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Effectiveness of a 16 week gymnastics curriculum at developing movement competence in children

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ABSTRACT

Objectives: Internationally, children's movement competence levels are low. This study's aim was to evaluate the effectiveness of a 16 week gymnastics curriculum on stability, locomotive and object control skills and general body coordination. It was hypothesised that the gymnastics intervention group would demonstrate significant improvements beyond a PE comparison group.
Design: This study used a non-randomised control design. The intervention and comparison groups were drawn from three primary schools. The study followed the transparent reporting of evaluations with nonrandomized designs (TREND) statement for reporting.
Methods: A total of 333 children (51% girls, 41% intervention) with a mean age of 8.1 years ($SD = 1.1$) participated. Intervention children (16 weeks × 2 h of gymnastics) were compared to children who received (16 × 2 h) standard PE curriculum. Children's movement competence was assessed using the Test of Gross Motor Development-2, Stability Skills Assessment and the Körper-Koordinationstest für Kinder. Multilevel linear mixed models, accounting for variation at the class level and adjusted for age and sex, were used to assess intervention relative to comparison differences in all aspects of movement competence.
Results: Stability and object control skills showed a significant ($p < 0.05$) intervention × time interaction effect. No difference was found in locomotor skills or general coordination.
Conclusions: Gymnastics is effective at developing stability skills and object control skills without hindering the development of locomotor skills or general coordination. Accelerated learning of stability skills may support the development of more complex movement skills.

1. Introduction

The ability to perform various movement skills (e.g. running, kicking, jumping) in a proficient manner is defined as movement competence[1,2] which comprises three discrete constructs[2]: locomotor, object control, and stability skills. Collectively, known as fundamental movement skills (FMS), these are seen as the foundation for more specialised movements required in many sports and physical activities.[3] Mastery of FMS is associated with health benefits[4] and longitudinal evidence suggests children who have better FMS skills are more likely to possess superior cardiovascular fitness at 16 years of age.[5] Typically, interventions designed to improve children's FMS have focused on the development of object control and locomotor skills.[6,7] Consistent with Gallahue et al.,[2] recent work has suggested stability skills are a separate construct in the FMS family[8] which currently are not adequately assessed or developed. Typically European assessment of movement competence does not focus on FMS but instead examines children's movement coordination with regard to their ability to undertake novel and unfamiliar gross motor tasks.[9] Collectively, the absence of stability skills and general body coordination, may contribute to a lack of movement competence. Burton and Rodgerson[10] argued that practice in physical education (PE) should be consistent with a theoretical model of movement competence and, interventions based in the PE setting should therefore develop and measure all aspects of children's movement competence.

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Australian children have poor stability skills,[8] they are significantly behind their Belgian counterparts in general non-sport specific body coordination[11] and they perform poorly in tests of locomotor and object control skills.[12,13] This may be attributed to diminished PE time in schools[14,15] and an increased focus on the development of team sports at the cost of individual sports such as gymnastics.[16] Gymnastics training has been found to produce superior stability skills.[8] A lack of gymnastics training may be a contributing factor for children failing to develop more complex object control skills[17] and having poorly developed general coordination and stability skills.[11] The aim of this study was to evaluate the effectiveness of a 16 week gymnastics curriculum developed by Gymnastics Australia (GA) to develop stability, locomotive and object control skills and general body coordination. It was hypothesised that the gymnastics intervention group would demonstrate significant improvements beyond a PE comparison group.

2. Methods

This study used a non-randomised control design (see Fig. 1) as the schools' principals were unwilling to follow a randomised process as it would involve making changes to the schools' timetables. Instead, the intervention and comparison groups were identified by the school principals, although it was requested that they did not select groups based upon judgements of who might benefit most from being involved in the intervention. Classes of children from three primary schools were allocated as intervention or comparison groups. The study followed the transparent reporting of evaluations with nonrandomized designs (TREND) statement for reporting. Power analysis, using a medium effect size $d = 0.39$, taken from the meta-analysis of the effectiveness of motor skill interventions in children,[18] indicated that it would require 140 participants in each condition to have 90% power for detecting a medium sized effect when employing the traditional 0.05 criterion of statistical significance.

Participant selection was guided by the Socio-Economic Indexes for Areas (SEIFA) Index of relative socio-economic advantage and disadvantage, developed by the Australian Bureau of Statistics (ABS). One low, one medium and one high socio-economic status (SES) school were selected. The study was approved by the lead author's University Ethics Committee and the Department of Education and Early Childhood Development. Children were asked to return written informed consent forms from their parents or guardians, with 89.5% returning the consent forms. This resulted in 333 children (intervention $n = 135$; comparison $n = 198$), 51% girls, with a mean age of 8.1 years ($SD = 1.1$). Two intervention classes were chosen from each school (one from years 1/2; and one from years 3/4) totalling six intervention classes. The remaining eight classes continued with their standard PE curriculum and made up the comparison classes group (four from years 1/2; four from years 3/4).

Movement competence was measured using three test batteries. A stability test battery consisting of the rock, log-roll and back support was used to examine postural stability.[8] These skills were scored individually and summed to produce a stability composite score. The TGMD-2[19] was used to assess proficiency in six locomotor skills (run, hop, slide, gallop, leap, jump) and six object control skills (strike, dribble, catch, kick, throw, roll). For both the TGMD-2 and the stability skill assessment, skill components were marked as 'present' or 'absent'. The components for the six locomotor skills were then summed to give a locomotor score, and likewise for the object control score and stability score. Non-sport specific body coordination was assessed using the Koorperkoodinatoin test fur kinder (KTK)[20] with four outcome-based subtests; reverse balance (RB, walk backwards on balance beams decreasing in width); hopping for height (HH, hop on one leg over an increasing number of 5 cm foam blocks to a maximum of 12 blocks); continuous lateral sideways jumping (CS, number of sideways jumps with feet together over a wooden slat in 15 s); and moving platforms (MP, moving across the floor during 20 s using two wooden platforms). These scores were summed to give an overall general movement coordination score.

Height and weight were measured with a Mentone PE087 portable stadiometer (Mentone Educational Centre, Melbourne, Australia) and SECA 761 balance scale (SECA GmbH & Co. KG., Birmingham, UK). Body mass index (BMI) was calculated as weight (kg)/height^2 (m^2). Two measures were taken for height and weight with the average being recorded. Grip strength was assessed with an isometric handgrip dynamometer (TTM Dynamometer, Tsutsumi, Tokyo).

To ensure a high level of reliability a battery of gold standard videos was created for each test and scored by the lead author (JR) and author 6 (RP). To ensure accuracy, authors recoded the videos three times; each iteration achieved the same total score and the scoring was therefore consistent.

Prior to assessments in the field setting, 10 research assistants (RAs) received six hours training in testing administration. The six RAs who had been selected to administer the KTK watched a battery of the gold standard videos for each test. RAs scored all children in the videos according to KTK guidelines and their scores were summed to give an overall coordination score. Using percent agreement, all RAs achieved 94% or higher when compared to the gold standard coordination score.

Two RAs were trained to code the 12 TGMD-2 skills, and two were trained to assess the three stability skills. Inter-rater reliability between the RAs and lead author was similarly established through coding gold-standard videos. The RAs and lead author scores were assessed through intra-class correlation coefficients (ICC) prior to testing in the field at pre and again at post. Subtest scores were found to be good for locomotor (pre-test: ICC = 0.90; 95% CI: 0.73–0.98, post-test: ICC = 0.91; 95% CI: 0.75–0.96), object control (pre-test: ICC = 0.82; 95% CI: 0.58–0.96, post-test: ICC = 088; 95% CI: 0.70–0.97) and stability skills (pre-test: ICC = 0.82; 95% CI: 0.53–0.93, post- test ICC = 0.90; 95% CI: 0.73–0.97).

Twenty five children completed the assessment simultaneously with groups of five rotating around five skill stations (two TGMD-2 and KTK stations, one stability station and one anthropometric station). Each group started and finished at a different station; this ensured the assessment was counterbalanced which guarded against factors such as fatigue influencing the scores. All children wore light sports clothes, and completed the KTK, stability skills and anthropometrics in bare feet. Before the execution of each skill, children watched one live and one pre-recorded demonstration. They had one practice attempt and two assessment trials for each of the stability skills and the TGMD-2 test battery. The KTK was administered according to the manual guidelines.[20] RAs were blind to which classes were in the intervention groups.

For the duration of the intervention period both groups received 2 h PE per week for two school terms (16 weeks intervention plus pre- and post-assessment testing during weeks 1 and 18). The intervention group received the gymnastics based PE curriculum taught by a gymnastics coach for the first hour during the first term, shadowed by the classroom teacher. The second hour of gymnastics was taught by the school's PE teacher. During the second term the PE teacher and classroom teacher taught one hour each. The comparison group received two hours of their normal PE curriculum for 16 lessons which comprised team sports with one lesson taught by the PE teacher and one by the classroom teacher (see supplementary material 1).

The gymnastics intervention "LaunchPad" was designed for children up to 12 years of age with three levels of resources: KinderGym

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