

The Analysis of Changes in the Physical Fitness of Hong Kong Preschoolers Following the Adoption of an Integrated Physical Fitness Curriculum

Chung, Joanne Wai Yee¹, Wong, Wing Sum², Wong, Thomas Kwok Shing³, Wong, Bonny Yee Man⁴, Kwok, Phoebe Sin Tung⁵, Yan, Vincent Chun Man⁶

¹Chair Professor, ⁵Research Assistant, ⁶Senior Research Assistant,
Department of Health and Physical Education, The Education University of Hong Kong, 10 Lo Ping Road, Tai Po, New Territories, Hong Kong

²Executive Director, Physical Fitness Association of Hong Kong, China, 17/F, Cheuk Nang Centre, 9-11 Hillwood Road, Tsim Sha Tsui, Kowloon, Hong Kong

³Distinguished Professor, School of Nursing, Guangzhou Medical University, 195, Dongfeng Xi Road, Guangzhou, China

⁴Research Officer, School of Public Health, The University of Hong Kong, 3/F The Jockey Club Building For Interdisciplinary Research, 5 Sassoon Road, Pokfulam, Hong Kong

Corresponding Author: Chung, Joanne Wai Yee

ABSTRACT

Background: This paper aimed to evaluate the effects of an integrated physical fitness curriculum on the physical fitness of Hong Kong preschoolers aged 3-6 years over a period of three years.

Methods: Three cross-sectional studies were conducted, one in each of the academic years from 2015/2016 to 2017/2018 on preschoolers' physical fitness. The integrated physical fitness curriculum was implemented in the second term of the three years in all participating kindergartens, with the data collected in the first year as the baseline. The second data collection was done in 2016/2017 and the last one in 2017/2018. The outcome measures included the preschoolers' body mass indices and their physical fitness parameters like sit and reach, standing long jump, bean bags throwing, balance beam walking, and continuous jump with both feet. Ethical approval was obtained from the Human Subjects Ethics Committee of The Education University of Hong Kong.

Results: The study enrolled 11,181, 10,815, and 6,309 preschoolers in the academic years 2015/2016, 2016/2017, and 2017/2018 respectively. The participants aged 4, 5, and 6 demonstrated significant improvement in most physical fitness parameters in 2016/2017 and 2017/2018 as compared with those of the same age in 2015/2016. Those aged 3, who had never been exposed to any of the interventions, had poorer performance in most physical fitness

parameters. Significant improvements in both body mass indices and their physical fitness parameters were evidenced after the interventions.

Conclusion: An integrated physical fitness curriculum can enhance the physical fitness of Hong Kong preschoolers for better health.

Keywords: preschoolers, physical fitness, integrated physical fitness curriculum, kindergartens, education

INTRODUCTION

Physical fitness deficiency among preschoolers

Engaging children in physical activity is a global public health concern [1-3] for it was reported in a systematic review that about half of the children aged 2-6 did not have sufficient physical activity. [3] These preschoolers (aged 2-6) were more likely to spend time in sedentary behavior. [4] As physical inactivity predisposed children to childhood obesity, this led to increased risks for chronic non-communicable diseases in later adulthood. [5] However, if physical activity was established as a habit at a young age it tended to last for the rest of a person's life. [6-7] Actions were, therefore, called for to increase children's physical activities; [2,8] and interventions at an early age is

particularly crucial.

Insufficient time for physical activity

Physical fitness refers to an individual's state of health and energy that enables one's participation in various types of physical activity in daily life. [9] Developing children's physical fitness has, indeed, been put as a top priority in the kindergarten curriculum. [10,11] To this end, recent physical activity recommendation for preschoolers in the US was at least 180 minutes of such activity (at any intensity) each day. [12-13] The Society of Health and Physical Educators (SHAPE America) of America recommended full-day childcare to provide at least 120 minutes of active daily play to young children. [14]

Back in Hong Kong, the Curriculum Development Council recommended that kindergarteners in half-day (3 hours at kindergarten) and full-day (6 hours at kindergarten) kindergartens should be allocated 45 to 60 minutes and 60 to 105 minutes respectively of activities for physical fitness, music, and arts routines. [11] For a child studying in a full-day kindergarten, only 20 to 35 minutes were allocated to physical activities (another 20 to 35 minutes for music, 20 to 35 minutes for arts). Such time allocation was far less than the minimum of 120 minutes recommended in the guideline of the Society of Health and Physical Education in the US. This finding implied that the physical fitness of Hong Kong preschoolers might have been adversely affected, and more ways have to be found to create conducive environments for physical fitness development.

An insight into the problem can be obtained from a local review which reported that the physical fitness of Hong Kong people was declining and more than 60% of the people exercised less than 30 minutes per week or walked 8,000 steps a day. [15] However, this review did not cover preschoolers aged 6 or below, and there were minimal studies in preschoolers (aged below 6). To supplement the evidence on declining physical fitness, another local case

study revealed that 6 out of 10 preschoolers were overweight, [16] which deserves immediate attention. Overweight or obesity was associated with physical inactivity [17-18] whereas good fundamental motor skills were reported to have a high correlation with vigorous physical activities and outdoor activities. [19-20] Preschoolers spending insufficient time on physical activity are at risk in their physical healthy development. To address the issue on the physical fitness of Hong Kong preschoolers, in the academic year 2015/2016, the research team of this study took up the challenge, and initiated and organized a 3-year "Jockey Club Keep-Fit Formula for Children Programme" as a pioneering attempt to evaluate the effects of the integrated physical fitness curriculum on preschoolers.

MATERIALS AND METHODS

Participants

The research team invited, by mail, all (n=1000) [21] kindergartens in Hong Kong and their students to participate in the study in 2015-2016, 2016-2017, and 2017-2018.

Intervention

Preschoolers spend several hours a day in their kindergartens. To increase their exposure to physical activity, kindergartens need curricula that promote physical activity with learning. The research team, therefore, introduced an integrated physical fitness curriculum (hereinafter referred to as 'the integrated curriculum'), which was developed and implemented by the Physical Fitness Association of Hong Kong (PFAHK) in the participating kindergartens as the intervention of the study. The integrated curriculum consisted of a series of cross-disciplinary learning activities that integrated academic learning with physical activity and health concepts in the kindergartens. The curriculum focused on five key learning areas:

- (1) Fit X Language - lessons for integrating physical activity with language. For example, preschoolers

played spelling games using vocabularies related to sports.

(2) Fit X Intelligence - lessons for integrating physical activity with mathematics, science & technology. For example, preschoolers used appropriate tools to measure the size of courts and fields.

(3) Fit X Self - lessons for integrating physical activity with self & society. For example, preschoolers set their own goals when participating in physical activities and trying to improve themselves.

(4) Fitness X People - lessons for integrating physical activity with other people & the world. For example, preschoolers used communication skills to collaborate with fellow classmates in physical activities.

(5) Fit X Arts - lessons for integrating physical activity with music & arts. For example, preschoolers built up aesthetic sensitivity through watching a dance performance.

All these learning activities were designed to focus on preschoolers' lower back and hamstring flexibility, lower limb strength and jumping skills, upper limb strength and throwing skills, balance, and coordination and jumping skills. They were incorporated into the classroom programs through the integrated curriculum. It consisted of a series of twelve lesson plans for each cross-disciplinary topic, developed for each of the three grades in kindergarten education. As a result, a total of 144 lesson plans were released for the five cross-disciplinary topics and the three grades in the three years.

To provide support to kindergartens, the research team allocated 6 hours of professional consultation to each kindergarten on a monthly basis. In-service training in the form of webinars and on-line learning were also organized to equip kindergarten teachers with the required knowledge, skills, and abilities to carry out the intervention.

Outcome measures

To determine which physical fitness parameters were used in this study, the research team had made reference to Mainland China's National Fitness Survey, a nation-wide survey conducted every 5 years. The survey covered people aged 3 to 69 and was first started in 2000. [22] Another reference was made to a local Physical Fitness Test for the Community which was conducted in 2011-12, [23] with same tests adopted by the National Fitness Survey. Among all participants in the local test, 584 were preschoolers aged 3 to 6 from 18 kindergartens. [23] Each preschooler was tested in the physical activities of sit-and-reach (cm), standing long jump (cm), tennis ball throwing (m), 10m x 2 shuttle run (s), balance beam walking, and continuous jump with both feet. Basing on the above, the research team adopted these physical fitness parameters and made operational changes to fit in with the local environments of Hong Kong kindergartens in the current study. The physical fitness parameters, as a result, included body mass index (BMI), sit-and-reach (cm), standing long jump (cm), bean bags throwing (m), balance beam walking, and continuous jump with both feet.

Data collection

The research team conducted three cross-sectional surveys in the three consecutive academic years from 2015/2016 to 2017/2018 with the implementation of the integrated curriculum as the intervention starting in the second term of 2015/2016.

Between December 2015 and August 2018, data on children's physical fitness (e.g., weight and height, test scores for sit and reach, standing long jump, bean bags throwing, continuous both-leg jump, and balance beam walking) were measured by the trained teachers in all participating kindergartens.

The data collected in the first term of the academic year 2015/2016 served as the baseline for comparison in the two ensuing years. Intervention targeted at children (principals and teachers) were implemented

in the academic year of 2015/2016. A second data collection was carried out in 2016/2017. Interventions continued, and then followed by the last data collection in 2017/2018.

STATISTICAL METHODS

The 2015/2016 were the baseline data without intervention. Therefore, the 2015/2016 data were used as the comparators for the 2016/2017 and 2017/2018. The body mass index (BMI) was calculated using the BMI formula and percentile calculator for children and teens (ages 2 to 19 years) on the website of Centers for Disease Control and Prevention (CDC) (<https://www.cdc.gov/healthyweight/bmi/calculator.html>). The differences between the BMI calculation between a child and an adult are that age and gender are required for determining the child's BMI percentile

and class. The BMI of the children at year 2015/2016 was used as the baseline (because the children in the year had not yet received any intervention). Then any BMI changes at year 2016/2017 and year 2017/2018 were ascertained using independent t-tests. Similarly, changes in preschoolers' performance in physical fitness in 2016/2017 and 2017/2018 were also compared with the baseline data in 2015/2016 by independent t-tests. All tests were considered as statistically significant at $p < 0.05$.

RESULTS

A total of 97 kindergartens accepted the invitation. All of their preschoolers (n=11,181) joined the study in 2015/2016. In the ensuing two academic years, a smaller number of 10,815 and 6,309 preschoolers respectively participated in the study.

The regional distribution of the kindergartens is shown in Table 1.

District*	Number of Participated Pre-schooler in District	Total Number of Pre-schooler in District [#]	Participation Rate (%)
Total	21,629	185,398	11.7
Hong Kong Island			
Central and Western	490	6,057	8.1
Eastern	744	12,357	6.0
Southern	723	4,820	15.0
Kowloon			
Kwun Tong	1,784	12,369	14.4
Sham Shui Po	1,673	9,442	17.7
Wong Tai Sin	1,665	7,644	21.8
YauTsimMong	568	6,469	8.8
New Territories			
Kwai Tsing	2,806	10,773	26.1
North District	1,427	12,970	11.0
Sai Kung	878	9,177	9.6
Sha Tin	2,080	14,460	14.4
Tai Po	101	6,865	1.5
Tsuen Wan	2,268	6,933	32.7
TuenMun	1,763	13,390	13.2
Yuen Long	2,476	17,752	14.0
Islands	183	3,626	5.1
*	There are 18 districts in Hong Kong. No pre-schooler was participated in 2 districts: Wan Chai (Hong Kong Island) and Kowloon City (Kowloon)		
#	The total numbers of pre-schooler in different district is adopted from the report "2015/16 Student Enrolment Statistics (Kindergarten, Primary and Secondary Levels)", Education Bureau of HKSAR (School Education Statistics Section, 2016)		

Cross-sectional analysis

Table 2 shows the BMI of the boys over the 3 years. The BMI of those aged 3 years or younger was significantly higher in 2016/2017 ($p < 0.001$) and 2017/2018 ($p < 0.001$). On the contrary, the other groups of boys had significantly lower BMI. These phenomena occurred in 2016/2017 ($p = 0.001$) for the boys aged 3-4 years, in 2016/2017 ($p = 0.006$) and

2017/2018 (p=0.034) for the boys aged 4-5years, and in 2016/2017 (p=0.046) and 2017/2018 (p=0.001) for the boys older than 5 years of age.

Table 2: Physical fitness of the boys in 2015/2016, 2016/2017, and 2017/2018

Boys	2015/2016 (n=6,040)		2016/2017 (n=5,729)			2017/2018 (n=3,382)		
	Mean	SD	Mean	SD	p-value	Mean	SD	p-value
3 years or younger								
Body Mass Index	14.0	0.75	15.9 [#]	1.63	<0.001	15.9 [#]	1.16	<0.001
Sit and reach (cm)	5.9	4.8	5.2 [@]	4.6	<0.001	6.0	5.0	0.782
Standing long jump (cm)	52.6	22.0	46.6 [@]	22.3	<0.001	44.8 [@]	22.0	<0.001
Throw bean bags (m)	2.6	1.2	2.4 [@]	1.2	<0.001	2.5 [@]	1.5	0.002
Walk balance bar (sec)	20.5	12.6	22.5 [@]	14.1	<0.001	20.7	12.0	0.700
Double-leg jump (sec)	12.3	6.2	13.0 [@]	5.8	<0.001	13.5 [@]	6.7	<0.001
3-4 years								
Body Mass Index	15.8	1.39	15.6 [@]	1.38	0.001	15.8	1.45	0.972
Sit and reach (cm)	5.3	5.0	5.0 [@]	4.8	0.015	5.1	5.3	0.283
Standing long jump (cm)	69.4	23.0	71.7 [#]	21.7	<0.001	71.2 [#]	23.9	0.015
Throw bean bags (m)	3.2	1.3	3.4 [#]	1.4	<0.001	3.4 [#]	1.7	<0.001
Walk balance bar (sec)	17.8	10.8	16.8 [#]	10.8	<0.001	17.5	9.9	0.385
Double-leg jump (sec)	10.2	5.2	9.2 [#]	4.2	<0.001	9.2 [#]	4.2	<0.001
4-5 years								
Body Mass Index	15.8	1.53	15.5 [@]	1.55	0.006	15.5 [@]	1.37	0.034
Sit and reach (cm)	5.4	5.6	4.2 [@]	5.6	<0.001	4.4 [@]	6.3	<0.001
Standing long jump (cm)	86.1	23.6	89.5 [#]	22.4	<0.001	87.7 [#]	25.1	0.016
Throw bean bags (m)	4.0	1.4	4.1 [#]	1.5	0.002	4.2 [#]	1.7	0.001
Walk balance bar (sec)	14.2	9.0	13.4 [#]	9.3	<0.001	14.2	8.8	0.858
Double-leg jump (sec)	8.0	4.0	7.1 [#]	3.0	<0.001	6.9 [#]	2.6	<0.001
Older than 5 years								
Body Mass Index	15.7	1.83	15.6 [@]	2.06	0.046	15.5 [@]	1.82	0.001
Sit and reach (cm)	4.4	5.6	4.2	5.9	0.404	4.5	5.9	0.921
Standing long jump (cm)	94.6	26.9	100.6 [#]	21.8	<0.001	89.9 [@]	29.9	0.004
Throw bean bags (m)	4.5	1.6	4.5	1.6	0.486	4.3 [@]	1.6	0.029
Walk balance bar (sec)	12.6	9.0	12.0	8.5	0.069	12.7	7.6	0.904
Double-leg jump (sec)	7.3	4.0	6.7 [#]	2.9	<0.001	6.6 [#]	2.9	<0.001

[#] significant improvement in physical fitness performance
[@] significant deterioration in physical fitness performance

Table 3: Physical fitness of the girls in 2015/2016, 2016/2017, and 2017/2018

Girls	2015/2016 (n=5,141)		2016/2017 (n=5,086)			2017/2018 (n=2,927)		
	Mean	SD	Mean	SD	p-value	Mean	SD	p-value
3 years or younger								
Body Mass Index	14.9	1.78	15.5	1.29	0.124	15.7	1.08	0.114
Sit and reach (cm)	7.1	4.4	6.3 [@]	4.5	<0.001	6.7 [@]	4.8	0.041
Standing long jump (cm)	52.3	20.2	44.4 [@]	19.7	<0.001	43.5 [@]	19.8	<0.001
Throw bean bags (m)	2.5	1.0	2.3 [@]	1.0	<0.001	2.2 [@]	1.4	<0.001
Walk balance bar (sec)	19.3	11.1	21.9 [@]	13.3	<0.001	20.7 [@]	11.6	0.002
Double-leg jump (sec)	12.1	5.8	13.2 [@]	5.7	<0.001	13.1 [@]	6.3	<0.001
3-4 years								
Body Mass Index	15.5	1.34	15.4	1.38	0.079	15.5	1.34	0.533
Sit and reach (cm)	7.0	4.7	6.5 [@]	5.1	<0.001	6.9	4.7	0.478
Standing long jump (cm)	65.6	20.2	68.0 [#]	18.3	<0.001	67.9 [#]	21.7	0.002
Throw bean bags (m)	2.9	1.1	3.0 [#]	1.1	<0.001	3.2 [#]	1.5	<0.001
Walk balance bar (sec)	17.9	10.6	17.3 [#]	10.8	0.018	18.1	10.1	0.540
Double-leg jump (sec)	10.1	4.8	9.2 [#]	4.0	<0.001	8.8 [#]	3.8	<0.001
4-5 years								
Body Mass Index	15.4	1.46	15.2 [@]	1.43	<0.001	15.3 [@]	1.41	0.002
Sit and reach (cm)	6.8	5.2	6.4 [@]	5.2	<0.001	6.4 [@]	6.2	0.028
Standing long jump (cm)	79.5	21.3	83.9 [#]	20.3	<0.001	83.5 [#]	23.2	<0.001
Throw bean bags (m)	3.6	1.3	3.7	1.3	0.056	3.9 [#]	1.5	<0.001
Walk balance bar (sec)	15.1	9.5	13.8 [#]	9.2	<0.001	15.3	9.0	0.339
Double-leg jump (sec)	8.2	4.2	7.1 [#]	3.2	<0.001	7.1 [#]	2.9	<0.001
Older than 5 years								
Body Mass Index	15.4	1.72	15.3 [@]	2.04	0.037	15.1 [@]	1.62	<0.001
Sit and reach (cm)	6.6	5.6	6.6	6.1	0.968	5.8 [@]	5.5	0.012
Standing long jump (cm)	87.2	24.5	93.8 [#]	18.8	<0.001	86.2	27.3	0.561
Throw bean bags (m)	4.0	1.5	4.2 [#]	1.4	0.018	4.1	1.4	0.539
Walk balance bar (sec)	13.1	8.9	11.8 [#]	7.5	<0.001	12.2	7.2	0.068
Double-leg jump (sec)	7.4	4.2	6.6 [#]	2.7	<0.001	6.3 [#]	2.1	<0.001

[#] significant improvement in physical fitness performance
[@] significant deterioration in physical fitness performance

Table 3 shows the BMI of the girls over the 3 years. There were no significant changes over the years for the girls aged 3 years or younger and 3-4 years. However, significantly lower BMI was identified in 2016/2017 ($p < 0.001$) and 2017/2018 ($p = 0.002$) for the girls aged 4-5 years and in 2016/2017 ($p = 0.037$) and 2017/2018 ($p < 0.001$) for the girls older than 5 years of age.

Physical fitness performance

As revealed in Table 2, the physical fitness performance of the boys aged 3 years or younger was significantly poorer in 2016/2017. They had poorer performance in sit-and-reach (lower back and hamstring flexibility), standing-long-jump (lower limb strength and jumping skills), throw-bean-bags (upper limb strength and throwing skills), walk-balance-bar (balance) and double-leg-jump (coordination and jumping skills); whereas in 2017/2018, boys had poorer performance in standing-long-jump, throw-bean-bags, and double-leg-jump. As shown in Table 3, girls aged 3 years or younger in 2016/2017 and 2017/2018 had poorer performance in sit-and-reach (lower back and hamstring flexibility), standing-long-jump (lower limb strength and jumping skills), throw-bean-bags (upper limb strength and throwing skills), walk-balance-bar (balance), double-leg-jump (coordination and jumping skills).

In 2016/2017 the boys and girls aged 3-4 years had significant improvements in the outcome parameters of standing-long-jump, throw-bean-bags, walk-balance-bar, and double-leg-jump, whereas in 2017/2018 they significantly performed better in standing-long-jump, throw-bean-bags and double-leg-jump (Tables 2 and 3). Both boys and girls, however, had significantly poorer performance in sit-and-reach in 2016/2017.

In 2016/2017 the boys aged 4-5 years had better performance in standing-long-jump, throw-bean-bags, walk-balance-bar, double-leg-jump, but worse performance in sit-and-reach (Table 2). As for the girls of

the same age in 2016/2017, they had better performance in standing-long-jump, walk-balance-bar, and double-leg-jump, but worse performance in sit-and-reach (Table 3). In 2017/2018, both boys and girls performed better in standing-long-jump, throw-bean-bags and double-leg-jump, but worse in sit-and-reach.

In 2016/2017 and 2017/2018 the boys older than 5 years of age had significantly better performance in standing-long-jump and double-leg-jump (Table 2). In comparison, girls in the same age group in 2016/2017 and 2017/2018 had significantly better performance in only double-leg-jump (Table 3).

DISCUSSION

In implementing the integrated curriculum as the intervention, the kindergartens did not need to allocate additional time for physical activity. All existing lessons were embedded with physical activity introduced under the integrated curriculum. This provided more opportunities for preschoolers to exercise and train their motor abilities while they were learning language, mathematics, arts, and so on. The findings in this study provided good evidence of positive effects of the integrated curriculum on the physical fitness of the preschoolers across different age groups. These effects included improvements in their BMI, and their

1. lower back and hamstring flexibility (as evidenced in the sit-and-reach test),
2. lower limb strength and jumping skills (as evidenced by the standing-long-jump test),
3. upper limb strength and throwing skills (as evidenced by the throw-bean-bags-test),
4. balancing skills (as evidenced by the walk-balance-bar test), and
5. coordination and jumping skills (as evidenced by double-leg-jump test).

Preschooler older than 3 years had better fitness performances than the baseline scores in 2015/2016 suggesting that the

intervention was effective in improving children's physical fitness even though it was less effective for the group older than 5 years of age. This group had busy schedules in preparing for graduation from kindergartens, attending admission interviews for primary school places, and taking part in various activities sponsored by the government. Hence there is a need to explore ways to sustain the benefits of the intervention in view of potential interrupting activities.

BMI is a good indicator of health. [24] The integrated curriculum increased the preschoolers' time for exercise by incorporating physical activity into the subject matters of all lessons. The increased exercise time improved preschoolers' health while satisfying their learning needs at the same time. Their health improvement was reflected by an increase in the BMI after the intervention. As mentioned before, a habit for physical activity is better to be cultivated at an early age. The findings in this study suggest that the integrated curriculum is important to quality preschool education.

Although integrating physical activity in normal classes was found in this study to be an effective means for improving preschoolers' physical fitness. The caveats, however, is that the results in this study came from small samples and have to be interpreted with caution, and future studies should use larger samples to ensure greater predictive power in the statistical analyses. Also, this study recommends that it is helpful to engage kindergarteners in physical activity if it is interesting, appealing, convenient, motivating, enjoyable, social, sustainable, and related to daily lives.

Despite considerable efforts made by the research team, there was a substantial drop in the number of participants in 2017/18 due to the introduction of various new policies by the government during that year, for example, promoting countryside adventures to study nature, [25-26] implementing the Free Quality Kindergarten Education Scheme. [27]

This drop at the later stage affected the predictive power of the study.

CONCLUSION

The integrated physical fitness curriculum has demonstrated a positive impact on the kindergarteners, with significant improvements in their physical fitness after having participated in the "Jockey Club Keep-Fit Formula for Children Programme". With better physical activity engagement in early childhood, children can have better physical health that can extend to their adulthood.

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