EFFECTS OF GYMNASTICS TRAINING ON PHYSICAL FUNCTION IN CHILDREN

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This study assessed the effects of one hour per week of gymnastics training over 9 weeks on seven physical function variables in children aged 4-9. Of the total 205 children measured pre-gymnastics training, 41 boys and 62 girls completed post-testing measurements. Pre- to post-intervention change scores showed there were beneficial effects for the 30-s sit-up test for abdominal strength (17% increase), sit and reach test for lumbar and hamstring flexibility (6.4% increase), plate tapping test for upper limb speed and coordination (5.8% improvement), and vertical jump test for lower limb power (4.6% increase). The tables of age and gender normative ranges produced should be helpful for practitioners conducting similar physical function testing of children 4-9 years.

KEY WORDS: gymnastics, physical function, children.

INTRODUCTION: Fitness, physical activity behaviour and motor skill development are important components of the physical education curricula and are potentially indicators of child health (Lloyd, Colley, & Tremblay, 2010). Physical fitness in children and adolescents has also been linked to positive health outcomes in adults (Kvaavik, Klepp, Tell, Meyer, & Batty, 2009). Moreover, motor skills can be used for talent identification to predict sporting success in children (Grice, 2003). Previous research has demonstrated the positive effects of a four-week after school programme addressing motor skills and fitness can have in young children (Matvienko & Iradge, 2009). Therefore, encouraging motor skill and fitness development in young children is likely to have substantial benefits on health outcomes and potentially subsequent sporting success in children. Understanding the benefits of participation in gymnastics training would provide pertinent information for this area. Establishing normative ranges for these physical function tests in children will be valuable for practitioners conducting similar physical function testing in the future, for both talent identification and the early identification of children in need of improvement. The purpose of this study was to assess the effects of one hour per week for nine weeks of gymnastics fundamental movement skills training on seven components of physical function in children.

METHODS: Two hundred and five children (74 male, 131 female; 6.2 ±1.3 years; 1.24 ±0.09 m; 23.9 ±4.9 kg) enrolled in general gymnastics classes were recruited. Ethical approval was granted by the University Ethics Committee. Prior to data collection parental consent and child assent was obtained. Children participated in one hour per week of general gymnastics training that included activities based on fundamental movement skills and body management. The programme focussed on developing six key movement patterns of landings, statics, spring, rotation, swing and locomotion. Data were collected during two sessions, before and after the nine-week gymnastics training programme. Of the total 205 children, 41 boys and 62 girls completed the post-testing measurements. Body mass and height were measured, along with physical function variables of sprint speed (20-m), balance (stork balance test) (Johnson & Nelson, 1979), upper limb speed and co-ordination (plate tapping test) (Adam, Klissouras, Ravazollo, Renson, & Tuxworth, 1988), grip strength (Adam et al., 1988), lower limb power (vertical jump test), abdominal strength (30 s sit-up test), lumbar and hamstring flexibility (sit and reach test) (Adam, Klissouras, Ravazollo, Renson, & Tuxworth, 1988). These tests were chosen because they have been clearly defined and validated in other studies (Beurden, Barnett, Zask, Dietrich, Brooks, & Beard, 2003; Espana-Romero, Artero, Jimenez-Pavon, Cuenca-Garcia, Ortega, & Castro-Piaero, 2010; Fjortoft, 2000), they are easy to administer and are time efficient, and as a set, they cover a variety of skill components.

For all tests a larger number represents better performance, except for the 20-m sprint and plate tapping tests, in which the aim was to complete the test as quickly as possible. Performance changes for each test were calculated and expressed as percentages, with 90% confidence limits (90%CL) to show the likely range of the true value. Means and standard deviations from baseline testing were used to define performance categories as shown in Table 1.

Table 1: Categories and definitions of performance based on mean and standard deviations.

Category	Definition
Excellent	More than three standard deviations above mean performance.
Good	Between two and three standard deviations above mean performance.
Above average	Between one and two standard deviations above mean performance.
Average	Within one standard deviation of mean performance.
Below average	Between one and two standard deviations below mean performance.
Poor	Between two and three standard deviations below mean performance.
Very poor	More than three standard deviations below mean performance.

RESULTS AND DISCUSSION: Normative ranges for each physical function component were calculated based on data from the 205 children that attended the first testing session (Tables 2 and 3). Change scores (expressed as percentages with 90%CL) were calculated for the 129 children (43 male, 86 female) who completed both pre- and post-intervention testing (Figure 1).

There was a small improvement in 20-m sprint time, although the true value of the effect is likely to be trivial. There were no sprint-specific activities undertaken in the gymnastics classes, which may explain the lack of substantial improvement in this measure. There was a substantial improvement in the 30 s sit-up test, with a 17% increase in the mean number of sit-ups the children were able to complete in 30 s. This was very likely to be a beneficial effect. Activities such as the maintenance of the 'tuck' position and other static positions appear to contribute towards improvements in muscular endurance in the abdominals and hip-flexor muscles. Changes in hand grip strength were trivial, although separate analysis revealed a small improvement in girls (0.5 ±2.2 kg), but a small decrease in boys (-0.8 ±2.0 kg). Reasons for these gender differences are unclear. There was a small decrease in performance of the stork balance test. However, the large variability in the observed value suggests the test was not an appropriate measure for this age group. A variation of this test, the flamingo balance test, may be more suitable for future testing (Adam et al., 1988). Substantial improvements were seen for the sit-and-reach test, with a mean improvement of 6.4% on baseline scores. This is very likely to be a beneficial effect. There was a greater mean improvement in the girls (2.7 ±3.6 cm) compared to the boys (1.2 ±2.9 cm), however, both improvements were beneficial so gymnastics training probably has a useful effect on hamstring and lower back flexibility in children.

There was a 1.3 s mean decrease (i.e. a small improvement) in the time taken to complete the limb speed and coordination tapping test with greater improvement seen in boys (-1.79 ±4.52 s) than girls (-0.81 ±5.02 s). Several activities within the gymnastics training programme such as swinging and springing may have contributed towards this small 5.8% improvement in limb speed and coordination, which are both important components of motor function. There was a small, but clear improvement (4.6%) in the vertical jump height test for lower limb strength and power. The improvement was similar in both boys and girls. Jumps are a key part of the training programme, and so the improvements observed are likely to be the result of practising and learning such movements.

The results of the baseline testing will help to establish normative ranges for children completing these physical function tests. The large sample size allows the results to be generalised to other active children in this age range with a good degree of confidence. These data will be valuable for practitioners conducting similar physical function testing in the future, for both talent identification and the early identification of children in need of improvement. These physical attributes form the basis of other athletic activities (e.g. track and field, diving).

There are a large number of ecercise 'interventions' implemented, but little information on whether they are successful and what changes are made. Gymnastics training may be useful for improving certain aspects of a child's physical function over a short duration. However, given an age and activity matched control group was not included, we cannot be certain the changes were solely due to the gymnastics training intervention alone. In addition, the reliability of these tests for this age group has not yet been reported. Children may have scored better on the post-intervention testing due to a learning effect, or the improvements may have been in accordance with the normal physical development. Including a non-training control group would help address some of this uncertainty. Further, a study design with three test sessions (baseline, mid-way, post, 6 weeks post) would enable a better evaluation of the training intervention, and also whether training benefits continue after cessation of the training.

Table 2
Categories of performance on each physical function test for children aged 4-6 years.

	20-m sprint	30 s sit-up	Stork test	Hand grip	Sit and reach	Plate tapping	Vertical jump
Boys (n=41)	5.52 ±0.51	8.3 ±5.4	1.93 ±1.57	8.7 ±2.5	29.5 ±4.2	25.0 ±5.2	19.2 ±4.9
very poor	>7.04	0*	<0.50*	0	<15.5	>40.4	<4.4
poor	6.55 - 7.04	1 - 2*	0.50 - 0.92*	1 - 3	15.5 - 19.5	35.3 - 40.4	4.4 - 9.2
below average	6.04 - 6.54	3 - 4*	0.93 - 1.35	4 - 5	20.0 - 24.5	30.1 - 35.3	9.3 - 14.2
average	5.02 - 6.03	5 - 14	1.36 - 3.15	6 - 11	25.0 - 34.5	19.8 - 30.1	14.3 - 24.1
above average	4.51 - 5.01	15 - 19	3.16 - 6.37	12 - 14	35.0 - 39.0	14.6 - 19.8	24.2 - 29.1
good	4.00- 4.50	20 - 24	6.38 - 8.54	15 - 16	39.5 - 43.5	9.5 - 14.6	29.2 - 34.0
excellent	<4.00	>24	>8.54	>16	>43.5	<9.5	>34.0
Girls (n=62)	5.69 ±0.57	9.7 ±4.6	2.09 ±1.25	8.4 ±2.5	31.1 ±4.2	24.1 ±4.9	18.6 ±5.5
very poor	>7.41	0*	<0.96	<1	<18.5	>38.9	<2.1
poor	6.85-7.41	1 - 2*	0.96 - 1.00	1 - 2	18.5 - 22.0	34.0 - 38.9	2.1 - 7.5
below average	6.27-6.84	3 - 4*	1.01 - 1.31	3 - 5	22.5 - 26.5	29.1 - 34.0	7.6 - 13.0
average	5.12-6.26	5 - 14	1.32 - 3.31	6 - 11	27.0 - 35.5	19.2 - 29.1	13.1 - 24.1
above average	4.55-5.11	15 - 19	3.32 - 5.41	12 - 13	36.0 - 39.5	14.3 - 19.2	24.2 - 29.6
good	3.97-4.54	20 - 23	5.42 - 5.71	14 - 16	40.0 - 43.5	9.4 - 14.3	29.7 - 35.1
excellent	<3.97	>23	>5.71	>16	>43.5	<9.4	>35.1

*These ranges were selected by the authors, as they could not be defined by the data.

Table 3
Categories of performance on each physical function test for children aged 7-9 years.

	20-m sprint	30 s sit-up	Stork test	Hand grip	Sit and reach	Plate tapping	Vertical jump
Boys (n=41)	4.92 ±0.38	15 ±5	2.79 ±2.06	13.2 ±3.1	26.1 ±4.5	18.4 ±3.3	23.8 ±4.0
very poor	>6.06	<2*	<1.12	<3	<12.5	>28.2	<13.5
poor	5.69 - 6.06	2 - 4*	1.12 - 1.52	3 - 6	12.5 - 16.5	25.0 - 28.2	13.5 - 16.8
below average	5.31 - 5.68	5 - 9	1.53 - 2.13	7 - 9	17.0 - 21.0	21.7 - 25.0	16.9 - 20.3
average	4.54 - 5.30	10 - 20	2.14 - 4.55	10 - 16	21.5 - 30.5	15.1 - 21.7	20.4 - 26.1
above average	4.16 - 4.53	21 - 25	4.56 - 7.28	17 - 20	31.0 - 35.0	11.8 - 15.1	26.2 - 30.7
good	3.77 - 4.15	26 - 30	7.29 - 9.69	21 - 22	35.5 - 39.5	8.5 - 11.8	30.8 - 34.2
excellent	<3.77	>30	>9.69	>22	>39.5	<8.5	>34.2
Girls (n=62)	5.03 ±0.43	15 ±3	3.12 ±2.36	11.9 ±3.0	31.5 ±5.4	19.3 ±3.7	22.8 ±5.5
very poor	>6.32	<5	<1.56	<3	<15.5	>30.3	<6.4
poor	5.90 - 6.32	5 - 7	1.56 - 1.68	3 - 5	15.5 - 20.5	26.7 - 30.3	6.4 - 11.8
below average	5.18 - 5.89	8 - 11	1.69 - 2.32	6 - 8	21.0 - 25.5	23.7 - 26.6	11.9 - 17.2
average	4.60 - 5.17	12 - 18	2.33 - 6.11	9 - 15	26.0 - 37.0	15.7 - 23.7	17.3 - 28.2
above average	4.17 - 4.59	19 - 22	6.12 - 9.93	16 - 18	37.5 - 42.5	12.0 - 15.6	28.3 - 33.7
good	3.74 - 4.16	23 - 25	9.94 - 12.78	19 - 21	43.0 - 47.5	8.3 - 12.0	33.8 - 39.1
excellent	<3.74	>25	>12.78	>21	>47.5	<8.3	>39.1

*These ranges were selected by the authors, as they could not be defined by the data.

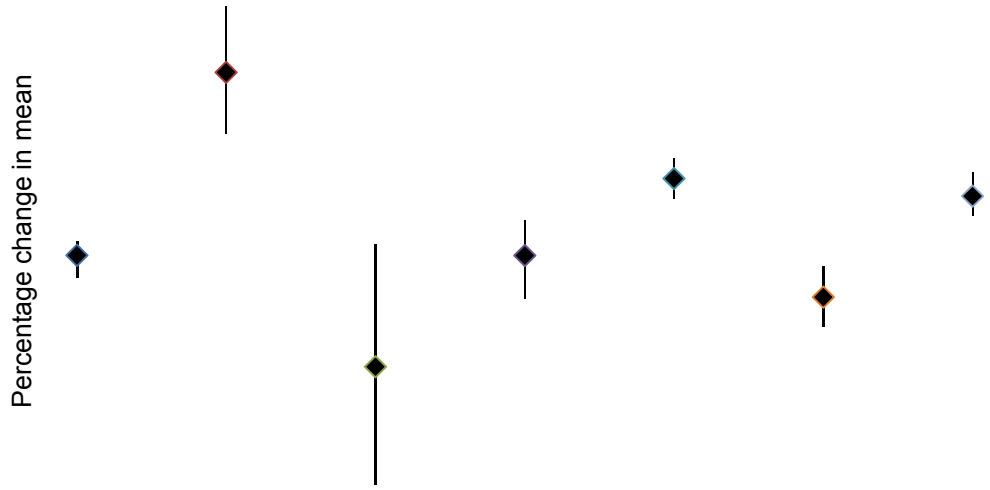

Figure 1: Percentage change in test performance (±90%CL) for 129 children (43 male, 86 female) aged 4-9 years.

CONCLUSION: Nine weeks of gymnastics training had a beneficial effect on abdominal strength, flexibility, coordination and lower body strength in children aged 4-9 years. Gymnastics training may be a useful means of improving some aspects of physical function in children over a nine week period. These data provide useful information on the validity of physical tests, based on the variability of children, but also norms, which should be helpful for practitioners conducting similar physical function testing of children 4-9 years in the future.

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