The Effectiveness of the BWF Shuttle Time programme on children's fundamental movement skills.

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Introduction

Fundamental Movement Skills (FMS) refer to an aspect of motor competence considered to be the building blocks that lead to specialised movement sequences required for adequate participation in many organised and non-organised sports and physical activities in children and adolescents (Lubans, et al., 2010). The mastery of these FMS is purported to be essential for the development of more specialised movement patterns enabling youth to participate in organised and non-organised physical activities (Gallhue, and Ozman, 2011; Clark, and Metcalfe, 2002). FMS are globally defined (Clark, and Metcalfe, 2002; Stodden, Goodway, Langendorfer, Roberton, Rudisill, & Garcia, 2008) as locomotor (e.g., running, hopping, jumping), manipulative or object control (e.g., throwing, kicking, catching, striking) and stability (e.g., balancing and twisting) skills (Gallahue, and Ozman, 2011). Given the multidimensional demands of badminton, such FMS provide the key foundation for later performance in badminton and other racquet sports. The mastery of these FMS has been purported to contribute to children's physical, cognitive and social development and is thought to provide the foundation for an active lifestyle (Stodden, et al., 2008). In recent years there has been increasing research interest on the topic of FMS development as it relates to health, particularly in children and adolescents (Logan, et al., 2015; Robinson, et al., 2015) and latterly adults (Stodden, Langendorfer, & Roberton, 2009; Stodden, Ture, Langendorfer, & Gao, 2013). A growing number of scientific studies support the notion that children who are more competent in FMS are less likely to be overweight/obese (Duncan et al., JSS), engage in more physical activity (Robinson et al., 2015) and have better academic achievement (Jaakola et al., 2015). The development of FMS, either in isolation or as part of the development of physical literacy, has therefore become prominent in school Physical Education curricula worldwide (Australian Curriculum, Assessment and Reporting Authority, 2012; Department for Education, 2013; Society of Health and Physical Educators, 2013).

Despite this, there is evidence that children's FMS competence worldwide is low (Robinson, et al., 2015) and there have been calls to trial effective interventions to better develop FMS during the primary school period (ages 5-11 years). As a consequence, a variety of intervention models have been trialled with school children with a view to enhancing children's FMS (e.g., Bryant, et al., 2015; Duncan, et al., 2017; Faigenbaum, et al., 2013; Robinson, et al., 2015). These interventions have had success but largely have focused on practice of the FMS skills in isolation and without a context of sport performance. There is also a growing body of literature which evidences the importance of developing these FMS in childhood in order to lead to more effective sport specialisation later in life (Moody, et al., 2014). It is therefore important that any school-based FMS intervention can effectively lead to future development of specialist sports skills once the FMS have been mastered. It is also important to differentiate the effects of FMS based interventions between childhood stages. The Stodden et al (2008) conceptual model suggests that the development of FMS in childhood will result in children undertaking greater levels of physical activity, which, in turn, will lead to healthier weight. Importantly, the Stodden model acknowledges that the association between FMS and PA differs depending on childhood stage with a bi-directional association in early childhood but a unidirectional association in middle and later childhood. Few studies to date have examined if the effects of FMS intervention are dependent on childhood stage.

The BWF Shuttle Time initiative was introduced in 2012 and provides a programme related to badminton development for children aged 5-15 years. Implicit within the activities included in the programme are the embedding and development of FMS which, although badminton related, likely also apply to a range of sports and physical activities. It is logical that engaging in the BWF shuttle time programme will positively enhance children's FMS, but research has yet to determine if this is the case. Within the shuttle time programme, via its origins in badminton, there is a focus on the development of object control skills. In the context of FMS based interventions, the development of object control skills has been posited as more important than locomotor FMS for overall motor development (Morgan, et al., 2013) and subsequent engagement in physical activity (Cohen, Morgan, Plotnikoff, Callister, & Lubans, 2014). This is because object control skills have greater skill component complexity and perceptual demand than locomotor skills, requiring more intensive skill instruction and practice (Morgan, et al., 2013). Meta-analytical research has also reported large effect sizes for motor competence interventions on locomotor skills but only medium effect sizes for object control skills (Morgan, et al., 2013), supporting the above statement. It may be that focusing more on object control skills initially allows for greater total time across an intervention programme with which to develop those skills.

To date, there appears to have been no scientific evaluation of the effectiveness of the BWF shuttle time programme as an intervention to enhance FMS in children. This study seeks to address this issue by examining the effects of a 6 week intervention based on the BWF Shuttle Time programme on FMS, weight status, motor fitness and motivation for physical activity in children in two age ranges; 6-7 years and 10-11 years.

Methods

Design

This study employed a repeated measures, cluster randomized intervention design where 4 classes from two schools in central England were allocated into two conditions: 1) Shuttle Time intervention; 2) control (CON) groups. The schools involved were comparable in terms of ethnic makeup and were all within the mid-range of socio-economic status for the county in which they were based. The children were drawn from School Year 2 (ages 6-7) and School Year 6 (ages 10-11). In this way we sought to not only evaluate the effect of the Shuttle Time intervention compared to the control group but also to examine if the effects of the intervention differed depending on stage of childhood from early (EC) to middle (MC) childhood. The Shuttle Time groups undertook a structured Shuttle Time programme over a 6 week period in place of one (of the two) statutory Physical Education sessions and lasted 40-60 minutes. Shuttle Time children therefore engaged in one Shuttle Time and one Physical Education session per week. The CON group did not perform specific INT but attended their two statutory Physical Education classes per week. The Physical Education activities engaged in by the three groups were the same and consisted of cricket, a sport also requiring object control skills. Prior to, immediately following and 10 weeks post the intervention participants in both groups were assessed on measures of FMS, perceived motor competence, motor fitness, weight status and motivation to engage in physical activity.

Participants

One hundred and twenty four children aged 6-11 years (67 boys, 57 girls; Mean ± *SD* = 8.5 ± 1.9 years) from two central England primary schools participated in this study following protocol approval from our institutional ethics committee and written informed parental consent. Participants were drawn from two classes in school Year 2 (n = 66, ages 6-7) and classified as early childhood (EC) or from two classes in school Year 6 (n = 58, ages 10-11) and classified as middle childhood (MC). From school records, ethnic classifications of these participants were: 95% 'Caucasian;' 2% 'South Asian' 3% 'Black'. The schools were selected using convenience sampling; they were located in areas ranked as 40-60% least deprived within England as a whole, using the Index of Multiple Deprivation (APHO, 2008).

Measures

FMS

Process measurements of FMS were employed in the present study. Process oriented movement skill assessment are concerned with how the skill is performed (Burton and Miller, 1998). Four tasks (2 locomotor, 3 object control) were employed to assess FMS assessed using the Test of Gross Motor Development-2 (TGMD-2) (Ulrich, 2000). In the current study the following skills were assessed: run, jump, catch, throw, strike. These were particularly selected as they are the key skills identified as targets for development by the UK National Curriculum for Physical Education for children of the age participating (Department for Education, 2013). Each skill comprises 3-5 components and the TGMD-2 assess whether each component of each skill was performed or not performed to determine the mastery of the skill. All skills were was video-recorded (Sony video camera, Sony, UK) and subsequently edited into single film clips of individual skills on a computer using Quintic Biomechanics analysis software v21 (Quintic Consultancy Ltd., UK). The skills were then analysed using this software and a process oriented checklist, enabling the videos to be slowed down, magnified, replayed and scored. Scores from two trials were summed to obtain a raw score for each skill. The scores for all the skills were then summed to create a total motor competence (scored 0-40) score. Scores from the run and jump were summed to create a locomotor competence score (0-16) and the catch, throw and strike, summed to create an object control score (0-24) following recommended guidelines of administration of the TGMD-2 (Ulrich, 2000). Two researchers experienced in the assessment of children's movement skills (having previously assessed movement skills in the context of a previous research study) analysed the motor competence videos. Both raters had been previously trained in two, separate sessions, lasting approx. 120min, by watching videoed skills of children's skill performances and rating these against a previously rated 'gold standard' rating. Congruent with prior research (Barnett, et al., 2014), training was considered complete when each observer's scores for the two trials differed by no more than one unit from the instructor score for each skill (>80% agreement). Inter- and intra-rater reliability analysis was performed for all the motor skills between the two researchers. Intraclass correlation coefficients for inter and intra-rater reliability were .925 (95% CI = .87 - .95) and .987 (95% CI = .94 - .98) respectively, demonstrating good reliability (Jones, et al., 2010).

Perceived Motor Competence

In order to assess the children's perception of their own FMS competence children completed the Pictorial Scale of Perceived Movement Skill Competence (PMSC; Barnett, et al, 2015) to provide their self- perceived movement skill competence scores in the same five skills as measured by the TGMD-2. The PMSC has been described extensively elsewhere, and prior research showed it to have good validity and reliability for this purpose (Barnett, et al., 2015). Briefly, for each skill, children were shown two, sex-specific illustrations of a child performing the skill competently and less competently and were then asked, "This child is pretty good at throwing, this child is not that good at throwing; which child is most like you?" From the selected picture, children were asked to further indicate their perceived competence by endorsing more specific descriptions with either competent or less competent picture, including, for the competent picture - 4: Really good at… or 3: Pretty good at, etc. – and, for the not so competent picture - 2: Sort of good at… or 1: Not that good at. Possible scores for the entire scale ranged from 4-20. Two week test-retest reliability data, available in a subsample of children (n = 43; 22 boys, 21 girls; mean age = 5.6, *SD* = .48 years), indicated good agreement (Intraclass correlation coefficient = .86, CI = .74 - .92) and internal consistency (Cronbach's α =.89) for the total PMSC perception score based on these four items.

Motor Fitness

Three measures of motor fitness; 10m flying sprint time, standing long jump and seated medicine ball (1kg) throw were assessed, procedures were congruent with those used previously by Duncan et al (2017) in their evaluation of school based training interventions. A 10-metre sprint run was timed using smart speed gates (Fusion Sport, Coopers Plains, Australia). Two infra-red gates were set up 10 metres apart. The participant had a flying start to ensure that sprint speed (Secs) was measured independently of the acceleration phase. Standing long jump (cm) was measured using a tape measure and following procedures described by Peterson (2015). The seated medicine ball throw, using a 1kg medicine ball, has been identified as a reliable and valid measure of upper body strength in children as young as 5 years old (2008). The medicine ball throw was conducted as a measure of upper body strength following procedures reported by Davis et al (2008). Children sat on the floor before throwing the medicine ball forwards like a chest pass three times with furthest distance thrown (cm) assessed using a tape measure. Children were instructed to throw the medicine ball with both arms and where a throw was executed with use of only one arm, the trial was repeated. In a subsample of participants (n = 20), one week test retest reliability was determined. Intraclass correlation coefficients for the three measures of muscular fitness were .9, .94, and .81, for the flying 10m sprint, standing long jump and seated medicine ball throw respectively. Intraclass correlation coefficients for the three product measures of FMS were .9 (CI = .86 - .95) for the 10m sprint, .94 (CI = .9 - .96) for the standing long jump, and .86 (CI = .82 - .91), for the seated medicine ball throw indicating acceptable reliability.

Motivation for Physical Activity

Motivation for being physically active was measured using the behavioural regulation for exercise questionnaire-2 (BREQ-II) (Markland, & Tobin, 2004). Recognising that there is no valid, child-based measure for behavioural regulations for exercise for the younger cohort of participants (ages 6-7) we were unable to measure this construct in the EC age group. Only the participants in the MC group completed this measure. Within the questionnaire, the term 'exercise' was replaced with 'sport and PA' in the BREQ-II. Participants were explained that the questionnaire was aimed at gaining insight into their reasons for participating in sport and PA. They were then presented with the stem: 'I participate in sport and physical activity because…' followed by items representing an autonomous motivational style (identified or intrinsic motivation) or a controlling motivational style (external or introjected regulation). Items were rated on a 5 point Likert scale (1 = strongly disagree, 5 = strongly agree). Internal consistencies of the four subscales as indexed by Cronbach's alpha ranged between .720 and .800. A relative autonomy index (RAI) was calculated, following guidelines for administration of the BREQ-II with high scores reflecting greater motivation for sport and PA.

Shuttle Time Intervention

The present study employed a 6 week version of the BWF Shuttle Time programme (Badminton World Federation, 2011). No specific optimum duration of the Shuttle Time programme is specified by the BWF and a 6 week trial period was chosen as, pragmatically it fits within a school half term, making it attractive for teachers for potential roll out in multiple schools. This decision was taken, congruent with studies examining efficacy of school based movement interventions (Bryant et al., 2015; Morgan, et al., 2013), in order to have little disturbance on the school curriculum, to be time efficient, to create a design that could be realistically integrated into the school curriculum. Prior research studies focused on FMS development have also used 6 week intervention periods with success (Bryant et al., 2015). The Shuttle Time programme was progressive, based on the exercises and activities specified by the BWF and consisted of a warm-up section (10 mins) and a main body section (approx. 40mins). The Shuttle Time groups also undertook a second weekly Physical Education lesson during the intervention period, as part of statutory Physical Education, which was focused on team games (Hockey and Basketball). The CON group continued their twice weekly statutory Physical Education lessons with one weekly session focused on cricket and the other on team games (Hockey and Basketball). In this way we tried to match the lessons the children undertook so the control group's statutory PE sessions comprised an object control stimulus in lieu of the Shuttle Time intervention. There was no difference in the delivery and content of the statutory Physical Education lessons for Shuttle Time and CON groups.

The principal investigators delivered all the intervention sessions with the assistance of a primary school teacher (See Figure 1). The other Physical Education session for the Shuttle Time group and Physical Education sessions for the CON group were delivered by the Physical Education teacher and in accordance with guidelines for the National Curriculum for Physical Education in England. The principal investigator documented adherence to the programme and compliance during the 6 week period. Any child who missed more than 1 sessions in the intervention period was not included in final analysis. This resulted in 2 exclusions from the final data set for analysis, 1 from the CON group and 1 from the Shuttle Time group due to the children moving schools during the intervention period.

Figure 1. Staff delivering the intervention activities

Table 1 outlines the content and schedule of the Shuttle Time programme. Similar to other research using this approach with children (Duncan, et al., 2017; Faigenbaum, et al., 2013; Bryant et al., 2015), participants in the intervention groups also received skill-specific feedback on the quality of each movement during intervention sessions.

Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
		Warm-Up (10-mins)			
Balance Exercises	Balance Exercises	Balance Exercises	Balance Exercises	Dynamic Balance	Dynamic Balance
Mobility Exercises #1,2 and 4	Mobility Exercises #1,2 and 4	Mobility Exercises #1,2 and 4	Mobility Exercises #1,2 and 4	Mobility Exercises #1,2 and 4	Mobility Exercises #1,2 and 4
Having a Lunge	Having a Lunge	Having a Lunge	Having a Lunge	Having a Lunge	Having a Lunge
	Balance and Throw	Balance and Throw	Balance and Throw	Balance and Throw	Balance and Throw
		Main Body (40-mins)			
Balloon tap	Balloon tap relay 1) With hand 2) With Racquet	Mirror Chase with Throw and Catch	Mirror Chase with Throw and Catch	Mirror Chase with Throw and Catch	Mirror Chase with Throw and Catch
Balloon tap relay	Mirror Chase with Throw and Catch	Grip Change with Shuttle	Grip Change with Shuttle	Shuttle Chase	Shuttle Chase
Mirror Chase	Grip Change with Shuttle	Balance the Racquet	Throwing Game 1	Forehand and Backhand Lift Merry go Round	Forehand and Backhand Lift Merry go Round
Mirror Chase with Throw and Catch	Balance the Racquet	Throwing Game 1	Backhand Short Serve	Backhand Short Serve	Backhand Short Serve
Balancing Shuttles	Keep your Court Free	Chase and Hit 1) Forehand 2) Backhand	Chase and Hit 1) Forehand 2) Backhand	Flat Play	Flat Play
	Balancing Shuttles	Balancing Shuttles	Balancing Shuttles	Balancing Shuttles	Balancing Shuttles

Table 1. Content and schedule of the Shuttle Time programme

Statistical Analysis

A series of repeated measures ANOVAs were used to examine any changes in dependant variables; BMI, FMS, perceived FMS, motor fitness and behavioural regulations for exercise, assessed pre, post and 10 weeks post the intervention period. Group (INT vs CON), sex and age group (6-7 years vs 10-11 years) were used as between subjects variables. In this way we sought to assess any short term (pre-post) and sustained (post-10 weeks post) changes in dependant variables between intervention and control groups, gender groups and between children in school year 2 and 6. Where any differences were found Bonferroni post-hoc analysis was undertaken to determine where differences lay. Partial η^2 was used as a measure of effect size and alpha level was set as P = 0.05 to indicate statistical significance. The Statistical Package for Social Sciences (SPSS version 24) was used for all analysis.

Results

Mean ± SD of all outcome variables pre, post and 10 weeks post for children aged 6-7 years and 10-11 years in the INT and CON groups are presented in Table 2.

	Pre								Post								10 Weeks Post							
	Age 6-7 Years				Age 10-11 Years				Age 6-7 Years				Age 10-11 Years				Age 6-7 Years				Age 10-11 Years			
	INT		CON		INT		CON		INT		CON		INT		CON		INT		CON		INT		CON	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
BMI (kg/m²)	16.5	1.9	16.7	1.7	20.2	5.4	20.2	2.8	15.8	3.5	16.7	1.9	19.1	3.4	20.8	4.5	16.6	2.4	16.8	2.2	19.2	3.7	20.5	2.8
FMS (0-40)	20.1	4.6	20.2	5.1	31.1	3.8	31.1	5.5	25.3	3.2	21.6	4.1	33	3.6	32.1	4.5	26.1	3.6	21.9	3.8	32.8	3.6	31.7	4.6
Perceived Motor Competence (0-20)	15.1	3.1	16.2	2.6	15	2.4	15.8	2.6	17.7	2.4	16.2	2.3	16.3	2.3	15.8	2.8	17.1	2.6	16.4	2.1	16.3	2.3	15.8	2.4
10m Sprint Speed (Secs)	2.93	0.2	2.92	0.2	2.5	0.4	2.45	0.2	2.83	0.2	2.85	0.3	2.35	0.5	2.49	0.2	2.78	0.2	2.81	0.2	2.31	0.2	2.51	0.2
Standing Long Jump (cm)	98.9	17.3	104.1	21.4	121.1	22.2	130.3	21.2	108.5	17.4	108.1	20.4	132.1	23.1	131.7	22.1	113	13.4	109.4	18.1	132.6	20.5	129.6	22.1
Seated Medicine Ball Throw (cm)	162.7	36.1	174	43.2	356.1	66.8	367.1	60.2	186.6	29.1	178.5	45.1	373.4	70.3	346.6	67.2	191.9	28.3	177.6	41.9	354.9	65.6	356.5	73.6
RAI	NA	NA	NA	NA	5.8	1.9	6.8	2.9	NA	NA	NA	NA	6.3	1.4	6.9	2.4	NA	NA	NA	NA	6.3	1.5	6.8	2.3

Table 2. Mean ± SD of all outcome variables pre, post and 10 weeks post intervention for children aged 6-7 years and 10-11 years in INT and CON groups

Body Mass Index

Results from repeated measures ANOVA with BMI as the dependant variable revealed no higher order interactions or main effects due to gender (all P>0.05). There was however a significant time X group interaction (P = 0.042, $P\eta^2$ = .029) and a significant main effect due to age group (P = 0.001, $P\eta^2$ = .288).

Bonferroni post-hoc pairwise comparisons indicated that, for the INT group, BMI decreased pre to post intervention (P =0.05). From post intervention to 10 weeks post intervention BMI values significantly increased (P = 0.05) with BMI at 10 weeks post intervention not being significantly different to BMI pre intervention (P = 0.136). BMI did not differ significantly pre, post to 10 weeks post intervention for the CON group (all P>0.05). Mean ± SE of BMI across time for the INT and CON groups is presented in Figure 2. Post hoc analysis for the main effect for age stage indicated that BMI was significantly higher in children aged 10-11 years (20.1 ± .394kg/m^2) compared to children aged 6-7 years (16.5 ± .344 kg/m^2).

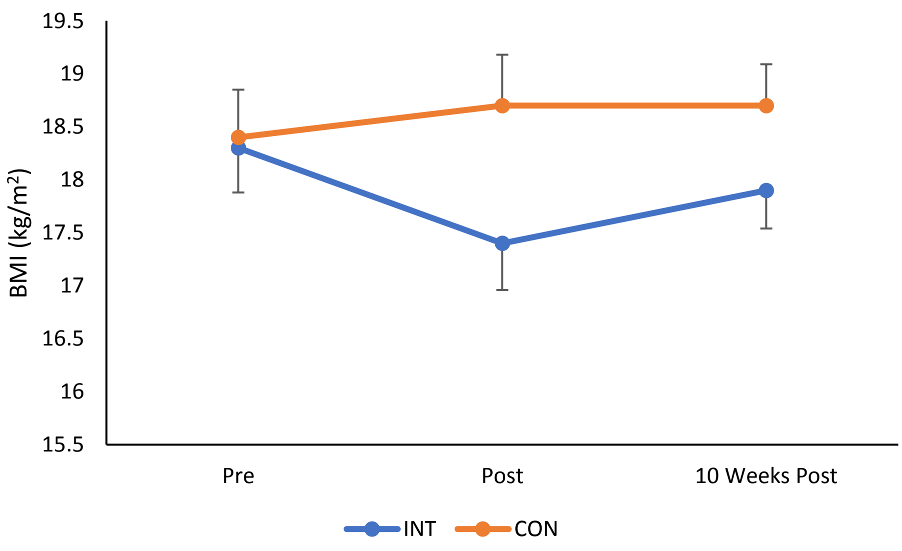

Figure 2. Mean ± SE of BMI across time for the INT and CON groups

FMS

When data for total FMS scores were considered results revealed a time X group X age group interaction ($P = 0.001$, $P\eta^2 = .176$, See Figure 3) as well as main effects for gender and age stage (both $P = 0.001$). Bonferroni post-hoc analysis indicated that there was no significant difference in total FMS in INT and CON groups age 6-7 years ($P = .998$) or children aged 10-11 years ($P = .978$) pre intervention. At post intervention ($P = .0001$) and at 10 weeks post intervention ($P = 0.0001$) children aged 6-7 years in the INT group had significantly higher total FMS compared to children aged 6-7 years in the CON group. There were no significant differences in total FMS scores for children aged 10-11 years in the INT and CON groups post intervention ($P = .431$) and 10 weeks post intervention ($P = .361$). For children aged 6-7 years and children aged 10-11 years in INT and CON total FMS significant increased pre to post intervention (all $P < 0.05$ or better). Total FMS scores at 10 weeks post intervention also remained significantly higher than post for children aged 6-7 years in INT and CON groups and children aged 10-11 years in the INT group (all $P < 0.05$ or better). However, total FMS scores only improved significantly from post intervention to 10 weeks post intervention for 6-7 year old children in the INT group ($P = .03$). The magnitude of change in total FMS scores was greatest for children aged 6-7 years in the INT group. In all cases, total FMS scores were higher for children aged 10-11 years compared to those aged 6-7 years, irrespective of group. Mean ± SE of total FMS was 22.5 ± .482 for children aged 6-7 years and 32.1 ± .514 for children aged 10-11 years. Boys also had significantly higher total FMS scores than girls, irrespective of age stage or group. Mean ± SE of total FMS was 28.6 ± .482 for boys and 25.9 ± .514 for girls.

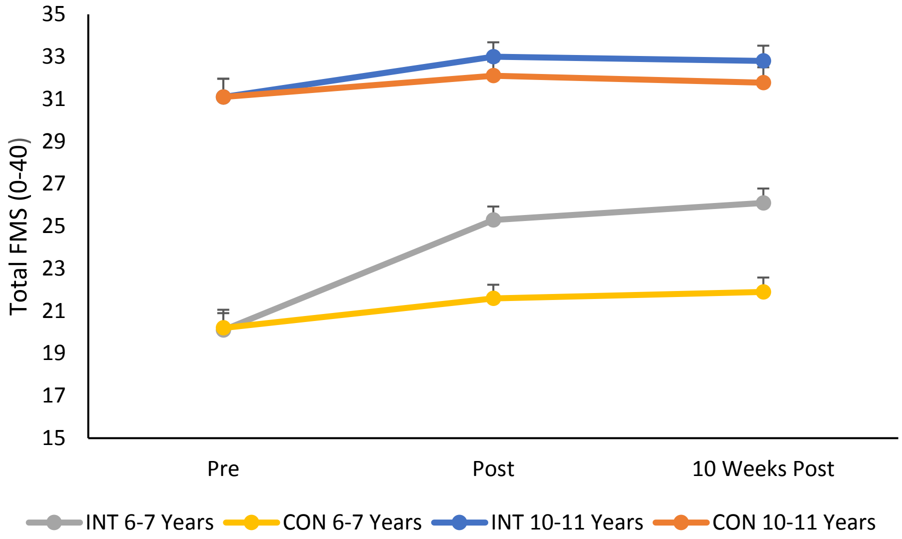

Figure 3. Mean ± SE of total FMS for children aged 6-7 years and 10-11 years in INT and CON groups.

Perceived FMS

For perceived FMS results indicated no higher order interactions or main effects due to age stage (all P>0.05). There was a significant time X group interaction (P = 0.001, $P\eta^2$ = .104) and main effect for age stage (P = 0.001, $P\eta^2$ = .097). Bonferroni post-hoc pairwise comparisons indicated that, for the INT group, perceived FMS was higher post intervention and 10 weeks post intervention compared to pre intervention (both P = 0.001). However, perceived FMS was not significantly different between pre and 10 weeks post intervention (P = 0.08). There was no difference in perceived FMS between pre, post and 10 weeks post intervention time points for the CON group (all P>0.05). There were also significant differences in perceived FMS between INT and CON groups post intervention (P= 0.017). Mean ± SE of perceived FMS across time for the INT and CON groups is presented in Figure 4. Post hoc analysis for the main effect for gender indicated that perceived FMS was significantly higher in boys (16.8 ± .262) compared to girls (15.4 ± .284).

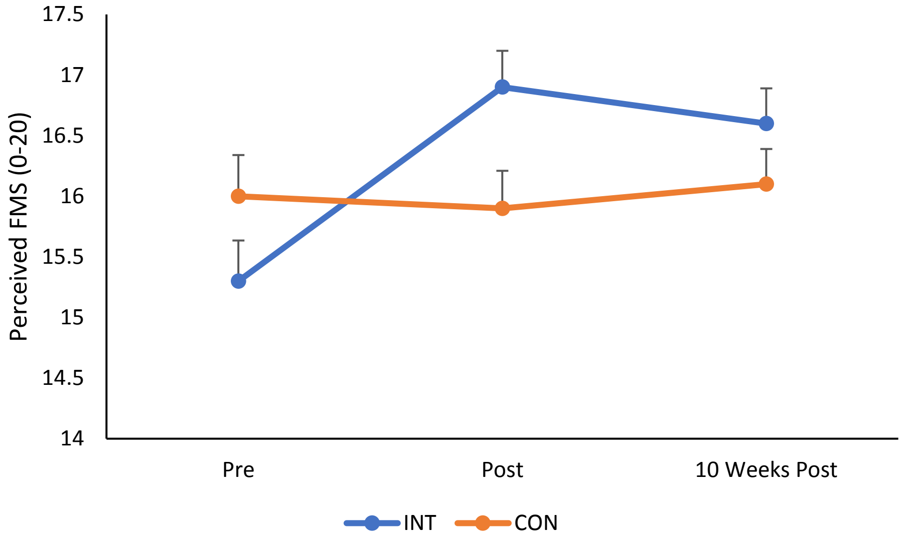

Figure 4. Mean ± SE of Perceived FMS across time for the INT and CON groups

Motor Fitness

Three measures of motor fitness were assessed, 10m sprint speed, standing long jump and seated 1kg seated medicine ball throw.

10m Sprint Speed

For 10m sprint speed results indicated a significant time X group X age group interaction (P = 0.002, $P\eta^2$ = .053) and main effects for gender (P = 0.001, $P\eta^2$ = .115) and age stage (P = 0.001, $P\eta^2$ = .505). Boys and children aged 10-11 years were significantly faster that girls and children aged 6-7 years respectively. Mean ± SE of 10m run speed was 2.57 ± .036 secs and 2.7 ± .028 secs for boys and girls respectively and 2.85 ± .026 secs and 2.4 ± .028 secs for children aged 6-7 and 10-11 years respectively.

In regard to the time X group X age group interaction, post-hoc analysis indicated no significant differences between INT and CON group in children aged 6-7 and 10-11 years at pre, post and 10 weeks post intervention (all P>0.05). However, 10m sprint speed decreased (i.e. performance increased) pre to post for INT groups aged 6-7 years (P = .0001), 10-11 years (P = .001) and the CON group aged 6-7 years (P = .003). This improvement was maintained from pre to 10 weeks post intervention for the aforementioned groups, however sprint speed was only significantly different (P = .025) from post to 10 weeks post for children aged 6-7 years in the INT group. Mean ± SE of sprint speed (secs) for children aged 6-7 years and 10-11 years in INT and CON groups is presented in Figure 5.

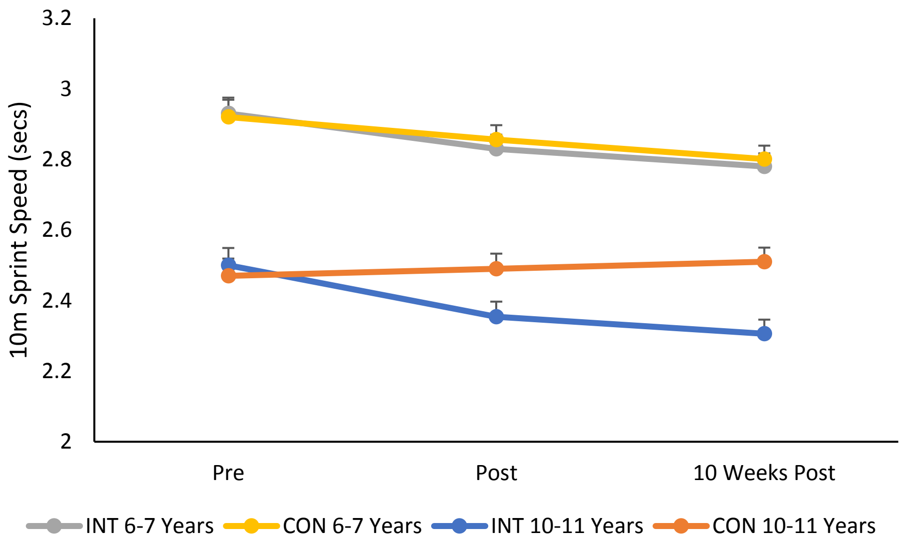

Figure 5. Mean ± SE of 10m sprint speed across time for the INT and CON groups in children aged 6-7 years and 10-11 years.

Standing Long Jump

For standing long jump there were no higher order interactions or main effect due to gender (all P>0.05). There was a significant time X group interaction (P = 0.001, $P\eta^2$ = .147, See Figure 6) and a significant main effect for age group (P = 0.001, $P\eta^2$ = .298). Bonferroni post-hoc analysis indicated that standing long jump distance increased pre to post for the INT group (P = .0001) but not the CON group (P = .728). Standing long jump scores were also significantly greater at 10 weeks post intervention, compared to post, for the INT group (P = .0001) but not the CON group (P = .956) but were not different from post intervention to 10 weeks post intervention for the INT (P = .306) or CON groups (P = .737). Irrespective of group children aged 6-7 years also had smaller standing long jump scores compared to children aged 10-11 years. Mean ± SE of standing long jump (cm) was 107 ± 2.3cm and 130 ± 2.5cm for children aged 6-7 years and 10-11 years respectively.

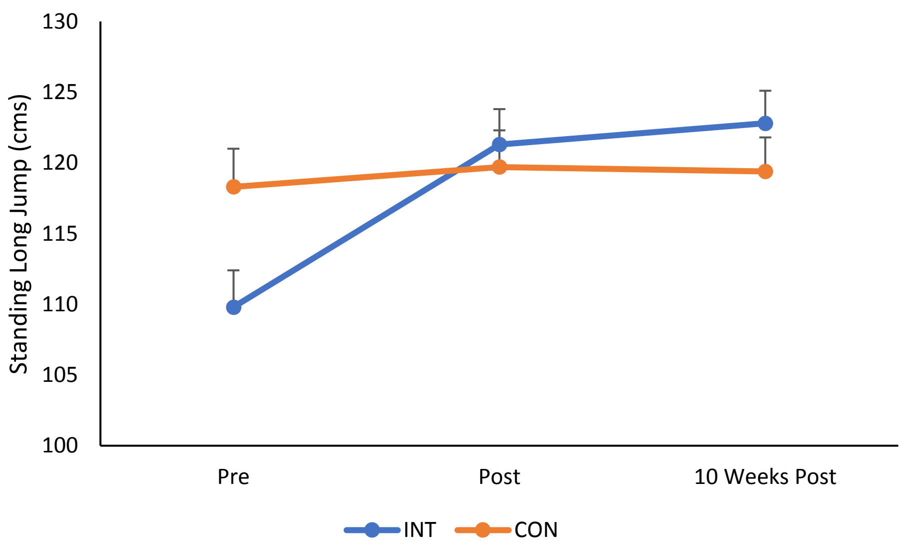

Figure 6. Mean ± SE of Standing long jump (cm) across time for the INT and CON groups

1kg Seated Medicine Ball Throw

For the 1kg seated medicine ball throw results from repeated measures ANOVA revealed a significant time X group X age group interaction (P = 0.001, Pη^2 = .061, See Figure 7). Bonferroni post-hoc pairwise comparisons indicated that there were no significant differences in medicine ball throw distance between the INT and CON groups at pre, post and 10 weeks post intervention in both the 6-7 years olds and 10-11 year olds (all P>0.05). For 6-7 year olds in the INT group, medicine ball throw performance increased pre to post (P= .001) and pre to 10 weeks post (P = 0.001). There were no significant differences in medicine ball throw performance pre, post to 10 weeks post for 6-7 year olds in the CON group.

For 10-11 year olds in the INT group medicine ball throw distance significantly increased pre to post (P = .0001) and then significantly decreased post intervention to 10 weeks post intervention (P = .0001). For 10-11 year olds in the CON group medicine ball throw distance significantly decreased pre to post (P = .003) and then significantly increased post to weeks post intervention (P = .027).

Results also indicated a significant main effect for gender (P = 0.001, Pη^2 = .098) and age stage (P = 0.001, Pη^2 = .791) where medicine ball throw distance was significantly higher for boys compared to girls and for children aged 10-11 years compared to 6-7 years. Mean ± SE of seated medicine ball throw distance (cm) was 284 ± 6.2cm and 253.7 ± 6.4cm for boys and girls respectively and 178.8 ± 5.8cm and 359.1 ± 6.7cm for children aged 6-7 and 10-11 years respectively.

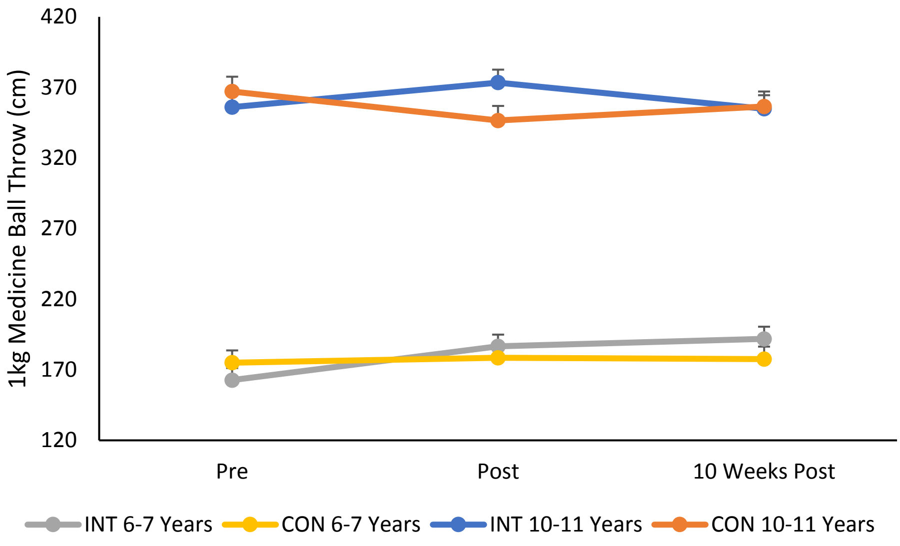

Figure 7. Mean ± SE of 1kg seated medicine ball throw distance (cm) across time for the INT and CON groups in children aged 6-7 years and 10-11 years.

Motivation for Physical Activity

Data for behavioural regulations for exercise was only assessed in children aged 10-11 years, recognising that there is no valid measure available to assess exercise motivation in children younger than this age. Consequently, results from a 2 (INT vs CON) X 3 (pre, post, 10 weeks post) X 2 (gender) repeated measures ANOVA for the relative autonomy index (RAI) revealed no significant higher order interactions or main effects due to gender or group (all P>0.05).

Discussion

This project sought to examine the effects of a 6 week intervention based on the BWF Shuttle Time programme on FMS, weight status, motor fitness and motivation for physical activity in children aged 6-7 and 10-11 years old. Prior studies have demonstrated the efficacy of motor competence based interventions on FMS, weight status and motor fitness (See Han, et al., 2018 for a review) and the BWF shuttle time programme is widely used in schools across the world to develop motor competence through a sports related movement programme. However, this is the first study to examine the efficacy of the BWF shuttle time programme on key measures related to sport and physical activity participation, such as FMS and motor fitness, and also differentiates the efficacy of the programme according to age stage, a variable often overlooked in the evaluation of motor competence based interventions. We also examined short term (pre-post intervention) effects and longer term (post-10 weeks post intervention effects) to provide an indication of the longer term retention of any change as a result of the programme. As a consequence the present study makes an original contribution to the literature and has practical significance as the results presented here can provide direction to coaches and teachers as to how effective the BWF Shuttle Time programme is and at what age stage it may have the greatest effect.

There are several key findings of the present study. Irrespective of age stage, BMI decreased for children who undertook the shuttle time intervention in lieu of one of their statutory PE lessons per week, from pre-post, compared to the control group. Such a change is positive and suggests participation in Shuttle Time may help to maintain healthy weight in children. Reductions in BMI following engagement in PE based intervention have been previously reported (Bryant et al., 2015, Han et al., 2018; Duncan, et al., 2017). It may be that PE lessons based on movement competence given by movement trained professionals provide a greater stimulus for BMI change than PE lessons based on traditional sports and delivered by non PE specialists.

A key tenant of the Shuttle Time programme is the development of competence in fundamental movement skills that are developed through badminton but are applicable to a range of different sports (Badminton World Federation, 2011). The results of the present study support the assertion that Shuttle Time enhances FMS, and is superior to statutory PE. Like the intervention group, the control group in the present study undertook PE lessons also focused on development of object control skills (Cricket), thereby trying to match the focus of the PE sessions between the intervention and control groups.

It is however important to highlight that the Shuttle Time programme was considerably more effective for younger children (ages 6-7 years), compared to older children (ages 10-11) years in the current study. We deliberately assessed children in Key Stage 1 and Key Stage 2 of the English National Curriculum, where the focus for PE in Key Stage 1 is on the development of fundamental movement skills, where the focus for Key Stage 2 is the development of sport specific skills. Prior literature has suggested that the development of FMS is optimised in children younger than 8 years of age as movement patterns are not fully developed more malleable to change (Gallahue and Ozman, 2011). Conversely, if children are not competent in FMS by the age of 8, retrospective action may be needed to upskill children in the FMS before sport specific skill development can be effective (Gallahue and Ozman, 2011). The intervention activities employed in the current study was focused on the development of FMS, both locomotor and object control skills, through badminton and FMS scores were higher for children age 10-11 years compared to their 6-7 year old peers. The older children may already have been competent in FMS to the stage where movement interventions focused on FMS were less likely to prompt large increases in movement competence. Likewise, for older children, an intervention of the frequency

(1 X week) and duration (6 weeks) may not be optimal for enhancement of FMS where the FMS are already partially developed. Further research refining the structure and format of activities undertaken within a Shuttle Time intervention for different age stages of children would therefore be welcome in providing greater tailoring of the BWF Shuttle Time programme for the needs of children at different points on the pathway of motor competence.

Of note, irrespective of age stage, for children who undertook the Shuttle Time Intervention perceived motor competence increased, compared to the control groups. A child's perception of their own motor competence is a key correlate of actual FMS (Liong, Ridgers, & Barnett, 2015) and is positively associated with physical activity in both children and adolescents (Babic, et al., 2014). Therefore, any intervention that leads to increases in a child's perception of their own motor competence should be considered as positive and could, in the longer term, lead to positive changes in actual FMS and greater engagement in health enhancing physical activity. In this context the BWF Shuttle Time programme had a positive impact on those that undertook it irrespective of age stage.

The current project is not without limitations. Although a comprehensive battery of measures was employed to assess weight status, actual FMS, perceived FMS, motor fitness and motivation to undertake physical activity, it was not possible to also assess habitual physical activity objectively. The schools participating in the study were unable to facilitate the children wearing accelerometers for the time needed (i.e., >4 days including weekends) to provide a valid measure of habitual physical activity. Future studies would be welcome which examine if there is longer term change in physical activity as a consequence of undertaking the BWF Shuttle Time intervention. We are also cognisant that the data presented here reflects the effect of a 6 week

Shuttle Time programme undertaken once per week, in lieu of statutory PE. A 6-week period was undertaken as prior work has demonstrated this duration of motor competence intervention can be effective and, importantly, fits within the demand of a crowded school curriculum. There is no stated optimum duration for undertaking the BWF Shuttle Time programme. However, it would be useful for future research to examine whether engaging in Shuttle Time for a longer period, or a greater frequency that in the present study, would result in different effects on the variables examined in the present study. Certainly, although a beneficial short term effect of engaging in Shuttle Time on BMI was evident, if the participants had engaged in the programme for a longer duration the reduction in BMI reported here post intervention may have been retained 10 weeks post intervention. Future research examining this issue would be welcome.

The **key take home message** from the current project should be that **the BWF Shuttle Time programme is particularly beneficial in developing FMS and motor fitness for children who have not yet matured their FMS** (i.e., ages 7 and below) (Gallahue and Ozman, 2011). For perceived FMS, the BWF Shuttle Time programme is effective in enhancing perception of motor competence for children in the age ranges where FMS has yet to mature (ages 6-7 years) and where FMS has matured (ages 10-11 years). Participation in the Shuttle Time programme over 6-weeks in lieu of statutory PE did not however appear to influence motivation for physical activity.

Acknowledgements

The authors would like to acknowledge Josh Hurst, Chelsey Lawson, and Alexandra Dobell for their assistance in pre and post assessment in this research.

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