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The Effects of Fun Swimming Game Intervention on Forced Vital Capacity and Peak Flow Rate of 5–6 Year-Old Children

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Abstract

Purpose: This study was to determine the effect of fun swimming games (FSG) on forced vital capacity (FVC) and peak flow rate (PFR). **Methods:** Sixty healthy children aged 5–6 were randomly assigned to the FSG group or the control group, with 30 subjects in each. Takei FVC machine and Mini Wright peak flow meter were applied for measurement of FVC and PFR, respectively. FSG group received one-hour water play and swimming instruction, once weekly, for 12 consecutive weeks while the control group did not. **Results:** No significant initial pre-test difference was found in age, height, weight, body mass index (BMI), FVC, or PFR between groups. After three months of FSG intervention, in the FSG group, the FVC and PFR were significantly increased (0.74 ± 0.22 to 0.83 ± 0.24 L, $p < .05$ and 122.30 ± 34.48 L/min to 129.83 ± 32.04 L/min, $p < .05$). However, the control group FVC and PFR reminded unchanged ($p > .05$). **Conclusion:** The research showed that one hour FSG for children improved respiratory parameters (FVC and PFR) when the exercise was done once a week one hour each session for three months.

Keywords: physical activity, respiratory function, water pool play

戲水游泳對5～6歲孩童肺活量與最大呼氣流速的效果

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摘要

目的：在觀察趣味的戲水游泳對於孩童肺活量與最大呼氣流速的效果。**方法**：總共60個5～6歲的健康孩童隨機分派在戲水游泳組與對照組，每組各30人。肺活量與最大呼氣流速分別以竹井（Takei）肺活量計與迷你賴特（Wright）流量計加以測量。戲水游泳組每週接受一小時的水上遊戲與游泳教學，連續12週，對照組則不做類似教學活動。**結果**：兩組間年齡、身高、體重、身體質量指數、肺活量與最大呼氣流速前測值皆沒有顯著差異。三個月的戲水游泳介入，戲水游泳組的肺活量與最大呼氣流速顯著的增加（分別由0.74 ± 0.22增至0.83 ± 0.24 L, $p < .05$與由122.30 ± 34.48增至129.83 ± 32.04 L/min, $p < .05$）。對照組的肺活量與最大呼氣流速沒有顯著

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變化（$p > .05$）。**結論**：本研究顯示為期12週每週1次每次1小時的戲水游泳顯著增加孩童肺活量與最大呼氣流速等呼吸測量參數。

關鍵詞：身體活動、呼吸功能、泳池遊戲

Background

Young children need active play in their lives. Physical activity (PA) has been found to be beneficial for children's development, and to have a positive effect on health and fitness. The National Association for Sport and Physical Education (NASPE) (1998) of the United States recommends children should engage in PA for at least 150 minutes per week. The PA component should be enjoyable and valuable in order for children to learn to associate the benefits of exercise with happiness (King & Ling, 2015).

There are many beneficial results of PA for young children, such as maintaining a healthy weight, developing strong bones, enhancing movement patterns, and improving motor skills. In addition, they can learn to socialize with others (Commonwealth of Australia, Departement of Health and Ageing, 2010). A study on exercise habits in children aged 10–13 found that after four days of observation there was a significant increase in children's PA if the children were engaged in social play (Mackett & Paskins, 2008). The increased PA and play led to measurable health benefits. All the activities of the children were in the local environment around their homes. The children's improvement of PA was related to playing and joining outdoor activities away from their homes (Mackett & Paskins, 2008). Similarly, Bjørgen (2016) found that PA helped children to develop social relations and those who engaged in PA were happier than those who did not. In a study "evidence based physical activity for school-age youth" recommended children and young people should undertake a minimum of 60 minutes of moderate to vigorous activity every day (Strong et al., 2005). This is also supported by the British Heart Foundation National Center for Physical Activity and Health (2014), which claimed that when children engage in 60 minutes of PA every day, they would improve their health.

If children participate in the PA they will get many advantages. A study on PA during physical education class in elementary school measured over two years (3 times/week) found that the physical education class enhanced physical fitness (Sallis et al., 1997).

The benefit of PA on the respiratory system was proved. An experimental swimming program for children and adolescents over the course of three months was conducted (Wicher et al., 2010). All participants had a total of 24 session training program, one hour each session, for 12 weeks. These findings were compared to the control group that did not have. The experimental group demonstrated a significant decrease in bronchial hyperresponsiveness (BHR) and improved lung function over the control group.

High PA and improvement of pulmonary function are positively correlated (Eijkemans, Mommers, Draaisma, Thijs, & Prins, 2012). Several studies about the influence of respiratory function of swimming exercise have been examined (Karapolat et al., 2009; Sable, Vaidya, & Sable, 2012; Sumartiningsih & Setiowati, 2011; Swenson & Agre, 2015; Wang & Hung, 2009). The improvement of peak flow rate (PFR) and forced vital capacity (FVC) was identified. Swimming is also considered to be beneficial even for asthmatic children, as the humidity of a swimming pool is considered protective against exercise-induced bronchoconstriction.

The parameters of respiratory function can be measured by FVC and PFR (Azad, Gharakhanlou, Niknam, & Ghanbari, 2011; Dugdale & Moeri, 1968; Eigen et al., 2001; Milner & Ingram, 1970). The equipment to measure FVC and PFR is relatively inexpensive and can be used effectively without specialized training, and it can also be safely used to obtain data from younger children (Dugdale & Moeri, 1968).

The study of the effect of PA on pulmonary function for pre-school children was limited so far. Therefore, the present study aims to determine if water play and swimming improve children's lung function. The information gained from this study can help parents, teachers, and coaches to improve the health of children.

Methods

Sixty 5–6 year-old children were recruited. The parents of participants agreed and gave written informed consent. The participants were divided into fun swimming game group (FSG) and control group, 30 members for each. Gender difference was not considered in grouping since previous researchers concluded that sex does not influence the respiratory function for normal children aged 3–6 (Eigen et al., 2001).

All participants attended a one-hour regular physical education class once a week. They did not have any previous swimming experience before the study. The FSG group participated in 12 sessions (one per week, for 60 minutes), while the control group kept their regular daily life. During study period, all children attended regular one hour PA class. Data were taken when the children were physically fit and healthy.

As shown in Table 1, the FSG program aims to attract participants to join in the PA, especially swimming and reduce the fear of the water (pool depth, 50–100 cm). Each FSG training session consisted of 10 minutes of warming up, 10 minutes of individual practice, 20 minutes of pairs practice, 15 minutes of games and 5 minutes of cooling down. The entire FSG program was designed into four parts: adaptation, easy, moderate to hard, and the primary lesson of breaststroke swimming. During the first part, participants were encouraged to play games in the water, such as running and walking. During the second part, children had fun with throwing and catching the ball as well as hiding and seeking. As for third part, cat & mouse, hula-hoop and finding a coin was conducted to encourage the participants to play with more brave and to be more comfortable in the water. The last part, the participants tried to practice all segments of breaststroke style.

The pre- and post-intervention data were collected and compared. The FVC and PFR were evaluated. A Takei vital capacity meter, model T.K.K.11510 vital, made in Japan was used to measure FVC. The subjects stood and took a maximum inhaled breath then slowly but maximally exhaled all of the air. An adequate test requires a minimum of three acceptable FVC maximum exhalations. Acceptable repeatability is achieved when the difference between the largest and the next largest FVC is ≤ 0.150 L (Miller et al., 2005). A Mini-Wright (low range) EN 23,747-peak flow meter manufactured in England applied to test the subjects' PFR. Each subject stood to exhale, the highest value from at least three acceptable blows was recorded (Miller et al., 2005).

The main training principle was to make children feel comfortable in the water. Once the subjects felt comfortable, the coach introduced some basic lessons of breaststroke style of swimming. According to plan, water games and breaststroke swimming reinforced each other. Furthermore, the coaches carefully observed and tried to ensure the funny of the activity.

For both FSG and control groups, data were analyzed using IBM SPSS 20 to determine the means and standard deviation for the

Table 1. FSG training program

Week		Major activity	Set	Rep	Time (min)	Rest (min)
1	Kicking & walking on pool	Sitting by the pool, kicking the leg in the water up & down.	5	8	8	2
		Shuttle Walk on the pool distance 5 m.	5	8	18	2
		5 group games faster walking into finish line.	6	5	15	0
2	Running on pool	Shuttle walk on the pool distance 5 m.	5	8	8	2
		Shuttle run on the pool distance 5 m.	5	8	18	2
		5 group games faster run into finish line.	6	5	15	0
3	Throw & catch the ball	In group throwing & catching the ball on the pool.	5	8	8	2
		In pairs throwing & catching the ball on the pool.	5	8	18	2
		5 group games throwing catching then shoot into basket.	6	5	15	0
4	Hiding & seeking	Practice hide on the pool with exhale & seek up inhale.	5	8	8	2
		In pairs practice hide & seek (exhale & inhale on the pool).	5	8	18	2
		5 group games count odd (hide) & even (seek).	6	5	15	0
5	Cat & mouse	Practice on the pool mouse is to exhale make bubbles as much as can & cat is up to inhale open mouth.	5	8	8	2
		In pairs practice 5–10 sec exhale on the water.	5	8	18	2
		5 group games cat catch the mouse.	6	5	15	0
6	Hula-hoop	In pairs practice make a bubbles from the left to the right.	5	8	8	2
		In pairs practice go inside vertical hula-hoop on the pool.	5	8	18	2
		5 group games of open mouth of the dragon.	6	5	15	0
7	Find a coin	Practice touch the floor of the pool.	5	8	8	2
		Practice touch the toe of their pairs.	5	8	18	2
		5 group games of collect the coin as much as possible.	6	5	15	0
8	Floating	Practice stand, hand, leg, and head position to float.	5	8	8	2
		Practice float to reach their pairs.	5	8	18	2
		5 group games of take the ball with floating.	6	5	15	0
9	Leg movement	Practice legs movement on the breaststroke style.	5	8	8	2
		In pairs practice legs movement reach a certain distance.	5	8	18	2
		5 group games of inside the ring of hula-hoop.	6	5	15	0
10	Arm movement	Practice arms movement on the breaststroke style.	5	8	8	2
		In pairs practice arms movement reach a certain distance.	5	8	18	2
		5 group games of inside the ring of hula-hoop.	6	5	15	0
11	Breathing practice	Breathing two times legs and one time arms movement.	5	8	8	2
		In pairs practice breathing reach a certain distance.	5	8	18	2
		5 group games of inside the ring of hula-hoop.	6	5	15	0
12	Practice full style	In pairs practice full segment of breaststroke style.	5	8	8	2
		In pairs practice full segment to reach a certain distance.	5	8	18	2
		5 group games of swim to the finish line.	6	5	15	0

Note: (1) The FSG group and the control group had general physical education classes on Wednesday, the FSG group added swimming games on Saturday, and the control group rested on Saturday. (2) Each lesson included a 10-minute warming up and a 5-minute cooling down. Rep: repetition; FSG: fun swimming games.

different variables. The normality test was conducted. According to test result, a paired *t*-test was used for pre- and post-height data with normal distribution. And Wilcoxon test was applied to test the pre and post weight, body mass index (BMI), FVC, and PFR data which normal distribution did not achieve. The Mann-Whitney test was used to compare variables between control group and FSG group. A p value < .05 was considered to be statistically significant.

Results

Parametric analysis of BMI, FVC, and PFR by unpaired *t*-test are shown in Table 2. From the data, the differences of age, height, weight, BMI, FVC, and PFR were not significant between the control group and the FSG group.

After a three-month intervention, there were significant differences in height, weight, and BMI between pre and post measurements in the control group. However, there was no significant difference in FVC and PFR in the control group as shown in Table 3.

The FSG group data showed significant differences between pre and post in height and BMI, but not in weight. As seen in Table 3, the FVC and PFR were also improved.

Discussion

Even though swimming game for 5–6 years old children is not available, a study of swimming intervention effects on FVC and PFR for children in 7–12 years old was reported (Wang & Hung, 2009). Significant improvement was found in PFR but FVC remain unchanged

Table 2. Baseline characteristics of participants

Variables	Control group	FSG group	*p* value
n	30	30	
Male	15	15	
Female	15	15	
Age (years)	5.54 ± 0.09	5.43 ± 0.09	NS
Height (m)	1.13 ± 0.06	1.12 ± 0.07	NS
Weight (kg)	21.02 ± 6.43	21.56 ± 6.69	NS
BMI (kg/m^2)	16.27 ± 3.47	16.98 ± 3.73	NS
FVC (L)	0.72 ± 0.36	0.74 ± 0.22	NS
PFR pre (L/min)	122.69 ± 24.09	122.30 ± 34.48	NS

Note: FSG: fun swimming games; BMI: body mass index; FVC: forced vital capacity; PFR: peak flow rate.

Table 3. Pre and post measurements in the control and FSG groups

Variable	Control group		FSG group	
	Pre	Post	Pre	Post
Height (m)	1.13 ± 0.06	1.16 ± 0.05§	1.12 ± 0.07	1.15 ± 0.08§
Weight (kg)	21.02 ± 6.43	21.85 ± 6.46*	21.56 ± 6.69	21.67 ± 6.64
BMI (kg/m^2)	16.27 ± 3.47	15.98 ± 3.38*	16.98 ± 3.73	16.13 ± 3.56*
FVC (L)	0.72 ± 0.36	0.69 ± 0.31	0.74 ± 0.22	0.83 ± 0.24*¶
PFR (L/min)	122.69 ± 24.09	123.26 ± 37.60	122.30 ± 34.48	129.83 ± 32.04*

Note: $^*p$ < .05, Wilcoxon test; $^§p$ < .05, paired *t*-test; $^¶p$ < .05, Mann-Whitney test, test between control group and FSG group. FSG: fun swimming games; BMI: body mass index; FVC: forced vital capacity; PFR: peak flow rate.

following a 6 weeks of training program, 3 times a week, 50 minutes each time.

The major finding of this study is that a simple activity in one-time-per-week FSG intervention could improve respiratory functions in children aged 5–6 years old.

PA participation has been shown to play an essential role in developing the respiratory functions of children. The survey studied PA and lung function growth in Guangzhou Chinese School children. The 1,713 school children (858 boys and 855 girls) ages between 9–11 years during an 18-month period were tested. The study found that the active PA girls had higher FVC than inactive girls (1.79 vs. 1.75 L). The reduction in lung function growth only found in girls with inactive of PA (Ji, Wang, Liu, & He, 2013). Similarly, a survey of PA participation based on training frequency of (1) less than once a week, (2) once a week, (3) 2–3 times a week, and (4) four or more times a week was investigated (Berntsen, Wisløff, Nafstad, & Nystad, 2008). A correlation was found between FVC increment and PA frequency. Cross-sectional evidence showed that PA engagement was positively associated with lung functions.

Longitudinal studies investigated effects of PA on respiratory function also showed PA has led to increments in FVC and PFR (Azad et al., 2011; Eigen et al., 2001; Karapolat et al., 2009; Sumartiningsih & Setiowati, 2011; Wicher et al., 2010). However, it should be noted that these findings were mostly derived from adult populations. This study demonstrated that one-hour of FSG a week for three months also had positive effects on children's respiratory systems. To our knowledge this is the first study demonstrating health benefits in such young children. Indeed, the increment of FVC and PFR is important to children's cardiopulmonary fitness because more air with oxygen can be delivered into body tissue in each breath (Fitzgerald, Fitzgerald, Lands, & Selvadurai, 2013). Thus, FSG could be a good choice for physical educators or coaches to promote PA and health for young children since any PA for children should be funny and attractive.

Similar to the control group, height, weight, and BMI in FSG group were significantly changed after intervention, which could be due to the increase in PA level by intervention in swimming pool. Indeed, the reduction of body weight is a well-known effect of PA despite an improved respiratory capacity, airway resistance, exercise tolerance, and work of breathing (Chanavirut, Khaidjapho, Jaree, & Pongnaratorn, 2006).

Swimming is an easily accessible, inexpensive and isotonic exercise form that is suitable for health promotion (Tanaka, 2009). In children, who learn to swim at an early age show advanced development in: motor skills, reaction time, power of concentration, intelligence, social behavior, social interaction, self-confidence, independence, and disentanglement in new and unknown situations. Children who participated in swimming programs were better adapted to lead a healthy lifestyle than those who did not (Amelia, 2012).

There is limitation in the present study since we did not record the activity log and dietary intake during intervention even though students and their parents were all verbally encouraged to maintain their regular diet and activity. All the participants spent most of their daytime in school; courses and food were mostly identically instructed and given. Regardless, we cannot exclude the possibility that PA level and dietary intake may also confound our results.

Conclusion

This study found that one session per week of FSG for three months is effective in improving respiratory parameters (FVC and PFR) in healthy children aged 5–6 years old.

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