Improving the fitness and physical activity levels of primary school children: Results of the Fit-4-Fun group randomized controlled trial

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Abstract

*Objective***:** To evaluate the impact of a multi-component school-based physical activity intervention (Fit-4-Fun) on health-related fitness and objectively measured physical activity in primary school children.

Methods: Four Hunter primary schools were recruited in April, 2011 and randomized by school into treatment or control conditions. Participants included 213 children (mean age = 10.72 years ±0.6; 52.2% female) with the treatment group (n=118) completing the 8-week Fit-4-Fun Program. Participants were assessed at baseline and 6-month follow-up, with a 91% retention rate. Cardio-respiratory fitness (CRF) (20m shuttle run) was the primary outcome, and secondary outcomes included body composition (BMI, BMI_Z), muscular fitness (7-stage sit-up test, Push-up test, Basketball throw test, Standing Jump), flexibility (Sit and Reach) and physical activity (7 days pedometry).

Results: After 6-months, significant treatment effects were found for CRF (Adjusted mean difference, 1.14 levels, $p<0.001$), body composition (BMI mean, -0.96 kg/m^2, $p<0.001$ and BMI z-score mean -0.47 z-scores, $p<0.001$), flexibility (sit & reach mean, 1.52cm, p=0.0013), muscular fitness (sit-ups) (mean 0.62 stages, p=0.003) and physical activity (mean, 3253 steps/day, $p<0.001$). There were no group by time effects for the other muscular fitness measures.

Conclusions: A primary school-based intervention focusing on fitness education significantly improved health-related fitness and physical activity levels in children.

Key words: Health-related physical fitness, physical activity, intervention, children, school.

Trial Registration No: ACTRN12611000976987

Introduction

Physical fitness is an important predictor of physical and psychological health in young people (Ortega et al., 2008; Parfitt et al., 2009). Recent studies demonstrate that children who display high levels of health-related fitness (HRF) (e.g. cardiorespiratory fitness, muscular fitness, flexibility and body composition), have a decreased risk of developing cardiovascular disease and other chronic illnesses (McMurray and Anderson, 2010), are less likely to suffer from anxiety and depression (Parfitt et al., 2009), and are more likely to perform better academically (Grissom, 2005; Van Dusen et al., 2011). Evidence also confirms that a large proportion of children are unfit (Ortega et al., 2011; Tomkinson et al., 2003), that children's fitness levels decline with age and fatness levels increase with age (Stratton et al., 2007), and that children do not participate in physical activity of sufficient volume and intensity to accrue the associated health benefits (Booth et al., 2005; Currie et al., 2008; Ortega et al., 2011). Considering the low levels of physical activity typically observed among youth (AHKC, 2012; Ekelund et al., 2011; Hardy et al., 2010) and secular declines in youth fitness levels (Boddy et al., 2012; Tomkinson and Olds, 2007; Tremblay et al., 2010), there is an urgent need to develop and evaluate interventions that promote high intensity activity but that are also appealing to young people. Indeed, the latest national physical activity guidelines include physical fitness parameters (USDHHS, 2009).

The school, via the curriculum, school ethos and community, has been widely acknowledged as an ideal setting in which to provide physical activity opportunities and to educate students about the importance of physical activity and the value of achieving and/or maintaining HRF standards (IUHPE, 2008; USDHHS, 2009). The Health and Physical Education (HPE) curriculum is considered to be focal point for physical activity promotion in the school setting (Centers for Disease Control & Prevention, 2011; Crawford, 2009; Kriemler et al., 2011). However, studies have questioned the quality and quantity of HPE lessons delivered in primary schools (McKenzie et al., 1994; McKenzie et al., 1995; McKenzie et al., 1993; Morgan and Hansen, 2007), with teachers reporting a range of barriers to achieving important student outcomes (Fairclough and Stratton, 2005; Kriemler et al., 2011; Morgan and Hansen, 2008). Evidently, the development of effective HPE programs that teachers can feasibly deliver, are clearly warranted.

Research in the area of physical activity and HRF in children is growing and the importance of designing and implementing quality HRF programs for children has emerged in the literature (Kriemler et al., 2011). A recent review of school-based physical activity and HRF interventions reported significant treatment effects in at least one measure of physical activity (for all 20 interventions), and 6 out of 11 trials reported a significant positive effect on HRF (Kriemler et al., 2011). However, only two of these physical activity interventions were considered high quality due to their rigorous methodological processes, and the fitness focus was often limited to cardiorespiratory fitness (CRF), rather than all HRF components (Kriemler et al., 2011). There is also limited evidence for physical activity and fitness programs that have a theoretical framework and adopt a multi-component approach (including a HPE curriculum component, behavior modification focus, family involvement, and delivered by a PE expert) - thus restricting their potential impact on fitness and behavior (Dobbins, De Corby, Robeson et al., 2009).

The Fit-4-Fun study was designed to overcome the limitations identified in the literature and to evaluate an innovative school-based physical activity program that utilised the three critical components of the Health Promoting School (HPS) framework (IUHPE, 2008). The Fit-4-Fun program aimed to build a school environment / ethos that supports physical activity, to create links between the school and the home via parental and family involvement in the program, and to support teaching and learning through the implementation of a quality HPE program. The Fit-4-Fun program was also based on Bandura's Social Cognitive Theory and Harter's Competence Motivation Theory and aimed to address possible mediators of behavior change in relation to physical activity in children (e.g. social support, self-efficacy, supportive environment, enjoyment) (Bandura, 1986; Harter, 1985). The feasibility of the Fit-4-Fun program was established in a small pilot study and the program was refined based on the process evaluation findings (Eather et al., 2012). The aim of the current study was to evaluate the Fit-4-Fun program in a cluster randomized controlled trial.

Methods / Design

Study design and participants

Ethics approval for this study was obtained from the University of Newcastle, NSW, Australia and the Newcastle-Maitland Catholic Schools Office, and is registered with the Australian and New Zealand Clinical Trials Registry (ACTRN12611000976987). School Principals, teachers, parents and study participants provided written informed consent. The methods of the Fit-4-Fun study have been reported in detail elsewhere (Eather et al., 2011).

Sample size calculation

A power calculation was conducted to determine the sample size necessary to detect changes in the primary outcome CRF (VO2max). Based on a previous study by Kolle et.al (2009), an increase of 6mL/kg/min was regarded as clinically important and achievable in children. Using an alpha of 0.05 and power of 80%, a sample size of 128 was needed to detect a 6mL/kg/min difference between groups. To account for the clustered nature of the data (an intraclass correlation of 0.03 was found for CRF fitness in the KISS school-based intervention) and potential drop-out, 226 participants were recruited from four schools (Kriemler et al., 2010).

In summary, Fit-4-Fun was a group RCT with 226 Stage 3 (Grade 5 and 6) students from four primary schools (mean age 10.7 ± 0.6 years; 52.2% female) located in the Hunter Region, NSW, Australia. Schools were randomized into the Fit-4-Fun treatment (n=118) or wait-list control conditions (n=108) following baseline assessments. The random allocation sequence was generated by a computer-based random number-producing algorithm and completed by a researcher not involved in the project to ensure an equal chance of allocation to each group. Assessments were conducted in April (baseline), June (immediate post-intervention) and December (6-month follow-up), 2011, and completed by trained research assistants who were blinded to treatment conditions at baseline assessments.

Treatments

The Fit-4-Fun intervention was informed by the Fit-4-Fun pilot study (Eather et al., 2011) and a detailed description of the intervention has been reported previously (Eather et al., 2012).

Intervention: The development of the Fit-4-Fun program was guided by Bandura's Social Cognitive Theory and Harter's Competence Motivation Theory behavior (Bandura, 1986; Harter, 1985), and included three major components based on the HPS framework (IUHPE, 2008). These included: an 8-week HPE curriculum program (60min / week), an 8-week home activity program (3 x 20min per week), and an 8-week daily break-time activity program (recess and lunch). The program was delivered by a member of the research team who is a trained physical educator and a detailed outline of the program components are displayed in Table 1.

Control (wait- list control group): The control group participated in their usual 60min / week HPE lesson over the 8-week intervention period delivered by their normal classroom teacher. The control group received the Fit-4-Fun program resources after the 6-month assessments.

Demographic information (i.e., age, sex, language spoken at home, country of birth) was collected via a student questionnaire.

Primary outcome:

CRF was measured using the 20m shuttle run test using standardized testing protocols (IUHPE, 2008).

Secondary outcomes:

Muscular fitness was measured using the Standing jump (Leger and Lambert, 1982), 7- stage Sit-up (Castro-Pinero et al., 2010; Mackenzie, 2005), Basketball throw (Gore, 2000) and Push-up tests (ACHPER, 2004). *Flexibility* was measured using the Sit and Reach test (back saver) (Welk and Merideth, 2008). *Body composition* was determined by calculating body mass index (BMI) using the standard equation ($weight[kg]/height[m]^2$) and body mass index z-scores (BMIz) (Welk and Merideth, 2008) were also used to determine relative weight status (Must and Andersen, 2006).

Physical activity: Participants wore sealed Yamax SW700 pedometers (Yamax Corporation, Kumamoto City, Japan) for 7 days (including at least three consecutive days and one weekend day) (Cole et al., 2000) to determine their physical activity levels. Pedometers have been shown to be a valid and reliable objective measure of physical activity (Schneider et al., 2003). To minimise the amount of lost data (i) teachers recorded participants results each morning at the same time, (ii) on weekends an information and recording sheet was sent home to parents, and (iii) teachers were asked to remind students to wear their pedometer during all waking hours. Non-wearing periods (e.g. during participation in water sports), were recorded and adjusted for via imputation (1000 steps for 10 minutes of moderate –vigorous activity and 1500 steps for vigorous activity) (McNamara et al., 2010).

Process evaluation

Measures of recruitment, retention, adherence and satisfaction were used to examine the feasibility of the Fit-4-Fun program. Evaluation questionnaires were administered to determine students' and teachers' satisfaction of the various program components and participation in extra-curricular and break-time activities (see Table 1) on a six-point likert scale from strongly disagree to strongly agree (e.g. "I enjoyed the theory-based learning activities and labs").

Statistical methods

Differences between participants in the treatment and control groups at baseline were examined using Chi square (χ^2) and independent samples *t*-tests in PASW Statistics 17 (SPSS Inc. Chicago, IL) software. Means and standard deviations were calculated for all variables, with the significance level set at 0.05 for all analyses.

Statistical analyses was conducted using linear mixed models with PROC MIXED in SAS V 9.1 (SAS Institute Inc, Cary, NC) and alpha levels were set at $p < .05$. Mixed models were used to assess all outcomes (primary and secondary) for the impact of treatment group (Treatment and Control), time (treated as categorical with levels baseline, 10-week and 6-month) and group-by-time interaction. This approach was preferred to using baseline scores as covariates, as the baseline scores for subjects who dropped out at 3 months and/or at 6 months were retained, consistent with an intention-to-treat analysis (Mallinckrodt et al., 2004). To examine potential clustering of effects at the school level, treatment and treatment-by-time were nested in the school condition and included as a fixed effect. School attended did not significantly contribute to any of the models exploring the effects of primary or secondary outcomes and were removed from the final models.

Results

Overview

Figure 1 illustrates the flow of participants through the trial. Four primary schools were recruited and 213 participants were assessed at baseline in April, 2011. The treatment and control groups were similar for all but 2 outcome measures (Sit and reach test & the 7-Stage sit up test) at baseline. Table 2 displays baseline demographic information and reports baseline primary and secondary outcomes.

Changes in primary and secondary outcomes

All 3-month and 6-month data is displayed in Table 3. The 6-month data will be discussed in detail given that school-based interventions often result in immediate changes in physical activity and fitness, but once the intervention ceases the treatment effects are often lost, or not assessed (Dobbins, De Corby, Husson et al., 2009; Kriemler et al., 2011).

After 6-months, significant treatment effects were evident in CRF (adjusted mean difference = 1.14 levels, $p<0.001$), body composition (BMI, -0.96 kg/m^2, $p<0.001$ and BMI z-score, 0.47 z-scores, $p<0.001$), flexibility (sit & reach mean, 1.52cm, p=0.0013), muscular fitness (7-stage sit-up, 0.62 stages, p=0.003) and physical activity (3253 steps/day, $p<0.001$). There were no group by time effects for three measures of muscular fitness (basketball throw, push-ups and standing jump) (Table 3).

Process Evaluation

Recruitment & Retention: All data regarding recruitment and retention are displayed in Figure 1. There was no significant difference between study groups with regard to retention ($p > 0.05$).

Adherence: All eight curriculum sessions were presented at the treatment schools with an attendance rate of 94%. Based on self-report, 47.1% of participants (n=48) participated in the break time activity program on at least 3 occasions per week. No significant relationships were found to exist between participation in break-time activities and baseline physical activity levels or sex. However, a significant difference existed according to age [($\chi 2(8)=20.63$, p=0.008), 10 yrs $\bar{x}$= 2.30 sd=1.423, 11years $\bar{x}$ = 3.30 sd =1.64, 12years $\bar{x}$=2.67 sd =1.803], with older students less likely to participate in break-time activities on more than 3 occasions per week (1=every day; 2=3-4 times per week; 3=1-2times per week; 4=not frequently; 5=never).

Satisfaction: Mean scores on the evaluation survey categories ranged from 4.29 to 5.33 out of 6 (1=*Strongly disagree* to 6=*Strongly agree*) (see Table 4) for the 14 items in the evaluation survey, indicating high to very high overall satisfaction rates for the Fit-4-Fun program. However, students reported difficulties with parent and family involvement in the home program with a mean score of 2.84 and 3.33 out of 6 for perceived parental and family involvement. No injuries or adverse effects were reported during the activity sessions or assessments.

Discussion

The primary aim of this study was to evaluate the impact of a novel, multi-component school-based intervention on HRF and objectively measured physical activity in primary school children. Fit-4-Fun was an innovative fitness education program promoting and providing opportunities for vigorous intensity activity to improve HRF. Treatment effects at 6-month follow-up were found for CRF, body composition, flexibility, muscular fitness (sit-ups) and physical activity. Our process data also supports that teachers and students were highly satisfied with the program.

The improvements across multiple HRF domains in this study are particularly encouraging. Significant improvements in the primary outcome, CRF, support previous studies showing that children can improve CRF over time (regardless of weight status) (Chromitz et al., 2010; Resaland et al., 2009), and challenge those researchers who have concluded that physical activity programs are unable to significantly improve CRF in children, due to the relatively high physical activity levels and high inherent aerobic power of children (ceiling effect)(Stone et al., 1998). The magnitude of our CRF results exceeded those reported previously (Dobbins, De Corby, Robeson et al., 2009; Harris et al., 2009; Katz et al., 2010; Magnusson et al., 2012; Thivel et al., 2011) and may be explained by (i) the focus on children’s exercise intensity and overall physical activity (via fun vigorous chasing activities, invasion games and sport challenges promoted during daily recess and lunch breaks at school, and at home), (ii) the level of support given to children by teachers and parents (in the classroom, in the playground and out of the school setting) (USDHHS, 2009), or (iii) to student engagement in the novel program activities (e.g. use of appealing small-sided games, fitness laboratories, fitness circuits and multi-sport challenges). Although limited (Kriemler et al., 2011), previous studies support our findings and demonstrate that the physical fitness levels of youth can improve relatively quickly using short and frequent periods of enjoyable and engaging fitness activities (Faigenbaum et al., 2009; Kriemler et al., 2011; Lubans et al., 2011; Lubans et al., 2010; Slawta and DeNeui, 2010). Our data also aligns with researchers who have succeeded in increasing levels of physical activity at recess and lunch and who highlight the importance of capturing this “free time” during the school day to involve children in physical activity (Huberty et al., 2011; Ridgers et al., 2010; Stratton and Mullan, 2005; Verstraete et al., 2006). Similarly, research in the area of primary school PE, demonstrates that enhancing the quality of PE programs and instruction, and increasing the amount of higher intensity physical activity within the curricular time, induces physical fitness benefits (Kriemler et al., 2011) - especially when the curriculum program is combined with environmental and family components (Dobbins, De Corby, Husson et al., 2009; Kriemler et al., 2011) or is delivered by a trained physical educator (McKenzie et al., 2001; Morgan and Hansen, 2008; Sallis et al., 1997).

Our substantial findings regarding body composition are also greater than those reported previously, with a recent meta-analysis stating that physical activity interventions in primary schools do not significantly improve BMI (weighted mean difference -0.05 kg/m^2) (Harris et al., 2009; Magnusson et al., 2012; Sveinsson et al., 2009). Our results suggest that changes in fitness may translate into changes in body composition (Chromitz et al., 2010; Resaland et al., 2009), and that school-based HPE programs that promote vigorous physical activity have good potential as an obesity prevention strategy (Chromitz et al., 2010; Resaland et al., 2009).

The literature regarding flexibility training in children is also sparse, with only a few physical activity interventions reporting changes in flexibility (Hutchens et al., 2010). To the authors' knowledge no previous primary school-based physical activity intervention has included strategies designed specifically to improve flexibility in children. One HRF program did not find any treatment effects for flexibility, measured by the sit & reach test (Derri et al., 2004), but differed from our study in that we included educational and practical activities that focused on flexibility in the curriculum sessions and home program (see Table 1), as opposed to a focus on cardiorespiratory fitness, motor skills and nutritional practices.

Our positive findings for physical activity are widely supported it the literature, with the majority of school-based physical activity interventions reporting a significant treatment effect in at least one domain of physical activity (in-school, out-of-school or overall), albeit using varied assessment protocols (Kriemler et al., 2011). A recent successful 10-month primary school-based study called GreatFun2Run by Gorley et. al. (2011) reported a significant increase in daily physical activity (Treatment minus Control =1532 steps per day) which is considerably lower than the improvements found in the Fit-4-Fun study (Treatment minus Control = 3412 steps per day)(Gorely et al., 2011).

The lack of treatment effects for three of the muscular fitness tests (Push-up test, Basketball Throw, Standing Jump) may be attributed to the self-directed nature of the program and lack of parental participation and /or support. It could be proposed that some students may have opted to perform the 'easier' activities in the home program or to perform the challenging muscular fitness activities less often, especially if they were not supported. This theory aligns with SCT (Bandura, 1986) and with Robbins et. al. (2004), who propose that levels of self-efficacy and support predict an individual's effort during exercise, their willingness to participate, and the frequency of participation - especially during very intense exercise (Bandura, 1986; Robbins et al., 2004). The Fit-4-Fun program did target levels of self-efficacy and social support, and pre-intervention "parent and child" information and practical sessions were held after school. However, parents are notoriously difficult to engage in school-based interventions (Lubans et al., 2009) and parental attendance at these sessions was poor (<30%), many students were not supported in the home environment regarding completion of home-based tasks, and may not have felt confident to try activities on their own (Samson and Solmon, 2011).

Emerging data increasingly supports the need for programs that promote and improve muscular fitness in children with evidence showing independent associations between muscular fitness (strength, endurance and power) and insulin sensitivity and clustered metabolic risk (Artero et al., 2011; Magnusson et al., 2011; Steene-Johannessen et al., 2009). The inclusion of regular 'muscle and bone strengthening' physical activity recommendations in recent national physical activity guidelines, demonstrates the importance of muscular fitness for population health (Jansseen and LeBlanc, 2010; USDHHS, 2009). The development of suitable strategies to increase participation in 'more challenging' muscular fitness activities and to increase parental and family support and participation in these activities is warranted.

The inclusion of fitness education and physical fitness testing in primary schools is a highly debated topic. In the past, fitness testing in schools frequently dominated the fitness education program or was performed in isolation, where learning was not facilitated and the testing environment often invoked negative emotional reactions from students (Graf et al., 2008; Jago et al., 2010). However, as demonstrated by the Fit-4-Fun Program, the appropriate delivery of fitness training and assessment within a comprehensive HPE curriculum in the primary school can be successful in primary school HPE programs (Cale and Harris, 2009; Wiersma and Sherman, 2008). This study has shown success in using fitness assessment to facilitate the learning of physical fitness concepts and as a tool for developing self-evaluation skills, developing physical activity goals, monitoring progress and motivating children to adopt physically active lifestyle behaviors at school and at home. In addition, the Fit-4-Fun Program has the potential to be a sustainable school-based program as it is based on the HPE curriculum and is not an addition to an existing over-crowded teaching program in many primary schools (Morgan and Hansen, 2007, 2008).

Our process data provide interesting insights into the feasibility and success of the program. Recruitment targets were exceeded and retention and attendance rates were very high. Students were also highly satisfied with the Fit-4-Fun Program (see Table 4). However, adherence to the home program and regular participation in break-time activities was lower than anticipated – which is comparable to those achieved in the Fit-4-Fun pilot study (Eather et al., 2012) but higher than those typically observed in secondary school interventions (Lubans et al., 2011; Lubans et al., 2012; Peralta, 2009). However, low adherence to the break-time program is not surprising given the evidence showing that the majority of primary-school aged children are spending a large percentage of their recess and lunch in either sedentary or light physical activity, and that participation rates decline with age (Ridgers et al., 2010; Ridgers et al., 2012). Limited playground space and the unwillingness of some students to change their current break-time activities may be possible explanations for our results.

Study strengths and limitations

The multi-component HPE intervention was delivered using the HPS framework, involved a multi-faceted approach to facilitating behavior change and extended HRF education beyond the classroom. The program was evaluated in a cluster RCT by trained research assistants using validated HRF and physical activity measures (Moher et al., 2010). However, there are some limitations that should be noted. Although the use of objectively measured physical activity using pedometry is a strength of this study, pedometers only detect ambulatory activity (and not activities such as resistance training or flexibility training) and therefore true treatment effects might not have been captured. Accelerometers could be used to evaluate future programs as they capture data relating to physical activity intensity, duration and timing (Trost, 2007). Furthermore, it is impossible to recruit a "true" control group in the school setting, given that HPE is a compulsory subject and there are 60mins of mandatory break time available to students during each school day for 'free play.'

Implications

Increasing physical activity and improving HRF in children has emerged as an important health priority. Research has shown that multi-component school-based interventions that involve a collaborative approach to improving physical activity and fitness (involving the school curriculum, the school environment and families) are the most efficacious (Kriemler et al., 2011). The positive results from this study will add to the growing body of evidence supporting the value of school-based interventions that target improvements in physical fitness in children and youth and will help inform future intervention design and implementation. Given the program was based on the subject matter of the school curriculum, the program has great potential for future large scale dissemination and / or translation into mandatory primary school HPE programs.

Conclusion

In summary, the Fit-4-Fun program resulted in significant improvements in HRF, including, CRF fitness, body composition and flexibility, and improved physical activity levels. Our findings provide further evidence to support the effectiveness of a multi-component school-based fitness intervention for improving the physical fitness and physical activity levels of primary school children.

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Competing interests: The authors declare that they have no competing interests.

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