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Author:
engel, A; broderick, C; Ward, RE; parmenter, B

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Study Protocol: The Effect of a Fundamental Motor Skills Intervention in a Preschool Setting on Fundamental Motor Skills and Physical Activity: A Cluster Randomised Controlled Trial

Alexander Engel*, Carolyn Broderick, Rachel Ward and Belinda Parmenter

School of Medical Sciences, UNSW Sydney, New South Wales, Australia

***Corresponding author:** Alexander Engel, School of Medical Sciences, UNSW Sydney, NSW 2052, Australia, Tel: (+61) 423 771 797; E-mail: alexander.engel@unsw.edu.au

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Abstract

Fundamental motor skills (FMS) are the building blocks to specialist movements that are used throughout one's life in all forms of physical activity (PA) and sports involvement. FMS are acquired through a combination of active play and structured exercise programs. The preschool years have been identified as the critical time to develop FMS Active children experience health benefits such as decreased systolic blood pressure, depressive symptoms, weight gain, and improved concentration, academic performance and bone mineral density. Links have been identified between FMS proficiency and increased PA levels. This study aims to develop and deliver a structured FMS program for preschool aged children (age 3-5 years) in a childcare setting and determine whether it is associated with a change in PA levels and anthropometric measures.

A randomized cluster control design will be employed. PLAYFun is a 12-week, games based FMS program aimed to provide children with the chance to learn, practice and develop their FMS within a preschool setting. Participants will be recruited from 4 childcare centres and will be eligible if they are aged 3-5 years and do not have developmental delay/chronic conditions that inhibit participation in PA. Centres will be randomized using concealed allocation. The control group will continue to receive usual childcare play activities while the intervention group will receive a supervised FMS intervention 2-5 sessions/week for 30 minutes duration in addition to usual childcare activities. Outcome measures will be measured pre-, post and 12-weeks post intervention. Intention to treat analysis will be used and effects on the primary outcomes will be calculated by difference between mean group scores accounting for baseline scores.

The authors believe the childcare setting may provide the ideal environment to emphasize the development of movement patterns that will be used throughout life and potentially enhance participation in physical activity.

Keywords: Fundamental motor skills; Physical activity; Preschool

List of Abbreviations

FMS: Fundamental Motor Skills; PA: Physical Activity; PLAYFun Program: The physical activity and fundamental motor skills in pre-schoolers program

Introduction

Fundamental motor skills (FMS) are the building blocks to specialist movements that are used throughout one's life through all forms of physical activity (PA) and sports involvement [1,2]. FMS can be broken down into two categories – locomotor and object control. Locomotor skills are the fluid coordination of the body as it moves in one direction or another. Object control skills are the efficient control of another object such as a bat or a ball [3]. FMS are typically developed in childhood and later refined into more sport-specific skills during adolescence and adulthood [4]. For example, running is vital to performance in many sports such as rugby, football and hockey; the overarm throw is central in sports such as cricket, baseball and water polo.

FMS are acquired through a combination of active play and structured exercise programs. Furthermore, their attainment is developmentally sequenced and depends upon a number of internal and external factors including biological, psychological, social, motivational, and cognitive factors [5]. The critical time to develop FMS is the early childhood years [6] as movement patterns have not yet been ingrained [7]. However, Australian schools and preschools are limiting the opportunities for children to develop their FMS proficiently through restriction of unstructured play and failure to provide quality physical education [8], an issue this study aims to address.

Regular PA is vital for the normal growth and development of pre-schoolers through to adolescents [9]. However, with a record number of Australian pre-schoolers exceeding the screen time guidelines (74%) and 28% not meeting PA guidelines [10] there is cause for concern considering physical inactivity is linked to overweight and obesity in children [11,12].

More active children experience health benefits such as lower systolic blood pressure, decreased depressive symptoms, reduced weight gain, improved concentration, academic performance and increased bone mineral density, among other things [13]. Whereas, less active children who are found to have decreased fitness, reduced self-

esteem, poorer academic achievement, and be more likely to be overweight/obese [14]. In addition, there is a strong association between obesity in childhood and adulthood, increasing the risk of development of a number of chronic diseases [15]. Childhood obesity has also been linked to an extensive range of preventable chronic diseases including orthopedic, neurological, pulmonary, gastroenterological, cardiovascular, metabolic, and endocrine conditions [16] and it has been projected that due to the increased prevalence of childhood obesity, today's children may have a shorter life expectancy than their parents for the first time in modern history [17]. 23% of Australian 2-4 year old's [18] and 27.4% of 5-18 year old's [19] are classified as overweight or obese, which is in line with increasing worldwide prevalence [20,21].

Several publications have found a link between at least one measure of FMS proficiency and increased PA levels in preschool aged children [22-25] as well as school aged children and adolescents [26-28], demonstrating that improving FMS proficiency has the potential to increase PA levels across a range of age groups. Current evidence suggests that overweight/obese children tend to be less proficient in FMS and complete lower levels of PA than their healthy weight counterparts [29]. Improving FMS may therefore lead to a reduction in the risk and rate of overweight and obesity, and its associated diseases, simply through increasing PA levels [30-32]. Recent studies have found that an effective way to improve FMS in children is through a structured FMS intervention [29,33]. Recommendations are that early childhood education centres should implement 'planned' motor skill programs to promote children's physical development [29]. This study aims to develop and deliver a structured FMS program for preschool aged children (age 3-5 years) in a childcare setting and determine whether it is associated with a change in PA levels and anthropometric measures.

Materials and Methods

Registration

This trial was retrospectively registered with Australia New Zealand Clinical Trials Registry on 26th July 2017 (ACTRN12617001083381).

Study objectives

The primary objective of this study is to evaluate the effect of the Physical Activity and Fundamental Motor Skills in Pre-schoolers (PLAYFun) Program within a preschool setting on FMS proficiency and physical activity (PA) levels.

The secondary objectives of this study are:

- To determine if a relationship exists in pre-schoolers between FMS proficiency and actual PA levels (measured by the Actigraph accelerometer), and/or perceived PA levels (measured by parental questionnaire).
- To determine if any improvements in FMS and/or PA resulting from the PLAYFun program are maintained at 3 months' post program.

Participants

Children will be invited to participate in the PLAYFun program if they are enrolled in a UNSW Early Years Centre, aged 3-5 years and do not have developmental delay or any chronic conditions that would inhibit their participation in PA. UNSW Early Years staff will initiate contact with the parents/guardians of children they identify as being eligible for the study. The study was approved by the Human Research Ethics Committee at the University of NSW (HC#16537).

Randomisation

The study is a clustered, randomised controlled trial. Following recruitment and testing, each of the four UNSW Early Years centres will be randomly allocated to either the PLAYFun program group or wait list control group (two centres in each group) by concealed allocation using opaque, sealed envelopes. The outcome assessor will remain blinded to the pre-schools assignment until completion of the trial. Randomisation will occur following the completion of all baseline testing. This is done to reduce selection bias.

Study design

An outline of the study design is presented in Figure 1. FMS, PA levels and perceived PA levels will be measured on all participants at baseline. The four centres will then be randomized into either the PLAYFun program or waitlist control groups. The initial two centres randomized into the program will then receive the 12-week PLAYFun program. The two centres randomized into the wait-list control group will continue with the normal preschool curriculum. Following the 12-week program FMS, PA levels and perceived PA levels will be measured again in all participants. All four centres then will have a 12-week break followed by assessment of FMS, PA levels and perceived PA levels to assess if any effects of the program are maintained 3 months post completion. Following completion of this testing the wait-list control group will then receive the PLAYFun program over a 12-week period. At completion of the 12 weeks, measurement of FMS, PA levels and perceived PA levels will be repeated for this group only.

Hypothesis

We hypothesize that both groups will increase their FMS proficiency and PA levels due to age and motor development across 12 weeks, yet those in the PLAYFun Program will increase by a greater amount than the control group. We also hypothesise that any increase in FMS proficiency will be associated with an increase in PA levels, and that those with greater FMS proficiency will have a higher level of PA.

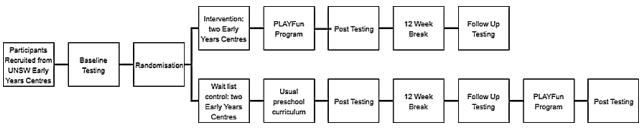

Figure 1: Flow chart explaining study design.

PLAYFun program

The PLAYFun program is designed to focus on improving specific FMS for preschool children aged 3-5 years. These movement foundations are precursor patterns to the more specialised, complex skills used in play, games, sports, outdoor education and physical recreation. The program is a 12-week motor skills program delivered within the preschool centre. Sessions will run for 40 minutes with 30 minutes dedicated to specific skill instruction and practice, and the remaining 10 minutes allowing for set-up and explanation of games. The program is scheduled to run five days/week; however, participants

only attend sessions on the days they attend the childcare centre. This means children can complete the sessions 1 to 5 times per week. Session attendance will be recorded in writing daily. The schedule is designed to allow all children, regardless of their days of attendance at the centre, to participate in every set of skills practice and games across the 12 weeks. Attendance patterns will be analysed at completion of the study.

Weeks 1-6 of the program will focus on introduction and mastery of six locomotor skills: running, galloping, hopping, leaping, jumping and sliding (sideways gallop); and six object control skills: striking, dribbling, kicking, catching, throwing and rolling of a ball. Each session will consist of three skills, one locomotor and two object controls, and is designed around a simple game that focuses on only one skill each session. The schedule of skills and game names for weeks 1-6 are outlined in Table 1.

	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6	
	Skill	**Game**	**Skill**	**Game**	**Skill**	**Game**	**Skill**	**Game**	**Skill**	**Game**	**Skill**	**Game**
Monday 1	Run	Bull rush	Slide	Ship to shore	Jump	Jump the river	Leap	Leap the river	Hop	Hopscotch	Gallop	Rob the nest
Monday 2	Strike	T-Ball hitting	Throw	Bean bag darts	Catch	Catchy rounders	Strike	T-Ball hitting	Throw	Bean bag darts	Catch	Catchy rounders
Monday 3	Dribble	Bouncy balls	Roll	Six pin bowling	Kick	Passing	Dribble	Dribble relay	Roll	Rolling darts	Kick	Soccer bowling
Tuesday 1	Gallop	Rob the nest	Run	Bull rush	Slide	Ship to shore	Jump	Jump the river	Leap	Leap the river	Hop	Hopscotch
Tuesday 2	Catch	Catchy rounders	Strike	T-Ball hitting	Throw	Bean bag darts	Catch	Catchy rounders	Strike	T-Ball hitting	Throw	Bean bag darts
Tuesday 3	Kick	Passing	Dribble	Bouncy balls	Roll	Six pin bowling	Kick	Soccer bowling	Dribble	Dribble relay	Roll	Rolling darts
Wednesday 1	Hop	Hopscotch	Gallop	Rob the nest	Run	Bull rush	Slide	Ship to shore	Jump	Jump the river	Leap	Leap the river
Wednesday 2	Throw	Bean bag darts	Catch	Catchy rounders	Strike	T-Ball hitting	Throw	Bean bag darts	Catch	Catchy rounders	Strike	T-Ball hitting
Wednesday 3	Roll	Six pin bowling	Kick	Passing	Dribble	Bouncy balls	Roll	Rolling darts	Kick	Soccer bowling	Dribble	Dribble relay
Thursday 1	Leap	Leap the river	Hop	Hopscotch	Gallop	Rob the nest	Run	Bull rush	Slide	Ship to shore	Jump	Jump the river
Thursday 2	Strike	T-Ball hitting	Throw	Bean bag darts	Catch	Catchy rounders	Strike	T-Ball hitting	Throw	Bean bag darts	Catch	Catchy rounders
Thursday 3	Dribble	Bouncy balls	Roll	Six pin bowling	Kick	Passing	Dribble	Dribble relay	Roll	Rolling darts	Kick	Soccer bowling
Friday 1	Jump	Jump the river	Leap	Leap the river	Hop	Hopscotch	Gallop	Rob the nest	Run	Bull rush	Slide	Ship to shore
Friday 2	Catch	Catchy rounders	Strike	T-Ball hitting	Throw	Bean bag darts	Catch	Catchy rounders	Strike	T-Ball hitting	Throw	Bean bag darts
Friday 3	Kick	Passing	Dribble	Bouncy balls	Roll	Six pin bowling	Kick	Soccer bowling	Dribble	Dribble relay	Roll	Rolling darts

Table 1: Skill and game names for weeks 1-6 of PLAYFun program.

Weeks 7-12 incorporate the skills into more complex games, requiring children to become efficient in their use of these skills within actual games, which aims to teach them how to use multiple skills at once. At this stage of the program the schedule runs on a 6-day cycle. Fifteen different games will be spread out across five days. The sixth day will be a facilitated free play day. On this day children will be provided with all the sports and play equipment from the program and encouraged to create their own games or to play the ones they liked

from any point throughout the program. The schedule of game days for weeks 7-12 are outlined in Table 2. Description of games for weeks 1-12 can be found in the supplementary data.

	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
Monday 1	Simon says	Free play day	Obstacle course	Foos Ball	The floor is lava	Modified kickball
Monday 2	Basketball	Free play day	Keep ups	Musical bums	Modified T-Ball	Sack races
Monday 3	Prize box/H.O.R.S.E	Free play day	Relays	Duck duck goose	Touch game	Piggy in the middle
Tuesday 1	Modified kickball	Simon says	Free play day	Obstacle course	Foos Ball	The floor is lava
Tuesday 2	Sack races	Basketball	Free play day	Keep ups	Musical bums	Modified T-Ball
Tuesday 3	Piggy in the middle	Prize Box/H.O.R.S.E	Free play day	Relays	Duck duck goose	Touch game
Wednesday 1	The floor is lava	Modified kickball	Simon says	Free play day	Obstacle Course	Foos Ball
Wednesday 2	Modified T-Ball	Sack races	Basketball	Free play day	Keep ups	Musical bums
Wednesday 3	Touch game	Piggy in the middle	Prize Box/H.O.R.S.E	Free play day	Relays	Duck duck goose
Thursday 1	FoosBall	The floor is lava	Modified kickball	Simon says	Free play day	Obstacle course
Thursday 2	Musical bums	Modified T-Ball	Sack races	Basketball	Free play day	Keep ups
Thursday 3	Duck duck goose	Touch game	Piggy in the middle	Prize Box/H.O.R.S.E	Free play day	Relays
Friday 1	Obstacle course	Foos Ball	The floor is lava	Modified kickball	Simon says	Free play day
Friday 2	Keep ups	Musical bums	Modified T-Ball	Sack races	Basketball	Free play day
Friday 3	Relays	Duck duck goose	Touch game	Piggy in the middle	Prize box/H.O.R.S.E	Free play day

Table 2: Game schedule for weeks 7-12 of PLAYFun program.

Fundamental motor skills

FMS will be measured using the Test of Gross Motor Development, Second edition (TGMD-2) [3]. This method is a validated standardised norm referenced measure of 12 FMS in children aged 3 to 11 [34]. The TGMD-2 splits the skills into two subcategories, locomotor skills and object-control skills, with each skill receiving a score which is standardised by age and gender. These scores are combined to produce a gross motor quotient (GMQ) which is an overall score and percentile rank. The TGMD-2 also has age equivalency scores that allow the child's individual ability to be compared to their developmental stage. This test will be conducted as per TGMD-2 methodology [3] (at baseline, 12- and 24 weeks). Children will be filmed (with parental consent) performing the TGMD-2 which will be independently scored at a later date by two researchers blinded to centre randomisation.

Physical activity – objective measures

PA levels of the participants will be measured using an omni-directional accelerometer, the Actigraph GT3X (Actigraph, LLC, Pensacola, FL). The Actigraph has been validated for use in preschool children [35]. PA was measured at each time-point (baseline, 12- and 24-weeks). Children wear the monitors 2 days/week whilst in attendance at the preschool. The monitors will be placed around the waist of the children, using the elastic belt, when they arrive at the centre and removed when they are picked up. Centres will not know which days their children are going to wear the monitors until the day before they are scheduled to wear them. This was designed to prevent the centres from scheduling any extra activities that would allow the children to be more active. Data will be collected in 10-second epochs with wear time validated using Choi et al. algorithms [36]. PA intensity will be derived using Butte et al. cut points [37] for preschool aged children. This will allow analysis of the time children spend in various intensities of movement (sedentary, light, moderate or vigorous). Activity data will be reported per day in both minutes and percentage of time. In line with existing research in this population [38-41], children with accelerometer data for a minimum of 5 hours will be included in the analysis.

Physical activity – parental reports

Perceived PA levels will be measured using the Preschool Aged Physical Activity Questionnaire (PrePAQ). The PrePAQ is completed by the participant's parents and consists of questions including the parents' physical activity levels, the home environment and whether the children completed a certain type of PA. If so, the parents provide information on how long this activity was completed across weekdays and weekends. The different types of PA are categorised into 5 levels: 1. Sedentary – no movement; 2. Sedentary play – limb or trunk moving; 3. Moving slowly; 4. Moving at a moderate pace; 5. Moving at a fast pace. By calculating the total time spent in each level of activity a total picture of the child's PA becomes evident. The PrePAQ has been validated for use in preschool children [42]. Parents will complete the questionnaire at each time-point throughout the study (baseline, 12- and 24-weeks).

Anthropometrics and resting cardiovascular measurements

Height, weight, waist circumference, resting blood pressure and heart rate will be measured twice at each assessment point (baseline, 12- and 24-weeks), with an average of the two measurements being used as the final measure. Height will be measured using a Seca 213 portable stadiometer (Seca GmBH & Co Kg, Hamburg Germany). Weight will be measured using Seca 803 a digital flat scale (Seca GmBH & Co Kg, Hamburg Germany). Body mass index will be calculated from height and weight measurements using the formula kg/m^2 [43]. The child's BMI is then compared to a standard reference curve, from the Centre for Disease Control and Prevention [44], based on the child's age and gender. The curve compares children of the same age. A BMI less than the 5th percentile is classed as underweight; a BMI in the 5th to 85th percentile is considered a healthy weight; a BMI between the 86th and 95th percentile is considered overweight and a BMI greater than 95% is considered obese. Participant's blood pressure will be taken using an infant and paediatric sphygmomanometer. Heart rate will be measured from the participant's radial pulse.

Sample size

Sample size estimates are based on the mean improvement in fundamental motor skills from results of a similar study by Adamo et al. [45]. This study was a recently published randomised cluster trial that used a childcare provider led physical activity program designed for preschool children to improve fundamental motor skills. With a mean change of +4.18 in TGMD-2 test points for the intervention group and -1.53 points for the control group and pooled baseline standard deviation of 10.99, we conducted a t-test pairwise comparison, to ensure the study had enough power to detect a between group difference between the intervention group and the control group. Setting beta at 0.2, and alpha at 0.05, a sample size of 60 (30 per group) was determined. To account for dropout over the course of the study, we added 10% to this sample, which is based on studies with a similar design to PLAYFun. Therefore, we aim to recruit 66 children (33 each group).

Data analysis

Results will be analysed as intention to treat. Data will be inspected for normality and expressed as mean and standard deviation. Where appropriate a one-way analysis of variance will be used to calculate any differences between groups at baseline and follow-up. Regression analysis will be used to identify any relationships between FMS and other outcome measures. Significance will be set at $p<0.05$. Correlations between FMS and PA will be examined.

Discussion

Two thirds of Australian children are overweight, screen time is increasing and only 19% meet the current PA guidelines [10]. Fisher et al. [22] has shown a relationship between proficient FMS and greater physical activity levels, and Logan et al. [29] has shown a relationship between increased PA levels and reduced weight. This study was therefore designed to address the current problem of overweight and reduced PA in Australian school children by intervening in the pre-school years to improve FMS. There are very few studies which examine the efficacy of a structured FMS program delivered directly to the child by a qualified exercise physiologist or equivalent.

Strengths and Limitations

One of the strengths of this study design is the randomisation being completed after baseline testing. This is done to ensure parents won't choose whether their child will participate in the study based on centre assignment. When all children are enrolled, and baseline testing is complete, the centres will be randomised and the program commenced the following week in the allocated centres. In addition, centres are also not aware of the days the children will be wearing the PA monitors, so that activities being planned for the week are not altered due to children wearing monitors on particular days. This will allow us to capture a true indication of the children's actual PA levels. The experience of the research team in completing and scoring the TGMD-2 to assess FMS is also an added strength to this study. Researchers who will take part in delivering, filming and scoring the TGMD-2, all have previous experience in using the test to assess FMS in the Physical Activity Levels and fundamental Motor Skills study (PALMs), completed in 2014-15. This study was completed to help validate a FMS program for pre-school aged children conducted in Sydney Australia. Researchers gained valuable experience in using the tool in this age-group. A further strength of this study is the consultation with the UNSW Early Years Centres in designing the program to allow maximum FMS practice in a fun environment. The biggest issue that was provided by the centre staff was the short attention spans of pre-school aged children. We therefore acknowledged that each session needed to remain short with plenty of variety to keep the children engaged.

One of the main limitations of the study is non-compliance of the children. While consent for participation is obtained from parents prior to the program commencing, the children may refuse to participation on occasions and may therefore not participate in the program every day that it is offered. Running an exercise intervention in an outdoor setting also has its limitations with adverse weather conditions, including rain and/or excessive heat impacting on delivery and compliance.

Conclusion

The physical and social environments created by preschools can have a major impact on the physical development of children [46,47]. The authors believe the childcare setting may provide the ideal environment to emphasise the development of movement patterns that will be used throughout life. The efficacy of FMS interventions within the preschool setting has not yet been thoroughly investigated, and if the PLAYFun Program is successful in improving FMS proficiency and increasing PA levels it may be an effective way forward for other preschool and childcare settings.

Trial Status

At the time of submission of this manuscript (October 2017), the trial was on-going at UNSW Sydney. Recruitment had commenced, randomisation had been completed and the PLAYFun program was successfully running in two UNSW Childcare Centres.

Conflict of Interest

None declared.

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Equipment for the study will be funded by the University of New South Wales.

Authors' Contributions

All authors declare they have made substantial contributions to conception and design of this study. All authors have been involved in the drafting of this manuscript and revising it critically for important intellectual content. All authors will give final approval of the version to be published. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content; and all authors have agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Ethics approval was approved by the Human Research Ethics Committee at the University of NSW (HC#16537).

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