CHILD-CENTRED PHYSICAL ACTIVITY: EFFECT ON MOTOR SKILL DEVELOPMENT IN TODDLERS

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ABSTRACT

Background: Over the last 20-30 years, children's physical activity levels have decreased significantly resulting in obesity rates reaching epidemic levels. To date there has been very little research regarding physical activity in toddlers, with the majority of research focussing on young children (3-5 year-olds) or on children at risk of motor or neurological deficiencies. **Purpose:** To investigate the effects of a nine-week, child-centred physical activity programme on cognitive and motor skill development, safety skills, balance and parent supervision in typically developing 12-24 month-old children. **Methods:** In a randomised, controlled design, 90 toddlers (age 17.0 ± 2.6 months; 52.2% male) and their parents were split into two treatment groups stratified by age and gender at baseline. The intervention completed was either nine weeks (one school term) of one-hour child-centred physical activity classes or normal physical activity for nine weeks. In the school holiday periods prior to, and following the intervention period anthropometric measures (mass and height), overall development (Bayley Scales of Infant Development – Screening Test), safety skills (nine-skill test battery), balance measures (centre of pressure) and parent-child supervision were assessed. **Results:** The nine-week physical activity intervention was successful in improving the overall safety skills score ($p < 0.05$). In addition, the ability to climb over a small-runged A-frame while using a cylinder grip and safe face-the-slope dismount and the execution of a safety roll down a foam wedge were improved as the result of the intervention ($p < 0.05$). There was no effect of the exercise intervention on overall development, measures of balance or supervision aspects. A main effect of Age Group on the mean change score in all subscales was reported with younger children (12-18 months) tending to show greater improvements as compared to older children (18-24 months). Regression analysis showed that 27.8% of the change in overall development could be predicted by knowing the age of the child and whether their day-to-day environment was mostly home care with their parent or other adult, or not. **Conclusions:** This was the first randomised, controlled trial that examined the effects of a child-centred physical activity programme on overall development, safety skills, balance and supervision in 12-24 month-old children in New Zealand. There is a need for more randomised, controlled trials that incorporate a multitude of external factors that may influence development, namely cognitive and motor skill development.

Keywords: motor skill development, cognitive development, toddlers, physical activity, balance

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CHAPTER 1

INTRODUCTION

Over the last 20-30 years, physical activity levels of children have decreased significantly and this has resulted in obesity rates reaching epidemic levels (Gunner, Atkinson, Nichols, & Eissa, 2005). This has led to an increase in the importance of health promotion for children and infants (Gunner, et al., 2005; Timmons, Naylor, & Pfeiffer, 2007). However, there is a lack of evidence to suggest that physical activity in infancy will control obesity in childhood and later life (Timmons, et al., 2007). Current research suggests that inadequate nutrition is a more important factor in obesity in this cohort (Parsons, Power, Logan, & Summerbell, 1999; Wells, Stanley, Laidlaw, Day, & Davies, 1996). The use of the term ‘children’ is not ideal when examining developmental changes and physical activity; largely due to the expansive differences that exist between children of various ages. For this reason, we will adopt the terms set out by the New Zealand Ministry of Education (2009), which categorises young children into three overlapping groups: infants for children aged up to 18 months; toddlers for children aged between one to three years; and young children aged between two and a half years up to school entry, who are also often referred to as pre-school children. The term children will be used for those that have reached the age of school entry (five years old). In New Zealand, children tend to enter school on or around their fifth birthday, which is different to many other countries.

Physical activity is associated with improving fundamental motor skills in children (Barnett, van Beurden, Morgan, Brooks, & Beard, 2008b; Sääkslahti et al., 2004).

In addition, children with better motor skill proficiency have 10-20% higher chance of participating in vigorous physical activity (Barnett, van Beurden, Morgan, Brooks, & Beard, 2009), enhanced cardiovascular fitness (Barnett, et al., 2008b), greater perceived sports competence as adolescents (Barnett, Morgan, van Beurden, & Beard, 2008a) and there are also positive associations with higher physical activity levels in children (Williams et al., 2008; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006). These factors all contribute to an increased likelihood of long-term participation in sport and exercise. Furthermore, motor proficiency is inversely associated with sedentary activity in children (Williams, et al., 2008; Wrotniak, et al., 2006), suggesting that motor skill development at a young age may be a key strategy for improving later physical activity levels and potentially obesity prevention.

Recent studies have also found that between 4-10% of children aged under five years are not meeting physical activity guidelines that suggest engaging in 180 minutes of physical activity a day (Goldfield, Harvey, Grattan, & Adamo, 2012; Hnatiuk et al., 2012). There is an assumption that young children or toddlers are naturally active however, it has been established that the vast majority of physical activity that toddlers engage in is low intensity and therefore they may not be meeting physical activity requirements (Gubbels, Van Kann, & Jansen, 2012; Hnatiuk, et al., 2012). Consequently, it may be important for physical activity guidelines, for both parents and practitioners, to specify the required intensity and duration of physical activity to ensure the benefits of improved bone properties, aerobic fitness and motor skills are gained.

The introduction of physical activity programmes in early childhood not only allows children to reach their predetermined brain development potential but also can enhance this potential (Holt & Mikati, 2011). However, it is unknown whether short-duration (4-6 weeks) interventions have any real effect on improving children's fitness or motor skill developments (Matvienko & Ahrabi-Fard, 2010). However, significant improvements to fundamental motor skills following a 4-week intervention in kindergarten and first-grade children have been reported (Matvienko & Ahrabi-Fard, 2010). In addition, many intervention studies have concentrated on children with neurological or motor deficits or as prevention programmes for children at risk of obesity (Angulo-Barroso, Burghardt, Lloyd, & Ulrich, 2008; Bluford, Sherry, & Scanlon, 2007; Valvano & Rapport, 2006), therefore there is a need for further research regarding intervention in typically developing children of all age groups, but particularly young children and toddlers.

Children with better motor skills also show enhanced academic (Bittmann, Gutschow, Luther, Wessel, & Kurths, 2005) and cognitive (Piek, Baynam, & Barrett, 2006; Voelcker-Rehage, 2005) skill. In particular, Piek and colleagues (2006) found that while fine motor skill in early childhood did not account for a significant proportion of the variance in fine motor skill or cognitive skill performance in school-aged children, gross motor skill in young children accounted for cognitive performance when the children reach school age. These findings support the need for ongoing research into the relationship between early motor development and later cognitive function.

In addition to the links between motor skill development and physical activity or cognitive skill, associations between motor skill development and injury rates are also being reported. Infants 15-17 months old have the highest injury rates before 15 years of age, which coincides with developmental milestones such as independent mobility and exploratory behaviour (Agran et al., 2003). The development of the upper body occurs earlier than that of the lower body, thereby enabling children to access more hazards, without having the strength or motor skill to avoid injury (Agran, et al., 2003). Fall-related injury at or around the home accounts for 56% of the hospitalisations in children aged 0-4 years (Safekids New Zealand, 2006). Therefore, it is suggested that enhancing balance and coordination in infants may be an effective strategy in reducing risk of fall-related injury.

A number of studies also highlight the importance of strong emotional and physical bonds between the child and the parent to facilitate motor development, and thus reduce the likelihood of injury (Mack, Gilchrist, & Ballesteros, 2007; Sääkslahti, et al., 2004; Timmons, et al., 2007). In addition, the interaction between child behavioural attributes and parental supervision practices has been shown to influence injury rate (Morrongiello & Corbett, 2006; Morrongiello, Klemencic, & Corbett, 2008). Parental support can also either directly or indirectly predict the child's physical activity level, although this relationship is more pronounced in younger children (Biddle & Goudas, 1996). In addition, the parent's level of physical activity has been found to be directly related to the children's level of activity (Moore et al., 1991; Poest, Williams, Witt, & Atwood, 1989). These findings suggest that the incorporation of parents into any intervention programme is necessary for its success as well as access to an appropriate environment including suitable equipment, interaction with others and some outdoor play (Fisher, van Jaarsveld, Llewellyn, & Wardle, 2010).

The incorporation of parents into intervention studies is supported by literature that suggests early childhood teachers believe that efforts to enhance parents' awareness of the importance of their child's physical activity requirements may help increase young children's levels of physical activity (Tucker, van Zandvoort, Burke, & Irwin, 2011). Furthermore, the teachers interviewed by Tucker and colleagues (2011) noted that parental role modelling is a key factor in encouraging and supporting physical activity in young children; whether it is through active play with the child or providing opportunities for physical activity.

In addition to the associations between parental factors and children's physical activity, links to early childhood centres have been examined. A number of studies (Bower et al., 2008; Gubbels, et al., 2012) have reported that children attending early childhood centres with supportive environments, including opportunities to be active, play equipment, and amount of space both indoors and outdoors, are more likely to achieve higher levels of moderate-to-vigorous physical activity (MVPA) than children attending less supportive early childhood centres. On the other hand, Gubbels and colleagues (2010) reported that attending early childhood centres between the ages of one and two years was positively associated with a greater increase in BMI between these ages. In addition, Sugiyama, Okely, Masters and Moore (2012) reported that children who attended early childhood centres were mostly sedentary and spent between 12-

36 minutes per day in MVPA. This work is also supported by Pate and colleagues (2008) who reported that three to five year-old children in early childhood centres were engaged in MVPA for less than 3% of the 30-second observation intervals; a minimum of 600 observation intervals were recorded for each child.

To date there has been very little research regarding physical activity in toddlers, with majority of research focussing on young children aged 3-5 years. This is most likely due to the difficulties associated with using very young children, including unpredictable nap times, shorter concentration spans and the problems of being in a strange environment (M. H. Johnson & Munakata, 2005). In addition, the use of accelerometers has been shown to be a valid and reliable method of assessing physical activity in children (Fisher et al., 2005) however, they are yet to be validated for use in children under five years (Cliff, Reilly, & Okely, 2009). Furthermore, there are many methodological issues pertaining to the use of accelerometers with conflicting evidence surrounding the placement of the device and no literature examining the accuracy of different device placement in children aged birth to three years (Cliff et al., 2009). Nevertheless, it is important to determine the effects of physical activity on outcomes such as motor skill development, cognitive development and safety skills.

The paucity of research examining physical activity and its effects on development in toddlers suggests there is a need for further research. In particular, intervention studies in typically developing children of all age groups, but especially young children and toddlers are required. Randomised, controlled trials (RCTs) are the best vehicle to investigate links between an intervention and its effects as they attempt to limit human bias and reduce uncertainty (Altman & Bland, 1999). This RCT enabled achievement of my goal of researching the impacts of physical activity in toddlers. With over 10 years experience working with children (5-10 year-olds) in a coaching capacity as well as time spent as an au pair, my passion for encouraging young children to enjoy sport and maintain physical activity was further developed through this research.

1.1 Aim and Objectives

The overall aim of this thesis was to examine the effects of a child-centred physical activity programme on development in toddlers (12-24 month-old children). Specifically the objectives of this study were:

a) To determine the effects of a physical activity intervention on cognitive and motor skill development in toddlers.
b) To investigate the effects of a physical activity intervention on safety skill development in toddlers.
c) To investigate the use of a force plate for assessing static balance in toddlers
d) To investigate the effects of a physical activity intervention on parent-child supervision.

1.2 Hypotheses

The major null hypotheses (H_0) for this research were:

$H_0$1: 9 weeks of a child-centred physical activity programme will not affect overall development measures, including cognitive, communication and motor skill in 12-24 month-old children.

$H_0$2: 9 weeks of a child-centred physical activity programme will not affect improvement in safety skills in 12-24 month-old children.

$H_0$3: 9 weeks of a child-centred physical activity programme will not affect balance in 12-24 month-old children.

$H_0$4: 9 weeks of a child-centred physical activity programme will not affect parent/caregiver supervision of their 12-24 month-old children.

1.3 Thesis Overview

This thesis is presented in five chapters. Chapter 2 is a review of the literature examining the research regarding infant development in relation to physical activity and interventions in young children. Chapter 3 describes the methodology employed in this study. Chapter 4 presents the results of a physical activity programme on cognitive, motor skill and communication development, improvement in safety skills, balance, and parent/caregiver to child supervision. Chapter 5 is the discussion of the results of this study in relation to the existing literature and of the implications of the current study. In addition, a review of the limitations of the methodology of this study will be discussed and final conclusions will be presented.

CHAPTER 2

LITERATURE REVIEW

This chapter aims to provide a background of the current research on toddler development and the evidence on the effectiveness of intervention programmes for promoting children's physical development. Motor skill development will be the key focus as this is the area of most research. However, the links between physical activity and cognitive development will also be examined. In addition, associations between attachment and motor skill development, particularly safety skill development and the reduction of injury rate, will be investigated. Methods of measuring the various aspects will also be addressed, as the variety in methodology provides the potential reason behind differences in findings.

2.1 Methodology

This exploratory literature review was conducted between February 2011 and February 2013 using the following databases: Medline, SportDiscus, Web of Science, Scopus, Scifinder Scholar and JSTOR. These databases were searched using various combinations of the key words: infants; toddlers; preschool children; young children; motor skill development; physical activity; cognitive development; safety skills; injury rate; attachment; supervision; and social interaction. No restrictions on date of publication were used. In addition to the articles found using database searches, all pertinent articles from the bibliographies of the articles were also reviewed. Furthermore, government websites such as the Ministry of Education, Ministry of Health and Sport New Zealand were examined for pertinent publications and reports.

2.2 Motor Development

The development that occurs during the toddler years is rapid with the most obvious changes occurring in language and motor skills, but all areas continue to develop (Colson & Dworkin, 1997). According to Mercer (1998) there are two major categories of development: maturation and learning. Although all changes are generally permanent and irreversible, the changes that occur due to the instructions built into our DNA are usually described as maturation (Harris & Liebert, 1992),which includes changes attributed to growth. There have been changing views of child development in the last century. Early views of development were based on the achievement of developmental milestones, largely centred on the research of Gesell (1925), while learning theories of development suggested that children play an active role in their own development with both perceptual and social incentives that assist with the progression of skills (Bruner, 1973). However, more recent theorising suggests that development is a dynamic system, but strongly influenced by a variety of factors, including interaction with peers, families, societies and cultures (Thelen, Ulrich, & Wolff, 1991). In particular, the dynamic perspective realises that even small differences in experience or environment, or another component of the dynamic system, at a young age can result in dramatic differences in later behaviour (Smith & Thelen, 2003). Therefore it is suggested that if the real-time activities of an infant can impact development so strongly, one must understand the processes by which this occurs in order to research the impact on behaviour patterns (Smith & Thelen, 2003).

The New Zealand Ministry of Education (2009) categorises young children into three overlapping groups; infants for children aged up to 18 months; toddlers for children aged between one to three years; and young children are aged between two and a half years up to school entry, who are often referred to as pre-school children. Motor development during the toddler period in particular is characterised by the commencement of walking and other locomotion skills such as running, jumping and hopping (Cardon et al., 2011), which are often defined as gross motor skills. In addition, fine motor skills, or manipulative skills, such as writing/drawing or using building blocks, begin to be observable during the toddler period (Cardon et al., 2011). Both fine and gross motor development is the result of cephalocaudal and proximodistal development of the central nervous system in the typically developing child (Adolph & Berger, 2005).

This section will examine studies that have investigated the potential link between physical activity and fundamental movement skills and sport participation or proficiency in later life. In addition, physical activity intervention studies will be reviewed. Methods of assessing motor skill development and measures of physical activity levels or energy expenditure will also be reviewed. The development of safety skills as a subset of motor skill development is investigated, along with the potential link between safety skill and motor skill development and the reduction of accidental injury.

2.2.1 Normal development

Motor development milestones are easily observable signs of normal development (Adolph & Berger, 2005). Often, the key determinants of motor development include age of holding head up, age of sitting without support, age of standing unaided, age of crawling, and age of walking unaided, which are easily identifiable aspects (for further milestones see Table 2.1). Although milestone assessments, often based on early work by Gesell (1925, 1948), help indicate a child's overall development, or specifically motor or cognitive development, they are usually based on a North American, predominately white, sample and even the latest revisions of many of these assessments are still at least ten years old (Black & Matula, 2000). Therefore, some studies choose to report raw scores rather than relying on the standardised norms which are often based on North American data (Black & Matula, 2000).

An early study by Nancy Bayley (1936) determined that the curve of motor development is characterized by a very rapid slope during the first 21 months of life where there are considerable gains in gross motor coordination. It was also found that gains in motor control occur over a smaller age range than mental or intellectual gains (Bayley, 1936). For example, 12% of participants first achieved walking alone at 11 months and 80% at 15 months while the ability to speak two words was gained by 22% at 11 months and 7% at 15 months (Bayley, 1936).

Table 2.1

Typical milestones of motor development (Brierley, 1993)

Age	Milestones
3 months	Lifts head, kicks vigorously, waves arms, hands loosely open.
6 months	Sits, stands with support only, turns head from side to side to look round, hold arms to be lifted, kicks strongly, can roll over. Whole hand grasp.
12 months	Walks when hand is held, crawls on feet and hands, sits on floor, may stand alone for few moments, may walk alone. Picks up small objects with precise pincer grasp. Drinks from cups, chews, takes objects to mouth less.
18 months	Walks unaided, sits on chair, pushes and pulls large toys, can carry teddy bear while walking, walks upstairs with help. Drinks without spilling, holds spoon and gets food to mouth.
2 years	Runs, walks up and down stairs two feet to a step holding on to rail or wall. Climbs on furniture to look out window or to open doors. Lifts and drinks from cup and replaces on table; chews completely; turns door handles.

Although all children will develop at different rates, they all go through the same order of development due to the maturation of certain neural pathways at certain ages (Brierley, 1993). According to Barkovich, Kjos, Jackson and Norman (1988), there is a predetermined pattern in which the brain matures resulting in the different activities associated with the various stages of development. However, these patterns or milestones may not be reflected in children of a wider range of ethnicities and environments than those the original research was completed with because they have had different opportunities of experiences, which lead to the development of different physical skills or proficiencies (Adolph & Berger, 2005).

The implication of this is that some literature report findings in terms of developmental age as opposed to chronological age, as in the early years of life, it is deemed to be more relevant (Foster & Hartigan, 2006), especially for children born pre-term or with very low or extremely low birth weight (VLBW and ELBW respectively). It is also generally assumed that tests of motor development are appropriate measures of overall development and are therefore often used to detect any developmental deficits (Bayley, 1936). Table 2.2 provides an overview of some of the infant assessments based on milestones (discussed further in section 2.3.5).

Table 2.2

Overview of infant assessments based on milestones (Black & Matula, 2000)

Test Title	Source	Age Range	Content Areas
Bayley Scales of Infant Development	Bayley (1969)	1 – 42 months	Mental, motor and behaviour
Cattell Infant Intelligence Test	Cattell (1940)	2 – 30 months	Cognitive
Denver Developmental Screening Test	Frankenburg, et al. (1967)	Birth – 6 years	Gross Motor, Fine Motor, Language and Social/Personal Behaviours
Gesell Developmental Schedules	Gesell (1925)	1 week – 36 months	Adaptive, Gross Motor, Fine Motor, Language, Personal-Social
Griffiths Developmental Scale	Griffiths (1967, 1970)	1 – 60 months	Locomotor, Hearing and Speech, Hand-eye Coordination, Performance, Practical Reasoning, Personal-Social

Note. Age range is shown for the revised editions of each assessment.

2.2.2 Associations with physical activity

Studies that have examined the relationship between childhood motor ability or fundamental movement skills and adolescent fitness (Barnett, et al., 2008a; Barnett, et al., 2008b), physical activity levels (Barnett, et al., 2009; Okely, Booth, & Patterson, 2001), self-perceptions and self-worth (Piek, et al., 2006) and participation in sport (Ridgway et al., 2009) are outlined in Table 2.3. The studies included in Table 2.3 are comprehensive, well-designed studies with clearly defined methods and large sample sizes.

The studies by Barnett and colleagues (2008a, 2008b, 2009) all utilised the same cohort of children from primary (elementary) schools in New South Wales (NSW), Australia. The original sample of 1045 children (mean age = 10.1 years) was reduced to 276 children in the follow-up testing six years later. Data collected from this cohort suggested that adolescent cardiorespiratory fitness is associated with object control proficiency ($p = 0.012$), which is also likely to produce more active adolescents. In addition, perceived sports competence acts as a mediator between these variables. The implication of the findings of these studies is that as these factors all contribute to an increased likelihood of long-term participation in sport and exercise, motor skill development at a young age may be a key strategy for improving later physical activity levels.

Gender was also considered as a separate variable in these studies as research indicates that gender has an effect on fine motor skill, language and social skill development (Lung et al., 2011). Barnett et al. (2008b) provide further evidence as gender differences at childhood were found in object control proficiency and locomotor skill proficiency. In addition, as adolescents, males were more active and had greater perceived sports competence than females. However, Barnett et al. (2008a) did not find the interaction effect between gender and object control proficiency to be statistically significant (p=0.390). Similarly, they did not find significant gender differences in the relationship between childhood object control proficiency and adolescent cardiorespiratory fitness. Barnett et al. (2009) found that gender was only a significant predictor of time spent in moderate to vigorous activity, even though males were significantly more active than females. This suggests that if childhood motor skill proficiency is the same, girls have an equal chance of participating in higher-intensity physical activity. Therefore, it may be necessary to target girls in childhood in order to increase the time spent in high intensity physical activity.

Fisher et al. (2005) and Okely et al. (2001) investigated fundamental movement skills such as jumping, catching, throwing and kicking and the association with physical activity habits or level. Fisher et al. (2005) utilised accelerometers to measure physical activity with a younger cohort of participants (mean ± SD age: 4.2 ± 0.5 years). Okely et al. (2001) used self-reporting of the adolescents in the sample. Although these studies were looking at different age groups (young children and adolescents), both found an association between fundamental movement skills and physical activity (R^2 = 0.03, p <0.001, Okely et al., 2001; r = 0.1, p = 0.04, Fisher et al., 2005). However, Fisher et al. (2005) concedes that the association found was weak, and Okely et al. (2001) point out that only 3% of the variation in participation in organised physical activity can be explained by fundamental movement skill scores.

As only weak associations and a large amount of unexplained variance between organised physical activity and fundamental movement skills were found in the aforementioned studies, the implication is that there are likely to be many other factors that play key roles in determining physical activity levels in children and adolescence. In particular, gender differences may have contributed to the small amount of explained variance observed. Furthermore, variables such as socio-economic status of the family, geographic location (rural versus urban) ethnicity and age (Myers, Strikmiller, Webber, & Berenson, 1996) may be associated with physical activity levels in children and adolescence. An in-depth analysis of the potential correlates with adolescents' and children's physical activity was completed by Sallis et al. (2000). They found that a variety of variables including sex, parental overweight status, physical activity preferences, intention to be active, previous physical activity and time spent outdoors were significantly associated with children's physical activity (Sallis et al., 2000). In addition, ethnicity, age, perceived activity competence, support from parents and others and sibling physical activity were significantly associated with adolescents' physical activity (Sallis et al., 2000). The abundance of associated variables suggests that further research needs to incorporate a wide variety of intervention methods to ensure children and adolescents have the best chance of improvement in physical activity measures.

Table 2.3

Studies investigating the link between childhood physical activity (PA) or fundamental movement skills and sport participation or proficiency in later life.

Study	Subjects	Protocol	Results
Barnett et al. (2008a)	Initial testing (2000): 1045 children (age range = 7.9-11.9 years) Follow-up testing (2006-7): 276 students	8 fundamental motor skills were tested (kick, catch, overhand throw, hop, side gallop, vertical jump, sprint run and static balance). Cardiorespiratory fitness was tested in the follow up test by the multistage fitness test (Beep test).	244 students (88.4%) completed the fitness test in 06-07. Mean composite skill score in 2000 was 17.7 (± 5.1). Mean number of laps in multistage fitness test was 50.5 (± 24.4). Object control proficiency was associated with adolescent cardiorespiratory fitness (p = 0.012), when adjusted for gender and accounting for 26% fitness variation.
Barnett et al. (2008b)	See Barnett et al. (2008a) Follow-up testing participants only.	Cardiorespiratory fitness was measured by the multistage fitness test. Sports competence and physical activity levels were self-reported following the fitness test.	Direct relationships were found between: childhood object control skill proficiency and physical activity (R_2 = 0.08), childhood object skill proficiency and perceived sports competence (R_2 = 0.14), and between perceived sports competence and physical activity (R_2 = 0.16). Perceived sports competence as a mediating variable helped to explain 18% of variance of adolescent PA (R_2 = 0.18) and 30% of variance of adolescent fitness (R_2 = 0.30).

Barnett et al. (2009)	See Barnett et al. (2008a)	Proficiency in object control and locomotor skill was measured in 2000. PA was self-reported in 2006/07.	A positive association between time in organised MVPA and childhood object control proficiency was found with certain models accounting for 12.7% (childhood motor skill proficiency and adolescent time in MVPA) and 18.2% (childhood motor skill proficiency and adolescent organised PA) of the variation.
Okely et al. (2001)	Australian study. Grade 8 (13.3 years) Male (n=517) female (n=465) Grade 10 (15.3yr) Male (n=470) female (n=392)	Six fundamental movement skills (run, vertical jump, catch, overhand throw, forehand strike, and kick) were assessed. PA, both organised and non-organised, was self-reported.	The ability to perform fundamental movement skills was significantly related to adolescent participation in organised physical activity, however only accounted for 3% of the total variation spent in organised activity. The interaction between movement skills and time spent in non-organised physical activity was not significant.
Piek et al. (2006)	Children (n=164, 9.10 ± 0.81 years) Adolescents (n=101, 13.84 ± 1.12 years) Split groups based on Developmental Coordination Disorder (DCD).	Fine and gross motor skills were assessed based on the McCarron Assessment of Neuromuscular Development (MAND). Participants also completed self-perception profiles appropriate to their age group.	Significant differences between the control and DCD groups were found in four competencies: scholastic, athletic, physical appearance and behavioural conduct ($p < 0.01$). In the DCD group, poor fine motor ability was associated with poorer perception of scholastic ability ($p = 0.03$).

Fisher et al. (2005)	Scottish study 394 children (4.2 ± 0.5 years)	PA measured using an accelerometer. 15 fundamental movement skills, based on the Movement Assessment Battery, were assessed.	Total movement skill score was weakly, but significantly, correlated with total PA ($r = 0.10$, $p = 0.039$) and with time spent in moderate to vigorous physical activity ($r = 0.18$, $p = 0.001$). There was no difference between boys and girls in the total fundamental movement skills score.
Ridgway et al. (2009)	Finnish study 9009 individuals born during 1966.	Motor development was assessed by parental report at age year 1. Follow up testing at 14 years. School grade awarded for physical education (PE) and a self-report on frequency or sports participation and number of different sports participated in.	Earlier infant motor development, both the age of walking supported and the age of standing unaided, was associated with improved school PE grade ($p < 0.001$). The age of walking supported was also positively associated with the number of different sports participated in ($p = 0.003$) and with greater frequency of sports participation ($p = 0.043$).

Research also supports the general hypothesis that the level of fundamental motor skill is related to skill-specific physical activity. Butcher and Eaton (1989) found that daily indoor free play of 5-year-old children, in early childhood centres, was positively related to running speed. On the other hand, they also showed that children who participated in low intensity, fine motor activities were more likely to have good visual motor control and balance. Similarly, Raudsepp and Pall (2006) support the hypothesis that level of fundamental motor skill is related to skill-specific physical activity, but not with general physical activity levels. However, Raudsepp and Pall (2006) only observed two fundamental motor skills, namely overhand throw and standing long jump, which may have contributed to the findings conflicting with that of Barnett et al. (2008a, 2008b, 2009). More conclusive relationships with overall physical activity levels may have been observed if a greater number of fundamental movement skills were assessed.

A comprehensive, longitudinal study by Ridgeway and colleagues (2009) observed motor development in 9009 individuals born in 1966 and related the age of walking with support or age of standing unaided with school physical education (PE) grade and self-reported sports participation at the age of 14 years. They showed that earlier motor development in infancy is associated with a higher school PE grade, which supports the findings of Barnett and colleagues (2008a, 2008b, 2009). In addition, age of walking was positively associated with the number of sports played and with the frequency of sports participation. These findings were independent of potential contributing factors such as gestational age and birth weight and body mass index at follow up. This epidemiological study further supports the notion that earlier motor skill development in infancy may be a key strategy for improving later physical activity levels.

2.2.3 Physical Activity Guidelines for Infants and Toddlers

There are no published physical activity guidelines for children aged 0-5 years in New Zealand, however it is suggested that children under five should be encouraged to move every day (Ministry of Health, 2012). As other countries, such as Australia, the United Kingdom (UK) and United States of America (USA), utilise specific physical activity recommendations for toddlers and young children, the need for appropriate and specific guidelines for New Zealand's infants and toddlers is highlighted. Table 2.4 illustrates the similarities and differences between the recommendations of the aforementioned countries. A limitation in these guidelines is that those from the USA and UK lack specific ages and instead simply refer to infants, toddlers, pre-schoolers and children. Guidelines from the UK do utilise specific milestones (such as walking unaided) to further define "children" however it is unclear up to what age this group incorporates.

Studies have shown that children are often not meeting guidelines, with Goldfield et al. (2012) reporting that only 9% of boys and 4% of girls are meeting the Canadian Physical Activity Guidelines. Conversely, Hnatiuk et al. (2012) reported 90.5% of toddlers met current Australian physical activity guidelines for children aged birth to five years. While Canada and Australia have similar guidelines in that both suggest young children should engage in 180 minutes of physical activity a day, the Canadian guidelines further define physical activity in terms of intensity level and suggest that children should accrue 60 minutes of moderate-to-vigorous physical activity a day, and this specifically is not being met.

As there is an assumption that toddlers and young children are naturally active, it may be important for physical activity guidelines to specify the required intensity and duration of physical activity to ensure the benefits of improved bone properties, aerobic fitness and motor skills are gained. This being said, there is limited and often contradictory literature surrounding the amount of physical activity young children and toddlers should be doing (Timmons, et al., 2007). Therefore, it is important that further research, including both observational and intervention studies, is completed to ensure specific and achievable guidelines are developed.

Table 2.4

Physical activity guidelines for infants and toddlers in selected Western countries

Australia	United Kingdom	United States of America
For infants (0-1yr) physical activity, particularly supervised floor play in safe environments, should be encouraged from birth.	Infants should be encouraged to be physically active daily, particularly through floor-based play in safe environments.	Infants should interact with parents and/or caregivers in daily physical activities dedicated to promoting exploration.
Toddlers (1-3yrs) and pre-schoolers (3-5yrs) should be physically active for at least 3 hours everyday, spread throughout the day.	Children capable of walking unaided should be physically active for at least 3 hours daily.	Toddlers should accumulate at least 30min of structured and at least 60min of unstructured physical activity every day.
Children younger than 2 years should not spend any time watching television or using other electronic media (DVDs, computer etc.). For children between 2-5 years these activities should be limited to less than one hour per day.	Infants and children should be discouraged from being sedentary. No sedentary behaviour should last for more than 1 hour (except sleep).	Pre-schoolers should accumulate at least 60min of structured and at least 60min, and up to several hours, of unstructured physical activity every day, and should not be sedentary for more than 60min (unless asleep).
Source: (Australian Government Department of Health and Aging, n.d.)	Source: (Physical Activity and Health Alliance, n.d.)	Source: National Association for Sport and Physical Education (NASPE) Active Start Guidelines (as cited in (Cliff, et al., 2009)

2.2.4 Intervention Studies

Early intervention is “the delivery of coordinated and comprehensive specialised services for children with developmental delays or those at-risk of developing disabilities or delays and their families from birth or point of identification until they enter the formal education system” (McLachlan, Fleer, & Edwards, 2010). The hypothesis that underlies early intervention programmes proposes that the introduction of such programmes not only allows children to reach the predetermined brain development potential, but also enhances this potential (Holt & Mikati, 2011). However, as suggested by Matvienko and Ahrabi-Fard (2010), it is unknown whether short-duration interventions have any real effect on improving children’s fitness or motor skill proficiency. In addition, as the definition of early intervention suggests, most studies concentrate on children with, or at risk of, neurological or motor deficiencies (Angulo-Barroso, et al., 2008; Valvano & Rapport, 2006) or as prevention programmes for children at risk of obesity (Bluford, et al., 2007).

The effects of physical activity on motor skill in young children have been examined in several intervention studies (Alpert, Field, Goldstein, & Perry, 1990; Matvienko & Ahrabi-Fard, 2010; Reilly et al., 2006). In particular, Alpert et al. (1990) found that daily aerobic exercises for 30 minutes over eight weeks improved agility and cardiovascular fitness in young children (3-5 years old) when compared to a control group that undertook free-play in a playground. However, there were no improvements to gross motor activity, which was assessed by observing the children in the playground for three 10-minute periods before and following the intervention period.

Conversely, Reilly et al. (2006) found a significant effect of an early childhood centre-based intervention incorporating improvements in fundamental movement skills in children aged four years. It is possible that the contradictory findings in terms of gross motor/fundamental movement skills is due to the small sample (n=24) of Alpert et al. (1990) compared to 545 children (at baseline) of Reilly et al. (2006). Furthermore, the method of assessment of gross motor skill differed greatly between the two studies, with Reilly et al. (2006) objectively examining gross motor skills using the Movement Assessment Battery (Fisher et al., 2005), which may also explain the disparity in findings.

The intervention study by Matvienko and Ahrabi-Fard (2010) examined the short- and longer-term effects of a four-week physical activity programme on jump rope, throwing, and shuttle runs in kindergarten and first-grade (5-7 year-old) children in Iowa, USA. The findings from this randomised control trial suggest that even with as little as four weeks of directed physical activity, improvements in motor skills can occur in young and school-aged children. The effects of short-duration interventions on younger children (0-5 years) are yet to be investigated.

The significant improvement in shuttle runs observed at the follow-up test is contradictory to other studies that show that cardiovascular fitness is often lost over breaks (Carrel et al., 2005). Matvienko and Ahrabi-Fard (2010) suggest that this difference may be due to the different emphasis of the intervention, which had a focus on fundamental movement skill acquisition as opposed to active lifestyle or cardiovascular fitness. Therefore, further research examining the effects of different intervention strategies may also be required to determine the most effective methods of promoting physical activity and enhancing motor skill development in infants, toddlers and young children.

There are also some unpublished studies examining younger children, namely “Top Tots” and “Tots in Action”, that were reviewed by Chau (2007) that were initiated to promote physical activity at an early age through a skills-development approach. “Top Tots” was a home-based intervention targeted at improving physical activity and promoting motor skill development in children aged 18 months to 3 years. Chau (2007) reported the preliminary findings of this study, which included enhanced motivation, and confidence of parents in engaging in physical activity with their children. In addition, parents felt that their children’s motor skills had improved, however actual data was not reported and has not yet been published.

The other unpublished intervention study for toddlers and young children, “Tots in Action”, was mainly a school-based (pre-kindergarten at elementary schools) intervention that aimed to promote physical activity in young children aged 4.5-5.5 years. The study examined physical activity levels during structured programmes relative to unstructured, free play. Physical activity levels were found to be greater when children participated in the school-based, structured physical activity programme. However, this was a pilot study conducted on a small sample (n=34) and only post-intervention measures were examined. The lack of randomised, controlled intervention trials in infants and toddlers highlights a need for future research in this age group (Chau, 2007).

Several studies have also examined the effects of physical activity on measures of adiposity in young children (Fitzgibbon et al., 2005; Mo-suwan, Pongprapai, Junjana, & Puetpaiboon, 1998; Moore, Nguyen, Rothman, Cupples, & Ellison, 1995). A 29-week intervention incorporating a 15-minute walk and a 20-minute aerobic dance class three times per week was found to reduce body mass index (BMI) gain in girls (4-5 years old) only (Mo-suwan, et al., 1998). Similarly, a longitudinal study examining the effect of physical activity on body fatness in children aged 3-5 years old found that inactive children of the same age were 3.8 times more likely than active children to have an increase in body fatness, as determined by the slope of triceps brachii skinfolds (Moore, et al., 1995). Although there was no significant sex difference, active girls still gained 1.0 mm in their triceps brachii skinfold while active boys lost 0.75 mm on average. This variance between sexes suggests that it is important to control for sex when examining the effect of an intervention on adiposity, even in young children.

Another longitudinal study, with a randomised, controlled design, found that children aged up to four years old who received a weight-control intervention (as opposed to a general health intervention) had reduced BMI increases at one and two years following the intervention period (Fitzgibbon, et al., 2005). The weight-control intervention (Hip-Hop to Health Jr.) included a 20-minute lesson on healthy eating or exercise and 20 minutes of physical activity, three times a week for 14 weeks, and was not specifically targeted at overweight children but was inclusive of all children at the schools included in the study. The sample was predominately African American as this group was identified as particularly at-risk of becoming overweight or obese (Hedley et al., 2004).

2.2.5 Methods of measuring motor development

Literature reviewed thus far indicates that there is a wide range of tools available to measure or infer the level of motor development and activity in various age groups. McKay and Angulo-Barroso (2006) suggest that quantifying motor activity in children and infants is wrought with a number of problems including the reliability of parent-reporting, that it is time consuming, uses intrusive direct observation methods, and utilises complicated calculations based on heart rate. As shown by Fisher et al. (2005), accelerometers provide valid and reliable information regarding the physical activity of children. Cardon, Van Cauwenberghe and De Bourdeadhuij (2011) suggest that such devices, or other methods of direct observation, should be used in studies of young children as their movements often occur in small, intense bursts.

A number of studies have reported the validity of these devices in children ranging in age from six to 16 years (Puyau, Adolph, Vohra, & Butte, 2002), and from 10 to 14 years (Trost et al., 1998), however, they are yet to be validated for use in children under five years (Cliff, et al., 2009). In addition, there are many methodological issues pertaining to the use of accelerometers (Cliff et al., 2009). In particular, there is conflicting evidence surrounding the placement of the device, and no literature examining the accuracy of different device placement in children aged birth to three years (Cliff et al., 2009).

Due to the rapid changes in movement patterns in this age group, it is important that accelerometer use is investigated to determine the most accurate device placement and type. Bagnato (2007) also suggests that younger children are harder to test on any aspect of development, because they have shorter concentration spans, high activity levels, and are less likely to complete tasks to please the assessor or anyone else, unlike children in middle childhood. Bagnato suggests for any assessment to be successful, it needs to be as 'authentic' as possible for young children.

Other methods of measuring motor development include many different scales or movement sets (Folio & Fewell, 1983). Motor milestones such as age of standing unsupported, or age of walking supported are often used as the baseline measure in longitudinal studies such as the Northern Finland Birth Cohort Study (Ridgway, et al., 2009). Milestones such as these are easy to determine and therefore are often used in studies utilising parent reporting. Although motor milestones are measures of gross motor skill development, they have not been used in intervention studies, as there are other methods of assessing both gross and fine motor skill development.

Two of the most widely used motor skill tests for young children are the Peabody Developmental Motor Scales (PDMS) (Folio & Fewell, 1983) and the Bayley Scales of Infant and Toddler Development (BSID) (Bayley, 1936) which are also based on development milestones. However they include a much wider range of skills or milestones. Both of these motor skills tests produce standard scores, which relate to the developmental age of the child being tested. However, Provost, Crowe and McClain (2000) point out that the BSID Motor Scale only contains a few items for each level of development, and misses out some such as running or kicking. It does however include sections on cognitive, language, social-emotional development as well as adaptive behaviour, making it a more comprehensive developmental scale as compared to the PDMS, which is solely motor development based. Raw scores on the motor scale of a BSID can be converted to a Psychomotor Development Index (PDI) score where the mean score is 100 and the standard deviation is 15 (Provost, Crowe, & McClain, 2000). Similarly, the scores from the two subsets of the PDMS, the fine motor scale and the gross motor scale, can be converted into standard scores called the Developmental Motor Quotients (DMQ). The mean DMQ and standard deviation values are also 100 and 15, respectively (Provost, et al., 2000), thus allowing for clear comparisons between studies, irrespective of chronological age, to be generated. However, as discussed in Section 2.1 some studies choose to report raw scores rather than relying on the standardised norms, as these are usually based on North American data (Black & Matula, 2000).

Although Provost et al. (2000) found ‘very good’ to ‘high’ correlations between the age equivalent scores of the BSID (2^{nd} Edition) and the PDMS (r = .87 with gross motor PDMS and r = .83 with fine motor PDMS), there was ‘unacceptable’ correlation between the standard scores of these scales (r = .64 with gross motor PDMS and r = .49 with fine motor PDMS). This is supported by Palisano (1986) who found ‘good’ to ‘high’ correlation between Bayley age-equivalent scores and Peabody gross motor scores, but ‘unacceptable’ correlation between Bayley age-equivalent scores and Peabody fine motor scores. It was also determined that mean Bayley quotients for full term infants were significantly higher than Peabody gross motor quotients. The implications of these studies are that although either a BSID or a PDMS could be used to help determine whether a child is eligible for services to assist with potential development delays, the poor concurrent validity of these scales may see some children missing out on early interventions due to the differences in scoring (Provost et al., 2000). However, in children that are not at risk of developmental delays and in intervention studies using the same scale pre- and post-intervention, the impact of the aforementioned issues should be limited.

Studies that use older children as participants (Barnett et al., 2008a; 2008b; 2009; Fisher et al. 2005; Okely et al., 2001) use a mixture of fundamental movements to test motor development. The skills are usually performed following a demonstration and are repeated more than once to ensure reliability. Examples of fundamental motor skills that are tested include kicking, catching, overhand throwing, hopping, side galloping, vertical jumping, sprint run, and static balance. Each skill tested is composed of several components, which together make up a total score for each movement skill. Okely et al. (2001) suggest that due to the repeated nature of these tests, where a participant is said to possess a particular skill if the various components are performed at least four times out of five, an inter-observer agreement of 90% can be reached. Table 2.5 outlines the components of the ‘run’ and ‘catch’ movement skills as described by the Department of Education, Victoria, Australia (Okely, et al., 2001; 1996).

Table 2.5

Components of the run and catch movement skills (State of Victoria Department of Education, 1996)

Skill	**Description of the Component**
Run	1. Eyes focused forward throughout the run.
	2. Knees bent at right angles during recovery phase.
	3. Arms bend at elbows and move in opposition to legs.
	4. Contact ground with front part of foot.
	5. Body leans slightly forward.
Catch	1. Eyes are focused on ball throughout the catch
	2. Preparatory position with elbows bent and hands in front of the body.
	3. Hands move to meet the ball.
	4. Hands and fingers positioned correctly to catch the ball.
	5. Catch and control of the ball with hands only.
	6. Elbows bend to absorb the force of the ball.

The components of the fundamental skills utilised by Okely et al. (2001) are process-oriented assessments as opposed to product-oriented or performance-based assessments. This enables children who attempt each skill to receive a score dependent on their ability to perform each of the components that when performed together reflect mastery of the skill. In addition, the use of components or parts of skills allows researchers or practitioners to see how children are progressing, especially as the result of an intervention.

2.2.6 Associations with reducing accidental injury

Children between birth and 14 years are at great risk of unintentional injury from falls, with an average of two children per year dying from fall-related injuries between 1997 and 2001 (Safekids New Zealand, 2006). During 2003 to 2007, falls were identified as the primary reason behind hospitalisation for children aged between birth and 14 years (Alantini, 2009). Epidemiological studies from around the world also show that falls are the most frequent cause of injury in children (Agran, et al., 2003; Mack, et al., 2007).

Falls from furniture were found to be the most frequent fall type, except for the birth to two months age group, where falls from ‘other height’ was the most frequent fall type (Agran et al., 2003). In addition, it was determined that falls down stairs were mainly limited to the 6-11 months age group, suggesting that there is an association of this type of fall with the developmental attributes of children between 6 and 11 months (Agran et al., 2003). Figure 2.1 displays the changes in specific fall types with age, as reported by Agran and colleagues (2003).

The development of the upper body occurs earlier than that of the lower body, thereby enabling children to access more hazards, without having the strength or motor skill to avoid injury (Agran, et al., 2003). Fall-related injury at or around the home accounts for 56% of the hospitalisations in children aged birth to four years (Safekids New Zealand, 2006). Therefore, enhancing balance and coordination in infants may be an effective strategy in reducing risk of fall-related injury.

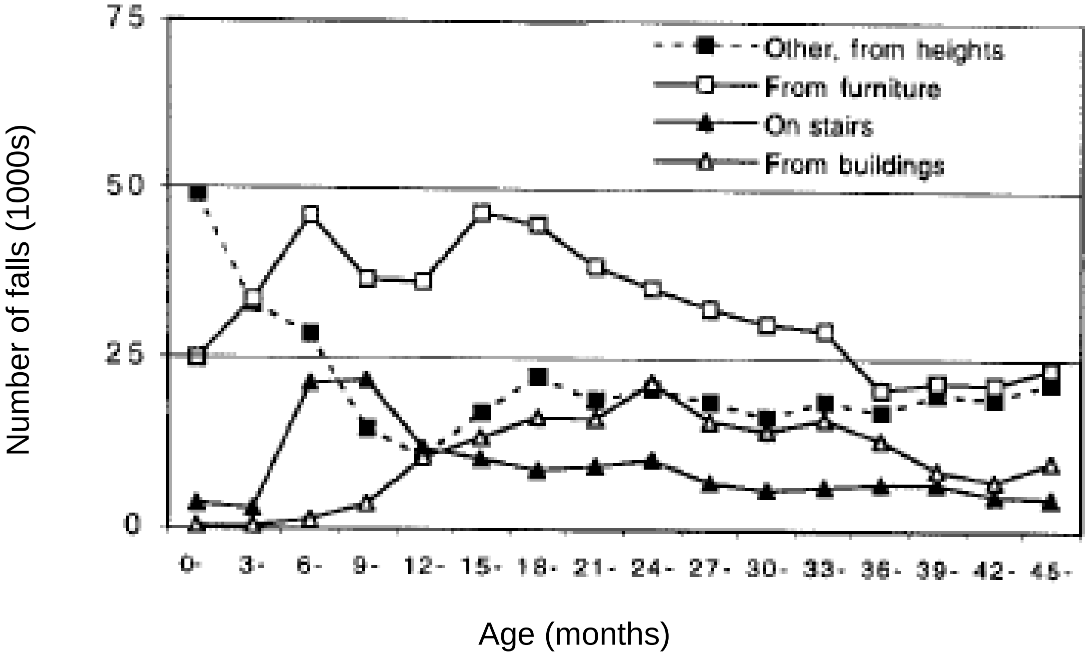

Figure 2.1 Changes in specific fall types with age (Agran et al., 2003).

Intervention studies that have aimed to reduce the risk of fall-related injury in children aged birth to five years have focused on education either through home or centre-based programmes. The success of these interventions is limited with Guyer et al. (1989) reporting no reduction in falls following home visits and education on falls in children aged birth to five years. Although Lindqvist, Timpka, Schelp and Risto (2002) reported a reduction in the rate of falls in school-aged children, there was no decrease in the rate of falls in children aged birth to six years following provision of information through a variety of methods. Only one study, targeted at reducing falls from windows, achieved positive reductions (Dowswell, Towner, Simpson, & Jarvis, 1996), however this is an isolated response to injury prevention education. The lack of success of education-based interventions in the reduction of falls or fall-related injury suggests that alternative strategies should be considered.

2.2.7 Development of safety skills and balance

In order to proceed along the motor development pathway, infants must be able to maintain balance in each position. In other words, in order to progress from sitting to crawling or from crawling to standing, infants must maintain their posture within a certain region (Adolph, 2000). Without sufficient postural control or balance, infants will fall over when their bodies move outside the tolerable region. Variations in surface and other environmental factors, such as parental expectation, may also influence the degree of postural control infants can maintain.

Balance is a contributing factor to locomotion, as well as other movement or safety skills. The human balance system uses visual, vestibular and kinesthetic inputs (Hsu, Kuan, & Young, 2009) in order to maintain postural control. There is very limited literature detailing the development of the balance system in children less than five years. Hsu, Kuan and Young (2009) showed that balance, as measured by sway velocity under several conditions, reaches adult levels by seven years. Conversely, Rival and colleagues (2005) suggest that postural stability processes are mature by about six years. Adolph (2000) suggests that infants learn to detect threats to balance through a perception-action system that is specific to each postural milestone. Consequently, infants learn to compensate through a variety of strategies, including extensive experience at each postural milestone, to maintain balance (Adolph, 2000).

The association of experience at each postural milestone with safety is highlighted by studies utilising “visual cliff-avoidance” whereby a “cliff” (drop-off) appears to exist due to the placement of a sheet of safety glass over the visible ground at a particular height. Studies have shown that infants' crawling experience, measured by duration of crawling, is a direct predictor of avoidance of the visual cliff (Adolph, 2000). Furthermore, when experienced crawlers become novice walkers, there is limited transfer of knowledge of the risk. This suggests that the coordination of systems required to plan actions relating to challenging situations is specific to the postural control milestone the child is currently developing (Adolph, 2000). The implications of these findings include ensuring developmental age-appropriate exercises are included in any physical activity programme in order to achieve optimal learning at each postural milestone.

In addition to the coordination of visual, vestibular and kinesthetic inputs for balance, the impact of environmental factors need also be considered. Ishak, Tamis-LeMonda and Adolph (2007) suggest that while parents are vital in the acquisition of new motor skills, there is little known about the relationship between parental expectations and motor skill development of their offspring. This study observed the relationship between parental expectations of the child's crawling ability in 34 mother-father-infant triads. It was observed that 70% of parents displayed safety-oriented parenting choices, suggesting that when the activity may result in harm to the infant, parents generally respond in a way that will limit the risk (Ishak, et al., 2007). A study of the interaction between parents and four to five year-old children during everyday outdoor play found that parents who were risk-takers (assessed by self-report) had children that took greater risks as well (Little, 2010). Furthermore, most parents spent most of their time supervising their children’s behaviour, with only two parents (out of 12) stepping in to stop their child before cautioning them (Little, 2010). It is therefore important to include parents in future physical activity intervention studies as they play a critical role in the continued development of motor and cognitive skills in their children and their interactions through supervision may be critical in eliciting changes to safety skills. The review of literature suggests safety skills have not been directly assessed as part of an intervention study.

2.3 Cognitive Development

2.3.1 Normal development

Cognitive development includes a wide range of abilities and skills that are involved with learning and intelligence. It has also been defined as the intellectual growth that begins at birth and continues through adulthood. The areas of cognition include information processing, intelligence, reasoning, language development and memory. These aspects of cognition are relatively easy to assess in adults and older children through standardised intelligence tests and other measures, which assess their ability to comprehend, reason and make judgements (Johnson & Blasco, 1997). However, these assessment tools are not suitable for infants or young children as these children are often very wary of strangers, perform inconsistently, have short attention spans and are easily distracted, meaning other methods must be used. In addition, as most infants and toddlers are incapable of performing language-based tasks, non-verbal methods of assessing cognitive development need to be utilised (Sommerville, 2010).

Dominant views of cognitive development stem from constructivist theories such as Piaget's and the idea that cognitive development occurs in a series of invariant stages that increase learning at each stage (Flavell, 1999). These stages begin in infancy and continue through to adulthood hence only the first stage that includes development until approximately 24 months is discussed here. Piaget's first stage, the sensorimotor period, has six sub-stages (see Table 2.6). Some key activities that relate to the sub-stages are also detailed.

Table 2.6

Ages, stages and activities of cognitive development

Age	Stage -Characteristic behaviour	Activities
0-2 months	Reflexive Stage -simple reflex activity such as grasping, sucking.	Watches person when spoken to. Smiles at familiar person talking. Beings to follow moving person with eyes. Cooing begins.
2-4 months	Primary Circular Reactions -reflexive behaviours occur in stereotyped repetition such as opening and closing fingers.	Shows interest in bottle, breast, familiar toy or new surroundings.
4-8 months	Secondary Circular Reactions -repetition of change action to reproduce interesting consequences such as kicking one's feet to move a mobile over the crib.	Smiles at own image in mirror. Looks for fallen objects. May stick out tongue in imitation. Laughs at peekaboo game. Vocalizes at mirror image. May act shy around strangers. Babbling begins.
8-12 months	Coordination of Secondary Circular Reactions -responses become coordinated into more complex sequences.	Responds to own name. Tries to establish contact with a person by cough or other noise. Reaches for toys out of reach. Responds to "no". Shows likes and dislikes. Shows excitement and interest in well-liked foods or toys. Starts to understand some words. Waves bye-bye. Holds out arm or leg for dressing. Repeats performance that is laughed at. Likes repetitive play. Shows interest in books. May understand some "where is…?" questions. May kiss on request. Comprehension of words appears.

12-18 months	Tertiary Circular Reactions -discovery of new ways to produce the same consequence or obtain the same goal.	Asks for objects by pointing. Starting to feed self. Negativism beings. Points to familiar objects when asked "where is…?" Mimics familiar adult activities. Know some body parts. Obeys two or three simple orders. First word spoken around 13 months. Vocabulary spurt begins around 18 months.
18-24 months	Invention of new means through mental combination -evidence of an internal representational system. Symbolizing the problem-solving sequence before actually responding.	Names a few familiar objects. Draws with crayons. Obeys found simple orders. Participates in parallel play. Uses 2-word utterances. Rapid expansion of understanding words.

Although Piaget's theory of cognitive development is still utilised by many organisations (e.g. Encyclopaedia of Children's Health, Child Development Institute, www.babyzone.com) to provide parents or practitioners information regarding children's development, more recent research suggests that a variety of perspectives are important in cognitive development in infants and toddlers (Flavell, 1999). It is suggested that rather than relying on one theory of development, a combination of elements from each perspective will help explain infant development (Flavell, 1999). In addition, Johnson and Munakata (2005) suggest that researchers need to focus on understanding the mechanisms behind cognitive development rather than relying on descriptions of behaviours at certain ages. Flavell (1999, p. 27) suggests the following potential elements may assist with the explanation of development:

a) Cognitive and social development in infancy builds on an innate or an early and maturing ability to read people;
b) Improved information-processing and other abilities, such as language, enable and facilitate theory-of-mind (awareness or knowledge of mental states) development; and
c) A variety of experiences produce and alter children's ability to predict and explain their own and other's behaviour.

The use of the Bayley Scale of Infant and Toddler Development (BSID-III) for assessment of cognitive, language, social-emotional development as well as adaptive behaviour has been briefly mentioned in Section 2.3.5 and other assessment tools for early childhood development are outlined in Table 2.7. Johnson and Blasco (1997) suggest that infant intelligence can also be estimated by evaluating responses to problem-solving tasks as well as language milestones. However, other precursors to cognition and language are also used to assess cognitive development in infancy. For example, gaze direction is considered to be a rudimentary assessment of attention; a key component of cognitive development (Flavell, 1999). Aslin and Fiser (2005) argue that assessments of cognitive development need to switch from looking for the presence or absence of certain behaviours at certain ages and instead focus on the mechanisms that underlie these behaviours. It is suggested that multiple stimulus-response (S-R) assessments are more suitable as they provide a range of performance under various stimuli, which can help researchers to understand infant learning processes (Aslin & Fiser, 2005).

Table 2.7

Overview of early childhood cognitive assessments (Kamphaus, Petoskey, & Rowe, 2000)

Name	Source	Age Range	Administration Time
Batelle Developmental Inventory (BDI)	Newborg et al. (1984)	0 to 8 years	120 min
Bayley Infant Neurodevelopmental Screener (BINS)	Aylward (1995)	3 to 24 months	10 min
Bayley Scales of Infant Development (BSID)	Bayley (1993)	1 to 42 months	25 to 60 min
Early Screening Profiles (ESP)	Harrison et al. (1990)	2 to 6.11 years	15 to 40 min
Kaufman Survey of Early Academic and Language Skills (K-SEALS)	Kaufman & Kaufman (1993)	3 to 6 years	25 min
Mullen Scales of Early Learning (MSEL)	Mullen (1995)	0 to 68 months	25 to 35 min
Transdisciplinary Play-based Assessment (TPBA)	Linder (1993)	0 to 6 years	60 to 90 min

2.3.2 Associations with motor skill development

The proposed relationship between motor skill and cognitive development is not a new one, with early studies by Piaget (1953) suggesting that activity and sensorimotor experiences influence cognitive ability. Since then, several studies have examined the association between motor skill development in infancy and cognitive ability in later life (Burns, O'Callaghan, McDonell, & Rogers, 2004; Bushnell & Boudreau, 1993; Piek, Dawson, Smith, & Gasson, 2008).

Piek and colleagues (2008) showed that gross motor skill in children aged four months to four years was a significant predictor of cognitive performance when children reached school age in Western Australia (6-11.5 years) while fine motor skill was not. This may be due to the theory of motor development acting as a controlling factor for further development (Piek et al., 2008) whereby, the achievement of certain milestones is required in order to progress to learning more challenging skills. Alternatively, a summary of neuro-imaging studies found that common brain structures are used for both motor and cognitive functioning and suggests that when deficits in motor ability are observed so too are reductions in cognitive ability and vice versa (Diamond, 2000; Wassenberg et al., 2005) implying the close relationship between motor and cognitive development. Nonetheless, it can be suggested that gross motor skill information from early childhood may be a better predictor of cognitive performance at school than fine motor skill or cognitive ability.

Gestational age has been found to be a significant determinant of later motor and cognitive ability, with children born before 29 weeks or below 1000 g at the greatest risk of developmental deficiencies in later life (Piek et al., 2008). For this reason, much of the literature regarding the associations between motor skill (both fine and gross) and cognitive ability has concentrated on pre-term or very or extremely-low birth weight (VLBW and ELBW, respectively) children (Burns, et al., 2004). This suggests that while assessment of gross motor skill in physical activity intervention studies may provide little information regarding the effectiveness of the intervention, this type of assessment can provide valuable information regarding future cognitive ability. Furthermore, future research on motor skill and cognitive development in infancy potentially needs to control for gestational age and/or birth weight.

Further support for the association between motor skill development in infancy and later cognitive ability was found by Burns and colleagues (2004). This study assessed 132 infants born with extremely low birth weight (less than 1000 g) in Queensland, Australia. The infants' motor ability was assessed at 12 months and at four years of age. Ability was classified into one of four categories; normal motor function; minimal motor problems; mild motor problems; and moderate to severe motor problems. At four years of age, children were also assessed to determine their cognitive ability. They concluded that motor ability classification at 12 months was a significant predictor of cognitive ability at four years.

Moreover, Murray and colleagues (2006) found that the earlier age of standing unaided was positively associated with enhanced working memory as a 33-35 year-old adult, as assessed by a neuropsychological test battery. This study did not control for gestational age, socio-economic status or birth weight and instead randomly selected participants from the Northern Finland Birth Cohort Study (Ridgway et al., 2009). The random sample provides support for the suggested association between gross motor skill in infancy and some aspects of cognitive ability in later life in the general population.

2.4 Attachment and Social Interaction

2.4.1 Normal development

Attachment theory, and conversely separation theory, is studied in terms of the mother-infant or caregiver-infant dyad with observation of the major physiological responses or behavioural components of attachment, such as smiling and crying (Ainsworth, Blehar, Waters, & Wall, 1978; T. Field, 1996). A review by Gagnon and Bryanton (2009) suggests that healthy attachment is one of four interconnected factors that fosters healthy infant development; protection from harm, responsive care, and breastfeeding are the other factors. Maggi, Irwin, Siddiqi and Hertzman (2010) describe attachment as the extent to which an infant develops a trusting relationship with the caregiver. The basic assumption of attachment theory is that an infant requires a bond or relationship with a caregiver in order to survive (Pietromonaco & Barrett, 2000). This trust is originally based on quick and appropriate responses with high levels of trust resulting in secure attachments (Maggi, et al., 2010). Furthermore, the internal working model of self and other, first introduced by Bowlby (1969), proposes that if the attachment figure is responsive and protective, but still allows exploration of the environment, the infant will develop an internal working model of self that is deserving and dependable. Conversely, if the attachment figure does not respond positively to the need for comfort and attention and does not allow exploration, the infant is more likely consider himself to be unworthy and ineffectual (Bowlby, 1969).

Ainsworth et al. (1978) suggested there are four phases of attachment development. First, there is the initial pre-attachment phase, which begins at birth and continues for a few weeks and is categorised by responsiveness to people, but with limited discrimination between these people. The second phase is “attachment-in-the-making” (Ainsworth et al., 1978), whereby an infant can begin to distinguish between familiar and unfamiliar figures but can also discriminate between familiar figures. Although Ainsworth et al. (1978) did not aim to link cognitive and attachment development, this phase of attachment development coincides with Piaget’s second and third substages of sensorimotor development (Piaget, 1953). The next phase of attachment development is the phase of clear-cut attachment and it is assumed that by one year of age, most children have reached this phase (Ainsworth et al., 1978). By this point, a child is “active in seeking proximity/contact… also in exploring his environment, manipulating the objects he discovers, and learning about their properties” (Ainsworth et al., 1978, p. 25). It is suggested that separation distress or anxiety is most likely to occur in this phase, although instances of earlier separation distress have been shown to occur (Ainsworth et al., 1978). The final phase, “the phase of a goal-corrected partnership” (Ainsworth et al., 1978, p. 28), occurs around four years old and is characterised by the lessening of the child’s self-interest in that the child is beginning to be able to see things from the mother’s point of view. It is suggested that once this phase is obtained, the relationship between mother and child becomes more of a ‘partnership’ as the interactions between the two parties are ever changing (Ainsworth et al., 1978). In addition to the four phases of attachment development, Johnson and Blasco (1997) suggest some typical social emotional milestones, including attachment development, which are presented in Table 2.8.

Table 2.8

Typical milestones of social emotional development (Johnson & Blasco, 1997)

Age	Milestone
1-3 months	Understands relationships between voices and faces
	Bonding (parent → infant)
	Smiles reciprocally
	Follows, with eyes only, person moving
3-6 months	Recognizes mother
	Attachment (infant → parent)
	Anticipates food on sight
	Smiles spontaneously
6-9 months	Discriminates emotional facial expressions and reacts differently
	Preference for a given person
	Stranger anxiety
	Understands means-to-an-end relationship in social interactions (act→clap→repeat act)
9-12 months	Differential fear response based on gender and age
	Social interactions become intentional and goal-directed
	Separation anxiety
12-15 months	Solitary play
	Begins formation of relationships (love, friendship, acquaintance, strangers)
	Offers ball to mirror image
	Kisses by simply touching lips to skin or licks
15-18 months	Self-conscious period; “coy” stage
	Hugs parents
18-21 months	First application of attributes to self (e.g. good, little, naughty)
	Initiates interaction by calling to adult
	Kisses with a pucker
21-24 months	Imitates others to please them
	Recursive nature of social thought (i.e. thinking about “How I behave to you and you to me”)
	Tolerates separation; will continue activity

2.4.2 Methods of assessment

Infants can be classified into three main groups based on their behaviour responses to the Strange Situation Procedure (Ainsworth & Wittig, 1969), which was the research method used by Ainsworth for researching attachment behaviours. There are also subgroups within each major group. Ainsworth's et al. (1978) description of the classification criteria for each group and subgroup is summarised in Table 2.9. More recent literature uses the same classification method to determine whether attachment is secure, associated with Group B classification, or insecure, associated with both Groups A and C. Insecure attachments are separated into avoidant and resistant/ambivalent attachments, which are associated with Groups A and C respectively (Greenberg, Cicchetti, & Cummings, 1990; Zelenko et al., 2005). More recent research has added a fourth main group; Group D, disorganised/disoriented attachment (Main & Solomon, 1990).

However, there is another, frequently used, method of assessing attachment between infant-caregiver dyads. The Attachment Q-Set (AQS) is also an observation method of assessing caregiver-child interaction. While the Strange Situation Procedure is carried out in a laboratory setting, the AQS measures attachment in a natural environment such as the home or day-care (Kappenberg & Halpern, 2006). This method requires the sorting of 90 descriptor cards, each containing a specific behaviour, into a number of piles by the observer. The piles correspond to a range of whether the descriptors are not at all characteristic of the child to those that are very characteristic of the child. A correlation between the distribution of the cards and a 'model' distribution is determined. The more positively correlated the distribution, the more securely attached the child (Kappenberg & Halpern, 2006).

The main advantage of the AQS is that it assesses security as a continuous variable, as opposed to assessment by the Strange Situation Procedure which categorises infants as either secure or insecure (Vaughn & Waters, 1990). This is an important distinction as variation in attachment patterns has been shown to be largely continuous thereby suggesting that the AQS method of attachment assessment may be more valid. In addition, the Strange Situation Procedure is completed in a specific experimental area and requires direct observation of participants over the course of eight episodes designed to elicit exploratory behaviour (Ainsworth & Bell, 1970). However, both procedures are lengthy and require trained observers and for this reason attachment patterns or behaviour are not often examined in intervention studies.

Additionally, a newly developed questionnaire has been designed for use with children younger than six years (Kappenberg & Halpern, 2006). The Kinship Centre Attachment Questionnaire (KCAQ) is completed by the parent or caregiver, and is more time efficient compared to either the Strange Situation Procedure or AQS. Furthermore, the KCAQ was designed to measure changes in attachment over time to allow use in foster care and adoptive families (Kappenberg & Halpern, 2006).

Table 2.9

Classification of infants based on the Strange Situation Procedure (Ainsworth, et al., 1978; Main & Solomon, 1990)

Group		**Subgroup**	
A Avoidant Insecure	Conspicuous avoidance of proximity to or interaction with the mother in reunion episodes. Tendency to treat the stranger in the same way as the mother, although perhaps with less avoidance. No distress during separation, or if there is some distress, it is due to being left alone rather than mother's absence.	**A_1**	Conspicuous avoidance of the mother in the reunion episodes, which is likely to consist of ignoring her altogether. If picked up, the infant tends not to cuddle in and may squirm to get down.
		A_2	Infant shows a mixed response to the mother on reunion. There may be moderate proximity seeking combined with strong proximity avoidance. Signs of mixed feelings when picked up or put down.
Group B Secure	Infant actively seeks proximity, contact or interaction with the mother, especially in reunion episodes. Little or no tendency to resist contact or interaction or to avoid the mother. Infant may or may not show distress during separation and may be somewhat comforted by the stranger, but it is clear he wants his mother.	**B_1**	Infant greets mother on return and shows strong initiative in interaction with her across a distance. Infant does not especially seek proximity to or physical contact with the mother. Infant is likely to show little/no distress in separation episodes, but may have some avoiding behaviour.
		B_2	Infant resembles a B_1 infant except that he is more likely to seek proximity to his mother.
		B_3	Infant actively seeks physical contact with his mother and attempts to maintain it. Also actively resists her attempts to release him. Distinguished from other groups and subgroups as he shows little sign of avoiding or resisting proximity to, contact with or interaction with his mother.

		B_4	Infant wants contact, especially during reunion, and seeks it by approaching, clinging and resisting release. However, infant is less active and competent in these behaviours than most B_3 infants. Shows signs of anxiousness throughout and seems distressed in the second separation phase.
Group C Resistant/ Ambivalent Insecure	Infant displays conspicuous contact- and interaction-resisting behaviour. Infant gives the impression of being ambivalent to his mother, as he also shows moderate-to-strong seeking of proximity and contact. Infant shows little to no tendency to ignore his mother during the reunion episodes. Infant may also be either more angry than infants in other groups or be conspicuously passive.	**C_1**	Proximity seeking and maintaining contact are strong in reunion episodes, and are more likely to occur in the pre-separation phase than in Group B infants. Angry, resistant behaviour is likely to be shown toward the stranger. Extreme distress is likely to be observed during separation.
		C_2	Most conspicuous characteristic is their passivity. Interactive behaviours are lacking in active initiative; exploratory behaviour is limited. However, obvious want for proximity and contact in reunion episodes is observed, although uses signalling rather than active seeking. Resistance behaviour tends to be strong, although not angry like C_1 infants.
Group D Disorganised/ disoriented	Disordering of expected temporal sequences. Simultaneous display of contradictory behaviour patterns. Incomplete or undirected movements and expressions. Direct indices of confusion and apprehension. Behavioural stilling. Different indices of disorganisation and disorientation appears in different infants.		

2.4.3 Associations with cognitive or physical development

The responsiveness of the mother and a secure attachment in infancy are linked with better social and mental skills later in life (St Petersburg U. S. A. Orphanage Research Team, 2008). In addition, research has shown that an insecure attachment in infancy, as the result of unstable, inconsistent or emotionally unresponsive caregiver, can lead to behavioural problems including crime and mental health problems (St Petersburg, 2008). An early study by Pastor (1981) found that secure (Group B) toddlers (20-24-month-olds) were more sociable and less irritated by conflict than their avoidant (Group A) or resistant (Group C) peers. Furthermore, it has been reported that an infant's degree of secure attachment with their mother is related to their cooperation in peer situations (van Lieshout, van Aken, & van Seyen, 1990). This association was found to exist from a young age (one year) through to adolescence.

Infants and toddlers classified with secure attachments are more likely to explore the surrounding environment, and successful exploration attempts will work to increase the child's self-confidence thereby encouraging further exploration (Maggi, et al., 2010). Children who have these positive learning experiences in infancy and early childhood are more likely to develop the cognitive abilities required to apply information gained from one experience to another (Maggi, et al., 2010).

Many of the above associations between attachment patterns and social or cognitive skills or behaviours have implications for physical or motor skill development. In particular, links between heart rate or cardiac activity and attachment have been investigated (Izard et al., 1991; Zelenko, et al., 2005). Sroufe and Waters (1977) were the first to record heart rate changes in infants during the Strange Situation Procedure and found that all infants reported increased heart rates during separation and those classified with secure attachments had faster heart rate recovery than those classified with insecure attachments. This has implications for future research, as heart rates in infants and toddlers cannot be relied upon for assessing exercise intensity as it can be for adults.

As there was limited research examining the heart rate responses of infant-mother (or caregiver) dyads, Zelenko et al. (2005) investigated the potential synchrony of heart rate responses during attachment assessment. They did not report any major differences in infant changes in heart rate during the various episodes of the Strange Situation Procedure. However, there were significant differences in maternal heart rate changes (Zelenko et al., 2005). In particular, mothers in the insecure-resistant dyad followed a different pattern of heart rate response to mothers in the other dyads. The authors suggest that this may be due to a need to continue comforting the infant following reunification, as there was continuous infant distress. The lack of success of comforting efforts may have created more stress leading to the slower recovery of heart rate (Zelenko, et al., 2005). However, the fact that this was an exploratory study with a small sample size (n=41) is highlighted. Further research is required to draw conclusions regarding the heart rate responses of both infants and their mothers in the various attachment groups.

Izard et al. (1991) examined cardiac activity stability through heart period, heart-period variance, heart-period range and vagal tone and explored the relationship between these variables and attachment classification of infants at three, four, five, six and nine months of age. The results indicated that insecure infants, both those classified in groups A and C, had higher heart rate variability. However, heart rate in infants has been found to be highly variable, regardless of attachment classification, with decreases with age due to the maturation of the autonomic nervous system (Massin & von Bernuth, 1997).

The implication of the aforementioned research is that future studies may wish to further investigate the variability of heart rate responses during other types of assessments, such as the BSID. This may provide interesting information regarding the physiological responses of infants with different levels of attachment in a wider variety of environments, however adequate validation of heart rate measures in infants and toddlers would be required.

2.4.4 Intervention studies

Studies examining the effects of various interventions on institutionalised children have reported significant improvements in motor skill (Taneja et al., 2003). Improvements in the motor, mental and social scores, as assessed by the Bayley Scale of Infant Development (Indian adaptation), were observed following a three-month intervention of 90 minutes of structured play each day (Taneja et al., 2003). Although these findings are limited to the particular population of children in orphanages or institutions, it is probable that similar interventions would be effective in other populations of children with developmental difficulties or delays.

Similarly, improvements in infants' social, emotional, communication and cognitive competence were observed in both full-term and very low birth weight (VLBW) infants (6-13months) following an intervention designed to enhance responsive behaviours (Landry, Smith, & Swank, 2006). Although the improvements were seen in both full-term and VLBW infants, it was reported that there were greater changes in social and emotional skills in VLBW infants. This further supports the need for effective interventions in infants and young children at risk of developmental delays, but also provides evidence for the association between attachment development and other aspects across the whole population.

At present, there is no literature examining the effects of a physical activity intervention designed to enhance attachment and motor skill development in either the general population or infants at risk of developmental delays. Moreover, investigation of the effects of physical activity on attachment behaviour and social interaction is limited. Therefore, there is the potential for future research in this area.

2.5 Parental Factors

2.5.1 Associations with physical activity

The parent's level of physical activity has been found to be directly related to the child's level of activity (Moore, et al., 1991; Poest, et al., 1989). These studies were completed using young children (ages not specified) enrolled in private or public nursery schools or child care centres; therefore the findings cannot be assumed to be relevant for infants and toddlers. However, Sallis and colleagues (1988) reported that both the father's and mother's energy expenditure was significantly correlated with the child's energy expenditure. In addition, the mother's exercise level was significantly correlated to the child's exercise level. Finn, Johannsen and Specker (2002) also reported an association between the child's physical activity level and father's BMI, but no relationship between child's activity level and their own BMI or their mother's BMI. This difference between studies may be due to the differing ethnic groups utilised. Sallis and colleagues (1988) studied Mexican-American families while Finn, Johannsen and Specker (2002) examined a predominately white American sample. Therefore, it is important that ethnicity is included as a descriptive variable in all studies examining physical activity habits or levels in children that are dependent on their parents.

Parental support can also either directly or indirectly predict the child's physical activity level, although this relationship is more pronounced in younger children (Biddle & Goudas, 1996). These findings suggest that the incorporation of parents into any intervention programme is necessary for its success (Fisher, et al., 2010). This is supported by literature that suggests early childhood teachers believe that efforts to enhance parents' awareness of the importance of their child's physical activity requirements may help increase young children's levels of physical activity (Tucker, et al., 2011). Furthermore, the teachers interviewed by Tucker and colleagues noted that parental role modelling is a key factor in encouraging and supporting physical activity in young children; whether it is through active play with the child or providing opportunities for physical activity. Therefore, although many parents expect early childhood services to provide the opportunities for their children to reach daily physical activity requirements, it is equally important for parents to provide opportunities and be positive role models.

2.5.2 Association with injury rates and safety skills

A report from the Centres for Disease Control and Prevention (CDC) suggests that strong emotional bonds between infants and caregivers is one factor that is most likely to influence safety, thus has the potential to reduce injury (Mack, et al., 2007). This report also supports the notion that more research is required to understand the associations between an infant's developmental stage and a wide variety of factors that contribute to motor skill development and injury rate reduction; including caregiver awareness, home environment, supervisory style and home hazards awareness. As discussed in section 2.2.7, there is a close relationship between parental behaviour and their children's behaviour in terms of risk taking (Little, 2010), and potentially injury risk. In addition, the interaction between child behavioural attributes and parental supervision practices has been shown to influence injury rate (Morrongiello & Corbett, 2006; Morrongiello, et al., 2008). However, the relationship is complex with other factors such as environmental hazards and stage of development contributing to injury risk.

2.5.3 Child-care versus Home-care

Participation in early childhood education has steadily increased in New Zealand since 2000. In Auckland, the average number of hours spent in any type of early childhood centre from birth to three years has increased from 18.7 hours per week in 2000 to 25.7 hours per week in 2012 (Education Counts, 2013). The average enrolment rate for 3-4 year olds in 2009 was 90.1%, which places New Zealand as the 11th highest in the Organization for Economic Co-operation and Development (OECD) as compared to an average international enrolment rate for 3-4 year-olds of 70.1% (Education Counts, 2013). Therefore, it is important to consider the different care environments young children and toddlers experience as it may have an impact on development.

Literature regarding the associations between early childhood centres and physical activity is equivocal. A number of studies have reported that children attending early childhood centres with supportive environments, including opportunities to be active, play equipment, and a sufficient amount of space both indoors and outdoors, are more likely to achieve higher levels of MVPA than children attending less supportive early childhood centres (Bower, et al., 2008; Gubbels, et al., 2012). On the other hand, Gubbels and colleagues (2010) reported that attending early childhood centres between the ages of one and two years was positively associated with a greater increase in BMI between these ages. In addition, Sugiyama, Okely, Masters and Moore (2012) reported that children who attended early childhood centres were mostly sedentary and spent between 12-36 minutes per day in MVPA, which is supported by Pate and colleagues (2008) who reported that children were engaged in MVPA for less than 3% of the 30-second observation intervals with a minimum of 600 observation intervals recorded for each child. Therefore, simply knowing whether a child is in childcare or not may not be sufficient to determine the effect on physical activity, or motor or cognitive development. As there is such a wide variety of factors associated with physical activity in early childhood centres, it is important that future research compares children in full time childcare to those at home with a parent in order to determine the optimal environment for development.

In addition, the associations between early childhood centre and attachment have been examined. Howes and colleagues (Howes, Rodning, Galluzzo, & Myers, 1988) reported that children classified as insecurely attached to both their mother and the caregiver at the early childhood centre facility had lower levels of play than children in any other group. Furthermore, children classified as securely attached to the caregiver spent more time engaged with peers than insecurely attached children. Therefore, it may be important to assess attachment security to both parents and early childhood caregivers when examining the effects of environment on physical activity or development.

2.6 Summary

The aim of this chapter was to examine the current research on toddler development in relation to physical activity. Motor skill development was the key focus with links between physical activity and cognitive development also examined. In addition, literature on the associations between attachment, parental factors and motor skill development, particularly safety skill development and the reduction of injury rate, were investigated. Methods of measuring the various aspects were also addressed, as the differences in methodologies are often the reason behind differences in findings.

Some gaps in the current literature were revealed. In particular, there is a lack of randomised, controlled intervention trials in healthy infants and toddlers that have focussed on motor skill development and cognitive development following the intervention. In addition, investigation of the effects of physical activity on attachment behaviour and social interaction is limited. The next chapter will introduce the research questions and the methodology used in the present study.

CHAPTER 3

METHODOLOGY

This chapter details the research design and specific methods of the study. The first section of the chapter details the specific research design, which leads to the participant information, study design and general procedure of the study. Explanation of the individual procedures and assessments utilised will then be discussed. The final section of this chapter details the statistical procedures that were used for analysis of the data.

3.1 Research Design

The epistemology underpinning this study is that children are active rather than passive learners who actively construct their understandings of the world within supportive relationships with family and peers (Crotty, 1998). The theoretical world view that underpins this study is essentially constructivist (Flavell, 1999), although it is clear from the research literature that contextual factors play an important part in shaping toddler's physical, cognitive and social-emotional development. A decision was made to use a mixed methodology, using a QUAN-qual research design because mixed methodologies are a pragmatic way to collect a range of data about a complex phenomenon (Onwuegbuzie & Collins, 2007; Pauch, 2009). The specific methods employed in this study are observation, collection of parent survey data and quantitative assessment of ground reaction forces.

3.2 Participants

Ninety typically developing children and their parents and/or caregivers from Auckland, New Zealand volunteered to take part in this study, which was approved by the Massey University Ethics Committee (see Appendix 1). Potential participants were recruited by a variety of methods, discussed in section 3.1.1. The parents/caregivers ("Participants") were informed of the aims, procedures and demands and any potential risks and discomfort that the study entailed before providing their written consent (see Appendices 2 and 3).

3.2.1 Participant recruitment

Sample size was estimated using data from of Eickmann et al. (2003) and an appropriate statistical software package (G-Power 3.1). A sample size of 38 participants per group (n=76) was found to be sufficient to detect an effect size of 0.65 at 80% power and a significance level of 0.05 in the psychomotor development index of the Bayley Scale of Infant Development. In addition, Onwuegbuzie and Collins (2007) suggest that 82 participants in total is sufficient for correlational or causal/comparative mixed-modelling studies. Therefore, based on above and allowing for participant attrition, we aimed to recruit 100 participants for this study.

Potential participants were recruited through a variety of methods. Local child-care centres, selected on a geographical basis from the New Zealand Ministry of Education's database of centres, were approached with information regarding the study and asked to display or to distribute to parents. Social media, in particular Facebook, was used to advertise the study to potential participants.

Table 3.1 illustrates the breakdown of recruitment by these methods. All potential participants completed an online screening questionnaire to determine their eligibility (see Appendix 4).

Table 3.1

Method of recruitment for total sample (n=90)

	Methods of Recruitment					
	Facebook Page	Information at local child care facility	Email (from Jumping Beans database)	Coffee group	Word-of-mouth/Friend recommendation	Other
Count (%)	10 (11.1)	8 (8.9)	13 (14.4)	15 (16.7)	39 (43.4)	5 (5.6)

3.2.2 Inclusion criteria

Participants were required to be available for the duration of the study and to attend one activity class of one-hour duration per week for one school term with their child, if assigned to the experimental group. In addition, participants needed to be available for both the baseline assessment (in either July or September/October school holiday periods) and the post-intervention assessment (in either September/October or December school holiday periods) and be proficient in English.

The children were also required to meet the following criteria (adapted from Hsu, Kuan & Young, 2009):

(1) No current or past medical diagnosis or injury affecting balance or motor skill development;

(2) No use of medication affecting the central nervous system (CNS) or known to affect balance/coordination;

(3) No symptoms of dizziness or light-headedness;

(4) No symptom suggestive of vestibular or neurological disorders;

(5) No psychological disorders including depression;

(6) Normal vision with or without glasses.

Children were also required to be able to stand unaided for approximately 20 seconds for the purpose of the static balance test and to not have attended Jumping Beans International classes (refer to section 3.4 for further details) or similar programmes prior to the study.

3.3 Study Design

Following recruitment, eligible participants were contacted and were split into two groups based on the children's ages: Group 1 children (n = 65) were aged between 13-18 months; and Group 2 children (n = 35) were aged between 9-12 months when first contacted. Ineligible (n = 60) or unrequired participants (n = 40) were also contacted to thank them for their interest and to explain they were ineligible or not required at this time.

Baseline assessments were scheduled for the school holiday period preceding the intervention term (Term 3 or 4 for Groups 1 and 2 respectively). Participants were received their random treatment group allocation, which was completed separately for Group 1 and 2, at these appointments. Participants attended a second appointment at least 10 weeks after their baseline assessment in the school holiday period following the intervention period. There was participant attrition of five participants between baseline and post-intervention assessments, spread across the two groups. Figure 3.1 is a schematic of the aforementioned study design.

Five participants were excluded from all data analysis due to age (either younger than 12 months or older than 24 months) or having not attended at least five (out of the nine) Jumping Beans classes as part of the intervention, resulting in a total sample of 90 participants. In addition, children who showed a decline in their total safety skills score at post-intervention were removed from the data analysis of safety skills. This was done to limit the effect of performance inconsistencies that often exist in young children as it was noted that these children were particularly uncooperative or upset during their follow-up assessment. One further participant was unable to complete the safety skills test battery post-intervention and therefore was not included in the analysis of safety skills.

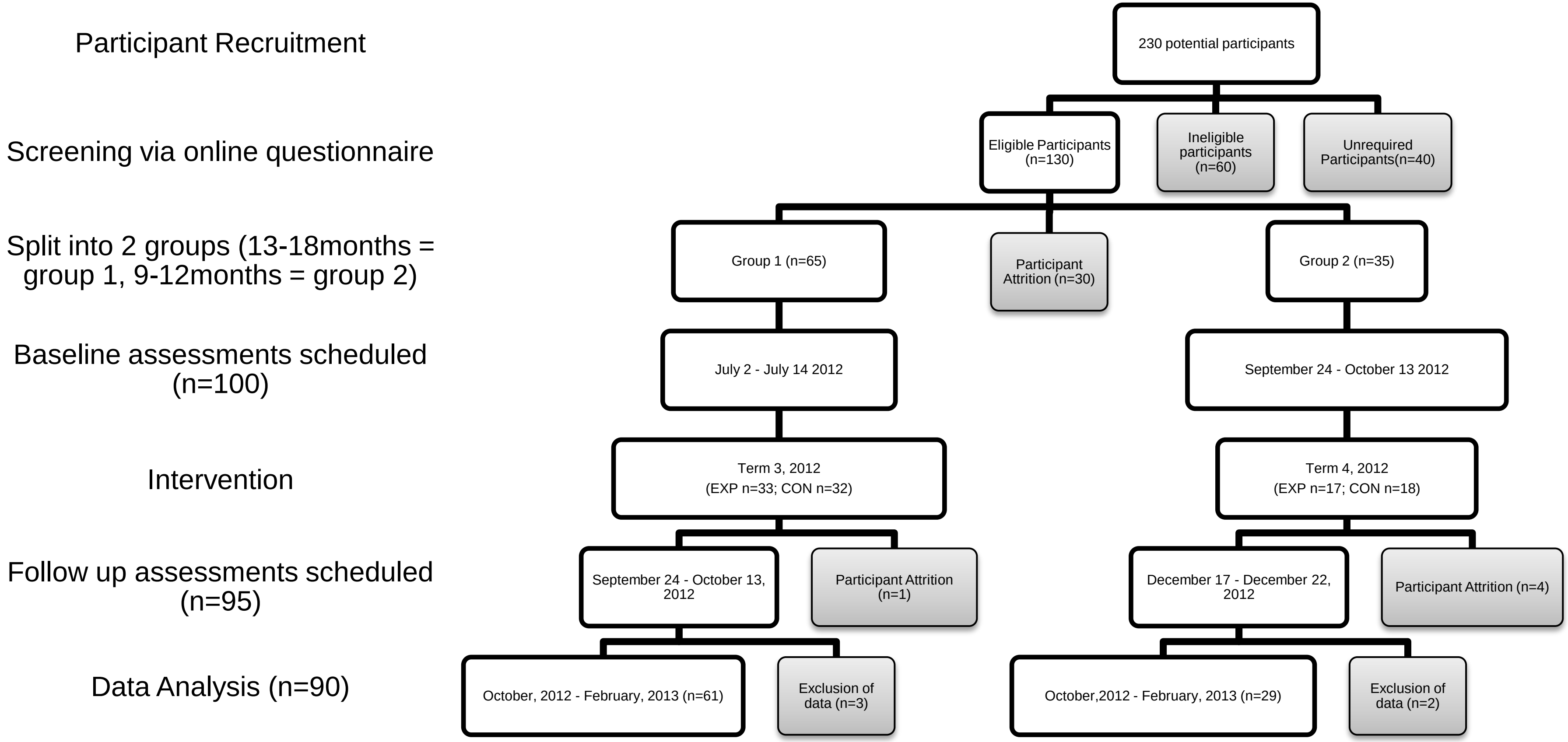

Figure 3.1. Schematic of the study design.

3.4 Overview of Study Procedure

On arrival to the laboratory, which was maintained at a temperature of 19-22°C, the parent/caregiver and their child were taken to the room for the BSID Screening Test, which took 15-40 minutes to administer. The BSID Screening Test room met the criteria set out by the Screening Test Manual (Bayley, 2006) including being quiet, well lit and free from distractions. The child's mass and height were then measured.

The parent/caregiver and their child were then escorted to the force plate where the child attempted to stand for a period of 10 seconds, which was repeated two or three times if the child was cooperative. Following the static balance test, the child completed the safety skills test battery in a separate area, while the parent/caregiver completed the supervision questionnaire in view of the child.

Finally, participants received their randomised group allocation, achieved with randomisation software (www.randomizer.org/form.htm) where separate randomisations based on gender were completed. Participants randomly placed in the experimental group then elected the Jumping Beans class they would attend for the duration of the intervention. All participants also received a logbook they were asked to complete for the duration of the intervention (9-weeks). Figure 3.2 illustrates the different study procedures and average time taken to complete each stage of the baseline assessment.

Participants attended a post-intervention appointment at least 10 weeks after their baseline assessment. The above procedure was repeated at this appointment and logbooks were collected. A feedback questionnaire was also completed at the post-intervention assessment. Participants in the control group were also asked to elect the Jumping Beans class they would like to attend in the following term.

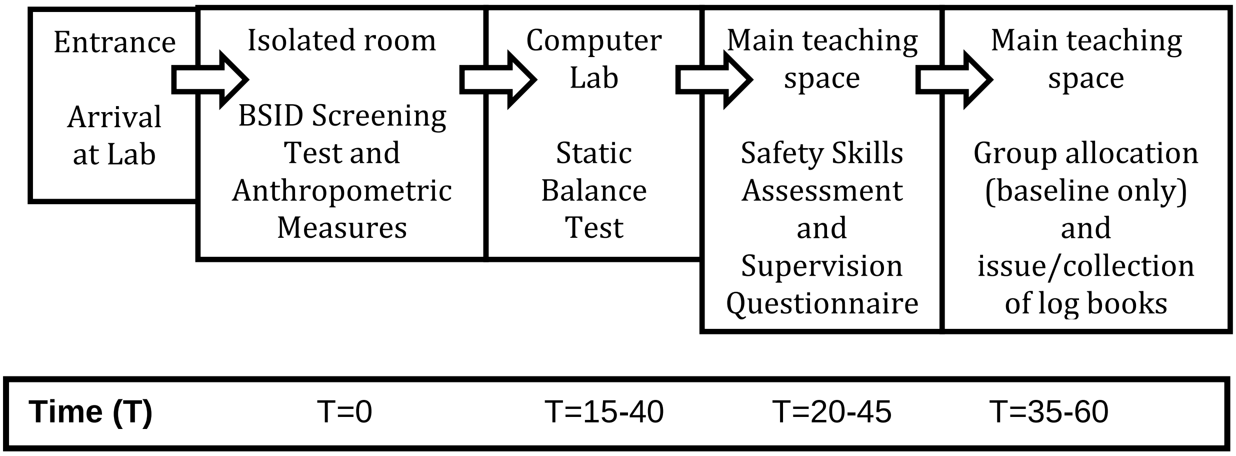

Figure 3.2. Flow chart detailing the study procedures and average time taken to complete each stage of the overall assessment.

3.5 Description of the Intervention

The intervention was one term (nine weeks) of Jumping Beans International "Toddler Beans" classes at any of the North Shore (Auckland) locations: Windsor Park; Sunnynook; Northcote; or Takapuna. Jumping Beans International offer fun, child-centred physical activity and development classes for children aged six weeks to six years (Jumping Beans International Limited, 2009b).

The "Toddler Beans" classes cater to children aged approximately 12 to 24 months and are one-hour long. These classes incorporate movement to music, ball skills and movement through the custom designed gym equipment. "Toddler Beans" classes also have a special focus on learning safety skills required as children become more mobile. All classes are under the supervision of qualified instructors who help to guide parents/caregivers to participate with their children (Jumping Beans International Limited, 2009).

Jumping Beans classes begin with free play on the custom designed equipment. The equipment set up is altered every two weeks in accordance with the change of programme. Movement to music, that includes cross-lateral patterning and socialisation aspects, follows free play. The lead instructor then explains the structure and function of the equipment set up and children and parents then resume use of the of equipment with the assistance of the two class instructors. Fine manipulative equipment is brought out approximately 15 minutes before the end of the class. This equipment also changes every two weeks and often includes balls, scarves, feathers, bubbles or spinning tops. A final parachute activity concludes each Jumping Beans class.

3.6 Description of Study Tests and Assessments

3.6.1 Anthropometric and demographic assessments

Parents/caregivers completed an online questionnaire (see Appendix 6) prior to attending the baseline assessment. This questionnaire was used to obtain demographic information about the child and parents and anthropometric information of the child at birth. The child's body mass was measured in the laboratory using scales accurate to 0.1kg (HW-200KGL, A&D, San Jose, USA) and height was measured using a readily available child's height chart.

3.6.2 Bayley Scales of Infant Development – Screening Test

The Bayley Scales of Infant Development (BSID) is a comprehensive scale of development that provides information regarding motor, cognitive and language development (Black & Matula, 2000). The BSID Screening Test is a compact version designed to assess whether a child is progressing according to normal developmental expectations for age (Bayley, 2006a). All items included in the BSID Screening Test were selected from the full Bayley Scales of Infant and Toddler Development Third Edition (BSID-III) (Bayley, 2006a). There are five subscales in the BSID Screening Test: Cognition, Receptive Communication, Expressive Communication, Fine Motor Skill and Gross Motor Skill.

The administration of the BSID Screening Test was completed according to the instructions outlined in the Screening Test Manual (Bayley, 2006a). These procedures must be adhered to for the cut scores to be relevant, as they were established using standardised administration and scoring under uniform conditions (Bayley, 2006a). Administration of the BSID Screening Test took between 15 and 40 minutes depending on the age and ability of the child, with older, more developed children requiring a longer testing period due to their further progression through the scales.

Pilot testing and preparation

The BSID Screening Test requires the administrator to be trained in the assessment of young children and have experience working with them (Bayley, 2006a). The preparation included viewing of the training DVD of the BSID-III (Bayley, 2006b) which covered fundamental administration, scoring and interpretation. This DVD was used to supplement the comprehensive screening test manual (Bayley, 2006a), which provides the detailed information required to administer each test item in the standardised manner essential for cut scores to be relevant.

In addition to the training DVD, video footage of administration of the BSID-II was viewed to further develop the skills required for this type of testing. In particular, methods for building rapport with the child and maintaining the child's focus were learnt. Following this initial preparation, the administration and scoring of the BSID Screening Test was piloted on children who were not included in the study, prior to baseline testing.

3.6.3 Safety skills assessment

Participants were assessed in nine safety skills on equipment provided by Jumping Beans International. These skills were selected with input from Jumping Beans International's co-founder and include many of the skills learned at

Jumping Beans “Toddler Beans” classes. The assessment criteria for each skill was developed based on the Jumping Beans International Training Manuals, pilot testing and with input from all Jumping Beans New Zealand licensees. The assessment criteria (see Appendix 7) detail the particular aspects of each skill that need to be met to achieve each competency level. The level of competency in each skill ranged from 0 to 5:

0. Not attempted
1. Fully assisted
2. Partially assisted
3. Supported
4. Independent
5. Mastery

The children’s shoes and socks/tights were removed and they were taken through a circuit, starting at the foam stairs (see Figures 3.3 and 3.4), whereby they attempted each skill a maximum of three times. Where possible, the children completed all skills without assistance from the researcher or parent, however both were located in close proximity to provide assistance if required.

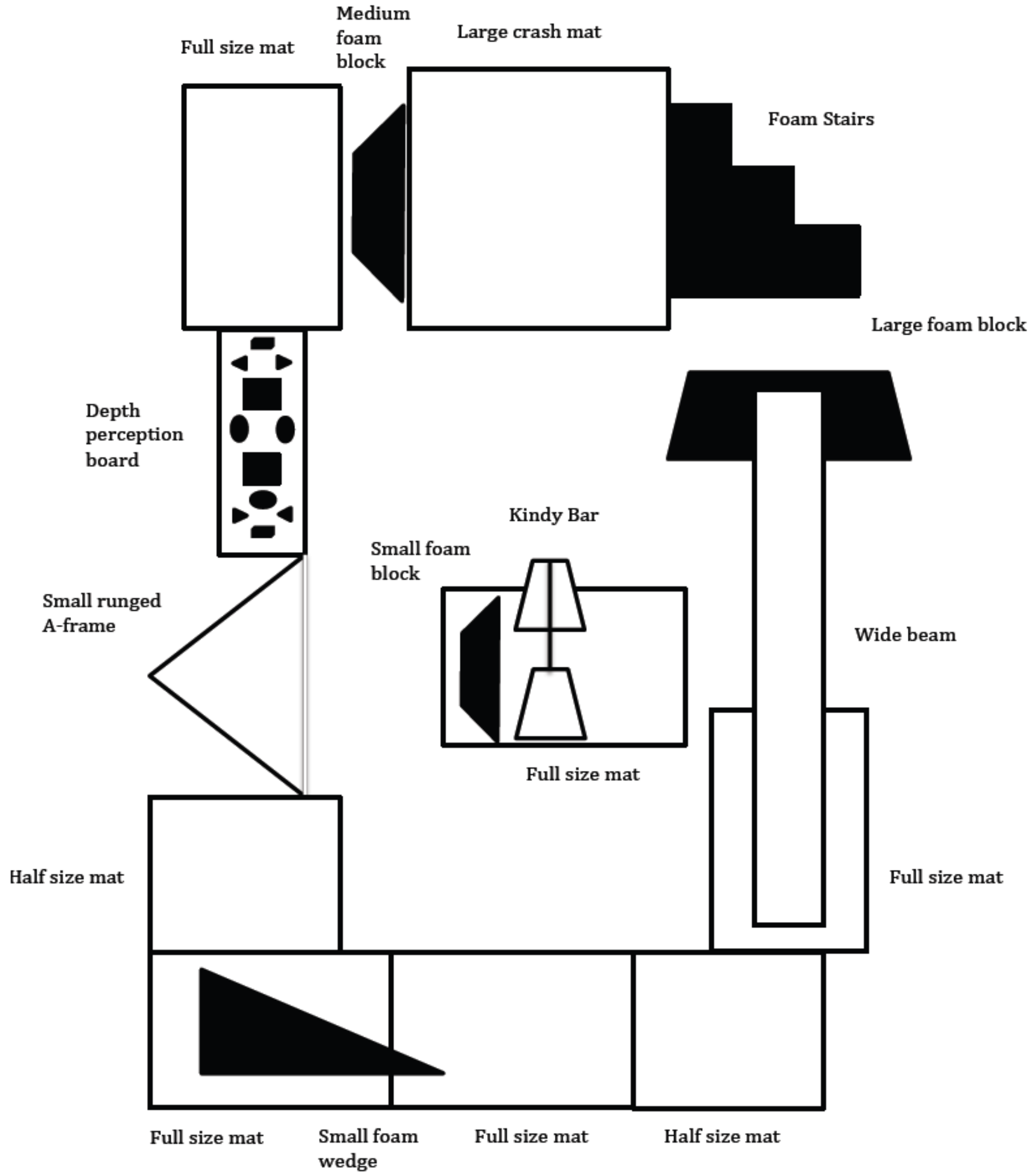

Figure 3.3. Diagram of the layout of the safety skills equipment.

The safety skills test battery consisted of the following:

a) Safe climbing down foam stairs facing the slope, from placement at the top of the stairs facing forwards.

b) Safe face-the-slope drop from foam block, from placement at the top of the stairs facing forwards or from climbing up and over stairs.

c) Jump to land on two feet.

d) Walking on stepping stones (depth perception board).

e) Climbing down a small-runged A-frame, from placement at the top of the A-frame or from climbing up and over.

f) Climbing over a small-runged A-frame, sitting at top and using cylinder grip and safe face-the-slope, leg-over dismounting techniques.

g) Execution of safety roll (Aikido roll) down a foam wedge.

h) Locomotion across a wide beam.

i) Hanging from a horizontal bar or trapeze, supporting body weight using a whole-hand grip.

Please see Appendix 8 for the dimensions of the various pieces of equipment.

Figure 3.4. Photograph of the safety skills equipment layout.

Pilot testing and preparation

Part of the preparation for both pilot and formal data collection involved attendance at Jumping Beans classes to observe safety skills in a number of children of different abilities. Discussions with the co-founder and licensees provided further information regarding the competence levels of various children in the classes.

New licensee training sessions were also attended, which provided information regarding the teaching and progressions of each safety skill. Practice of each safety skill was completed with children who were not included in the study at these licensee-training sessions. Following training in the administration of each of the safety skills, subsequent Jumping Beans classes were attended to practise scoring the children in these classes based on the safety skills assessment criteria developed.

3.6.4 Static balance test

Static balance was assessed using a force plate (AccuGait, AMTI, MA, USA) and by determining the standing centre of (foot) pressure (CoP) from the ground reaction forces recorded at a frequency of 200 Hz. The children were shown to the force plate and placed in the centre of the plate (see Figure 3.5). The objective of aiming to stand as still as possible for 10 seconds was explained to the parents, and they then aided the researcher in assisting the child to remain standing with eyes open for 10 seconds. Where possible, this was repeated to ensure at least one 10-second sample was collected.

Figure 3.5. Photograph of child standing on force plate.

The displacements of the centre of foot pressure in the medio-lateral (CoP_x), Equation 3.1, and the anterio-posterior (CoP_y), Equation 3.2, planes were calculated using the following approximations:

Equation 3.1: $\Delta\ CoP_x=\Delta M_y/F_z$

Where, ΔM_y is the change in anterio-posterior torque

F_z is the vertical ground reaction force

Equation 3.2: $\Delta\ CoP_y=\Delta M_x/F_z$

Where, ΔM_x is the change in medio-lateral torque

F_z is the vertical ground reaction force

The range of the centre of pressure (mm), the maximal excursion of centre of pressure in any direction, was used to describe the children's balance. It is an estimation of overall postural performance or stability. The speed (frequency) of the centre of pressure displacement (mm/s) was also be used to describe children's balance as it is suggested that this measure is a more functional method of posture as it represents the amount of activity required to maintain stability (Rival, et al., 2005)

3.6.5 Parent-child supervision questionnaire

A short, five-question, questionnaire (see Appendix 8) was used to assess the parent/caregiver to child supervision. This questionnaire is based on the Parent Supervision Attributes Profile Questionnaire (PSAPQ) developed by Morrongiello and Corbett (2006) which was shown to be a valid and reliable index of maternal supervision as it relates to child injury risk. The various questions relate to areas of supervision that include play, self-care, risk tolerance and vigilance. This questionnaire was completed by the parent while their child was being taken through the safety skills circuit and took five to ten minutes to complete.

3.7 Participant Control

To reduce the potential for physical activity-induced variability between the treatment groups all participants were asked to complete a logbook detailing their child's supervised physical activity for the nine-week intervention period (refer to Appendix 5 for the logbook format). All participants were asked to record the duration of any supervised physical activity each day, such as dance classes, swimming lessons, playground time or park time, for the 9-week period. This was recorded in terms of number of minutes per day engaged in supervised physical activity, and an average per week and per day over the nine-week intervention period was calculated.

Participants in the experimental group were also asked to record Jumping Beans classes attended to ensure compliance with the intervention could be determined. Participants who attended fewer than five classes (out of nine) were excluded from the data analysis.

3.8 Data Analysis

3.8.1 Quantitative analysis

Statistical analysis of the quantitative data was completed using the Statistical Package for the Social Sciences (SPSS 20.0, Chicago, IL). All continuous data was inspected visually and statistically for normality and variance. Normally distributed data with equal variance is described using mean ± SD and non-normally distributed data using median [25, 75 percentiles]. Categorical data is described using frequency percentages. Independent t-tests or chi square tests (for parametric data) and Mann-Whitney tests (non-parametric data) were used to determine any differences between descriptive characteristics at baseline. Independent t-tests were used to determine the differences between treatment groups in the change variable of each major dependent variable. Analysis of variance (ANOVA) was used to determine the difference between conditions across various age groups. Post-hoc analysis with Bonferroni adjustments determined where the differences lay.

Correlation between outcome measures and anthropometric and demographic variables was assessed using either Pearson's or Spearman's correlation coefficients, dependent on whether data was parametric or not. An r value of ± 0.1 represents a weak correlation, ± 0.3 a moderate correlation, and ± 0.5 a strong correlation (Field, 2009). In addition, multiple regression testing was used to examine the associations between outcome measures while controlling for variables that significantly influence the outcome measures. Statistical significance was considered to exist when $p < 0.05$ and where appropriate, effect sizes (Cohen's d for parametric data and omega squared (ω^2) for ANOVA) were calculated to show practical significance (A. Field, 2009). Cohen's d effect size values of ± 0.20 represent a small effect, ± 0.50 a medium effect and ± 0.80 a large effect (Leech, Barrett, & Morgan, 2008). Omega squared effect size values of 0.01 represent a small effect, 0.06 a medium effect and 0.14 a large effect (Kirk, 1996).

The number of minutes spent in supervised physical activity that was collected from the logbooks was averaged per week and per day over the nine-week intervention period. Data was inspected visually and statistically for normality and variance. Differences between treatment groups were investigated using Mann-Whitney tests (non-parametric data).

3.8.2 Qualitative analysis

Data collected from the Parent-Child Supervision Questionnaire was categorical data and therefore described using frequency percentages. Mann-Whitney tests were used to determine any differences between the treatment groups at baseline. In order to determine the effect of the intervention on parent-child supervision, the number of parents that changed their answer from baseline to post-intervention was calculated. Mann-Whitney tests were used to investigate differences in the number of parents that changed their answers between treatment groups.

3.9 Summary

This chapter firstly described the research design and specific methods of the study. The participant recruitment procedures were then outlined, followed by the study design and general procedure of the study. Individual procedures and assessments utilised in this study were then discussed. The final section of this chapter detailed the statistical procedures that were used for analysis of numeric data and explained how qualitative data was analysed. Results of the study are presented in the next chapter.

CHAPTER 4

RESULTS

This chapter presents the results of this study in five main sections. First, the descriptive characteristics of the sample will be reported. Analysis of the Bayley Scales of Infant Development Screening Test scores will then be reported, followed by the analysis of the safety skills. The fourth section consists of the analysis of the balance measures and the final section is the analysis of the parent-child supervision questionnaire.

4.1 Descriptive Characteristics

The experimental and control groups were very closely matched at baseline with no differences in all anthropometric and demographic variables that were used to describe the sample, except for birth order ($U = 785.5$, $z = -2.043$, $p = 0.04$; Table 4.1). Based on parental reporting, children in this study spent between 45 – 500 min per week (140.3 [102.0, 207.5]) engaged in supervised physical activity. There was no difference between treatment groups (EXP vs. CON, 129.1 [97.5, 169.4] vs. 161.5 [103.3, 252.3]; $p = 0.11$).

Table 4.1

Descriptive characteristics of participants (n=90)

	Experimental (n=45)	Control (n=45)	*p*-value
Age (months)	17.2 ± 2.5	16.9 ± 2.6	0.51
Sex (% male)	53.3%	51.1%	0.83
Height (cm)	80.0 [76.0,81.0]	80.0 [75.5,82.5]	0.72
Mass (kg)	11.4 ± 1.4	11.4 ± 1.4	0.89
Birth weight (kg)	3.4 ± 0.6	3.4 ± 0.6	0.74
Head circumference (cm)	34.7 ± 1.6	34.4 ± 1.6	0.48
Mother's age group 31-35 years	37.8%	44.4%	0.36
Father's age group 31-35 years	28.9%	44.4%	0.50
Mother's education level (% tertiary)	86.7%	95.6%	0.14
Father's education level (% tertiary)	77.8%	95.6%	0.38
Gestational term (37-42weeks)	97.8%	95.6%	0.56
Ethnicity (% Pakeha)	82.2%	84.4%	0.81
Birth order (% youngest born)	57.8%	35.6%	0.04*
Day-to-day care environment (% mostly home care with parent)	68.9%	68.9%	0.95

*significant difference between treatment groups ($p < .05$)

4.2 BSID - Screening Test

The total sample was split into three age groups that corresponded to the ages set out by the BSID-Screening Test Manual (Bayley, 2006) that relate to the cut scores. The cut scores refer to three categories of development: competent, emerging and at-risk (refer to Appendix 10) corresponding to certain raw scores for each subscale. The mean raw scores were rounded to the closest integer to determine the average cut score for each age group. The three age groups are:

1 - children aged between 12 months, 16 days to 18 months, 15 days for the duration of the study

2 - children aged 12 months, 16 days to 18 months, 15 days at baseline and 18 months, 16 days to 24 months, 15 days at post-intervention

3 - children aged 18 months, 16 days to 24 months, 15 days for the duration of the study.

Independent sample t-tests were used to analyse whether there were differences in the change value of each subscale between the treatment groups.

4.2.1 Cognitive ability subscale

All average cognitive raw scores, across all age groups, indicate "competent" children. There was a significant, yet smaller than typical, difference in the change in cognitive ability in children in Age Group 2 between the treatment groups (EXP vs. CON, 1.6 ± 4.5 vs. 5.2 ± 2.4, $t(27) = -2.65$, $p = 0.01$, $d = -0.25$; Table 4.2), with children in the control group exhibiting greater improvements in their cognitive ability. There were no other significant differences between treatment groups in terms of the change in cognitive ability over the duration of the study.

Table 4.2

Mean (± SD) raw scores of Cognitive Ability [33[α]] by age group

Age Group		**Baseline**	**Post**	**Change**	***p*-value**
1 (n=34)	EXP	18.1 ± 2.8	22.9 ± 3.3	4.8 ± 5.0	0.90
	CON	17.3 ± 2.7	22.3 ± 2.9	5.0 ± 4.6	
2 (n=29)	EXP	20.8 ± 2.6	22.4 ± 3.9	1.6 ± 4.5	0.01*
	CON	19.4 ± 2.3	24.6 ± 2.5	5.2 ± 2.4	
3 (n=27)	EXP	24.2 ± 2.1	22.5 ± 2.9	-1.7 ± 2.6	0.56
	CON	21.9 ± 2.2	21.1 ± 3.3	-0.8 ± 4.5	
Total Sample	EXP	20.6 ± 3.5	22.6 ± 3.3	2.0 ± 5.0	0.29
	CON	19.4 ± 3.0	22.6 ± 3.2	3.1 ± 4.8	

Note. EXP: experimental group, CON: control group; Age Group 1 = 12 mo., 16 day to 18 mo., 15 day; Age Group 2 = 12 mo., 16 day to 18 mo., 15 day at baseline, 18 mo., 16 day to 24 mo., 15 day at post-intervention; Age Group 3 = 18 mo., 16 day and 24 mo., 15 day
[α]Total possible raw score for cognitive subscale is 33
* Significant difference between treatment groups ($p < 0.05$)

There was a main effect of Age Group on the change in cognitive ability score in the total sample ($F(2,87) = 8.43$, $p < 0.001$, $\omega^2 = 0.14$), experimental group ($F(2,42) = 8.21$, $p = 0.001$, $\omega^2 = 0.24$) and control group ($F(2,42) = 10.35$, $p < 0.001$, $\omega^2 = 0.30$) as shown in Figure 4.1. More specifically, in the total sample, experimental and control groups, the change in cognitive ability was significantly greater in children in Age Group 1 (TOTAL, 4.9 ± 4.7, $p < 0.001$; EXP, 4.8 ± 5.0, $p = 0.001$; CON, 5.0 ± 4.6, $p = 0.001$) compared to those in Age Group 3 (TOTAL, -1.2 ± 3.7; EXP -1.7 ± 2.6; CON, -0.8 ± 4.5). In addition, the change in cognitive ability was significantly greater in children in Age Group 2 (TOTAL, 3.3 ± 4.0, $p < 0.001$; CON, 5.2 ± 2.4, $p = 0.001$) as compared to those in Age Group 3 in the control group and total sample.

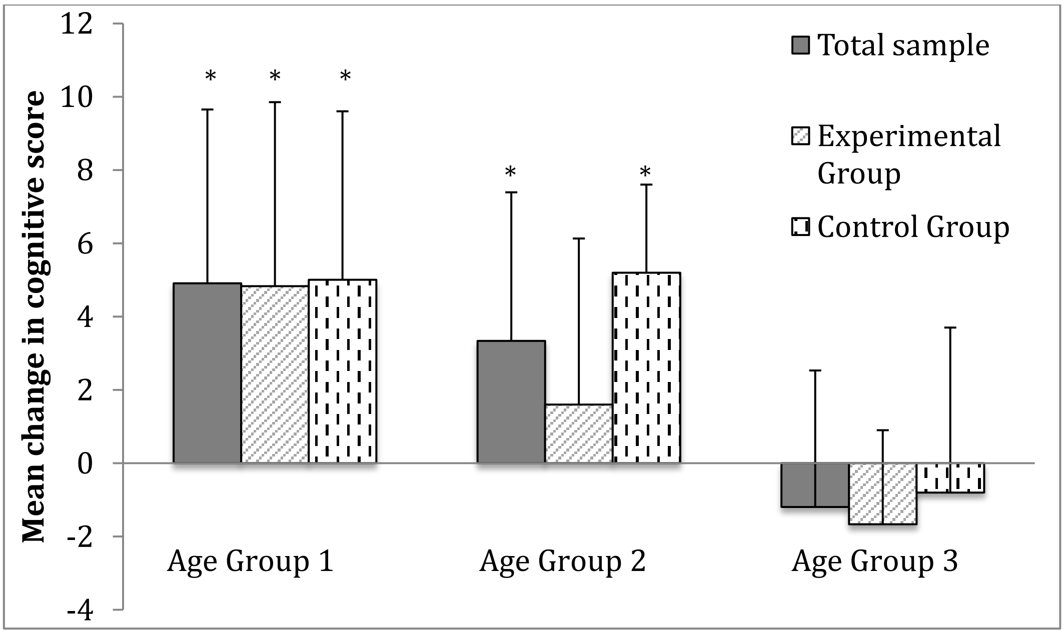

Figure 4.1. Mean (± SD) change in cognitive ability score. Age groups on horizontal axis are based on ages of the children at baseline and post-intervention.

Note. Age Group 1 = 12 mo., 16 day to 18 mo., 15 day; Age Group 2 = 12 mo., 16 day to 18 mo., 15 day at baseline, 18 mo., 16 day to 24 mo., 15 day at post-intervention; Age Group 3 = 18 mo., 16 day and 24 mo., 15 day
*Significantly greater change in cognitive ability ($p < 0.05$) as compared to Age Group 3

4.2.2 Receptive communication subscale

All average raw receptive communication scores indicate “competent” children, except for at baseline in Age Group 1 (control group only) whose average raw score implied “emerging” ability. There were no significant differences between treatment groups in terms of the change in receptive communication score over the duration of the study (see Table 4.3).

Table 4.3

Mean (± SD) raw scores of Receptive Communication [24[β]] by age group

Age Group		**Baseline**	**Post**	**Change**	***p*-value**
1 (n=34)	EXP	12.3 ± 2.8	17.1 ± 3.9	4.7 ± 5.0	0.24
	CON	11.1 ± 1.3	17.7 ± 3.9	6.6 ± 4.1	
2 (n=27)	EXP	14.3 ± 3.0	17.8 ± 4.8	3.5 ± 6.3	0.80
	CON	13.4 ± 3.3	17.4 ± 4.0	4.0 ± 4.7	
3 (n=29)	EXP	18.2 ± 2.3	17.3 ± 3.4	-0.8 ± 4.0	0.82
	CON	16.1 ± 3.1	15.6 ± 3.1	-0.5 ± 4.3	
Total Sample (n=90)	EXP	14.6 ± 3.6	17.4 ± 4.0	2.8 ± 5.6	0.59
	CON	13.5 ± 3.4	16.9 ± 3.7	3.4 ± 5.2	

Note. EXP: experimental group, CON: control group; Age Group 1 = 12 mo., 16 day to 18 mo., 15 day; Age Group 2 = 12 mo., 16 day to 18 mo., 15 day at baseline, 18 mo., 16 day to 24 mo., 15 day at post-intervention; Age Group 3 = 18 mo., 16 day and 24 mo., 15 day
[β]Total possible raw score for receptive communication subscale is 24

There was a main effect of Age Group on the change in receptive communication score in the total sample ($F(2,87) = 13.20$, $p < .001$, $\omega^2 = 0.21$), experimental group ($F(2,42) = 4.20$, $p = .02$, $\omega^2 = 0.13$) and control group ($F(2,42) = 10.47$, $p < .001$, $\omega^2 = 0.30$; Figure 4.2). More specifically, the change in receptive communication was greater in children in Age Group 1 (TOTAL, 5.0 ± 4.6, $p < 0.001$; EXP, 4.7 ± 5.0, $p = 0.02$; CON, 6.6 ± 4.1, $p < 0.001$) compared to those in Age Group 3 (TOTAL, -0.6 ± 4.1; EXP, -0.8 ± 4.0; CON, -0.5 ± 4.3). In addition, the change in receptive communication was greater in children in Age Group 2 (TOTAL, 3.7 ± 5.5, $p = 0.003$; CON, 4.0 ± 4.7, $p = 0.03$) as compared to those in Age Group 3 in the control group and total sample.

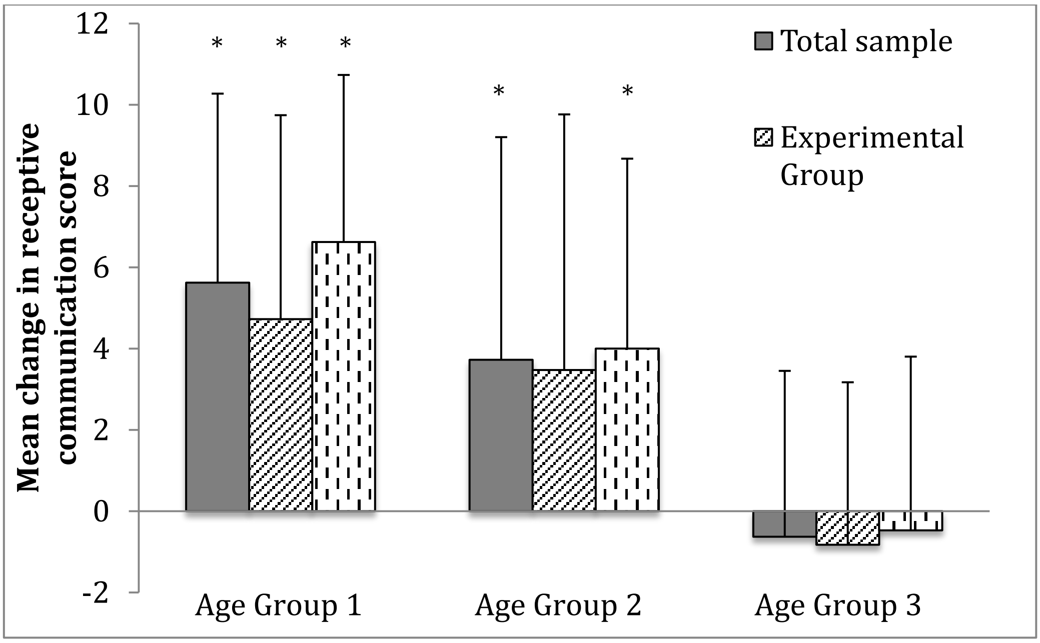

Figure 4.2. Mean (± SD) change in receptive communication score. Age groups on horizontal axis are based on ages of the children at baseline and post-intervention.

Note. Age Group 1 = 12 mo., 16 day to 18 mo., 15 day; Age Group 2 = 12 mo., 16 day to 18 mo., 15 day at baseline, 18 mo., 16 day to 24 mo., 15 day at post-intervention; Age Group 3 = 18 mo., 16 day and 24 mo., 15 day

*Significantly greater change in receptive communication score ($p < 0.05$) as compared to Age Group 3

4.2.3 Expressive communication subscale

The average raw expressive communication scores at baseline indicated “emerging” ability across all age groups. At post-intervention, the average raw scores indicate “competent” children in Age Group 1 and Age Group 2. Children in Age Group 3, on average, were still “emerging” in terms of their expressive communication scores. There were no differences between treatment groups in terms of the change in expressive communication score over the duration of the study (see Table 4.4).

Table 4.4

Mean (± SD) raw scores of Expressive Communication [24$^{\theta}$] by age group

Age Group		**Baseline**	**Post**	**Change**	***p*-value**
1 (n=34)	EXP	12.4 ± 2.3	15.6 ± 4.1	3.2 ± 4.9	0.99
	CON	11.9 ± 1.7	15.1 ± 3.7	3.2 ± 4.4	
2 (n=27)	EXP	13.6 ± 1.9	15.5 ± 4.1	1.9 ± 4.9	0.20
	CON	12.7 ± 1.1	16.7 ± 3.8	4.0 ± 3.4	
3 (n=29)	EXP	15.3 ± 2.8	15.3 ± 2.9	0.0 ± 5.0	0.87
	CON	14.5 ± 2.2	14.3 ± 2.9	-0.3 ± 3.4	
Total Sample (n=90)	EXP	13.6 ± 2.6	15.5 ± 3.7	1.9 ± 5.0	0.70
	CON	13.0 ± 2.0	15.3 ± 3.5	2.3 ± 4.1	

Note. Age Group 1 = 12 mo., 16 day to 18 mo., 15 day; Age Group 2 = 12 mo., 16 day to 18 mo., 15 day at baseline, 18 mo., 16 day to 24 mo., 15 day at post-intervention; Age Group 3 = 18 mo., 16 day and 24 mo., 15 day
$^{\theta}$Total possible raw score for expressive communication subscale is 24

There was a main effect of Age Group on the change in expressive communication score in the total sample ($F(2,87) = 5.15$, $p = 0.01$, $\omega^2 = 0.08$) and control group ($F(2,42) = 5.27$, $p = 0.01$, $\omega^2 = 0.16$; Figure 4.3). More specifically, the change in expressive communication was greater in children in Age Group 1 (TOTAL, 3.2 ± 4.6, $p = 0.01$; CON 3.2 ± 4.4, $p = 0.05$) compared to those in Age Group 3 (TOTAL, -0.1 ± 4.1, $p = 0.03$; CON, -0.3 ± 3.4, $p = 0.01$) in both the total sample and the control group. In addition, the change in expressive communication was also greater in children in Age Group 2 (TOTAL, 2.9 ± 4.3; CON, 4.0 ± 3.4) as compared to those in Age Group 3 in the control group and total sample. No differences between children in the experimental group were found ($p = 0.24$).

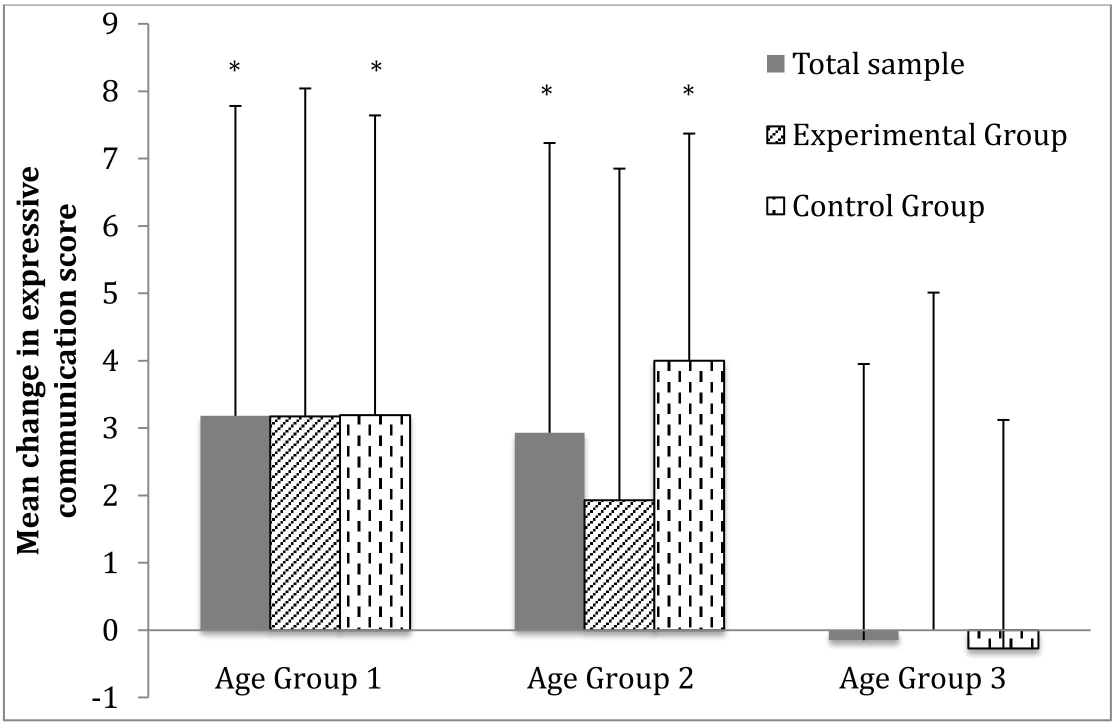

Figure 4.3. Mean (± SD) change in expressive communication score. Age groups on horizontal axis are based on ages of the children at baseline and post-intervention.

Note. Age Group 1 = 12 mo., 16 day to 18 mo., 15 day; Age Group 2 = 12 mo., 16 day to 18 mo., 15 day at baseline, 18 mo., 16 day to 24 mo., 15 day at post-intervention; Age Group 3 = 18 mo., 16 day and 24 mo., 15 day
*Significantly greater change in receptive communication score ($p < .05$) as compared to Age Group 3

4.2.4 Fine motor skill subscale

The average raw score in the fine motor skill subscale indicates “competent” ability across all age groups both at baseline and post-intervention, with the exception of children in Age Group 3 at post-intervention (control only) where the average raw score indicated “emerging” ability. There were no differences between treatment groups in any of the age groups (see Table 4.5).

Table 4.5

Mean (± SD) raw scores of Fine Motor Skill [27^] by age group

Age Group		**Baseline**	**Post**	**Change**	***p*-value**
1 (n=34)	EXP	14.9 ± 2.1	17.2 ± 1.5	2.3 ± 3.2	0.63
	CON	15.2 ± 1.4	17.0 ± 1.4	1.8 ± 2.3	
2 (n=27)	EXP	15.8 ± 1.9	17.2 ± 1.7	1.4 ± 2.5	0.05
	CON	14.4 ± 1.7	17.5 ± 1.0	3.1 ± 1.9	
3 (n=29)	EXP	16.5 ± 2.6	16.8 ± 0.9	0.3 ± 2.6	0.34
	CON	17.1 ± 1.2	16.4 ± 2.0	-0.7 ± 2.5	
Total Sample (n=90)	EXP	15.6 ± 2.2	17.1 ± 1.4	1.4 ± 2.9	0.88
	CON	15.6 ± 1.8	17.0 ± 1.6	1.4 ± 2.7	

Note. Age Group 1 = 12 mo., 16 day to 18 mo., 15 day; Age Group 2 = 12 mo., 16 day to 18 mo., 15 day at baseline, 18 mo., 16 day to 24 mo., 15 day at post-intervention; Age Group 3 = 18 mo., 16 day and 24 mo., 15 day

[^]Total possible raw score for fine motor subscale is 27

There was a main effect of Age Group on the change in fine motor skill score in the total sample ($F(2,87) = 8.32$, $p < 0.001$, $\omega^2 = 0.14$) and control group ($F(2,42) = 10.68$, $p < .001$, $\omega^2 = 0.30$; Figure 4.4). More specifically, the change in fine motor skill was greater in children in Age Group 1 (TOTAL, 2.1 ± 2.8, $p < 0.01$; CON 1.8 ± 2.3, $p = 0.01$) compared to those in Age Group 3 (TOTAL, -0.3 ± 2.6; CON, -0.7 ± 2.5). In addition, the change in fine motor skill was greater in children in Age Group 2 (TOTAL, 2.2 ± 2.3, $p = 0.001$; CON, 3.1 ± 1.9, $p < 0.001$) as compared to those in Age Group 3 in the control group and total sample. No differences between children in the experimental group were found ($p = 0.17$).

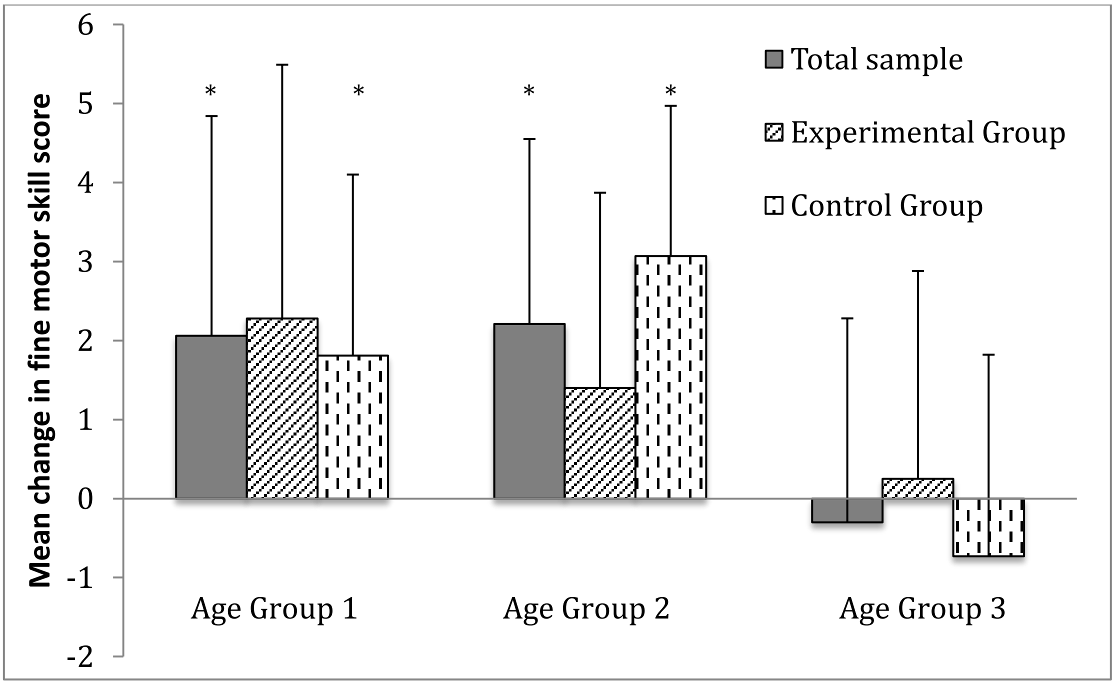

Figure 4.4. Mean (± SD) change in fine motor skill score. Age groups on horizontal axis are based on ages of the children at baseline and post-intervention.

Note. Age Group 1 = 12 mo., 16 day to 18 mo., 15 day; Age Group 2 = 12 mo., 16 day to 18 mo., 15 day at baseline, 18 mo., 16 day to 24 mo., 15 day at post-intervention; Age Group 3 = 18 mo., 16 day and 24 mo., 15 day

*Significantly greater change in fine motor skill (p < 0.05) as compared to Age Group 3

4.2.5 Gross motor skill subscale

The average raw score in the gross motor skill subscale indicated “competent” ability across all age groups at baseline and post-intervention, expect for children in Age Group 1 (control group only) at baseline where the average raw score implied “emerging” ability. There was a difference in the change in gross motor skill between the treatment groups in children in Age Group 2 at the post-intervention assessment (EXP vs. CON, 0.9 ± 1.9 vs. 3.0 ± 2.8; $t(27) = -2.35$, $p = 0.03$, $d = -0.88$), with children in the control group exhibiting greater improvements in their gross motor skill (see Table 4.6).

Table 4.6

Mean (± SD) raw scores of Gross Motor Skill [28[μ]] by age group

Age Group		**Baseline**	**Post**	**Change**	***p*-value**
1 (n=34)	EXP	17.1 ± 2.2	20.2 ± 1.4	3.1 ± 2.9	0.60
	CON	16.2 ± 2.8	19.9 ± 2.4	3.7 ± 3.4	
2 (n=27)	EXP	18.6 ± 1.2	19.5 ± 1.6	0.9 ± 1.9	0.03*
	CON	17.4 ± 1.8	20.4 ± 1.6	3.0 ± 2.8	
3 (n=29)	EXP	18.9 ± 2.7	19.4 ± 1.9	0.5 ± 3.5	0.67
	CON	20.1 ± 1.2	20.1 ± 3.5	-0.1 ± 3.3	
Total Sample (n=90)	EXP	18.1 ± 2.2	19.8 ± 1.6	1.7 ± 3.0	0.44
	CON	17.9 ± 2.6	20.1 ± 2.6	2.2 ± 3.5	

Note. Age Group 1 = 12 mo., 16 day to 18 mo., 15 day; Age Group 2 = 12 mo., 16 day to 18 mo., 15 day at baseline, 18 mo., 16 day to 24 mo., 15 day at post-intervention; Age Group 3 = 18 mo., 16 day and 24 mo., 15 day
[μ]Total possible raw score for gross motor subscale is 28
* Significant difference between treatment groups ($p < 0.05$)

There was a main effect of Age Group on the change in gross motor skill score in the total sample ($F(2,87) = 8.43$, $p < 0.001$, $\omega^2 = 0.14$), the experimental group ($F(2,42) = 3.92$, $p = 0.03$, $\omega^2 = 0.12$) and the control group ($F(2,42) = 5.98$, $p = 0.01$, $\omega^2 = 0.18$). More specifically, the change in gross motor skill score was greater in children in Age Group 1 (TOTAL, 3.4 ± 3.1, $p < 0.001$; EXP, 3.1 ± 3.0, $p = 0.05$; CON, 3.7 ± 3.4, $p = 0.006$) compared to those in Age Group 3 (TOTAL, 0.2 ± 3.3; EXP, 0.5 ± 3.5; CON, -0.1 ± 3.3). In addition, children in Age Group 2, in the control group only (CON, 3.0 ± 2.8, $p = 0.04$), showed a greater change in gross motor skill score as compared to those in Age Group 3 (Figure 4.5).

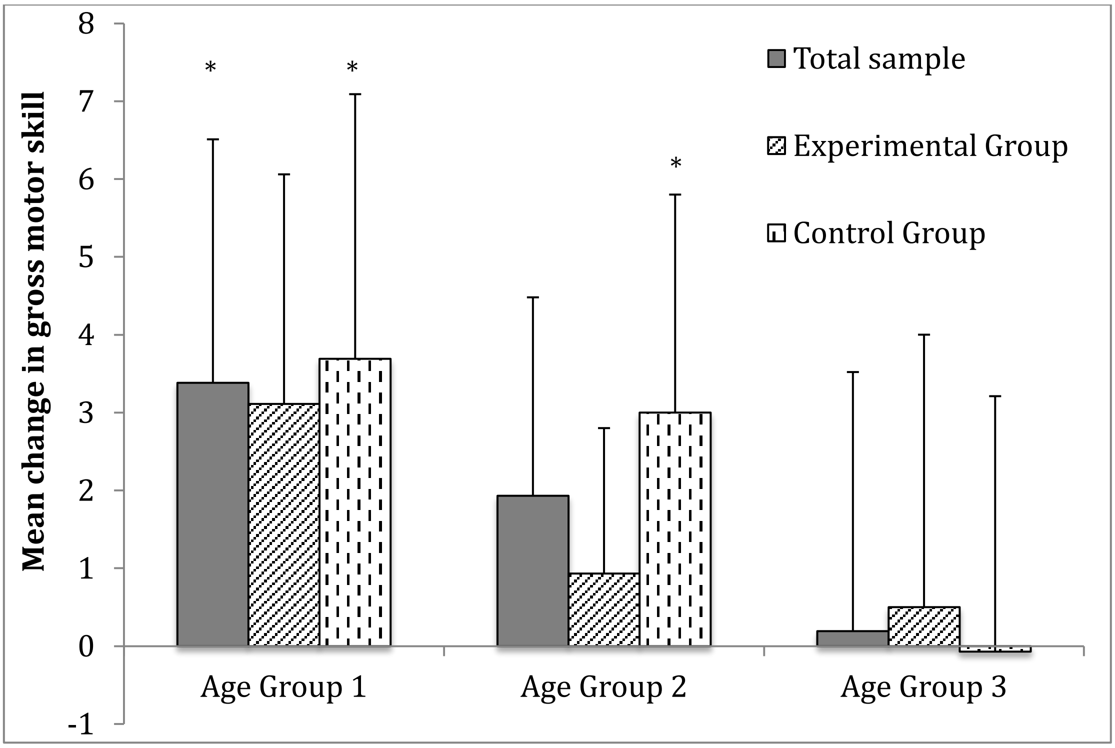

Figure 4.5. Mean (± SD) change in gross motor skill score. Age groups on horizontal axis are based on ages of the children at baseline and post-intervention.

Note. Age Group 1 = 12 mo., 16 day to 18 mo., 15 day; Age Group 2 = 12 mo., 16 day to 18 mo., 15 day at baseline, 18 mo., 16 day to 24 mo., 15 day at post-intervention; Age Group 3 = 18 mo., 16 day and 24 mo., 15 day

*Significantly greater change in gross motor skill (p < 0.05) as compared to Age Group 3

4.2.6 Correlation analysis

There were high positive correlations between the change scores of all subscales of the BSID (p < 0.01; Table 4.7). In addition, all subscales were negatively correlated with both children's height and age at baseline (p < 0.01). Furthermore, the changes in cognitive ability, receptive communication and expressive communication were positively correlated with whether the child was in home care with parent or other adult, or not (p < 0.05). In addition, there was a trend towards an association between the change in gross motor skill score and sex (r_{pb} = .21, p = 0.051).

Table 4.7

Correlation matrix for the change in BSID subscales and descriptive variables in the total sample (n=90)

	Variables								
Variables	1	2	3	4	5	6	7	8	9
1. Change in Cognitive Ability Score	-	.65**	.71**	.64**	.59**	-.46**	-.59**	-.19	.24*
2. Change in Receptive Communication Score	-	-	.66**	.56**	.57**	-.39**	-.54**	-.19	.21*
3. Change in Expressive Communication Score	-	-	-	.51**	.41**	-.35**	-.45**	-.16	.31**
4. Change in Fine Motor Skill Score	-	-	-	-	.57**	-.39**	-.43**	-.17	.18
5. Change in Gross Motor Skill Score	-	-	-	-	-	-.48**	-.41**	-.31**	.14
6. Height at baseline	-	-	-	-	-	-	.66**	.73**	-.01
7. Age at baseline	-	-	-	-	-	-	-	.47**	-.13
8. Mass at baseline	-	-	-	-	-	-	-	-	-.02
9. Day-to-day environment[α]	-	-	-	-	-	-	-	-	-

[α]Point-biserial correlation (r_{pb})

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

4.2.7 Regression analysis

Due to the high correlations between the subscales of the BSID Screening Test, further analysis was completed using the change in total development score, as calculated by the sum of the individual raw scores at post-intervention minus the sum of the individual raw scores at baseline. Similarly, due to the high correlation between height at baseline and age group ($r = .57$, $p < 0.001$) further analysis was completed using age group only. To investigate how well day-to-day environment, age group and sex predict the change in total development score a step-wise linear regression was computed (Table 4.8). The assumptions of linearity, normally distributed errors, and uncorrelated errors were checked and met.

Table 4.8

Means, standard deviations and inter-correlations of predictor variables for the change in total development score

Variable	M	SD	1	2	3
Change in total development score	11.17	17.22	- .11	.27*	- .50**
Predictor variable					
1. Age group	1.92	0.82		- .12	.06
2. Day-to-day environment	0.77	0.43			.16
3. Sex	0.52	0.50			

*$p = 0.005$; **$p < 0.001$

When age group was entered alone, it significantly predicted the change in total development score ($F(1,88) = 29.00$, $p < 0.01$, adjusted $R^2 = .24$). When the day-to-day environment variable was added to the regression model, there was improved prediction of the change in total development score ($F(2,87) = 18.15$, $p < 0.01$, adjusted $R^2 = .28$). Sex was not included in Model 2, as it was not significantly correlated with the other predictor variables or the change in total development score. Both models resulted in large effects (Cohen, 1988). The beta weights (Table 4.9) suggest that being in the younger age groups contributes most to predicting the change in total development score, but the day-to-day environment of the child also contributes to this prediction.

Table 4.9

Forward step-wise linear regression analysis summary of predicting the change in total development score (n=90)

Model	Coefficient (*B*)	Standard error *B*	β	R^2
<u>Model 1</u>$^{\alpha}$				0.25*
Intercept	31.2	4.0		
Age group	-10.4	1.9	-0.5*	
<u>Model 2</u>$^{\beta}$				0.29*
Intercept	23.4	5.1		
Age group	-9.9	1.9	-0.5*	
Environment	8.8	3.7	0.2**	

Note: $^{\alpha}F(1,88) = 28.9$; $^{\beta}F(2,87) = 18.2$; *$p < 0.001$, **$p < 0.05$

4.3 Safety Skills

4.3.1 Total Safety Skill Score

There was no difference in the baseline safety skills total score (out of 45) between the treatment groups ($t(84) = 0.12$, $p = 0.91$). There was a medium effect of the physical activity programme on the post-intervention safety skills total score in the experimental group ($t(84) = 2.45$, $p = 0.02$, $d = 0.53$; Table 4.10) which was also reflected in the change in total score. On average, the experimental group had significantly greater improvement in the safety skills total score ($t(84) = 2.13$, $p = 0.04$, $d = 0.46$).

Table 4.10

Mean safety skills total score (± SD) at baseline, post-intervention and the difference between baseline and post-intervention

	Baseline	**Post-intervention**	**Difference**
Experimental (n=42$^{\alpha}$)	16.3 ± 6.2	27.5 ± 5.2	9.7 ± 7.5
Control (n=44$^{\beta}$)	16.1 ± 6.2	24.3 ± 6.7	6.5 ± 6.5
Significance (*p*-value)	0.91	0.02*	0.04*
Effect size (*d*-value)	0.03	0.53	0.46

* Significant difference between treatment groups ($p < 0.05$)
$^{\alpha}$n=42 due to missing data at post-intervention and due to the removal of participants who showed a decline in the total safety skills score at post-intervention noted to be due to lack of cooperation or distress.
$^{\beta}$n=44 due to the removal of participants who showed a decline in the total safety skills score at post-intervention noted to be due to lack of cooperation or distress.

In addition, paired t-tests showed the total safety skills score at post-intervention was significantly greater than the total safety skills score at baseline in both the experimental group ($t(41) = 9.69$, $p < 0.01$, $d = 0.83$) and the control group ($t(43) = 6.77$, $p < 0.01$, $d = 0.72$; Figure 4.6).

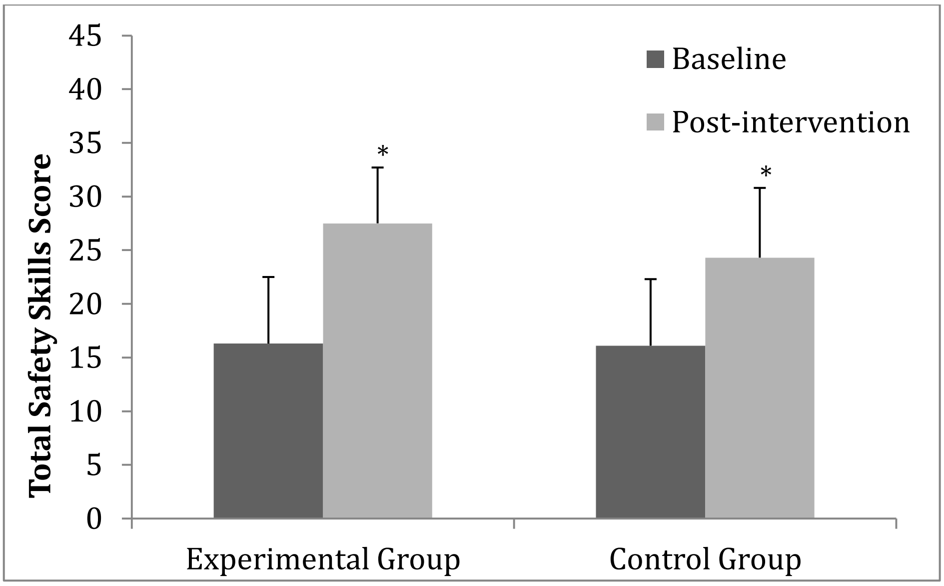

Figure 4.6 Mean safety skills total score (± SD) at baseline and post-intervention in the experimental and control groups

* Significant difference between baseline and post-intervention scores (p < 0.01)

There was no main effect of Age Group on the change in total safety skills score (F(2,83) = 2.15, p = 0.12). The change in total safety skills score was significantly correlated with being the youngest child (r_{pb} = .22, p = 0.04). However, there were no other significant correlations between the change in total safety skills score and any of the other descriptive characteristics or any of the developmental measures (cognitive, receptive and expressive communication or fine and gross motor skill subscales).

4.3.2 Individual Safety Skills Scores

All skills significantly improved over the duration of the study in both treatment groups (p < 0.01; Table 4.11). Furthermore, the ability to climb over the small-runged A-frame while using a cylinder grip and safe face-the-slope, leg-over dismount (Safety Skill F; t(41) = 10.37, p = 0.001, d = 0.75) and the execution of a safety roll (Safety Skill G; $t(43) = 8.46$, $p = 0.02$, $d = 0.50$) were significantly improved following the intervention.

Table 4.11

Mean (±SD) individual safety skills scores (each out of 5) at baseline, post-intervention and the difference between baseline and post-intervention

Safety Skills	**Experimental Group**			**Control Group**		
	Baseline	Post	Difference	Baseline	Post	Difference
A	1.6 ± 0.9	2.5 ± 0.7*	0.9 ± 1.2	1.8 ± 0.9	2.6 ± 0.8*	0.8 ± 1.2
B	2.1 ± 0.7	3.2 ± 0.9*	1.1 ± 1.1	1.8 ± 0.9	2.9 ± 0.9*	1.0 ± 1.2
C	1.1 ± 0.8	2.1 ± 1.0*	1.0 ± 1.1	0.9 ± 0.4	2.0 ± 1.2*	1.2 ± 1.1
D	2.1 ± 0.9	3.0 ± 0.8*	0.9 ± 1.2	2.1 ± 1.1	2.7 ± 1.1*	0.7 ± 1.4
E	2.1 ± 1.1	3.4 ± 0.8*	1.3 ± 1.3	2.0 ± 1.0	2.9 ± 0.7*	0.9 ± 1.2
F	1.5 ± 0.8	3.3 ± 1.0*	1.8 ± 1.1$^{\sigma}$	1.6 ± 0.9	2.5 ± 1.0*	1.0 ± 1.2
G	1.6 ± 0.9	3.0 ± 0.5*	1.4 ± 1.1$^{\omega}$	1.7 ± 1.0	2.5 ± 0.8*	0.8 ± 1.2
H	2.1 ± 1.2	3.4 ± 1.1*	1.3 ± 1.1	2.1 ± 1.2	2.9 ± 1.2*	0.9 ± 1.5
I	2.0 ± 1.3	3.5 ± 1.2*	1.4 ± 1.8	2.2 ± 1.2	3.2 ± 1.3*	0.9 ± 1.5

* Significant difference from baseline score ($p < 0.01$)
$^{\sigma}$ Significant difference from control group ($p = 0.001$, $d = 0.35$)
$^{\omega}$ Significant difference from control group ($p = 0.023$, $d = 0.25$)

There was no effect of Age Group on the change in Safety Skill F ($F(2,83) = 1.72$, $p = 0.19$) or on the change in Safety Skill G ($F(2,83) = 1.16$, $p = 0.32$). The change in Safety Skill F and Safety Skill G were both positively correlated with being the youngest child ($r_{pb} = .25$, $p = 0.02$ and $r_{pb} = .29$, $p = 0.01$ respectively). There were no significant correlations found between the change in Safety Skill F or G and any of the other descriptive characteristics nor any of the developmental measures (cognitive, receptive and expressive communication or fine and gross motor skill subscales).

4.3.3 Regression analysis

Further analysis was completed separately for the change in total safety skills score, the change in Safety Skill F and the change in Safety Skill G, due to the moderate to high correlations between these variables. To investigate how well birth order, sex and day-to-day environment predict the change in total development score a hierarchical multiple linear regression was computed (Table 4.12). The assumptions of linearity, normally distributed errors, and uncorrelated errors were checked and met.

Table 4.12

Means, standard deviations and inter-correlations of predictor variables for the change in total safety skills score

Variable	M	SD	1	2	3
Change in total safety skills score	8.03	7.16	.22*	-.20*	-.07
Predictor variable					
1. Birth order	0.48	0.50		-.05	.03
2. Sex	0.51	0.50			.07
3. Day-to-day environment	0.77	0.43			

*p < 0.05

The hierarchical regression model meant that birth order, specifically children who were youngest born compared with those that were not, was the first predictor investigated. When birth order was entered alone, it significantly predicted the change in total safety skills score (F(1,84) = 4.35, p = 0.04, adjusted R^2 = .038). However, as indicated by the adjusted R^2, only 3.8% of the variance in the change in total safety skills score could be predicted by knowing whether the child was the youngest born or not. When sex was added to the regression model 6.4% of the variance in the change in total safety skills score could be significantly predicted by knowing both the sex of the child and whether they were the youngest born (Model 2; $F(2,83) = 3.91$, $p = 0.02$, adjusted $R^2 = .064$). The entire group of variables, including day-to-day environment, did not significantly predict the change in total safety skill score ($F(3,82) = 2.71$, $p = 0.05$, adjusted $R^2 = .057$; Table 4.13) and reduced explanation of the variance in the change in total safety skills score to 5.7%.

Table 4.13

Hierarchical multiple regression analysis summary for predicting the change in total safety skills score

Model	Coefficient (*B*)	Standard error *B*	β	R^2
Model 1$^{\alpha}$				0.05*
Constant	6.52	1.05		
Birth Order	3.16	1.52	0.22*	
Model 2$^{\beta}$				0.09*
Constant	7.98	1.30		
Birth Order	3.04	1.50	.21*	
Sex	-2.74	1.50	-.19	
Model 3$^{\gamma}$				0.09
Constant	8.75	1.84		
Birth Order	3.07	1.50	.215*	
Sex	-2.68	1.51	-.188	
Environment	-1.06	1.78	-.063	

Note: $^{\alpha}F(1,84) = 4.35$; $^{\beta}F(2,83) = 3.91$; $^{\gamma}F(3,82) = 2.71$; $*p < 0.05$

The beta weights (see Table 4.13) suggest that being the youngest born contributes most to predicting the change in total safety skills score, but the sex of the child also contributes to this prediction.

To investigate how well birth order and sex predict the change in Safety Skill F score a forward step-wise multiple linear regression was computed (Table 4.14). The step-wise regression model meant that birth order only, specifically children who were youngest born compared with those that were not, was entered into the model. It significantly predicted the change in Safety Skill F score ($F(1,84) = 5.55$, $p = 0.02$, adjusted $R^2 = .051$). However, as indicated by the adjusted R^2, only 5.1% of the variance in the change in Safety Skill F score could be predicted by knowing whether the child was the youngest born or not (Table 4.15).

Table 4.14

Means, standard deviations and inter-correlations of predictor variables for the change in safety skill F score

Variable	M	SD	1	2	3
Change in Safety Skill F score	1.38	1.25	.25*	.02	.06
Predictor variable					
1. Birth order	0.48	0.50		-.05	.03
2. Sex	0.51	0.50			.07
3. Day-to-day environment	0.77	0.43			

*$p < 0.05$

Table 4.15

Forward step-wise multiple regression analysis summary for predicting the change in safety skill F score

Model	Coefficient (*B*)	Standard error *B*	β	R^2
Model 1[α]				0.06*
Constant	1.09	0.18		
Birth Order	0.62	0.26	0.25*	

Note: [α]F(1,84) = 5.55; $*p < 0.05$

The final forward step-wise multiple linear regression computed was to determine how well birth order and sex predict the change in Safety Skill G score (Table 4.16). The step-wise regression model meant that birth order only was entered to the model. It significantly predicted the change in Safety Skill G score ($F(1,84) = 7.59$, $p = 0.007$, adjusted $R^2 = .072$). However, only 7.2% of the variance in the change in Safety Skill G score could be predicted by knowing whether the child was the youngest born or not (Table 4.17).

Table 4.16

Means, standard deviations and inter-correlations of predictor variables for the change in safety skill G score

Variable	M	SD	1	2	3
Change in Safety Skill G score	1.09	1.15	.29*	-.06	.14
Predictor variable					
1. Birth order	0.48	0.50		-.05	.029
2. Sex	0.51	0.50			.068
3. Day-to-day environment	0.77	0.43			

$*p < 0.05$

Table 4.17

Forward step-wise multiple regression analysis summary for predicting the change in safety skill G score

Model	Coefficient (*B*)	Standard error *B*	β	R^2
Model 1[α]				0.08*
Constant	0.78	0.17		
Birth Order	0.66	0.24	0.29*	

Note: [α]F(1,84) = 7.59; *p < 0.05

4.4 Balance

There was no difference between the treatment groups in baseline measures of range of centre of pressure (CoP; t(28) = -1.63, p = 0.11) or speed of centre of pressure (t(28) = -0.45, p = 0.66; Table 4.18). There were no differences between treatment groups at post-intervention (t(28) = -0.05, p = 0.96). Further analysis of balance was completed on the total sample (n=30) due to the lack of differences between treatment groups.

Table 4.18

Mean (± *SD) measures of balance at baseline and post-intervention*

	Experimental Group (n=16)	Control Group (n=14)	Total Sample (n=30)
CoP range (mm) – Baseline	112.3 ± 21.9	128.2 ± 31.2	119.7 ± 27.4
CoP range (mm) – Post-int.	108.8 ± 18.2	109.1 ± 16.4	108.9 ± 17.1
Difference in CoP range (mm)	-3.5 ± 27.1	-19.1 ± 35.1	-10.8 ± 31.6
CoP speed (mm/s) – Baseline	95.8 ± 18.4	99.5 ± 25.9	97.6 ± 21.9
CoP speed (mm/s) – Post-int.	93.6 ± 15.5	97.2 ± 15.9	95.2 ± 15.5
Difference in CoP speed (mm/s)	-2.3 ± 24.3	-2.3 ± 32.0	-2.3 ± 27.6

Note. Total sample is 30 due to the lack of matched data at baseline and post-intervention. CoP: centre of pressure

There was no main effect of Age Group on the change in the range (F(2,27) = 2.36, p = 0.11) or the change in the speed of the centre of pressure (F(2,27) = 1.91, p = 0.17). The difference in the centre of pressure range was not correlated with any descriptive characteristics, however the difference in the centre of pressure speed was negatively correlated with the child’s head circumference at birth (r = -.43, p = 0.02). Neither measure of balance was correlated with any of the measures of development or the difference in total safety skills score.

4.5 Child-Parent/Caregiver Supervision

4.5.1 Protectiveness

Most parents selected “none of the above” at both baseline (35.6%) and post-intervention (30.0%; Figure 4.7) when asked how protective they were of their child. There was no difference between treatment groups in terms of the number of participants that changed their answer to question one between baseline and post-intervention (EXP, 48.9%; CON, 42.2%; U = 945.0, Z = -0.63, p = 0.53). In the experimental group, most parents selected “none of the above” at both baseline and post-intervention, while in the control group, the majority of participants selected Answer A at baseline and Answer B at post-intervention (Table 4.19).

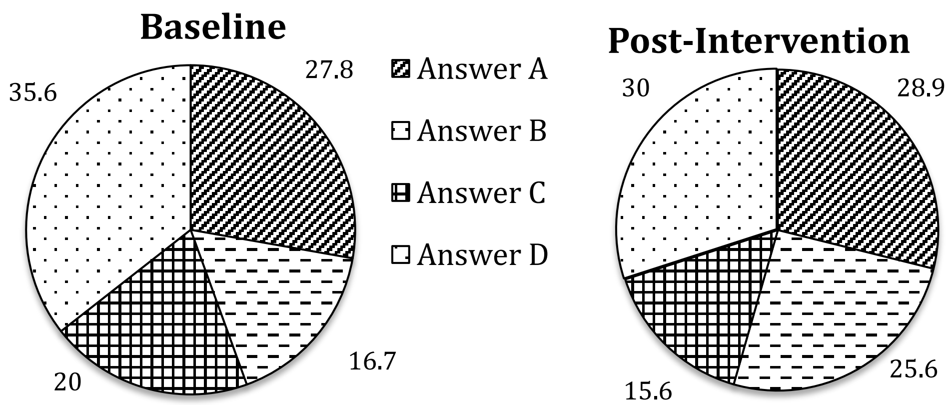

Figure 4.7 Summary of parental perceptions concerning protectiveness in the total sample (n=90)

Note: Answer A: I feel very protective; Answer B: I think of all the dangerous things that could happen; Answer C: I keep my child from playing rough games or doing things where he/she might get hurt; Answer D: None of the above

Table 4.19

Parent responses to "How protective are you of your child?" at baseline and post-intervention in the experimental and control groups

	Experimental Group (n=45)		Control Group (n=45)	
	Baseline (%)	Post-int.(%)	Baseline (%)	Post-int. (%)
Answer A	22.2	28.9	33.3	28.9
Answer B	6.7	13.3	26.7	37.8
Answer C	26.7	20.0	13.3	11.1
Answer D	44.4	37.8	26.7	22.2

Note: Answer A: I feel very protective; Answer B: I think of all the dangerous things that could happen; Answer C: I keep my child from playing rough games or doing things where he/she might get hurt; Answer D: None of the above

4.5.2 Child's Play time

Most parents selected "I warn him/her about doing things that could be dangerous" at both baseline (36.7%) and post-intervention (34.4%). There was no difference between treatment groups in the number of participants that changed their answer to question two between baseline and post-intervention (EXP, 44.4%; CON, 60.0%; U = 855.0, Z = -1.47, p = 0.14; Figure 4.8). In both the experimental and control groups, most participants also selected Answer C: "I warn him/her about doing things that could be dangerous" at both baseline and post-intervention (Table 4.20).

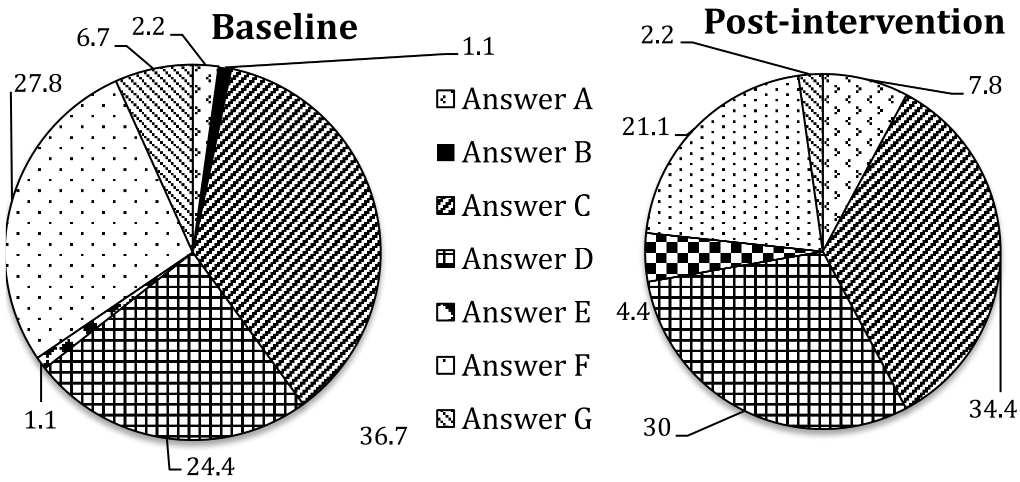

Figure 4.8 Summary of parental perceptions concerning their child's play time in the total sample (n=90)

Note: Answer A: I make him/her keep away from anything that could be dangerous; Answer B: I feel fearful that something might happen to my child; Answer C: I warn him/her about doing things that could be dangerous; Answer D: I keep an eye on my child's face to see how he/she is doing; Answer E: I feel a strong sense of responsibility; Answer F: I try things with my child before leaving himself/herself to do them on their own; Answer G: None of the above

Table 4.20

Parent responses to "How would you describe your actions during your child's play time?" in the experimental and control groups

	Experimental Group (n=45)		Control Group (n=45)	
	Baseline (%)	Post-int. (%)	Baseline (%)	Post-int. (%)
Answer A	0.0	4.4	4.4	11.1
Answer B	0.0	0.0	2.2	0.0
Answer C	37.8	35.6	35.6	33.3
Answer D	31.1	28.9	17.8	31.1
Answer E	0.0	4.4	2.2	4.4
Answer F	26.7	24.4	28.9	17.8
Answer G	4.4	2.2	8.9	2.2

Note: Answer A: I make him/her keep away from anything that could be dangerous; Answer B: I feel fearful that something might happen to my child; Answer C: I warn him/her about doing things that could be dangerous; Answer D: I keep an eye on my child's face to see how he/she is doing; Answer E: I feel a strong sense of responsibility; Answer F: I try things with my child before leaving himself/herself to do them on their own; Answer G: None of the above

4.5.3 Supervision

Most participants selected “I stay close enough to my child that I can get to him/her quickly” at both baseline (48.9%) and post-intervention (48.9%; Figure 4.9). There was no difference between treatment groups in terms of the number of participants that changed their answer to question three between baseline and post-intervention (EXP, 46.7%; CON, 64.4%; U = 832.5, Z = -1.69, p = 0.09). In both the experimental and control groups, majority of participants also selected Answer E: “I stay close enough to my child that I can get to him/her quickly” at both baseline and post-intervention (Table 4.21).

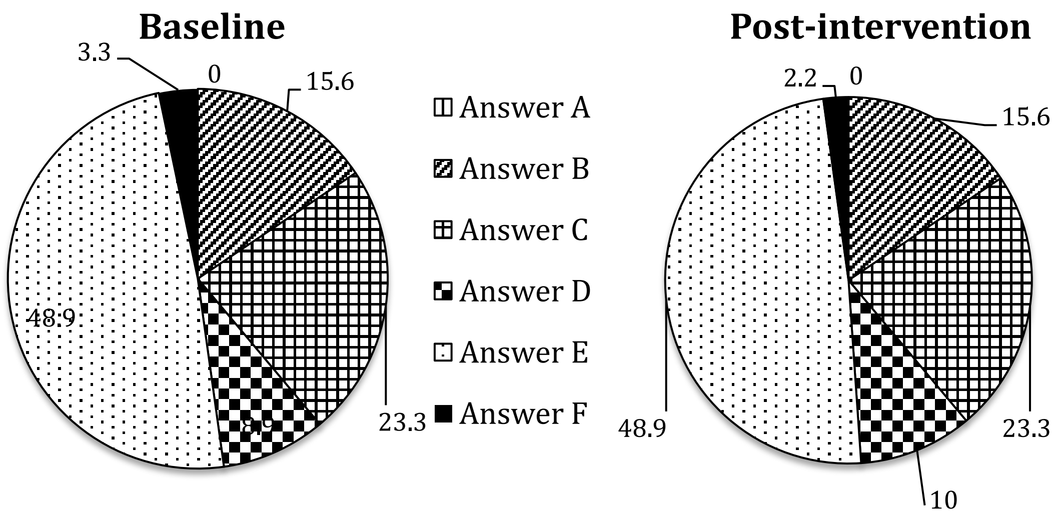

Figure 4.9 Summary of parental perceptions concerning supervision in the total sample (n=90)

Note: Answer A: I have my child within arm’s reach at all times and I always know exactly what my child is doing; Answer B: I can trust my child to play be himself/herself without constant supervision; Answer C: I stay within reach of child when he/she is playing on playground equipment; Answer D: I keep a close watch on my child; Answer E: I stay close enough to my child that I can get to him/her quickly; Answer F: None of the above.

Table 4.21

Parental responses to "How would you describe your supervision of your child?" in the experimental and control groups

	Experimental Group (n=45)		Control Group (n=45)	
	Baseline (%)	Post-int. (%)	Baseline (%)	Post-int. (%)
Answer A	0.0	0.0	0.0	0.0
Answer B	20.0	20.0	11.1	11.1
Answer C	24.4	17.8	22.2	28.9
Answer D	6.7	4.4	11.1	15.6
Answer E	46.7	57.8	51.1	40.0
Answer F	2.2	0.0	4.4	4.4

Note: Answer A: I have my child within arm's reach at all times and I always know exactly what my child is doing; Answer B: I can trust my child to play be himself/herself without constant supervision; Answer C: I stay within reach of child when he/she is playing on playground equipment; Answer D: I keep a close watch on my child; Answer E: I stay close enough to my child that I can get to him/her quickly; Answer F: None of the above.

4.5.4 Risk tolerance

Most parents selected Answer E, "I wait to see if he/she can do things on his/her own before I get involved" at both baseline (32.3%) and post-intervention (35.6%; Figure 4.10). There was no difference between treatment groups in terms of the number of participants that changed their answer to question four between baseline and post-intervention (EXP, 57.8%; CON, 66.7%; U = 922.5, Z = -0.87, p = 0.39). In both the experimental and control groups, an equal number of participants selected Answer B: "I let my child take some chances in what he/she does" and Answer E: "I wait to see if he/she can do things on his/her own before I get involved" at baseline (Table 4.22). At post-intervention, most parents selected Answer E in both the experimental and control groups.

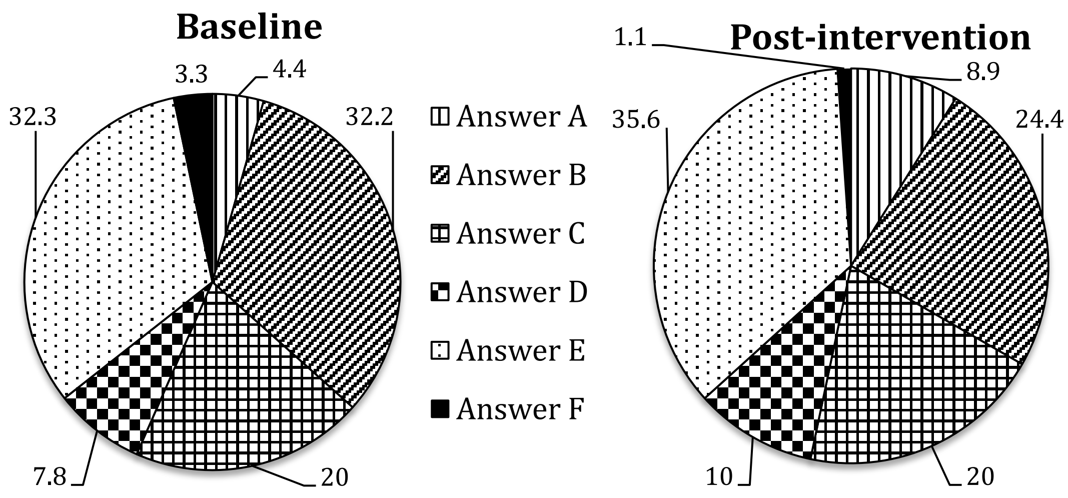

Figure 4.10 Summary of parental perceptions concerning risk tolerance in the total sample (n=90)

Note: Answer A: I let him/her learn from his/her mishaps; Answer B: I let my child take some chances in what he/she does; Answer C: I let my child experience minor mishaps if what he is doing is lots of fun; Answer D: I encourage my child to take risks if it means having fun during play; Answer E: I wait to see if he/she can do things on his/her own before I get involved; Answer F: None of the above.

Table 4.22

Parental responses to "How would you describe your risk tolerance for your child?" in the experimental and control groups

	Experimental Group (n=45)		Control Group (n=45)	
	Baseline (%)	Post-int. (%)	Baseline (%)	Post-int. (%)
Answer A	6.7	11.1	2.2	6.7
Answer B	28.9	26.7	35.6	22.2
Answer C	24.4	17.8	15.6	22.2
Answer D	8.9	8.9	6.7	11.1
Answer E	28.9	35.6	35.6	35.6
Answer F	2.2	0.0	4.4	2.2

Note: Answer A: I let him/her learn from his/her mishaps; Answer B: I let my child take some chances in what he/she does; Answer C: I let my child experience minor mishaps if what he is doing is lots of fun; Answer D: I encourage my child to take risks if it means having fun during play; Answer E: I wait to see if he/she can do things on his/her own before I get involved; Answer F: None of the above.

4.5.5 Trying new things

Most participants selected Answer A, "I encourage my child to try new things" at both baseline (32.3%) and post-intervention (35.6%; Figure 4.11). There was no difference between treatment groups in terms of the number of participants that changed their answer to question five between baseline and post-intervention (EXP, 60.0%; CON, 51.1%; U = 922.5, Z = -0.84, p = 0.40).

In both the experimental and control groups, most participants also selected Answer A: "I encourage my child to try new things" at both baseline and post-intervention (Table 4.23).

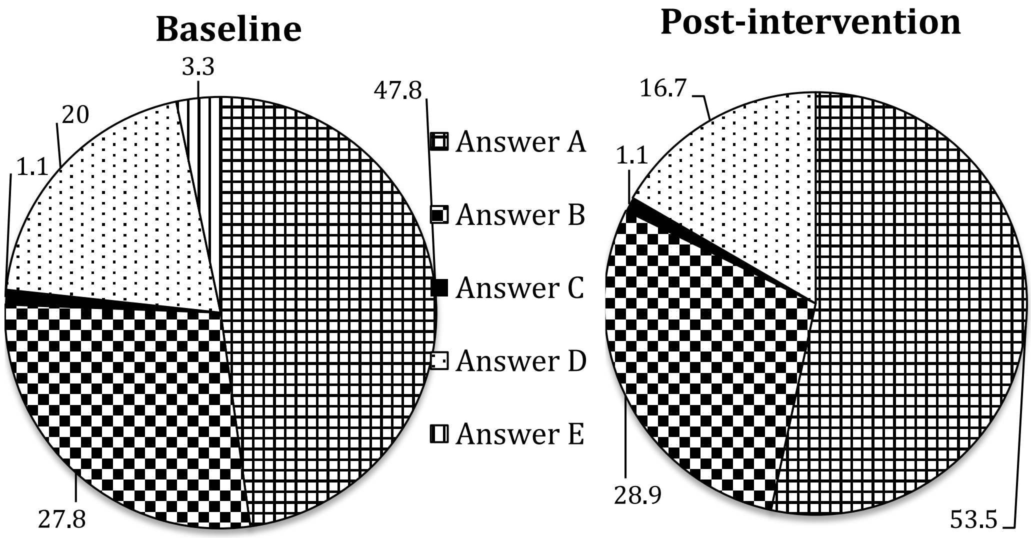

Figure 4.11 Summary of parental perceptions concerning trying new things in the total sample (n=90)

Note: Answer A: I encourage my child to try new things; Answer B: I let my child do things for himself/herself; Answer C: I feel fearful that something might happen to my child; Answer D: I try new things with my child before leaving himself/herself to do them on their own; Answer E: None of the above.

Table 4.23

Parental responses to "How often do you let your child try new things for themselves?" in the experimental and control groups

	Experimental Group (n=45)		Control Group (n=45)	
	Baseline (%)	Post-int. (%)	Baseline (%)	Post-int. (%)
Answer A	46.7	55.6	48.9	51.1
Answer B	31.1	33.3	24.4	24.4
Answer C	0.0	0.0	2.2	2.2
Answer D	20.0	11.1	20.0	22.2
Answer E	2.2	0.0	4.4	0.0

Note: Answer A: I encourage my child to try new things; Answer B: I let my child do things for himself/herself; Answer C: I feel fearful that something might happen to my child; Answer D: I try new things with my child before leaving himself/herself to do them on their own; Answer E: None of the above.

4.6 Summary

Chapter 4 presented the results of this study in five main sections. Firstly, the descriptive characteristics of the sample were reported. Analysis of the Bayley Scales of Infant and Toddler Development scores were reported in section 4.2, followed by the analysis of the safety skills in section 4.3. Section 4.4 described the analysis of the balance measures and the final section (4.5) was an analysis of the supervision questionnaire. These results will now be discussed and related to previous literature in Chapter 5.

CHAPTER FIVE

DISCUSSION

This was the first randomised, controlled trial that examined the effects of a child-centred physical activity programme on overall development, safety skills and balance in 12-24 month-old children in New Zealand. The main finding was that a nine-week intervention of child-centred physical activity was successful in improving the overall score within a battery of safety skills. In particular, the ability to climb over a small-runged A-frame while using a cylinder grip and safe face-the-slope dismount and the execution of a safety roll down a foam wedge were significantly improved. There was no effect of the exercise intervention on cognitive ability, overall development, static balance and supervision aspects.

5.1 Safety Skills

The safety skills assessed in this study were selected based on their inclusion in the physical activity classes and due to the potential in reducing fall-related injury in young children. The review of literature suggests this was the first time such skills were assessed as part of an intervention study. The improvement in the total safety skills score was significantly greater in children who were in the experimental group (see Table 4.10) suggesting that a relatively short (nine weeks) exposure to child-centred physical activity was successful in terms of safety skills development in this cohort.

To date, many intervention studies have concentrated on children with neurological or motor deficiencies (Angulo-Barroso, et al., 2008), therefore this study is important as it reports the effects of physical activity interventions on typically developing children. Furthermore, most studies (Alpert, et al., 1990; Matvienko & Ahrabi-Fard, 2010; Reilly, et al., 2006) are limited to children aged three to five years, possibly due to the difficulties associated with working with younger children such as toddlers. While there is no research examining the same skills used in this study, other short-term intervention studies have reported improvements in fitness and agility (Alpert et al., 1990) and in fundamental movement skills (Reilly et al., 2006) in three to five year olds. However, there is still a lack of research examining the effects of short-duration interventions on fundamental movement skills or safety skills in younger children (birth to three years). Therefore, this study provides important and original data on typically developing children aged 12-24 months.

All children, both the control and experimental groups, improved their total safety skill score as well as all nine individual safety skills over time (see Figure 4.6). This suggests that typical development over the nine-week intervention resulted in improvements in the ability to complete the safety skills assessed as part of this study. However, there was an effect of the intervention on two specific safety skills. The two safety skills that showed the greatest improvements as the result of the intervention were the ability to climb over the small-runged A-frame while using a cylinder grip and dismount using the safe face-the-slope technique (Safety Skill F) and the execution of a safety roll down a foam wedge (Safety Skill G; refer to Table 4.11). This suggests that on average, children in the experimental group moved from being ‘fully/partially assisted’ to being ‘supported’ or ‘completely independent’ over the course of the intervention in both safety skills. As the “Toddler Beans” physical activity classes have a particular focus on learning safe grips, climbing down safely and other safety skills (Jumping Beans International Limited, 2009a) it was expected that these skills would improve. Furthermore, as the average number of classes attended by participants in the experimental group was 7.9 (± 1.3), the commendable compliance to the intervention may have assisted with the improvements in these skills. On the other hand, it is possible that an intervention of longer duration or greater dose (more classes per week) may have resulted in greater improvements in all of the safety skills.

Although this study did not examine the effect of learning safety skills on the injury risk from falls, anecdotal evidence suggests that Jumping Beans has some success in both reducing falls and injury from falls (Jumping Beans International Limited, 2009c). Fall-related injury at or around the home accounts for 56% of the hospitalisations in children aged birth to four years (Safekids New Zealand, 2006), possibly due to the earlier development of the upper body (relative to the lower body) and therefore greater access to hazards (Agran, et al., 2003). By teaching children how to safely climb over and down obstacles, such as an A-frame, they are given the skills required to reduce accidents from falls from furniture or other heights, which account for the most falls in children aged 12-15 months (Agran et al., 2003). Due to the limited success of education interventions aiming to reduce fall-related injury in children (Guyer, et al., 1989; Lindqvist, et al., 2002), physical activity interventions with a focus on learning safety skills could be an alternative strategy for the reduction of falls or fall-related injury. Presentation and teaching of the safety skills and methods to the parent/caregiver of the child, such as during

Jumping Beans classes may be necessary to elicit improvements in safety skill development and therefore reductions in falls. However, further research needs to examine whether there is a direct link between learning safety skills and reducing falls or injuries from falls.

It is also important to note that all safety skills that showed an improvement as a result of the intervention were correlated with being the youngest born child (see Tables 4.12, 4.14 and 4.16). The positive correlation shows that children who are the youngest born, regardless of treatment group, were more likely to have a greater improvement in the total safety skills score and in Safety Skill F and Safety Skill G. Studies reporting the association between fundamental movement skills and physical activity habits or levels have reported a weak association between these variables in children aged 4.2 ± 0.5 years (Fisher, et al., 2005) or that only 3% of the variation in participation in organised physical activity can be explained by fundamental movement skill scores (Okely, et al., 2001). Hierarchical multiple linear regression analysis showed that only 3.9% of the variance in the change in total safety skills score was attributed to being the youngest born (see Table 4.13). Although there is a lack of research to support or contradict this finding, it has been reported that there is an abundance of variables associated with adolescents' and children's physical activity levels and ability (Sallis, et al., 2000). The reasons underpinning the association between birth order and safety skills development in this study are unknown however, it is possible that factors such as time spent with parent or siblings and older peers or enhanced parental learning may be behind this association. Future studies should monitor birth order as it may have associations with a variety of outcome measures in young children such as determining physical activity levels or ability.

The addition of sex as a predictor to the multiple regression model increased the amount of explained variance to 6.4% with males more likely to show a greater improvement than females, which is in line with other studies (Barnett, et al., 2008b; Barnett, et al., 2009; Lung, et al., 2011). Although Barnett, van Beurden, Morgan, Brooks and Beard (2008b) reported gender differences at childhood (7.9-11.9 years) in terms of object control proficiency and locomotor skill proficiency, it was also reported that gender was a significant predictor of time spent in MVPA when children reached adolescence (Barnett, et al., 2009). There were no significant gender differences found in this study in terms of the safety skills, however based on previous research (Barnett et al., 2008b; Barnett et al., 2009; Lung et al., 2011), it may be necessary to target girls in childhood in order to increase the time spent in high intensity physical activity and potentially reduce obesity in later life.

The present study included the use of unestablished methodology for assessment of the safety skills. As these skills have not been assessed in this age group, it was necessary to develop tools and practices for use with this particular sample. In order to provide reliable and valid data on the development of safety skills, either as the result of typical development or due to an intervention, it will be vital to perform validity and reliability research on the assessment tool. Due to the time constraints of this study, it was not possible to achieve this prior to data collection. Furthermore, in order to examine whether enhanced learning in specific safety skills occurs due to a physical activity intervention, transfer tests may have been more applicable. The use of transfer tests would remove any influence of practicing that occurred during the physical activity intervention in this study. However, as an assessment tool has not yet been developed, there is a need for valid and reliable assessment tools for examining learning of safety skills in toddlers and young children.

5.2 Balance

The literature review suggests this was the first time balance was measured using a force plate in this age group. There was no difference between the treatment groups in the range of centre of pressure or speed of centre of pressure at baseline or post-intervention (see Table 4.18), therefore the total sample will be described. As the use of the force plate for measuring balance had not been performed in this age group, it was unknown what attrition of data would occur. The number of participants who were able to complete the test at both baseline and post-intervention was 30; one third of our total sample. There were 12 more children who completed the balance test at baseline only and another 26 children who completed the balance test at the post-intervention assessment only, which suggest that there may have been a learning effect over the course of the study or children were more able to perform the test when they were slightly older. Therefore, future studies should complete a familiarisation trial prior to actual testing in order to ensure as many children as possible are comfortable performing the balance test. Due to the restriction of testing in school holiday periods, it was not possible to perform a familiarisation trial in this study.

There were non-significant improvements in the range of centre of pressure and speed of centre of pressure between baseline and post-intervention in the total sample (n=30); however this may have been the result of a learning effect. While there is no previous research to compare the data of this study to, Hsu, Kuan and Young (2009) reported mean (± S.E.) sway velocity of 2.55 ± 0.30 cm/s and mean (± S.E.) circular area of 13.5 ± 2.9 cm^2 in three year olds. These variables cannot be directly compared to the data from the current study however provide evidence to support the notion that static balance is not completely developed until children reach 6-8 years of age. Rival and colleagues (2005) reported the same measures of balance as utilised in this study however only used children between six and 10 years old. It was reported that the mean (± SD) range and speed of centre of pressure were 13.43 ± 0.7 mm and 49.21 ± 2.5 mm/s respectively in six year-olds (Rival et al., 2005). This study found a mean (± SD) range and speed of centre of pressure of 108.9 ± 17.1 mm and 95.2 ± 15.5 mm/s respectively in children 17.4 ± 2.6 months old. The speed (frequency) of centre of pressure displacement (mm/s) is suggested to be a more functional method of assessing balance as it represents the amount of activity required to maintain stability (Rival et al., 2005). As the speed of centre of pressure decreased linearly from six years to adult levels (Rival et al., 2005), it is possible that the addition of data at younger ages would allow practitioners to establish whether children are typically developing in terms of balance.

It has been reported that balance, as measured by sway velocity under several conditions, reaches adult levels by seven years (Hsu, et al., 2009). Conversely, Rival and colleagues (2005) reported that adult levels of balance, as measured by centre of pressure range and speed, were not achieved by 10 years of age. Further research needs to be done to establish whether there is a linear relationship between age and speed of centre of pressure, which as mentioned may be a more appropriate measure of balance than sway velocity or range of centre of pressure.

5.3 Bayley Scales of Infant Development – Screening Test

Typical development of motor skill and cognitive ability has been well researched in this age group but mainly focussed on a North American, predominately white, sample (Black & Matula, 2000). Furthermore, much of the milestone research is from the early 20th century, with even the latest revisions of many assessment tools still at least 10 years old (Black & Matula, 2000). This study utilised the Bayley Scales of Infant Development (BSID) method of assessing overall development of the children, and in particular, motor skill and cognitive ability. Although the BSID was first established in the 1960s, a screening test has been developed more recently (Bayley, 2006a) and all of the items in this screening test were included in the BSID 3rd edition (BSID-III). The present study reported raw scores for each of the subscales of the BSID Screening Test rather than relying on the standardised norms, as these were based on North American data and therefore may not be accurate for our sample (Black & Matula, 2000). In addition, the sample was split into three age groups that aligned with the ages set out by the BSID-Screening Test Manual (Bayley, 2006) that relate to the cut scores (refer to Appendix 10).

While there were differences between treatment groups in Age Group 2 in the cognitive and gross motor subscales (refer to Tables 4.2 and 4.6), there were no significant differences between the treatment groups in the total sample or other Age Groups in any of the subscales (see Tables 4.2-4.6); therefore further analysis was completed on the total sample. A main effect of Age Group on the mean change score in all subscales was reported (see Figures 4.1-4.5). Younger children, (those in Age Group 1 and 2) were more likely to show greater improvements in their cognitive ability, receptive communication, expressive communication, fine and gross motor skills across the total sample as compared to slightly older children (Age Group 3).

There is a lack of intervention studies examining typically developing children (Angulo-Barroso, et al., 2008; Valvano & Rapport, 2006) hence, it is difficult to compare findings of this study with previous research. Furthermore, many intervention studies have concentrated on increasing the amount and/or level of physical activity (Trost, Fees, & Dzewaltowski, 2008) or involved obesity prevention (Fitzgibbon, et al., 2005; Hesketh & Campbell, 2010; Mo-suwan, et al., 1998; Moore, et al., 1995) as opposed to enhancing development. Although these studies had different objectives, several have reported significant improvements in fundamental movement skills (Alpert, et al., 1990; Matvienko & Ahrabi-Fard, 2010; Reilly, et al., 2006). However, there is still a lack of research on the effects of physical activity interventions on younger children (birth to three years) with the aforementioned studies focussed on children aged three to five years.

The lack of differences in the developmental subscales due to the intervention may be due to the short duration (nine weeks) of physical activity classes; as previously mentioned it is still unknown whether short-term interventions have any real effect on development in typically developing children (Matvienko & Ahrabi-Fard, 2010). Furthermore, as there were no differences between treatment groups in the amount of supervised physical activity (measured by parental reporting; refer to section 5.5), all children were engaged in similar amounts of physical activity therefore potentially reducing the effect of the intervention on developmental measures. Future research should assess the effects of a physical activity intervention in an “at-risk” sample with typically developing children that are not meeting physical activity guidelines. In addition, the method of assessment may not have been sensitive enough to detect changes over a short period. The BSID Screening Test was designed to predominately detect if children are progressing according to normal expectations or not (Bayley, 2006). While there are more in-depth assessment tools (refer to section 2.2.5), the BSID Screening test was utilised in this study largely due to the shorter administration time. This study assessed many different variables and in order to achieve reliable results in all aspects it was important to keep the overall assessment duration as short as possible. Future research that focuses on the effects of a physical activity intervention on overall development may wish to utilise a more in-depth assessment tool to ensure if improvements in development occur, they are detected.

The present study found significant correlations between certain descriptive variables and each of the subscales of development. In particular, the change score (difference between baseline and post-intervention scores) in all subscales was negatively correlated with the child’s age and height at baseline. This correlation supports the one-way ANOVA testing that found an effect of Age Group on the change scores. Both suggest that younger children were more likely to have greater improvements in all subscales of development, as compared to older children. This supports the early work of Bayley (1936) that suggests development, in particular motor control, occurs very rapidly until approximately 21 months and then slows down. Therefore, it may be more appropriate to design interventions after children reach 21 months, possibly with adjustments for prematurity also made, to measure changes in development that are the result of the intervention as opposed to simply typical development.

Another key result of this study was the effect of the child being mostly in home care with the parent, or other adult, as a predictive factor of the change in overall development (27.8% together with Age Group; Table 4.9). Literature regarding the associations between attending childcare and physical activity is equivocal. A number of studies have reported that children attending early childhood centres with supportive environments, including opportunities to be active, appropriate play equipment, and a sufficient amount of space both indoors and outdoors, are more likely to achieve higher levels of MVPA than children attending less supportive early childhood centres (Bower, et al., 2008; Gubbels, et al., 2012). On the other hand, Gubbels and colleagues (2010) reported that attending early childhood centre between the ages of one and two years was positively associated with a greater increase in BMI between these ages. In addition, Sugiyama, Okely, Masters and Moore (2012) reported that children who attended early childhood centres were mostly sedentary and spent between 12-36 min per day in MVPA; results supported by Pate and colleagues (2008) who reported that children were engaged in MVPA for less than 3% of observation intervals. This suggests that simply knowing whether a child attends childcare, or not, may not be sufficient to determine the contributing effect on physical activity or development. Future research should delve further into children’s day-to-day environment as it has the potential to affect a variety of outcome variables.

5.4 Parent-child Supervision

There was no difference between treatment groups in terms of the number of participants that changed their answer to any of the questions in the parent-child supervision questionnaire between baseline and post-intervention (see Figures 4.7-4.11). In addition, the answers selected by most of the parents at baseline and post-intervention were not different between the treatment groups (see Tables 4.19-4.23). This suggests that there no was impact of the intervention on the aspects of supervision assessed in this study.

The lack of differences between the treatment groups over time may be due to the fact that parents never felt their children were at risk of being harmed during the intervention or during assessments. It has been observed that 70% of parents display safety-oriented parenting choices and generally responding to activities in a way that will limit the risk of injury to their infant (Ishak, et al., 2007). However, it may be that the parents in the current study were risk-takers and therefore were more comfortable with their children undertaking risk-taking behaviour, as observed by Little (2010). The supervision questionnaire did not examine parent's risk-taking behaviour, which may be required for further studies to determine whether changes to aspects of parental supervision are more apparent in parents with certain risk-taking behaviour. The lack of differences in supervision as the result of the intervention may also be due to the sample in the current study, which will be discussed in the following section.

5.5 Descriptive Characteristics

While this study did not directly measure the physical activity levels of children, parental reporting of time spent in supervised physical activity supports the idea that there is large variability in the physical activity levels of young children (Finn, et al., 2002). Children in this study spent between 45 – 500 min per week (mean ± SD, 167.7 ± 94.9 min) engaged in supervised physical activity. This data was used to ensure there was no major difference between the treatment groups in terms of the amount of activity children were engaged in. While it was not specifically recorded, it was assumed that this was predominantly structured physical activity due to what parents were asked to record; namely any other physical activity classes or lessons such as swimming or music and movement, as well as supervised playground or park time. On average, children spent approximately 24 minutes per day engaged in supervised, and most likely structured, physical activity. This is similar to the amount of structured physical activity suggested by the American guidelines (refer to section 2.2.3). As none of the other guidelines recommend physical activity in terms of structured or unstructured activity, it is difficult to compare physical activity in this sample to recommendations. Furthermore, there is a lack of research reporting the amounts of physical activity in toddlers (12-24 months old), with most concentrating on 3-5 year olds. Parental reporting in this study was relatively crude and future studies should incorporate new methods, such as accelerometers, in addition to parental reporting in order to better assess whether children are meeting physical activity guidelines of both structured and unstructured activity.

Examining physical activity levels in this cohort was not a main objective of this study, however future research could examine the time spent in MVPA, or other exercise intensities, during specific physical activity programmes, such as Jumping Beans, and compare to time spent on playgrounds or during playtime at home with parents, siblings or peers. Research of this nature would provide practitioners further information regarding the type of activity required to achieve improvements in safety skills, and potentially overall development. Furthermore, activity levels reached during programmes such as Jumping Beans could be compared to activity levels reached during playtime at playgrounds, home care with parent or other adult, or at an early childhood centre. This would also contribute to the literature regarding physical activity and toddlers.

In our sample, 91.1% of mothers and 77.8% of fathers have a post-school qualification compared to 42.5% of people in the Auckland region (over 15 years of age) and 33.9% of people throughout New Zealand (Statistics New Zealand Tatauranga Aotearoa, 2006). This suggests that our sample has a superior education level than the majority of New Zealanders. In addition, as economic status is often inferred from education level, it is probable that our sample is of a higher economic status than the majority of New Zealanders. Furthermore, our sample was also predominately Pakeha/European (83.3%) compared to 56.6% of people in the Auckland region and 67.6% of the people in New Zealand (Statistics New Zealand Tatauranga Aotearoa, 2006). Moreover, 11.1% of people in the Auckland region (14.6% in New Zealand) belong to the Maori ethnic group while only 1.1% of people in our sample identified as Maori. The implications of these data are that any results from this study cannot be generalised to all New

Zealanders, as the sample used was not representative of all of New Zealand in terms of education level and ethnicity.

5.6 Implications for Future Research and Policy or Practice

There is a need for more randomised, control trials in infants and/or toddlers examining the effects of physical activity interventions on overall development, safety skills, balance and supervision or attachment. It is suggested that future research takes an interdisciplinary approach, as there are many different associations between various aspects of infant development. External factors, such as parental composition (mother or father as primary caregiver), home environment and socio-economic status should be considered when designing research studies as these factors may influence results. Furthermore, factors such as birth weight or gestational age should be recorded in all studies as different effects have been reported in certain aspects of development therefore they may need to be controlled for. Other future directions for research in this area may include:

- Randomised, controlled trials examining different intervention lengths or doses (number of classes per week) on similar outcome variables.
- Examination of the direct links between learning safety skills and reducing falls or injuries from falls.
- Examination of the relationship between age and balance measures such as speed of centre of pressure.
- Intervention studies that begin at different ages to examine whether effects are more pronounced in younger (e.g. less than 21 months) or older (e.g. over 24 months) children.

- Physical activity intervention studies that examine an “at-risk” sample with children that are potentially not meeting physical activity guidelines.
- Incorporation of the parent’s risk-taking behaviour to determine whether changes to aspects of parental supervision are more apparent in parents with certain behaviour profiles in terms of risk-taking.
- Examination of activity levels reached during specific physical activity programmes, such as Jumping Beans, and compare to activity levels reached on playgrounds or during playtime at or around the home with parents, siblings or peers.

In addition to the aforementioned implications for future research, this study has important implications for other user groups. In particular, due to New Zealand having a relatively high average rate of enrolment in early childhood education (11^{th} highest in the OECD for 3-4 year-olds; Education Counts, 2013), it is important to consider the finding that the child being mostly in home care with the parent, or other adult, predicted almost one third of the change in overall development (27.8% together with Age Group; Table 4.9). While literature regarding the associations between attending childcare and physical activity is equivocal, it is essential that government agencies and educators further investigate the impact of the day-to-day environment on development in toddlers. Furthermore, due to the divergent early childhood environments that exist and the variance in the amount of time spent in these environments, future research should closely investigate any differences that may exist between these care environments in terms of the impact on development.

5.7 Limitations

There were a number of limitations with this study that should be addressed for future research in this area:

- The short duration intervention (nine hours of activity over nine weeks) may have limited the potential improvements in all of the safety skills and overall development.
- The use of unestablished methodology for assessment of the safety skills meant that data presented is not necessarily reliable and valid. Due to the time constraints of this study, it was not possible to achieve reliability and validity testing prior to data collection.
- Transfer tests may be more applicable for the assessment of the safety skills in order to remove the influence of practicing that occurred during the physical activity intervention in this study.
- There was large attrition of data in the assessment of balance. A familiarisation trial prior to actual testing may have produced a greater sample however due to the restriction of testing in school holiday periods, it was not possible to perform a familiarisation trial in this study.
- The supervision questionnaire did not examine parent's risk-taking behaviour; information that may be required in future studies to determine whether changes to aspects of parental supervision are more apparent in parents with certain behaviour profiles in terms of risk-taking.
- Due to the differences between the sample in this study and the demographics of New Zealand, any results from this study cannot be generalised to all New Zealanders.

5.8 Conclusions

The overall objective of this study was to examine the effects of a nine-week, child-centred physical activity programme on overall development, safety skills and balance in 12-24 month-old children. The following conclusions can be drawn from this study:

- A nine-week, child-centred physical activity programme significantly improved total safety skills score and particularly the ability to climb over the small-runged A-frame while using a cylinder grip and safe face-the-slope dismount (Safety Skill F) and the execution of a safety roll down a foam wedge (Safety Skill G).
- There were no significant improvements in overall development as the result of the intervention however; all changes can be attributed to typical development. Younger children (12-18 months) tended to be more likely to show greater improvements in all developmental subscales as compared to older children (18-24 months).
- Almost one third (27.8%) of the change in overall development can be predicted by knowing the age of the child and whether their day-to-day environment is mostly home care with their parent or other adult, or not. This suggests that future studies should examine children's day-to-day environments as it has the potential to affect a variety of outcome variables.
- It is possible to measure balance using a force plate in young children (12-24 months-old), however only one third of the sample was able to complete this assessment.

5.9 Research Summary

A primary rationale for conducting this research was to provide information regarding the effects of a physical activity intervention on development in toddlers. The review of the literature revealed a lack of intervention studies in healthy infants and toddlers with a focus on motor skill development and cognitive development. In addition, investigation of the effects of physical activity on attachment behaviour and social interaction was scarce. Therefore, the present study was the first randomised, controlled trial to examine the effects of a child-centred physical activity programme on overall development, safety skills and balance in 12-24 month-old children in New Zealand. This study utilised new methodologies for the assessment of safety skills in toddlers, and was able to utilise a force plate for assessing static balance in a previously untested cohort. The nine-week physical activity intervention was successful in improving overall score within a battery of safety skills. Although there was no effect of the exercise intervention on cognitive ability, overall development, static balance and supervision aspects, all changes can be attributed to typical development. There is still a need for more randomised, controlled trials in typically developing infants and toddlers and it is suggested that future research takes an interdisciplinary approach, due to the variety of aspects that may influence infant development. There are also important implications of this study for government bodies; with a need to further investigate the impact of the day-to-day environment on development in toddlers.

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Appendix 1 – Ethical Approval

MASSEY UNIVERSITY
TE KUNENGA KI PUREHUROA

20 March 2012

Deborah Pigou
15 Advance Way
Albany
AUCKLAND 0632

Dear Deborah

Re: **HEC: Southern A Application – 11/84**
Child-centred physical activity: Effect on motor skill development in infants

Thank you for your letter dated 15 March 2012.

On behalf of the Massey University Human Ethics Committee: Southern A I am pleased to advise you that the ethics of your application are now approved. Approval is for three years. If this project has not been completed within three years from the date of this letter, reapproval must be requested.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee.

Yours sincerely

A/Prof Hugh Morton, Chair
Massey University Human Ethics Committee: Southern A

cc Dr Ajmol Ali
School of Sport & Exercise
ALBANY

A/Prof Steve Stannard, HoS
School of Sport & Exercise
PN621

A/Prof Claire McLachlan
School of Arts, Development & Health Education
PN900

Dr Kama Weir, HoS
School of Arts, Development & Health Education
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Massey University Human Ethics Committee
Accredited by the Health Research Council

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MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA

4 April 2012

Deborah Pigou
15 Advance Way
Albany
AUCKLAND 0632

Dear Deborah

Re: HEC: Southern A Application – 11/84
Child-centred physical activity: Effect on motor skill development in infants

Thank you for your letter dated 2 April 2012 outlining the changes you wish to make to the above application.

The changes have been approved and noted, as follows:

- additional research team member (Paula Southworth);
- participants provided with Jumping Beans classes free of charge;
- MSI funding for the project.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee. If over time, more than one request to change the application is received, the Chair may request a new application.

Yours sincerely

A/Prof Hugh Morton, Chair
Massey University Human Ethics Committee: Southern A

cc Dr Ajmal Ali
School of Sport & Exercise
ALBANY

A/Prof Claire McLachlan
School of Arts, Development & Health Education
PN900

A/Prof Steve Stannard, HoS
School of Sport & Exercise
PN621

Dr Kama Weir, HoS
School of Arts, Development & Health Education
PN900

Appendix 2 – Participant Information Sheet

MASSEY UNIVERSITY
COLLEGE OF SCIENCES
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School of Sport and Exercise
Private Bag 102 904, North Shore, Auckland 0745
Tel: 09 4140800
Fax: 09 443 9640
www.massey.ac.nz

Child-centred physical activity: Effect on motor skill development in infants

INFORMATION SHEET FOR PARENTS/CAREGIVERS

Invitation to Participate in Research Study

Due to the increasing rates of obesity around the world there has been an increase in the importance of health promotion in children and infants. This has lead to the emergence of many different exercise regimes that are purported to enhance childhood development (e.g. Jumping Beans International). The purpose of this study is to examine the influence of a particular physical activity program on infant development. This project will be conducted by Deborah Pigou, a student at Massey University, School of Sport and Exercise. The project will be supervised by Dr Ajmol Ali and Assoc Prof. Claire McLachan from Massey University and assisted by Simon Bennett and Paula Southworth at Massey University and Julie Chambers from the Starship Trauma Service team.

Participant Recruitment

We aim to recruit 100 typically developing children aged between 12 and 18 months who have not attended Jumping Beans classes before and their parents/caregivers to participate in this study. To participate in the study you will need to be available for the duration of the intervention, which is 10 weeks, as well as the baseline and post-intervention assessments. To be eligible for this study, your child will need to be able to stand unaided at the beginning of this study and not have any known condition, or be on any medication, that may affect balance or motor skill development. In addition, following the baseline assessment if your child shows delayed performance you will be referred to your GP for further assistance and will be excluded from this study.

Project Procedures and Participant Involvement

We invite you to bring your child into the Sport and Exercise Science Laboratory at Massey University, Albany Campus, for the baseline assessment, where you will be briefed on the procedures and potential risks of this study. You will be asked to sign a consent form for yourself and your child and to provide information about your child at birth (including birth weight and head circumference) and some demographic data (including your age and your child's age, ethnicity, child's gender, and your level of education). Your child will then be assessed on balance, coordination and some safety skills such as climbing down stairs backwards. You will also be asked to complete a parent/caregiver-child supervision questionnaire.

Depending on the group you are assigned to, you will either elect a Jumping Beans 'Toddler Beans' class in your area to attend for the 10-week programme or you will maintain normal activity during the 10-week period. Participants asked to maintain normal activity during the study will have the opportunity to attend Jumping Beans classes for one term at the conclusion of the study. The classes are provided free of charge (value of $140 per term). This opportunity will be honoured in Term 4, 2012 for the experimental group and in Term 1, 2013 for the control group. Jumping Beans classes run for one hour each week. All participants will be directed to the Sport and Recreation New Zealand (SPARC) website for further information regarding active movement for your child and will be asked to complete a weekly logbook detailing any supervised physical activity your child does (for example, swimming classes).

You and your child will then return to the laboratory for post-intervention assessment, which will include all measures assessed at baseline.

All participants will receive individual information regarding your child's development as well a summary of the findings of the study.

Participant's Rights

You, on behalf of your child, are under no obligation to accept this invitation. Should you choose to participate, you have the right to:

• decline to answer any particular question

• withdraw from the study at any time, even after signing a consent form (if you choose to withdraw you cannot withdraw your data from the analysis after the data collection has been completed)

• ask any questions about the study at any time during participation

• provide information on the understanding that your name will not be used unless you give permission to the researcher

• be given access to a summary of the project findings when it is concluded

Confidentiality

All data collected will be used solely for research purposes and has the possibility of being presented in a professional journal. All personal information will be kept confidential by assigning numbers to each participant. No names will be visible on any papers on which you provide information. All data/information will be dealt with in confidentiality and will be stored in a secure location for a minimum of five years on the Massey University Albany campus. After this time it will be disposed of by an appropriate staff member from the School of Sport and Exercise.

Project Contacts

If you have any questions regarding this study, please do not hesitate to contact either of the following people for assistance:

Researcher: Deborah Pigou
School of Sport and Exercise, Massey University
debbiepigou@gmail.com

Supervisors: Dr. Ajmol Ali
School of Sport and Exercise, Massey University
(09) 414 0800 ext.41184; a.ali@massey.ac.nz
Associate Professor Claire McLachlan
School of Arts, Development and Health Education, Massey University
(06) 356 9099, ext. 8957; c.j.mclachlan@massey.ac.nz

Committee Approval Statement

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern A, Application 11/84. If you have any concerns about the conduct of this research, please contact A/Prof Hugh Morton, Chair, Massey University Human Ethics Committee: Southern A telephone 06 350 5799 x 4265, email humanethicsoutha@massey.ac.nz.

Compensation for Injury

If physical injury results from your participation in this study, you should visit a treatment provider to make a claim to ACC as soon as possible. ACC cover and entitlements are not automatic and your claim will be assessed by ACC in accordance with the Accident Compensation Act 2001. If your claim is accepted, ACC must inform you of your entitlements, and must help you access those entitlements. Entitlements may include, but not be limited to, treatment costs, travel costs for rehabilitation, loss of earnings, and/or lump sum for permanent impairment. Compensation for mental trauma may also be included, but only if this is incurred as a result of physical injury.

If your ACC claim is not accepted you should immediately contact the researcher. The researcher will initiate processes to ensure you receive compensation equivalent to that to which you would have been entitled had ACC accepted your claim.

Appendix 3 – Participant Consent Form

MASSEY UNIVERSITY
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www.massey.ac.nz

Child-centred physical activity: Effect on motor skill development in infants

CONSENT FORM FOR VOLUNTEERS

This consent form will be held for a minimum period of five (5) years

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I understand that I have the right to withdraw from the study at any time and to decline to answer any particular questions.

I agree to provide information to the researcher on the understanding that my name will not be used without my permission. (The information will be used only for this research and publications arising from this research project).

I agree to participate in this study under the conditions set out in the Information Sheet.

Full name of child (printed) ______________________________

Age ____________________ Date of Birth _______________

Signature of parent or legal guardian ______________________________

Full Name (printed) ____________________________ Date _______________

Relationship to child ____________________ Phone Number _______________

Participant code [ ]

Appendix 4 – Online Screening Questionnaire

1. What is your name and your email address?
2. Are you the primary caregiver for your child and are you proficient in English?
3. How old is your child?
   a. Younger than 11 months
   b. Between 11 and 12 months
   c. Between 12 and 18 months
   d. Between 18 and 24 months
   e. Older than 24 months
4. Can your child stand by themselves for roughly 30 seconds?
5. Is your child taking any medication that may affect his/her balance or coordination?
6. Are you aware of any issues regarding your child's motor or cognitive development?
7. Have you and your child attended Jumping Beans classes (or similar) before?
8. Can you and your child attend a 1-hour baseline assessment between 9am and 4pm on one of these days? (You may select more than one day)
   Options were appropriate the group:
   Group 1 options: Monday 2 July – Friday 13 July
   Group 2 options: Monday 24 Sept – Saturday 13 Oct
9. Can you and your child attend a 1-hour follow up assessment between 8am and 4pm on one of these days? (You may select more than one day)
   Options were appropriate the group:
   Group 1 options: Monday 24 Sept – Saturday 13 Oct
   Group 2 options: Monday 17 Dec – Saturday 22 Dec
10. Please select which class you and your child would attend if placed in the experimental group (you may select more than one class):
    a. Mondays in Windsor Park at 9.30am for 14-22months
    b. Mondays in Windsor Park at 1.15pm for 8-18months
    c. Tuesdays in Sunnynook at 9.30am for 14-22months
    d. Tuesdays in Sunnynook at 1.15pm for 8-18months
    e. Thursdays in Northcote at 9.30am for 14-22months
    f. Thursdays in Northcote at 12.30pm for 8-18months
    g. Fridays in Takapuna at 9.30am for 14-22months
    h. Fridays in Takapuna at 1.15pm for 8-18months

Appendix 5 – Additional Information and Logbook for Participants

CHILD-CENTRED PHYSICAL ACTIVITY: EFFECT ON MOTOR SKILL DEVELOPMENT IN INFANTS

Additional Information and Logbook for Participants

Child's Name: ______________________________

Thank you for your participation in this research study examining the influence of a child-centred physical activity program on motor development.

If you have any questions regarding this study, please do not hesitate to contact either of the following people for assistance:

Researcher: Deborah Pigou
School of Sport and Exercise, Massey University;
debbiepigou@gmail.com
022 0611 945

Supervisor: Dr. Ajmol Ali
School of Sport and Exercise, Massey University
(09)414-0800 ext.41184; a.ali@massey.ac.nz

Associate Professor Claire McLachlan
School of Arts, Development and Health Education, Massey University
(06)356 9099, ext.8957; c.j.mclachlan@massey.ac.nz

For further information regarding physical activity for your child, please visit Sport and Recreation New Zealand's (SPARC's) website on Active Movement for young people:

http://www.sparc.org.nz/en-nz/young-people/Ages-0-5-Years/

The resources found on this website are endorsed by the Royal New Zealand Plunket Society, GymSports NZ, Barnardos, the Ministry of Health, the National Heart Foundation, the Cancer Society, and Swimming NZ.

LOGBOOK

Please complete the weekly log-book of supervised physical activity for your child for the duration of the study.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Activity *Duration*	Eg. Swimming class 10-11am			Moving to Learn class 2-2.45pm			
Week 1							
Week 2							
Week 3							
Week 4							
Week 5							

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Activity *Duration*	Eg. Swimming class 10-11am			Moving to Learn class 2-2.45pm			
Week 6							
Week 7							
Week 8							
Week 9							
Week 10							

Appendix 6 – Anthropometric and Demographic Online Questionnaire

Parent Information - Mother

1. Mother's full name:
2. How old are you?
   a. 25 years or younger
   b. 26 - 30 years
   c. 31 - 35 years
   d. 36 - 40 years
   e. 41 - 45 years
   f. 46 years or older

3. What is the highest level of education you have completed?
4. Please enter your contact phone number:

Mobile:

Home:

Parent Information - Father

5. Father's full name:
6. How old is your partner?
   a. 25 years or younger
   b. 26 - 30 years
   c. 31 - 35 years
   d. 36 - 40 years
   e. 41 - 45 years
   f. 46 years or older

7. What is the highest level of education your partner has completed?

Child's Information

8. What is your child's full name?

9. How much did your child weigh at birth (in grams)?

10. What was your child's head circumference at birth (in cm)?

11. What is your child's birth date?

day

month

year

12. What is your child's sex?

Male

Female

13. Please describe your child's race/ethnicity.

14. What was your child's due date?

day

month

Year

15. Please describe you child's birth order.

a. Only Child
b. First Child
c. Middle Child
d. Youngest Child
e. Other (please specify)

16. Please describe your child's day-to-day environment.

a. mostly home care with parent
b. mostly home care with nanny/other adult
c. part-time day care
d. full-time day care
e. Other (please specify)

Appendix 7: Safety Skills Assessment Criteria

A. **Safe climbing down foam stairs facing slope, from placement at top of stairs**
   1: Child tries to come down stairs facing forwards or adult must help turn child and assists climbing down.
   2: Some assistance from adult is required (to untangle legs or turn child both ways) but otherwise child independently turns at top and climbs down one leg at a time.
   3: Child only needs support to independently turn at top and climb down one leg at a time.
   4: Child turns only left or only right to face the slope and independently climbs down, one leg at a time.
   5: Child turns both left and right to face the slope at top of stairs and independently climbs down, one leg at a time, until feet touch the ground

B. **Safe face-the-slope drop from foam block/stairs, from placement at top of stairs**
   1: Child tries to come down facing forwards or adult must help turn child and gently slides child down block
   2: Child requires assistance to turn at the top, but will slide down the slope without assistance
   3: Child will turn at the top (maybe only 1 way) and slide down until feet reach the ground with support only
   4: Child can turn both left and right at the top and will slide down until feet touch the ground with support
   5: Child can turn both left and right at the top and will independently slide down until feet reach the ground

C. **Jump down to land on two feet**
   1: Child steps down one foot at a time with assistance (1/both hands held)
   2: Child jumps down but is fully assisted (both hands held)
   3: Child jumps down with partial assistance/support
   4: Child independently jumps down but does not always land on 2 feet (1/2 out of 3 times)
   5: Child independently jumps down and always lands on 2 feet (3/3 times)

D. **Walking on stepping stones (depth perception board) assisted**
   1: Child crawls along board
   2: Child shuffles/walks along board but is fully assisted with both hands or body held
   3: Child shuffles/walks along board with support from adult (1 hand can be held)
   4: Child walks along board and is mostly independent (adult is there for support but not really required)
   5: Child walks along board with ease

E. **Climbing down small runged A-frame from placement at top**
   1: Adult assists child's leg movements and child is unwilling to move own hands.
   2: Adult assists child's leg movement while child moves own hands
   3: Child independently climbs down but may not always feel for rungs with feet and does not move hands until full stretch is reached and support or guidance from the adult is required.

4: Child independently climbs down. Legs move one at a time and child feels for rungs with feet.
5: Child independently climbs down, keeping anchored in 3 places at all times. Alternate legs and hands move simultaneously.

F. Climbing over small runged A-frame, sitting at top using a cylindrical grasp and safe face-the-slope, leg over dismount
1: Child will sit at top but does not use a cylindrical grasp (may reach for the adult) and adult fully assists with leg-over dismount on both sides
2: Child will sit at top and mostly uses a cylindrical grasp, and adult assists with leg-over dismount on 1 or both sides.
3: Child sits at top and mostly uses a cylindrical grasp but requires some support in leg-over dismount on 1 or both sides
4: Child sits at top and uses a cylindrical grasp on both hands (or can complete without using hands) and is able to complete leg-over dismount on 1 side without assistance from adult.
5: Child sits at top and uses a cylindrical grasp on both hands (or is able to complete without using hands) and is able to complete leg-over dismount on both sides without assistance from adult

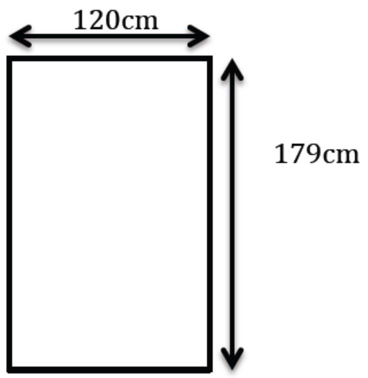
G. Execution of safety roll (side/shoulder roll) down foam wedge
1: Child's arms are tucked in by adult, and adult rolls child down foam wedge (side roll)
2: Child independently attempts to tuck arms in and tries to complete a side roll from lying on back or side but assistance from adult is required
3: Child completes a relaxed side roll independently or adult assists child in completing a shoulder roll from standing by gently pulling child's opposite arm towards them and rolling child down foam wedge
4: Child independently tucks arm under body and rolls down wedge from standing but may require support from parent
5: Child completes a shoulder roll at least 2 times without support or assistance

H. Locomotion across wide beam/plank
1: Child crawls along beam or walks fully assisted (both hands are held or body is supported)
2: Child shuffles/walks along beam with partial assistance (one hand held)
3: Child shuffles/walks along beam and is supported by adult
4: Child walks along beam independently but is unable to turn at the end without support/assistance
5: Child walks independently along beam with no shuffling and is able to turn around at the end.

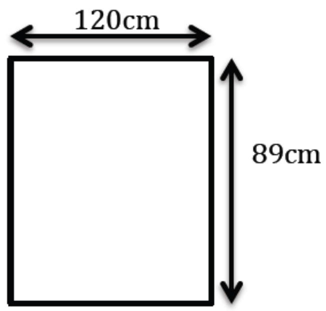
I. Hanging from a kindy bar/trapeze using whole hand grip
1: Fully assisted with adult's hands on top and leg underneath child as support. There is the correct grip but no hanging.
2: Supported hang with adult's hands on top. Correct grip but limited hanging
3: Hangs for count of 5, may still be assisted with adult's hands on top
4: Independent hanging for count of at least 5 with no assistance from adult
5: Independent hanging for count of 10 with swinging

Appendix 8: Dimensions of Safety Skills Equipment

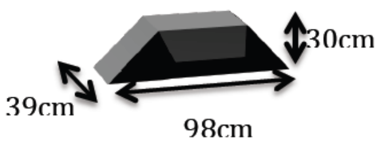
Full size mat:



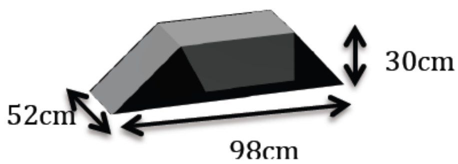
Half size mat:



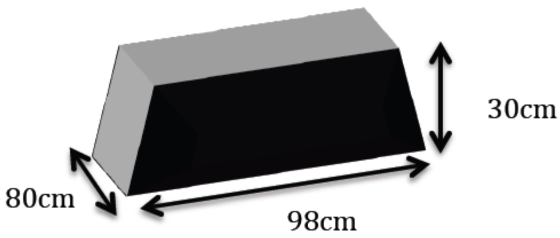
Small block:



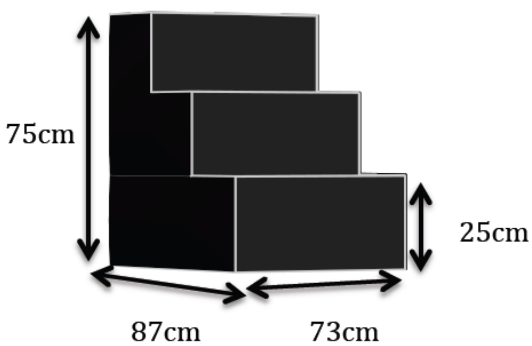
Medium block:



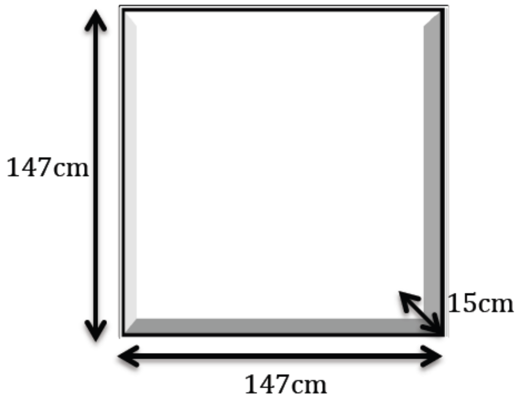
Large block:



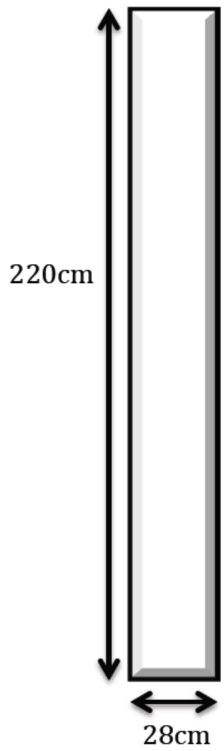
Stairs:



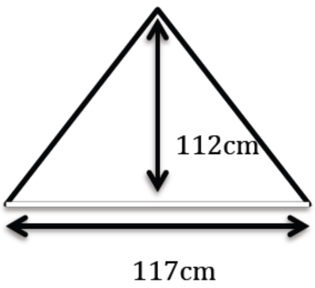
Crash Mat:



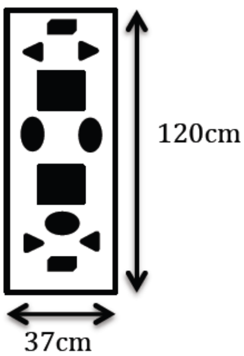
Wide Beam:



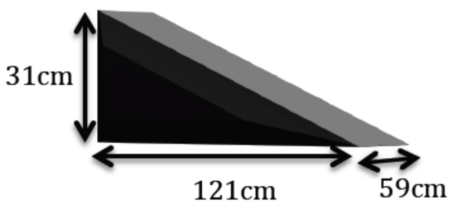
A-frame:



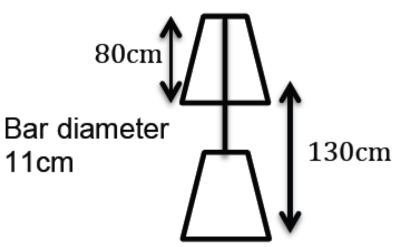
Depth perception board:



Wedge:



Horizontal Bar:



Appendix 9: Parent-child Supervision Questionnaire

Please select the most appropriate/typical answer for each question.

1) How protective are you of your child?

a. I feel very protective of my child.
b. I think of all the dangerous things that could happen.
c. I keep my child from playing rough games or doing things where he/she might get hurt.
d. None of the above.

2) How would you describe your actions during your child’s play time?

a. I make him/her keep away from anything that could be dangerous.
b. I feel fearful that something might happen to my child.
c. I warn him/her about doing things that could be dangerous.
d. I keep an eye on my child’s face to see how he/she is doing.
e. I feel a strong sense of responsibility.
f. I try things with my child before leaving himself/herself to do them on their own.
g. None of the above.

3) How would you describe your supervision of your child?

a. I have my child within arm’s reach at all times and I always know exactly what my child is doing
b. I can trust my child to play be himself/herself without constant supervision.
c. I stay within reach of child when he/she is playing on playground equipment.
d. I keep a close watch on my child.
e. I stay close enough to my child that I can get to him/her quickly.
f. None of the above.

4) How would you describe your risk tolerance for your child?

a. I let him/her learn from his/her mishaps.
b. I let my child take some chances in what he/she does.
c. I let my child experience minor mishaps if what he is doing is lots of fun.
d. I encourage my child to take risks if it means having fun during play.
e. I wait to see if he/she can do things on his/her own before I get involved.
f. None of the above.

5) How often do you let your child try new things for themself?

a. I encourage my child to try new things.
b. I let my child do things for himself/herself
c. I feel fearful that something might happen to my child.
d. I try new things with my child before leaving himself/herself to do them on their own.
e. None of the above.

Participant code: ________
Date: _______

Appendix 10: BSID Screening Test Manual Appendix A – Cut Scores

Table A.5 Subtest Cut Scores: Ages 12 months 16 days – 18 months 15 days

	Total Raw Score		
Subtests	**At Risk**	**Emerging**	**Competent**
Cognitive	0–13	14–16	17–33
Receptive Communication	0–9	10–11	12–24
Expressive Communication	0–9	10–12	13–24
Fine Motor	0–10	11–13	14–27
Gross Motor	0–12	13–16	17–28

Table A.6 Subtest Cut Scores: Ages 18 months 16 days – 24 months 15 days

	Total Raw Score		
Subtests	**At Risk**	**Emerging**	**Competent**
Cognitive	0–16	17–20	21–33
Receptive Communication	0–11	12–15	16–24
Expressive Communication	0–11	12–15	16–24
Fine Motor	0–11	12–16	17–27
Gross Motor	0–16	17–18	19–28