shows weekend activity for girls. The between groups 2 x 2 ANOVA revealed no significant differences were found between weekday minutes of MVPA for the control and intervention condition from baseline to post intervention. Similar findings were displayed for the weekend data that no significant differences were found pre-post research across the two experimental conditions.

Table 9.9 Descriptive statistics and internal reliability for each construct of The TPB pre- and post- PE lessons

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<th>Constructs of TPB</th>
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<tr>
<td>4. Subjective Norms</td>
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</tr>
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<td>4. Subjective Norms</td>
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All constructs attained the set internal reliability criterion of $\alpha = 0.70$ (Nunnally and Bernstein, 1994).

At baseline there were no significant differences in constructs of the TPB for boys assigned to the control and intervention session. However this was not true of the girls. Girls assigned to the control lesson had significantly higher (P
< 0.05) levels of attitude and behavioural belief in comparison to the girls assigned to the intervention.
Table 9.10 The TPB constructs one way ANOVA for boys and girls post intervention by condition

<table>
<thead>
<tr>
<th>TPB Construct</th>
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<th>Mean</th>
<th>F</th>
<th>Sig</th>
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Table 9.10 illustrates the comparisons from the repeated measures mixed design MANOVA. The data shows that there were no significant changes for
9.4 Discussion

The purpose of this study was to assess the impact of a TGfU pedagogical approach on objectively measured MVPA during PE classes and constructs of SDT in children aged 11-12 years old. In addition this study investigated the effects of a TGfU intervention during PE lessons on children's seven day habitual activity levels and intentions to be physically active outside of the PE lesson through the constructs of the TPB.

There have not been any studies conducted so far that have focused on the effect of the TGfU approach on MVPA levels during PE. Importantly the teacher assessments for attainment levels obtained by the students across the twelve week study were significantly increased pre-post intervention for each activity and regardless of the condition that the boys and girls were assigned to. This reinforces previous literature (Butler, 2006) that TGfU does not negatively impact on skill development for high or lower skilled students.

This study revealed that boys engaged in significantly ($P < 0.01, d = 2.19$) higher levels of objectively measured mean MVPA during 12 weeks of PE lessons under the TGfU versus the traditional (control) condition. The large
effect size reported for the difference in MVPA between control and intervention for boys suggests a very strong association between TGfU and the increase in activity levels. The activity increase in the TGfU condition was also reinforced by the SOFIT observational MVPA, which revealed significantly higher levels of MVPA ($P < 0.01$). A dominant feature of the TGfU approach is the use of conditioned game play to practise skills in a game context. This was reinforced by the SOFIT data (table 9.1) which revealed that a significantly higher % of lesson time was spent in game play ($P < 0.01$) for boys in the intervention condition. It is possible that the conditioned game element of TGfU may have been partly responsible for the increased MVPA levels. Van Acker et al. (2010) found that using conditioned games significantly increased ($P < 0.05$) levels of MVPA in a study conducted in Belgian and Portuguese schools. An increase in MVPA during lessons delivered using a TGfU approach is in line with previous research which has shown that games based activity during the PE lesson can produce higher levels of PA in comparison to skill dominated lessons (Yelling et al. 2000). Yelling et al. found that during a six lesson unit of netball 55% of a skills based lesson and 42% of a games dominated lesson were spent with HRs below 50% HR reserve, providing support for the notion that skills based lessons may produce lower HR and MVPA levels. SOFIT analyses revealed that % lesson time spent in skill play was significantly higher for boys ($P < 0.01$) in the control condition and this was reflected by significantly lower ($P < 0.05$) levels of objectively measured MVPA. It is important to remember that
the Yelling et al. (2000) study was only conducted in one school over a short six lesson period. Also it has been found that HR can be affected by external factors such as emotional stress (Fairclough and Stratton, 2005b).

In contrast to the finding that MVPA levels were higher during lessons employing a TGfU approach, this was not the case for girls. In fact the control lesson for activity 1 (netball) elicited significantly higher levels of objectively measured MVPA in comparison to the intervention \( (p < 0.001, d = 1.59) \). For activity 2 there were no significant differences between intervention and control in girls \( (p = .228, d = 0.44) \), as reflected by a small effect size.

However, SOFIT observational analyses revealed no significant difference in observed MVPA between conditions for girls. Verstraete et al. (2007) used SOFIT and accelerometry to measure the effect of a two year health based intervention. They found the accelerometer data to produce higher % of MVPA in comparison to subjective measures of SOFIT. The study also used one minute epoch’s on the accelerometry data which can level down the vigorous intensity activity (Verstraete et al. 2007). They also explain the difference in methods to be associated with the time frames i.e. SOFIT is coded every twenty seconds and the study used one minute epoch’s (Verstraete et al. 2007). The present study used one second epoch’s to assess activity which is a more accurate assessment of activity as the device becomes more sensitive to changes in activity (Rowlands et al. 2004). All
students wore the accelerometers in comparison to only four randomly selected students being observed through SOFIT on a lesson-lesson basis which may lend explanation for the differences in MVPA between the methods (Fairclough and Stratton, 2005c). In addition Fairclough and Stratton (2005c) note that the motor skill competence and motivation of the four students selected for SOFIT are unlikely to be a true representation of the whole class. The comparative analysis in this study revealed that SOFIT and the RT3® triaxial accelerometry were not in agreement and the limits of agreement were not clinically acceptable for accurately measuring time engaged in MVPA during PE (Scruggs et al. 2005). Although the two methods were shown to be significantly correlated ($P < 0.01$) the 95% limits of agreement between the two methods were observed as -14.6% to 24.5%. Given that time spent in MVPA ranged from 39% - 53% and 41 - 68% across both activities for girls and boys respectively, the 95% limits of agreement (-14.6% to 24.5%) were too wide and are likely to significantly misrepresent time spent in MVPA (Scrugg et al. 2005). These results are in line with previous findings from Scrugg et al. (2005) who found that the RT3 triaxial accelerometer was not in agreement with SOFIT with wide 95% limits of agreement (-11.30 to .82 minutes). However, Scruggs et al. (2005) employed 1 minute epoch’s which can potentially mask PA time. The present study employed 1 second epochs, however, the levels of agreement were still found to be too wide. It is important to remember that the SOFIT protocol is one of the only tools that can be used to investigate and gain a good representation
of lesson contextual factors (Scruggs et al. 2005). Fairclough and Stratton (2005c) also explain that using a combination of different PA measures can lend explanation for the links between MVPA, lesson contexts and teacher behaviours (Fairclough and Stratton, 2005c).

SOFIT revealed no significant increases in % time spent in game play for girls in the intervention condition. This contextual factor may lend support for the non significant increases in MVPA displayed for girls. Previous research has shown that time spent in game play can significantly increase activity levels (Yelling et al. 2000). However, it is important to note that SOFIT did display a TGfU format of the lesson i.e. conditioned game play, but significantly (P < 0.05) more time was spent in general knowledge in the intervention condition. This could have potentially been linked to the teacher adjusting to the TGfU approach as it has been suggested that interventions should take place over a two year period and teachers take time to adjust and feel comfortable with teaching in a new ‘style’ (McKenzie et al. 2004). This may have impacted negatively on time spent in the game situation and hence less opportunity to accumulate MVPA (Yelling et al. 2000).

Importantly there were no differences in self determined behaviour between control and intervention groups for girls at baseline. Interestingly, however, non-significant trends for differences in self determined behaviour were observed as a result of the TGfU condition; higher levels of external
regulation and lower levels of intrinsic motivation. If the three innate needs of SDT are disrupted and students become extrinsically motivated, then they tend to show less interest in the activity and ultimately put in less effort towards achieving (Ryan and Deci, 2000) which impacts negatively upon levels of MVPA. A possible explanation for this finding was the difference between boys and girls' competence at baseline. Girls displayed significantly (p = 0.033) lower levels of competence at baseline in comparison to boys in this study. Competence is described by Deci et al. (1991) as ‘understanding how to attain various external and internal outcomes and being efficacious in performing the requisite actions’ (p. 327). The low levels of competence displayed for girls may have negatively affected the ability of the girls to take responsibility for their own learning, and may have hindered the effective implementation of the TGfU approach. In addition SDT analyses revealed that boys had greater levels of intrinsic motivation (p = .071) versus girls at baseline. It is important to note that there is an age related decline in PA levels, particularly for girls, with an increase in age particularly during adolescence (HSE, 2008) which may potentially be linked to lower levels of intrinsic motivation in comparison to boys. This may relate to observations that girls have a tendency to possess greater contingent self worth and be influenced more by external factors during this period of adolescence than boys (Standage et al. 2005).
The findings from the study are contradictory to previous findings from Mandigo et al. (2008) who reported that girls receiving ‘traditionally’ taught lessons are more likely to report negative experiences in comparison to humanistic approaches such as TGfU which produce positive enjoyment. Mandigo et al. (2008) explained that this preference and enjoyment of humanistic approaches could be related to the interaction with other students promoting a sense of inclusion and a greater sense of achievement being involved in challenges of a more appropriate level of relevance to small groups of participants. However the lower competence levels displayed at baseline for girls in this study may have negatively affected this greater sense of achieving (Ryan and Deci, 2000).

It is important to remember that activity type may also influence girls’ preference towards individual activities (Fairclough and Stratton, 2005c). It has been discussed that individual activities such as gymnastics are perceived as more feminine by girls and therefore girls tend to approach them with more confidence than other types of activities (Fairclough and Stratton, 2005c; Corbin, 2002). This could also be a potential reason for the disappointing effect of TGfU with girls in the study. Further research is necessary to determine possible differences in responses to self determined environments during PE between boys and girls (Ntoumanis, 2001; Standage et al. 2005).
Boys’ responses to the TGfU lesson in this study were very positive. Analyses revealed that boys in the TGfU lessons displayed a significant (p < 0.05, d = 0.84) increase in levels of autonomy post intervention. Autonomy is an essential aspect of SDT that needs to be satisfied for the positive benefits of self determined behaviour to occur (Deci et al. 1991; Ntoumanis, 2001; Dupont et al. 2009). The significantly higher levels of MVPA displayed during the TGfU lesson could be related to heightened levels of autonomy, Ryan Deci (1991) explain that this increase in constructs of SDT may lead to more satisfaction and interest in the activity. It is also possible that the TGfU pedagogical approach promoted a lesson structure that was inherently more active because of the conditioned game element (Van Acker et al. 2010), and thus promoted higher levels of MVPA (Yelling et al. 2000). Alternatively, the high level of small group work, may have promoted a more cohesive, challenging, and inclusive environment with the effect of increasing MVPA, although no significant changes in relatedness were observed between the students and the teacher. However, it may be that the children felt more related to other students in the class which was not directly measured. This could be investigated in future work. TGfU specifically enhances levels of autonomy by learning relevant skills in a game situation and focuses on an individuals’ progression, giving them the opportunity to self endorse activities and be agentic (Butler, 1996). Interestingly there was a non-significant trend for intrinsic motivation, of relevance to self-determined behaviour, to be higher in the intervention lessons when compared to the control group in boys. It is
possible that by promoting a self determined environment using TGfU that raised intrinsic motivation levels of students may in turn positively influence levels of satisfaction and levels of participation and effort during PE (Standage et al. 2005). It was hypothesised based on previous research by Hagger et al. (2009) that there would be transference of these autonomous supportive motivation aspects from one context (PE) to another (seven day habitual activity) impacting directly on PA levels outside of school.

Seven day habitual activity was monitored pre and post intervention for both the control and TGfU intervention groups. No significant differences were found between the intervention and control condition during weekday or weekend activity for boys or girls pre-post intervention. However it was noted that although non significant, boys in the intervention condition displayed higher levels of MVPA minutes (108.67 ± 33.08 pre to 162.83 ± 75.21 post) for weekend habitual activity pre-post intervention and for weekday habitual activity (124.1 ± 74 pre to 130.11 ± 32.55 post) in comparison to the control boys (103.13 ± 42.42 weekday and 83.9 ± 63.45 weekend). It should be noted than on average for weekend and weekday activity all boys reached the recommended 60 minutes of MVPA (NICE, 2009).

This was an interesting finding when considering the results of SDT constructs. Over the block of PE lessons it was found that boys in the TGfU lessons displayed significantly (p < 0.05) higher levels of autonomy pre-post
intervention. As Hagger et al. (2002) outline SDT constructs can help form positive intentions specifically through the adoption of intrinsic motives. Hagger at el. (2002) found that once an individual becomes more self determined (intrinsically motivated) this was directly associated with an increase in attitude and ultimately a positive effect on intentions to be physically active. However, it is important to remember that an intention-behaviour gap still exists meaning that even though children may have higher intentions to be physically active it does not mean that this intention will translate into an actual behaviour (Martin et al. 2005).

However it is important to remember that these changes in seven day habitual activity across weekday and weekend were not significant ($P < 0.05$). Even though autonomy was shown to be significantly enhanced with TGfU in PE lessons this was not apparently transferred into activity outside of school. This finding is supported by Martin et al. (2005) who conducted a study to assess the impact of the TPB on predicting cardiorespiratory and PA levels in African American children. Martin et al. (2005) found that children (age 9.81 ± 0.70 years) assessed in the study lacked the cognitive skills to translate intentions into behaviour and displayed a lack of relationship between intentions and MVPA. This may help to explain why SDT constructs were enhanced in the PE lesson but these intrinsic motives were not transferred fully to leisure-time activity outside of the PE lesson. It is important to note that the children used in the Martin et al (2005) study were younger than the
sample used in the present study. An alternative explanation for the findings displayed in the present research is that the boys in the study who reached the recommended 60 minutes pre and post intervention already possessed high levels of intentions (5.81 pre and 5.92 post) and that these high levels of intention were translated in behaviour. This is supported by Trost et al (2002b) who found that objectively measured PA was predicted by both intention and PBC.

The TPB constructs did not significantly differ between conditions or pre-post intervention for boys. The TPB analysis revealed that intentions were high post intervention with boys displaying mean scores of 5.92 and 5.81 for control and intervention condition respectively on a 7 point Likert scale. Similarly mean attitude and PBC scores were also high post intervention (5.39 and 5.68 control and intervention PBC, 6.09 and 6.09 for control and intervention attitude). Brickell et al. (2006) found that a high level of attitude and PBC directly influenced intentions. The boys in the present study displayed high levels of attitude and PBC suggesting that these constructs were transferred into intentions. This suggestion is supported by the boys reaching the recommended levels of daily activity. In addition these constructs did not significantly differ pre-post intervention reinforcing the fact that scores for intentions at baseline were already high for boys which may explain them reaching the recommended 60 minutes of MVPA per day. Girls
in the study displayed non significant ($P > 0.05$) lower levels of intentions in comparison to boys.

There were no significant differences in habitual PA levels for girls pre-post intervention or according to condition for weekday and weekend activity. Girls assigned to the control group displayed average weekday PA levels of 111.76 ± 30.64 and 91.38 ± 27.32 minutes pre-post respectively. Girls' in the control groups accumulated weekday MVPA minutes of 101.32 ± 56.46, 87.72 ± 66.99 minutes pre-post respectively. It is important to note that on average the girls’ also reached the recommended 60 minutes of daily activity. The results showed that on a weekday 96.1% of girls reached the daily recommendation and 69.3% of girls met the recommendation on a weekend day.

Girls assigned to the intervention condition displayed MVPA minutes of 113.19 ± 25.18 pre and 106.75 ± 82.51 pre-post intervention for weekday activity. Intervention group girls' activity at weekends increased from 81.14 ± 52.77 pre to 99.75 ± 74.39 minutes post-intervention but was not significant ($p = .609$). Girls assigned to the intervention displayed a non significant decrease in MVPA pre-post intervention. This was the opposite to the results displayed for the boys who displayed higher levels of MVPA pre-post intervention. Interestingly in the findings from the PE lessons, girls displayed significantly lower levels ($p < 0.01$) of PA during PE in comparison to boys.
and during activity 2 (netball) girls in the intervention session displayed significantly ($P = 0.00$) lower levels of MVPA in comparison to the control session. This finding was further supported by the results found for SDT and the constructs of the TPB. Non-significant trends for differences in self determined behaviour were observed as a result of the TGfU condition during PE for girls; higher levels of external regulation and lower levels of intrinsic motivation. This lends support for the theory proposed by Hagger et al. (2009) that if a student displays low levels of self determined behaviour there is no transference of motivation from the PE lesson to PA outside of the school environment. Hagger et al. (2009) outlines that there is a link between self determined behaviour and intentions to be physically active during leisure time, specifically through autonomous motivation. Although non significant, autonomy was lower in the girls subjected to the TGfU approach than the control girls. This may explain lower levels of seven day habitual activity for intervention girls.

The girls in the study displayed lower levels of attitude and PBC in comparison to boys, although these differences were non significant. These results are important as they may have an important direct influence on intentions to be physically active (Hagger et al. 2002). This lends support to the current data that girls’ PA levels outside of PA were not significantly lower than boys activity but that the girls in the study did display lower minutes of
habitual activity accompanied by lower levels of attitudes and PBC (Hagger et al. 2002).

Limitations of the current study need to be acknowledged when interpreting the findings of the present study. The results from the present study cannot be generalised to the population as the study only took into account schools from the Bedfordshire region. In addition Rowlands et al (2004) cut off points were employed to analyse the accelerometry data which as previously mentioned could mean increased MVPA levels were observed as the intensity threshold. Rowlands et al (2004) validated 3 mets for moderate intensity exercise in comparison to others that have used 4 mets for moderate intensity exercise (Riddoch et al. 2007). It may also be that the sample size needs to be increased in order to observe significant changes through an increase in power. In addition within the schools different teachers were used to teach the control and intervention class. This was a delimitation of the study but nevertheless could have affected the results due to the individual teaching abilities of different teachers.

The present study focused upon the impact of creating a self determined environment during PE and how this environment influenced PA levels during PE and PA outside of school. Future research should investigate the influence of activity type on the effectiveness of the TGfU approach and whether creating an autonomy-supportive environment during activities that
girls find more motivating or interesting would produce different levels of activity and differences in the constructs of SDT. The current data shows changes pre-post intervention over 12 weeks but did not take into account lesson-lesson changes which may have highlighted how gender affected the responses to the TGfU approach over time i.e. if the girls initially responded differently to the TGfU intervention than boys and if these differences were starting to become less apparent as they adjusted to the TGfU approach. Possible differences in the time course of responses to the TGfU approach, and their longevity, between boys and girls, also warrants attention.

9.5 Conclusion

In summary the influence of TGfU on levels of MVPA during PE lessons (rugby and football) and subsequent enhanced contribution to the recommended 60 minutes of activity per day is promising, but was only apparent for boys in this study. It was also found that autonomy was significantly increased post intervention for boys in the TGfU condition. The findings from this present study support the recent findings of Hagger et al. (2009) who found that motivation is transferred from one context (PE) to another (PA outside of school). More specifically Hagger et al. (2009) found that the PE teacher can have a very important role in the promotion of PA outside of school specifically through creating a more autonomous environment during PE. If the PE teacher is perceived as creating an
autonomy supportive environment during PE this may ultimately impact on leisure time activity through its positive influence on intentions and attitudes. As Hagger et al. (2009) conclude this finding is 'important for PE curricula and the promotion of PA as it implies PE teachers may utilise the PE context to convey autonomy-supportive messages about PA that will promote autonomous motivation towards PA outside of school' (p. 707). Given that TGfU was found to significantly ($P < 0.05$) increase MVPA and autonomy during PE in comparison to a control group during PE lessons for boys. Given the prominent effects of TGfU displayed for boys in terms of MVPA and autonomy and the transfer of these autonomy supportive aspects of SDT into PA outside of school using TGfU, PE teachers should consider using the TGfU approach during PE lessons for boys. The data from this study revealed that girls did not experience the same benefits as boys from using TGfU. Therefore future research should investigate alternate interventions such as health related PE to enhance levels of PA and motivation to achieve lifelong participation in PA for girls.
Chapter 10 General Discussion
## 10.0 Study Map

Summary of findings and objectives of research conducted during the thesis.

<table>
<thead>
<tr>
<th>Study</th>
<th>Objectives and Key Findings</th>
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</thead>
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<tr>
<td>Study 1: Reliability and validity of several</td>
<td><strong>Objectives:</strong> - To identify the re-test reliability of the following physical activity methods: RT3 Triaxial accelerometers, Bodysmedia armband, and Actiheart. - To assess the validity of the physical activity monitors by comparison with oxygen consumption measure (Metalyser 3B) during standardised bouts of exercise.</td>
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<tr>
<td>physical activity monitors to assess physical</td>
<td><strong>Key findings:</strong> - The RT3 ® triaxial accelerometer was found to be the most valid and reliable physical activity monitor for use in school children aged 11-12 years old.</td>
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<td>activity in school children.</td>
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<tr>
<td>Study 2: Physical activity levels during middle</td>
<td><strong>Objectives:</strong> - To accurately quantify physical activity levels during middle school physical education lessons in the Bedfordshire area, to establish if current recommendations i.e. 50% of lesson time in activity of at least a moderate intensity, are met.</td>
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<td>school physical education.</td>
<td><strong>Key findings:</strong> - On average during PE lessons students spent 44.9 ± 5.6 % of the PE lesson engaged in MVPA which translated to 16.4 ± 2.3 minutes which fell short of the USDHH (2000) 50 % (20 minute) target.</td>
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### Study 3: Does physical education significantly contribute to the recommended 60 minutes moderate-vigorous physical activity per day?

**Objectives:**
- To quantify activity levels during PE and quantify the contribution PE to the recommended 60 minutes MVPA per day in English middle school children.

**Key Findings**
- PE lessons fell short of the 50% (20 minute) criterion (USDHH, 2000).
- Children in the study achieved the daily recommendation of 60 minutes MVPA per day (DoH, 2004) during weekday activity; however, at the weekend it was shown that children did not achieve the daily recommendation.
- PE was also found to be of importance in terms of the unique contribution it makes to levels of VPA which potentially increases cardio respiratory fitness.
- This study highlighted the need to focus on an intervention or approach to maximise the contribution of PE to the recommended target of MVPA per day.

### Study 4: Pilot Study to Assess the Influence of a TGfU Approach on Physical Activity Levels Monitored During Physical Education Lessons

**Objectives:**
- Assess the impact of a TGfU approach on objectively assessed MVPA levels.

**Key Findings**
- This pilot study highlighted the potential for the TGfU intervention to increase PA levels above the 50% criterion (USDHH, 2000) without comprising lesson objectives set within the national curriculum.
- Importantly the study also indicated that the 50% criterion is an achievable target in the aim for PE lessons to significantly contribute to the daily PA levels.
Study 5: Preliminary Studies: The Influence of a TGfU Approach on Physical Activity Levels and Motivational Responses During Physical Education Lessons.

Objectives:
- To investigate the impact of the TGfU approach on objectively measured physical activity levels during PE.
- To investigate the impact of the TGfU approach on motivational levels; specifically on the constructs of ‘Self Determination Theory’.

Key Findings
- The study showed the positive impact of the TGfU intervention in promoting activity levels within the PE lesson.
- No significant changes were found in self determined behaviour. However, it may be that the intervention needs to be undertaken for longer in order to display these effects.
- Creating a self determined environment is of particular importance as this may be an effective way of promoting PA within PE lessons and encouraging students to engage in self determined PA behaviours outside of PE.
10.1 Integration and Summary of Research Findings

The general consensus internationally is that PE lessons display typically low levels of PA (Fairclough, 2003a; Trost, 2004; McKenzie et al. 2000; Yelling et al. 2000; McKenzie et al. 2006; Fairclough and Stratton, 2005b). TGfU is a curriculum model that was developed to bridge the gap between skills developed and utilising the skill in a games context during PE (Bunker and Thorpe, 1986). TGfU incorporates small sided conditioned games to practise skills in a games context (Mitchell et al. 2006). It has been shown that using
small sided and conditioned games enhances MVPA during PE (Yelling et al. 2000; Van Acker et al. 2010). In addition it has been recognised (Butler, 2006) that TGfU promotes intrinsic values. In particular, SDT has attracted growing interest in the PE lesson and it has been shown that creating a more self determined environment promotes intrinsic values (Taylor and Ntoumanis, 2007; Standage et al. 2005; Wallhead and Ntoumanis, 2004; Ntoumanis, 2001). It has been found that an increase in self determined behaviour (intrinsic motivation) results in an increase in PA (Lonsdale et al. 2009). These intrinsic values promoted by a self determined behaviour have also been shown to impact positively on intentions to be physically active outside of school through the TPB (Hagger et al. 2009). The present research was conducted to investigate (1) the accuracy of PA monitors to objectively assess PA during PE (2) the current levels of PA accrued during PE lessons in the Bedfordshire area (3) what role does PE play in the accumulation of daily activity recommended for health (4) the role of TGfU within the PE context to promote MVPA and its potential to create a self determined environment, and (5) to track the influence of TGfU to establish any impact upon children’s intentions to be physically active and immediate habitual activity levels.

Figure 10.0 provides a summary of all the study findings from the present research.
Figure 10.0 Summary of links between constructs from Self Determination Theory and the Theory of Planned Behaviour representing the pathway from TGfU to lifelong participation in PA. Numbers identify the references.

10.2 Physical Activity Monitors and Children

Children’s PA is typically difficult to measure due to the short sporadic bursts and inconsistency of children’s activity (Corder et al. 2008; Rowlands and Eston, 2007). Trost (2007) has highlighted the importance of being able to accurately measure PA in children due to the promotion of PA in children becoming public health priority. In addition Trost (2007) explains ‘there will always be a trade off between practicality and accuracy when it comes to selecting a PA measurement tool for use among children and adolescents’ (p. 299). Study 1 demonstrated that the most reliable and valid assessment of PA in children aged 11-12 years involved in the study was the RT3 ® triaxial accelerometer. This was in line with previous research that found the RT3 ® triaxial accelerometer to be a valid and reliable measure of PA (Rowlands et al. 2004).

However, it is important to remember that there are limitations with all measurements and ‘not one single method can be described as optimal in all situations’ (Trost, 2007, p.10). For example as acknowledged throughout the thesis the intensity thresholds for accelerometry cut off points vary between
authors (Rowlands et al. 2004; Treuth et al. 2004; Riddoch et al. 2007) and therefore could affect the levels of PA recorded during the thesis and should be taken into consideration when considering the results of this research. These limitations for PA monitors tend to be independent of each other so research suggests that a combination of methods may provide more accurate assessment (Rowlands and Eston, 2007).

During the research conducted the SOFIT was used in conjunction with RT3 ® triaxial accelerometry to provide a more accurate assessment of PA amongst children during PE. However, a comparative analysis between the two PA assessment tools highlighted that the two instruments did not agree within acceptable clinical limits. Although both instruments are assessing ‘PA’ the SOFIT is a behavioural measure and the RT3 ® triaxial accelerometer provides a measure based on movement, therefore the likelihood of the two methods agreeing is small (Fairclough and Stratton, 2005c). In addition the SOFIT measure monitors four randomly selected children whereas the RT3 ® triaxial accelerometer was worn by all students in the lesson. Therefore it is unlikely that four children were truly representative of the whole class (Fairclough and Stratton, 2005c). It has been found in previous research that the activity codes of SOFIT are not necessarily in agreement with objective PA measurement (Scruggs et al. 2005; Fairclough and Stratton, 2005c). However, the use of SOFIT did provide an important link between lesson
context, teacher behaviour and PA within the lesson which was crucial to the studies.

10.3 Physical Activity Levels in Physical Education

It has been long established that one of the primary aims of PE is the promotion of lifelong physically active lifestyles (Van Acker et al. 2010; Seghers et al. 2009; Fairclough, 2003a; Corbin, 2002). Study 2 demonstrated that the current levels of PA displayed during PE in the Bedfordshire area falls short of the 50% MVPA USDHH (2000) target which has been outlined as an appropriate level to significantly contribute to the recommended 60 minutes of MVPA per day (DoH, 2004). This finding was in line with previous findings regarding activity levels during PE (Fairclough, 2003a; Trost, 2004; McKenzie et al. 2000; Yelling et al. 2000; McKenzie et al. 2006; Fairclough and Stratton, 2005b). This research displayed large variations in the MVPA levels between different activity types which is potentially due to the movement required for each activity i.e. team games use large muscle movements hence an increase in $O_2$ demand (Fairclough and Stratton, 2005b). Despite these variations all activity types fell short of the 50% criterion.

The current concerns regarding children’s PA levels (DoH, CMO Report, 2004; Riddoch et al. 2007; HSE, 2008; The Information Centre, 2009) has
meant that the emphasis and importance placed on the school setting and particularly the PE lesson has attracted growing interest (McKenzie and Lounsbery, 2008; Cale and Harris, 2008). It has also been well documented that for some children PE lessons are the only time they have to participate in organized PA (McKenzie, 2001; Fairclough and Stratton, 2005a; Jago et al. 2009). In addition children do not tend to make up PA time lost from not participating in PE in their own time (Fairclough and Stratton, 2005b; McKenzie and Lounsbery, 2008). It should be mentioned that PE has many objectives and not all of PE’s aims are based around promotion of PA (McKenzie and Lounsbery, 2008) and this is the challenge for teachers to incorporate all aspects whilst promoting physically active lifestyles (Seghers et al. 2009).

PE has been described as having a ‘muddled mission’ due to the diverse and quantity of aims PE has i.e. motor skill, cognitive, social and emotional development (McKenzie and Lounsbery, 2008). In addition to this it has been noted that PE by itself cannot provide all the activity to satisfy the needs of children and that PE is one of many strategies which requires substantial collaborations (McKenzie and Lounsbery, 2008) particularly between education settings and public health sectors (Seghers et al. 2009). However, it has long been accepted that one of PE’s primary aims is lifelong activity through the promotion of active healthy lifestyles (Bailey et al. 2009) and that ‘PE should be an enjoyable experience during which students learn...
generalisable movement skills that will transfer into diverse activities, sports and games offered at school, in the community and later in life’ (Bailey et al. 2009, p.25).

10.4 Physical Education and Daily Physical Activity

Study 3 investigated PE’s contribution to the recommended 60 minutes a day recommendation (DoH, 2004). Habitual activity monitoring revealed that MVPA accumulated on a day when PE was timetabled gave higher daily activity than a normal PE day or weekend day. In addition, the findings also show that weekend activity on average fell short of the 60 minutes daily target. This reinforces the notion that when children do not have PE they do not compensate for this PA (McKenzie and Lounsbery, 2008). It is important to note that the children who participated in this study were recruited from an area of high socio-economic status (4.3% FSM eligibility) since it has been found in a review of the literature that there is a positive association between socio-economic status and PA levels (Gidlow et al. 2006). An interesting finding from study 3 was the potential of PE to contribute to daily VPA. VPA provided from PE accumulated on average almost ten minutes, which is almost a third of the weekly recommendation (Armstrong and Welsman, 1997). The infrequency and time restraints on PE are frequently reported (Van Acker et al. 2010; McKenzie et al. 2009), however, PE can make a significant contribution on the days when PE is conducted and previous interventions have been shown to increase PA levels within the PE lesson by
an average of 18% (McKenzie and Lounsbery, 2008). The results from this study highlighted the need for an intervention to increase PA levels during PE to reach the 50% criterion target without compromising lesson objectives which will potentially reduce the risk of cardiovascular disease through the attainment of the daily recommendation of activity (Andersen et al. 2006). The general challenge of PE teachers is to provide adequate opportunities for PA whilst encouraging PE through life and achieving other PE objectives (Seghers et al. 2009). Instructional strategies used within the lesson need to incorporate PA, skill and emotional needs of pupils and therefore they are paramount in achieving the aim of lifetime adherence of PA through PE (Seghers et al. 2009).

10.5 Preliminary Studies to Investigate the Potential of Teaching Games for Understanding on Physical Activity and the Motivational Environment

Study 4 piloted the potential of an intervention, TGfU, to increase PA levels and study 5 added further knowledge to this by investigating the effects of TGfU not only on PA levels but its potential in enhancing self determined behaviour.
There was a common finding amongst schools involved in the intervention that TGfU significantly enhanced MVPA levels in the TGfU lessons. However these findings were not supported by an increase in constructs of SDT. Interestingly in school ‘C’ amotivation, which is outlined as the least self determined form of behaviour (Ryan and Deci, 2000) had significantly increased. In practical terms this meant that the increase in MVPA was mirrored by a decrease in motivation which was in line with the findings of Fairclough (2003b) who found a decrease in motivation in response to an increase in intensity of the activity. However, at school 'B' no significant changes in constructs of SDT were experienced. This was reassuring given the concern regarding intensity of activity reflecting a decrease in motivation. Armitage (2005) concluded that it takes 5 weeks to change exercise behaviours, the students at school 'B' were only subjected to the intervention for three weeks therefore it could be that the intervention was too short to actually quantify the change in self determined behaviour.

Interestingly at school ‘A’ control lesson MVPA was found to be significantly greater than the intervention lessons in addition to no changes in SDT pre-post intervention. This was a surprising result in terms of MVPA, however, as this school was only subject to two lessons of the intervention. It has been found that interventions normally produce cumulative effects over time due to factors such as teachers taking time to adjust to a new style of teaching (McKenzie et al. 2004; Jago et al. 2009). An important finding of the study
was the successful promotion of MVPA at school ‘B’ and ‘C’ and in particular the amount of potentially health enhancing VPA (Armstrong and Welsman, 1997) accumulated as result of the intervention (which was significantly higher versus the control lessons). This result was very promising considering TGfU incorporates the wider educational focus of PE in comparison to other studies that have primarily focused on promoting health enhancing PA (Baquet et al. 2002).

TGfU has the potential to impact upon habitual PA behaviours through the motivational climate created during PE (Hagger et al. 2009). Central to this theory is the concept of autonomous motivation which is promoted through the development of a self determined environment. More specifically if children have an enhanced perception of autonomy support from their PE teachers then this will influence their autonomous motivation and help form intentions to be physically active in the future (Hagger et al. 2009). However, very few studies have actually looked at how motivational factors in PE are translated into PA behaviours out of school. This research is considered ‘useful for intervention design as it provides a rationale for promoting autonomous motivation in a context where a captive audience exists i.e. PE that will have an influence on motivation in another context where access is limited i.e. leisure time’ (Hagger et al. 2009, p. 691). Hagger et al. (2009) suggest that teaching activities during PE will promote autonomous motivation in leisure time and suggest that strategies such as ‘providing
choice, giving a rationale for activities and acknowledging conflict, providing informational feedback, fostering personally relevant goals and empowering students in lessons are all autonomy supportive strategies’ (Hagger et al. 2009, p. 705). TGfU promotes individual goals e.g. during the rounders intervention in study 4 children had the option to use a tennis racket or small rounders bat when on the batting side, this way students could progress at their own pace thereby empowering the students (Butler, 2006). Opportunities for individual feedback from the teacher during a TGfU lesson are higher due to the fact children are placed in small group situations. TGfU also gives a rationale for the activities; practising the skill in the correct context that it will be used in. In addition to the autonomy construct of SDT, Butler (2006) highlights that TGfU promotes other elements of SDT such as small group work which will directly impact upon relatedness which is a direct determinant of self determination.

Studies 4 and 5 highlighted the potential of TGfU in terms of PA promotion. However, given these results and the absence of any positive changes in SDT it was necessary to conduct the study over a longer period of time to look at the cumulative effects of the TGfU intervention on PA during PE and habitual activity PA.
10.6 Mediating the Transference of Being Physically Active During Physical Education to Leisure Time Activity.

Study 6 part 1 investigated the impact of the intervention, TGfU, on PA levels during PE and the effect on the constructs of SDT over a whole school term. The research showed that there were significant gender differences in response to the intervention. No significant differences were experienced in levels of MVPA as a result of the TGfU intervention for girls. This was reflected by the pre-post measurements taken for constructs of self determination which displayed increases in external motivation in conjunction with decreases in intrinsic motivation suggesting that a self determined environment was not created by TGfU for girls. At baseline it was found that boys displayed significantly higher levels of self determined behaviour in comparison to girls. This may relate to observations that girls have a tendency to possess greater contingent self worth and be influenced more by external factors during this period of adolescence than boys (Standage et al. 2005). Ryan and Deci (2000) outline that a disruption in the three innate needs reflected by an increase in extrinsic motivation results in a loss of interest in the activity which impacts negatively upon levels of MVPA.

Boys displayed positive benefits of TGfU including significantly increased their levels of MVPA, a significant increase in autonomy and a non significant increase in intrinsic motivation. It has been previously suggested that an
increase in autonomy is linked to an increase in satisfaction and interest in the activity which would have a positive effect on MVPA (Deci and Ryan, 2002). Similarly Standage et al. (2005) have outlined that an increase in self determined behaviour i.e. an increase in intrinsic motivation, has a positive impact upon effort and interest in the activity again linked to an increase in PA. As previously mentioned self determined behaviour has also been linked to changes in intentions towards PA in leisure time and that PE teachers can directly influence a transfer of motivation between the PE context and leisure time activity (Hagger et al. 2009). The primary aim of PE has been consistently outlined as the promotion of lifelong PA (Bailey et al. 2009). This is of particular importance to the PE curriculum and aims because it implies ‘PE teachers may utilize the PE context to convey autonomy supportive messages about PA that will promote autonomous motivation towards PA outside of school’ (Hagger et al. 2009, p. 709).

10.7 Teaching Games for Understanding and the Promotion of Healthy Active Lifestyles

Study 6 part B investigated the potential of implementing a TGfU curriculum model in the PE lesson on intentions to be physically active through the TPB and to quantify any effect on immediate habitual activity. Hagger et al. (2009) found that there was a transfer of motivation from one context to another i.e. PE to PA outside of school. In addition Hagger et al. (2009) found that
perceived autonomy support experienced form PE teachers irrespective of peers and parental influences had an autonomous impact upon leisure time activities specifically impacting upon the attitudes and PBC components of the TPB.

Girls' habitual activity did not significantly increase as a result of the intervention nor did their intentions to be physically active as measured using the TPB. This was in line with the findings of Hagger et al. (2009) who stated that a transfer of motivation will occur through an impact upon perceived autonomy. The girls did not display any changes in SDT constructs during PE and in fact they had a non significant increase in extrinsic motivation reflecting no changes in the TPB and habitual activity. Pre intervention it is important to note that girls displayed lower levels of attitude and PBC in comparison to boys.

It was found that boys assigned to the TGfU condition experienced non significant increases in habitual activity post intervention. There were no changes in the TPB as a result of the intervention, however, boys displayed higher levels of attitude and PBC post intervention. Brickell et al. (2006) found that high levels of attitudes and PBC directly influenced intentions. The changes in self determined behaviour as a result of the TGfU intervention and more specifically a significant increase in autonomy was reflected by high levels of attitude measured by the TPB. This could promote a transfer of
motivation from PE into PA in leisure time (Hagger et al. 2009). Hagger et al. 
(2002) specify that self determined behaviour, particularly enhancing the 
construct of autonomy, which will impact directly on attitudes, can influence 
intentions to be physically active. This is a highly important finding when 
considering whether the TGfU may have potential in terms of promoting 
lifelong PA as a result of engagement in physical education.

10.8 Future Work

The present study provided evidence that PE lessons taught using a TGfU 
approach may have potential as a health promoting tool for lifelong PA. The 
study showed that MVPA levels and self determined behaviour constructs 
were significantly increased post intervention as a result of TGfU. These 
changes were more prominent for the boys in the study. In addition these 
changes observed in SDT constructs and MVPA levels during PE were 
reflected by an increase in habitual seven day activity post TGfU intervention. 
It is important to note however, that future studies need to be conducted 
across more schools incorporating more children from various ethnic and 
socio economic backgrounds. This will establish if the findings are conclusive 
enough to promote a widespread dissemination of the findings to promote the 
use of TGfU in schools.
This research showed that the application of the TGfU model requires further development if it is to be effectively applied to girls. More research is needed focusing on girls across different activities to establish how they might also respond positively to a TGfU approach during PE lessons. It also noted that providing more choice in PE can promote autonomous motivation (Hagger et al. 2009). The activities used within this research were confined to invasion games and it may be that girls have more preference for individual games. For example, Van Acker et al. (2010) found that a modified games form conducted on a unit of Korfball, which is the only game that has specifically implemented rules incorporating girls and boys, promoted MVPA levels significantly for girls. It was also noted that there were some cumulative effects of the TGfU intervention over the course of the study which is line with previous findings (McKenzie et al. 2004). It may be that the intervention needs to be implemented for a longer duration for significant effects to be observed. McKenzie et al. (2004, p. 1386) suggest intervention periods of two years are necessary due to the cumulative effects of interventions and the time period for teachers to adjust to changes that 'required them to understand, accept, and implement new concepts and teaching methods before they became habitual'. In addition, given the limited success of TGfU in enhancing self determined behaviour and MVPA in girls it would be of value to include health based PE activities in addition to competitive skills based activities in future research studies.
Health based PE is also of particular importance due to the knowledge we have surrounding lifetime activities (Fairclough et al. 2002). It has been specified that activities that ‘carry over’ to adulthood are more health centred (Fairclough et al. 2002). In particular for girls no team games were included in the top ten female adult activities and individual activities such as swimming, cycling, dancing, and badminton dominated adult participation (Fairclough et al. 2002). Fairclough et al. (2002) also concluded that team games predominated over lifetime activities in key stage three and four of the curriculum. It has been shown that females have a preference for individual activities (Fairclough and Stratton, 2005c) which can be promoted through health based PE. Verstrate et al. (2007) reported that girls and boys MVPA levels were significantly enhanced as a result of a health based intervention based upon the PE component of the SPARK intervention. This is an important finding as it shows that girls’ MVPA can be successfully enhanced by developing models. However this study and others have not investigated the combination of objectively measured PA and the influence on motivation, and in particular the cognitive benefits of certain activities or the ways in which activities are presented to affect these mechanisms (Bailey et al. 2009).

There has been a lack of longitudinal studies focussing on the effects of school PE on adult behaviours (Trudeau and Shepherd, 2008). There is a need to track behaviours from PE into adulthood objectively (Van Sluijs et al. 2007). Most of the research in this area has been retrospective and as
Trudeau and Shepherd (2008) outline it is hard to isolate confounding factors in such studies. The effects of TGfU need to be tracked over a long period of time and this behaviour tracked into adulthood to understand how PE can play a part in adult health behaviours. This is particularly important to succeed in the quest to achieve one of PE’s aims which is lifelong PA (Trudeau and Shepherd, 2008).

10.9 Conclusion

McKenzie and Lounsbery (2008) describe PE as ‘the pill not taken’ and given the findings of this research it would suggest that this is the case. It is important to remember that there are various barriers that can limit the contribution that PE may make to daily activity i.e. limited curriculum time, low subject status and inadequate resources (McKenzie and Lounsbery, 2008). However as this study has demonstrated there is significant potential for PE to impact upon life long learning in the context of healthy lifestyles whilst adhering to the time limits and objectives placed on PE by the National Curriculum.

As this research and other studies have shown PE typically falls short of the 50% target for PE to make a significant contribution to recommended daily activity levels. However, as this study has shown, reaching this target without compromising lesson objectives or time restraints is an achievable goal. The
beneficial effects of TGfU in promoting MVPA levels during PE was apparent in boys in particular, and it is possible that had the intervention occurred for a longer duration that the cumulative effects of TGfU may have been seen for girls too. The potential motivational benefits observed as a result of TGfU are also important. The current study has demonstrated the potential of TGfU to impact upon self determined behaviour and highlighted the importance this may have for lifelong activity through its impact upon intentions to be physically active.

There is a need for more research in this area to investigate the potential of PE for promoting lifelong physical activity in the context of both physiological knowledge and psychological theories relevant to behavioural change and maintenance. It has been demonstrated through the findings of this study and others (Bailey et al. 2009; McKenzie et al. 2009; Verstrate et al. 2007) that PE has the potential to positively impact upon lifelong PA if the correct interventions are developed to enable enjoyable and educational PE to reach boys and girls across different ethic and socio economic groups. Bailey et al. (2009) explain ‘the need to engage young people in lifelong learning for lifelong engagement in PA, is resulting in gradual changes in PE and school sport programmes’ (p.23). It is imperative that these gradual changes keep occurring in PE in order to provide young people and children with the correct skills necessary to live a full and healthy lifestyle.
Chapter 11 References
11.0 References


National Institute for Health and Clinical Excellence (NICE) (2009) *Promoting Physical Activity and Sport for Pre-School and School-Age Children and Young People in Family, Pre School, School and Community Settings*, London, NHS.


Appendix A: Study 5: School ‘A’ TGfU Lesson Plans
Westfield Middle School Intervention Lesson 3 (Adapted from Mitchell et al. 2006)

4. Controlling/receiving:
   • Control – passing - moving
   • Controlling – getting the ball away from your feet
   • Receiving and shooting

TGfU Session;

   • Begin with standard warm up (teachers decision).

   • **Game 1; APPROX 5-10 mins.**
     - Passing, control and receiving balls.
     - 3 v 3 possession Game
     - Objective to make 5 consecutive passes without the ball touching your feet.

   • **Questions after 1st Game APPROX 2-3 MINUTES**
     - What must you do in this game to make 5 successful passes?
     - How can your team keep the ball?
     - How can you prevent the ball from hitting your feet?

   • **Practice Task 5-10 MINUTES**
     - Stay in teams of 3. Make a triad and practice receiving and sending the ball focusing on control and first touch – follow your pass.
     - EXTENSION – Add in a goal and practice passing in triad and finish with a shot on goal.

   • **GAME 2; APPROX 10 Minutes**
     - Back into 3 v 3 Game.
     - Narrow goals to make it harder to score so focus is on accurate shooting and passing to enable students to get into a goal scoring position.
     - Maximum of three touches before passing in order to emphasise passing and control.
Westfield Middle School Intervention Lesson 4

Westfield objectives

6. Basic tackling:
   - The reverse stick tackle
   - Closing down an opponent

TGfU Session;

   - Begin with standard warm up (teachers decision).

   - Game 1; APPROX 5-10 mins.
     - Marking an opponent closing them down (pressuring)
     - 4 v 4 Game
     - Objective Pick a player that you are going to mark for whole game.
       Stay with that player and when they receive the ball close them down.
       Stay close to your player. Think about how you were able to tackle.

   - Questions after 1st Game APPROX 2-3 MINUTES
     - How can you make it hard for your opponent to receive the ball?
     - Where should you stand to mark them?
     - What type of tackle are you able to use? Introduce and demonstrate reverse stick tackle.

   - Practice Task 5-10 MINUTES
     - Gate in middle with defender (gate width = difficulty). Groups of four.
       Two defenders stood in between two gates. First defender cannot tackle can only shadow or channel player so attacker does not get through gate. Second player can tackle in particular practice reverse stick tackle. Aim of attacker to get through both gates and get ball over line to waiting second attacker.
• GAME 2; APPROX 10 Minutes
  - Back into 4 v 4 Game.
  - Defenders to gain possession when opposition have the ball. Only shoot and score if you are in the D. Hit outs if the ball goes out of play over backline. Opportunity to teach hit outs.
  - Any foul by a defender in the d is goal to opposition to emphasis good tackles.
Appendix B – Study 5: School ‘B’ TGfU Lesson Plans
TGfU Sessions Newnham Middle School Girls Football (Adapted Lessons Mitchell et al. 2006).

Lesson 2 – Objectives - Passing the Ball, using the instep, passing triangle positional play – midfield.

Session Outline;

GAME

3 v 3 possession game

Condition – Make 5 consecutive passes.

QUESTIONING;

What must you do in the game?

How can your team keep the ball?

PRACTICE TASK

Triad practice approx 10 yards apart – control and passing (instep and laces both feet).

Extension – Pass and move to a different space.

GAME 2

3 v 3

Condition - No goalkeepers narrow goals, maximum of three touches before passing, ball must stay below head height.
Lesson 4 – Objectives - Heading the ball, attacking header, defensive header, the throw in.

Session Outline;

GAME 1

3 v 3

Heading game, small goals
Condition – Throw, head, throw (only throwing, catching and heading allowed), goal must be scored by heading.

QUESTIONNING

When might you be able to score with your head?
Where should you head the ball to?
Why head it down?

PRACTICE TASK

Three static practice. One header and two feeders. Alternate feeds and head back to feeder.

Progression – Directional headers.

GAME 2

6 v 6

Conditions – Can only score with head, Can pick up the ball inside 10 meters and throw to team mate for header.
Lesson 6 – Objectives - Evaluation and Games

Session Outline;

GAME 1

6 v 4 – Attacking play, maintaining possession.

Conditions – Must make 5 passes before allowed to shoot. Score as many goals as possible.

GAME 2

5 v 5 – Beating a player, creating space.

Conditions - Keep the ball for 2-3 seconds, take on player before you make a pass.

GAME 3

5 v 5 Unconditional game.
Appendix C – Study 5: School ‘C’ TGfU Lesson Plans
Lesson 1 School ‘C’

Objectives: Attacking Play and Maintaining Possession

- **Game**
  - 3 v 3 games shoot anywhere. If shot missed target possession goes to other team. No tackling.

- **Questioning**
  - Establish methods of attack i.e. taking ball around the player. Dodging.

- **Practice**
  - Practice skills of maintaining possession- dodging. Groups of 3.

- **Game**
  - 3 v3 Focus on using attacking play to penetrate D and score goals. Only able to shoot anywhere in attacking half of pitch. No tackling.

- **End of Session Questioning**
  - Most of goals scored from?
  - Was it because we were able to get closer to the goal?
  - Why was attacking good?
  - What dodges did we use?
  - Feel More confident to take the ball yourself?
Lesson 2

Objectives: Tackling/Defending

- **Game**
  - 2v2 Shoot anywhere in attacking half of pitch. Miss possession goes to opposite team. Allowed to tackle. Think about how you were able to tackle.

- **Questioning**
  - How were you able to tackle. Focus on low block tackle.

- **Practice.**
  - Gate in middle with defender (gate width = difficulty). Only shadow or channel player cannot tackle. Second player can tackle. Aim of attacker to get ball over line. In groups of 4.

- **Game**
  - 6v6 Students decide which positions they have. Defenders to gain possession when opposition have the ball. Only shoot and score if you are in the D. Hit outs if the ball goes out of play over backline. Opportunity to teach hit outs.
  - Progression if any foul by a defender in the d is goal to opposition.

- **End of session questioning**
  - Scores in games?
  - Why did the opposition score more?
  - Good defending? Early tackling?
  - Which tackle was the most successful?
  - Did you use all tackles?
  - When is a hit out given? Where is it taken from?
Lesson 3

Objectives: Defensive Fouls/Penalty Corners.

- **Game**
  - 5v5 - markers for width of pitch. Wingers encouraged to make use of width. Fouls by defence in 'd' is goal to other team.
  - Highlights importance of safe tackling and penalty corners.
  - Differentiation: Size of pitch – pupils have more space have more time on ball and hopefully will give more confidence.

- **Questioning**
  - Any goals scored from defensive errors?
  - When do we award a foul?
  - Explanation of penalty corner.
  - Where do we normally take them from?

- **Practice**
  - Penalty Corner practice Attacking
  - Set up and injecting the ball.
  - Progression of adding in the defence.
  - Progression 5v5 Game begins with a penalty corner if it is unsuccessful and opposition get the ball turns into game play so the defensive go on the attack. Once ball goes out of play it is penalty corner to opposition. If goal game begins with penalty corner for the opposition.

- **Questioning**
  - How many short corners were successful?
  - Are your penalty corners successful?
  - Why are they not successful?
  - What can we change to make them successful?

- **Game**
  - 5v5 Defending foul in attacking half = penalty corner. Only condition on game.

- **Questions at end of session**
  - Scores on pitches?
  - How many goals from penalty corners?
- When penalty corners were scored what made them work?
- Was it important to have roles for each person?
- What roles were important?
Appendix D: TGfU Lesson Plans Study 6: School ‘D’ Girls
School ‘D’ TGfU Netball (activity one) weeks 1 – 6, Adapted from Mitchell et al. (2006)

Week 1 – Recap Session – Basic Rules, passing and moving into space.

- **Game** – 3 v 3 on third of court to introduce children back to netball.
  - Condition – Need to bounce the ball in the hoop positioned on the back line to score.

- **Skill** – Groups of 3.
  - Pass and move drill.

- **Questions - Guided by Teacher.**

- **Game** – High Five’s with nets 5 v 5.
  - Condition – Extra point awarded if pass is made then the child has successfully moved into space to receive the ball back.
Week 2 – Principles of attack – moving ball down court and getting free.

- **Game** – 5 v 5 High Five’s game.
  
  - Condition – Need to achieve five passes before a goal is allowed to be scored.

- **Skill** – Getting Free – Groups of 5
  
  - Dodging drill. Feeder central. Attacker and defender either side aim is to dodge to leave player and receive ball from feeder.

  Alternate sides.

  ![Diagram](image)

  A - A ↔ F → B - B

- **Questions - Guided by Teacher.**

- **Game** – High Five’s 5 v 5.
  
  - Condition – Two points awarded if opposition do not intercept ball from centre pass (emphasise dodging to get free).
Week 3 – Marking a player – Intro to new positions

**Game** – Progress to 7 a side. (Learning Aid Provided to introduce new positions)

- Condition – Children to recognise the positions that they are playing and know the areas they can enter.
- Condition 2 – Defenders to stay with players they are marking whether they have the ball or not.

- **Skill** – Marking a Player
  - Groups of 3. Focus on staying with player whether they have the ball or not in order to prevent them receiving the ball.

- **Questions** - Guided by Teacher.

- **Game** – 7 a side game
  - Condition – If defensive team intercept ball before attackers make three passes the defending team receives a point.
**Week 4 – Getting the ball into the circle and shooting.**

- **Game** – 4 v 4 half court game.
  - Condition – 1 point for receiving ball in circle successful even if shot misses.
  - Two points if successful pass into circle and shot is successful.

- **Skill** – Moving ball into circle.
  - Groups of 4. No defenders. Moving ball into circle to shooter who takes up different positions within the circle.

- **Questions - Guided by Teacher.**

- **Game** – 7 a side game.
  - Condition – Extra point awarded for defence if they intercept pass.
  - Condition 2 – 2 points if successful pass is made into the circle with a shot even if the shot is not successful.
Week 5 – Moving the ball from defence to attack

- **Game** – 7 a side game with chalked areas within thirds of court to create space and prevent crowding around ball.

  - Condition – Each player to stay within their set zones – emphasis on creating space to move the ball from defence to attack.

- **Skill** – Transferring the ball from defence to attack.

  - Groups of 7. Make movement to receive ball in sequence down the court. No defenders. Stay in your chalked zone. Spots placed on court to mark position where players should ideally start from.

- **Questions** - Guided by Teacher.

- **Game** – 7 a side game.

  - Condition – Extra 2 points awarded for successful transference from back line pass/defence down court into attacking circle without interception from defending side.

Week 6 – Mini Tournament and Assessment.
Week 1 – Dribbling, turns and outwitting a defender.

- **Game** – 1 v 1 cones either end on 20 x 10 yard pitch.
  - Condition – Dribble ball past opponent to their goal line in order to score
  - After a goal is scored ball is returned to player who conceded the goal and opposition player must start back at half way line.

- **Questions - Guided by Teacher.**

- **Skill** – Individual free dribbling.
  - Ball each dribbling within specified area. Teacher calls ‘turn’ ‘speed up’ or ‘slow down’ to force changes in direction or speed.

- **Game** – 1 v 1 cones either end on 20 x 10 yard pitch.
  - Condition – Dribble ball past opponent to their goal line in order to score
  - After a goal is scored ball is returned to player who conceded the goal and opposition player must start back at half way line.
**Week 2 – Develop passing**

- **Game** – 3 v 3 possession game
  - Condition – Make 5 consecutive passes

- **Questions** - Guided by Teacher.

- **Skill** – Passing – Groups of 3
  - Use one touch to control and set up next pass.
  - Pass using both inside of both feet.

- **Game** – 3 v 3 game.
  - Condition – maximum of three touches before passing.
  - Ball stays under head height.
Week 3 – Develop Shooting

- **Game** – 6 v 6 game
  - Condition – Shoot when possible and hit the target.

- **Questions - Guided by Teacher.**

- **Skill** – Shooting
  - Partners with static ball.
  - All shots below waist height (set up as below)
    
    ![Diagram](chart.png)

  Cones

- **Game** – 6 v 6 game
  - Condition – Shoot when possible and hit the target.
  - Set specific number of shots each team should aim to have
    (decided by teacher depending on ability).
Week 4 – Develop Attack

- **Game** – 6 v 6 game
  - Condition – Early pass to target player in order to create shooting opportunity.
  - One defender to mark target player.

- **Questions - Guided by Teacher.**

- **Skill** – Shooting from target player. Pass to target player who lays off ball for a shot.
  - Groups of 6 – 4 shooters, 1 GK, 1 target player.
  - Accurate pass to target player, accurate lay off from target player.
  - Accurate shot on goal.

- **Game** – 6 v 6 game
  - Condition – Nominate target player, focus on providing support for target player and shielding them to ensure they can get a shot.
  - Condition 2 – If target player scores it is worth 2 goals.
Week 5 – Tackling/defending strategies

- **Game** – 4 v 4 game.
  - Condition – Focus on marking/guarding an opponent player.

- **Questions** - Guided by Teacher.

- **Skill** – Prevent opponent from turning, focus on keeping the right distance away and the right stance.
  - 1 v 1 plus two feeders.
  - Feeders alternate playing ball in to player whilst other player tries to prevent turn and guards and marks the player.
  - Shadowing rather than diving into the tackle.

- **Game** – 4 v 4 game.
  - Condition – Focus on marking/guarding an opponent player.
**Week 6 – Winning the ball**

- **Game** – 3 v 3 game (no goals)
  - Condition – Control ball and try to get the ball to opponents line.
  - Take on opponent (dribbling) before making a pass.

- **Questions - Guided by Teacher.**

- **Skill** – 1 v 1 practice.
  - Defender passes ball to attacker and advances to close them down whilst the attacking player tries to dribble around defender.
  - Focus is on channelling and tackling.

- **Game** – 3 v 3 game (no goals)
  - Condition – Control ball and try to get the ball to opponents line.
  - Take on opponent (dribbling) before making a pass.

**Week 7 – Mini Tournament.**
Appendix E: TGfU Lesson Plans Study 6: School ‘E’ Boys
Week 1 – Recap Session – Playing the game and passing/maintaining possession.

- **Game** – 4 v 4 to introduce children back to rugby (tag rugby).
  - Condition – Can pass and run in any direction. Once tag is pulled off must stop and pass.
  - A dropped ball must go to the other team.

- **Skill** – Groups of 4.
  - Passing along line to introduce rules of rugby.

- **Questions - Guided by Teacher.**

- **Game** – 4 v 4 Tag Rugby
  - Condition – Same as first game but ball is not allowed to passed forward. Try is now scored by placing ball on backline.
Week 2 – Maintaining possession of ball and advancing the ball.

- **Game** – 4 v 4 game (tag rugby).
  - Condition – Tag rugby score a try without passing the ball forwards.
  - Try scored by placing ball on back line.
  - Dropped ball goes to the other team for a free pass.
  - If ball goes out of bounds start with a free pass.

- **Questions** - Guided by Teacher.

- **Skill** – Groups of 4.
  - Running single file to score a try. Focus on running forward and placing ball down firmly
  X1 X2 X3 X4
  - X4 begins with ball runs forward places ball firmly to ground moves to the side, X3 runs through picks up ball runs forward and then places ball firmly down etc.
  - Extension – Instead of placing ball down player turns and passes to next player in line – emphasising supporting ball carrier.
• **Game** – 4 v 4 Tag Rugby
  
  - Condition – Same as first game but focus on using the correct technique to score a try.
  
  - Support ball carrier from behind.
Week 3 – Maintaining Possession – Advancing ball, drawing a defender, support.

- **Game** – 4 v 4 game (tag rugby). Find ways to beat defender with a pass.
  - Condition – Tag rugby score a try without passing the ball forwards.
  - Try scored by placing ball on back line.
  - Dropped ball goes to the other team for a free pass.
  - If ball goes out of bounds start with a free pass.

- **Questions - Guided by Teacher.**

- **Skill** – Groups of 4.
  - Play 2v1v1

  X1  →  X3

  X4  X2

  - X1 starts with the ball and combines with X2 to try and beat players X3 and X4.
  - X3 once beaten is eliminated from game and X4 can only move once X3 has been beaten.
- Cue – wait for X3 to advance before passing the ball to beat the defender.

- **Game** – 4 v 4 Tag Rugby
  - Condition – Same as first game but focus on beating defenders using what they have practised in skill task.


**Week 4 – Introduction to tackling**

- **Game** – 4 v 4 game (tag rugby).
  - Condition – Tag rugby score a try without passing the ball forwards.
  - Try scored by placing ball on back line.
  - Dropped ball goes to the other team for a free pass.
  - If ball goes out of bounds start with a free pass.

- **Questions** - Guided by Teacher.

- **Skill** – Groups of 2.
  - Demonstration of tackling technique lead by teacher.
  - Opportunity for children to practise tackling on each other.

- **Game** – 4 v 4 Contact Rugby
  - Condition – Same as first game but contact tackling is allowed for the students who feel comfortable with contact. Teacher used own discretion to split the children into teams. Two pitches contact game, two pitches still on tag rugby.
Week 5 – Recap tackling skills, use of tackling in game situation

- **Game** – 4 v 4 game (tag rugby).
  - Condition – Tag rugby score a try without passing the ball forwards.
  - Try scored by placing ball on back line.
  - Dropped ball goes to the other team for a free pass.
  - If ball goes out of bounds start with a free pass.

- **Questions** - Guided by Teacher.

- **Skill** – Groups of 2.
  - Demonstration of tackling technique lead by teacher.
  - Opportunity for children to practise tackling on each other.

- **Game** – 4 v 4 Contact Rugby
  - Condition – Same as first game but contact tackling is allowed for the students who feel comfortable with contact. Teacher used own discretion to split the children into teams. Two pitches contact game, two pitches still on tag rugby.

Week 6 – Assessment Session

Mini Tournament for Assessment.
School ‘E’ – TGfU Football (activity two) Adapted from Mitchell et al. (2006)

Week 1 – Maintaining possession of the ball – supporting the ball carrier

- **Game** – 3 v 3 in 30 x 20 yard pitch
  - Condition – three touches (two touches to receive ball and one to pass or shoot).
  - Head-height rule

- **Questions** - Guided by Teacher.

- **Skill** – Groups of 3 (2 v 1)
  - Pass and support drill, 1 defender, 2 attackers.
  - 1 attacker moves to support player with ball to receive a pass.

- **Game** – 3 v 3 in 30 x 20 yard pitch
  - Condition – three touches (two touches to receive ball and one to pass or shoot).
  - Head-height rule
Week 2 – Attacking the ball – turning with the ball

- **Game** – 1 v 1 in 20 x 10 yard pitch with two feeders.
  - Condition – Receive pass from feeder and turn to pass to other feeder.
  - Head-height rule

- **Questions** - Guided by Teacher.

- **Skill** – Groups of 2
  - Receive and turn with the ball in one move
  - Inside of foot to pass and receive ball.

- **Game** – 3 v 3 in 30 x 20 yard pitch, two feeders
  - Condition – receive pass from feeder.
  - Work as tem to get ball to other feeder that is on opposite sideline.
  - Cannot return pass to feeder who gave pass.
  - Each pass earns one goal.
Week 3 – Maintaining possession of the ball – combining short and long passes

- **Game** – 6 v 6 in 30 x 20 yard pitch with two feeders.
  - Condition – three touches, two forwards, two defenders, two midfield.
  - Stop ball on goal line to score.

- **Questions** - Guided by Teacher.

- **Skill** – 4 v 4 possession game plus two outside corner players per team.
  - Combine ling and short passes to keep possession.
  - Short passes to draw opponent. Long passes to open up game.
  - Corner players cannot be tackled.

- **Game** – 6 v 6 in 30 x 20 yard pitch
  - Condition – No conditions but focus on using long and short passes to score a goal.
Week 4 – Defending space, marking and pressuring the ball.

- **Game** – 4 v 4 in 40 x 30 yard pitch
  - Condition – must mark one player for whole game

- **Questions** - Guided by Teacher.

- **Skill** – 1 v 1 plus two feeders.
  - Prevent opponent from turning and passing to opposite feeder.
  - Focus on marking player

- **Game** – 4 v 4 in 40 x 30 yard pitch
  - Condition – Mark player and prevent them from turning.
Week 5 – Attacking the goal – target player to create shooting opportunities.

- **Game** – 6 v 6 in 40 x 30 yard pitch
  - Condition – each team must allocate someone to be their ‘target player’.
  - Only one person allowed to mark target player.
  - Full size goals

- **Questions** - Guided by Teacher.

- **Skill** – Groups of 5
  - Target player in box in front of goal
  - Firm pass into target player, target player to lay off the ball to left or right, immediate first time shot from player who initially passed the ball.
  - Switch around roles within group.

- **Game** – 6 v 6 in 40 x 30 yard pitch
  - Condition – each team must allocate someone to be their ‘target player’.
  - Target player cannot run with ball i.e. so must pass ball.
  - Goals scored by a ‘lay off’ from target player scores 2 points.

**Week 6: Assessment Week – mini tournament.**
Appendix F: Paper Submission to the ‘Journal of Teaching in Physical Education’