

Swimming Exercises Increase Peak Expiratory Flow Rate in Elderly Men

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Abstract Peak expiratory flow rate (PEFR) refers to the maximum velocity of expiration. Because PEFR can quantitatively represent the state of airway stenosis, it is often used as a long-term measurement for bronchial asthma patients with chronically obstructed breathing. Our main aim in the present study was to evaluate the long-term effect of swimming exercises on elderly people by measuring PEFR, and the secondary aim was to investigate whether the effect is gender-associated. Subjects were aged ≥ 65 years and did not have a current or past history of smoking, respiratory diseases, and/or heart diseases (8 men; mean age, 81.8 ± 4.7 years; mean height, 161.1 ± 7.5 cm; mean weight, 59.8 ± 8.0 kg; mean swimming history, 12.6 ± 5.1 years; 13 women; mean age, 77.5 ± 3.5 years; mean height, 149.9 ± 4.2 cm; mean weight, 54.5 ± 8.2 kg; mean swimming history, 12.0 ± 4.4 years). Subjects swam the breaststroke and/or crawl based on their preference for about 25 minutes. All subjects performed swimming exercises in the same swimming facility for 7 months. During this period, all subjects swam once a week and exercised a total of 28 times. PEFR of male subjects gradually increased during the observation period ($P < 0.05$), and significant increases were seen at 16 weeks, 24 weeks, and 28 weeks, compared to first-time measurements ($P < 0.05$). PEFR in elderly males increased by swimming once a week for 28 weeks, while PEFR in elderly females did not significantly change throughout the study period. This may suggest that the PEFR increasing effect of swimming on elderly people is gender-dependent.

Keywords: *swimming, elderly, PEFR, PEF, respiratory function*

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1. Introduction

Peak expiratory flow rate (PEFR) refers to the maximum velocity of expiration. Because PEFR can quantitatively represent the state of airway stenosis, it is often used as a long-term measurement for bronchial asthma patients with chronically obstructed breathing. [1,2] Additionally, PEFR can be easily measured with readily available equipment. Forced expiratory volume for one second expressed as a percentage of forced vital capability (FEV1%) is another indicator for air flow velocity. However, PEFR is superior to FEV1% for detecting slight changes in air flow velocity in patients with reduced respiratory function [3].

Previous studies have shown that swimming exercises more effectively improve respiratory function by increasing FEV1% than land-based exercises. [4,5,6,7] This is because ventilation volume during swimming exercises is significantly restricted by high water pressure. [6,7] However, as mentioned above, FEV1% is not sufficiently sensitive to detect slight changes in air flow in, for example, elderly people with reduced respiratory function.

To date, only a few studies have examined PEFR in elderly people. [8] Moreover, to the best of our knowledge,

there are no reports on the long term effect of swimming exercises on elderly people. Our main aim in the present study was to evaluate the long-term effect of swimming exercises on elderly people by measuring PEFR, and the secondary aim was to investigate whether the effect is gender-associated.

2. Methods

2.1. Subjects

Twenty-one elderly people participated in this study. Subjects were aged ≥ 65 years and did not have a current or past history of smoking, respiratory diseases, and/or heart diseases (8 men; mean age, 81.8 ± 4.7 years; mean height, 161.1 ± 7.5 cm; mean weight, 59.8 ± 8.0 kg; mean swimming history, 12.6 ± 5.1 years; 13 women; mean age, 77.5 ± 3.5 years; mean height, 149.9 ± 4.2 cm; mean weight, 54.5 ± 8.2 kg; mean swimming history, 12.0 ± 4.4 years). Subjects performed swimming exercises periodically before participating in this study, with a mean frequency of 2.6 ± 1.1 times per month.

Five subjects had high blood pressure and two had hyperlipidemia. None of the subjects had problems with

daily activities, nor did any drop out during the study period. All subjects provided informed consent to participate in the study, and all procedures were approved by the Committee of Human Experimentation at Nippon Sport Science University.

2.2. Observation Period and Swimming Frequency

All subjects performed swimming exercises in the same swimming facility for 7 months. During this period, all subjects swam once a week and exercised a total of 28 times.

2.3. PEFR Measurements

PEFR was measured with a Spirometer (Fukuda Industry, ST-100, CHIBA, JAPAN) prior to swimming exercises. When measuring PEFR, subjects wore casual clothing that did not hinder movement and sat down with both legs on the floor and back straight. They breathed in maximally, and then completely breathed out through a mouthpiece with their noses clipped. They practiced several times to accustom themselves to the measurement method.

2.4. Protocol

Before starting the swimming exercises, muscle mass was measured with the bioelectrical impedance method (TANITA BC-525), and subjects stretched on land and in water. Subsequently, subjects swam at their preferred speed. Subjects swam the breaststroke and/or crawl based on their preference for about 25 minutes. Heart rate during swimming was measured with an Accurex heart rate monitor (Polare, JAPAN). Before swimming, mean heart rates of men and women were 68.2 ± 9.2 bpm and 65.8 ± 3.1 bpm, respectively. During swimming, the mean heart rate of men increased to 110.5 ± 9.4 bpm and that of women increased to 111.8 ± 7.6 bpm.

The mean swimming distance was 200.0 ± 50.0 m for men and 211.5 ± 58.5 m for women at the first session, and this extended to 265.4 ± 76.9 m for men and 281.3 ± 55.6 m for women at the final session. Water temperature and chlorine density were maintained at 31.0 ± 1.0 degrees Celsius and 0.42 ± 0.71 mg/l, respectively.

2.5. Statistics

Statistical significance was set at $p < 0.05$ for all analyses. Data for all measurements were presented as mean \pm standard deviation (SD). PEFR and Gender were analyzed by 8x2 repeated measures analysis of variance (ANOVA) with observation period (pre-training and one to seven months) as a within-subjects factor and Gender (male vs. female) as a between-subjects factor. Multiple comparison was performed with Scheffé's post-hoc analysis.

3. Results

PEFR of male subjects gradually increased during the observation period ($P < 0.05$), and significant increases were seen at 16 weeks (7.26 ± 2.21 l/sec), 24 weeks (7.02 ± 2.49 l/sec), and 28 weeks (7.33 ± 2.14 l/sec), compared to first-time measurements (6.05 ± 2.64 l/sec). Furthermore, the PEFR of 16 and 28 weeks were significantly increased as compared with that of one month later (Figure 1). However, no significant difference in PEFR was detected in female subjects, despite the mean value increasing by 0.9% compared to the first-time measurement (4.54 ± 1.06 l/sec). There was no significant interaction effect.

The mean muscle mass of male subjects was 42.9 kg for the first-time measurement, and increased to 45.4 kg (5.8% increase) after 28 weeks. Similarly, the mean muscle mass of female subjects was 34.3 kg for the first-time measurement, and increased to 35.4 kg (3.2% increase) after 28 weeks.

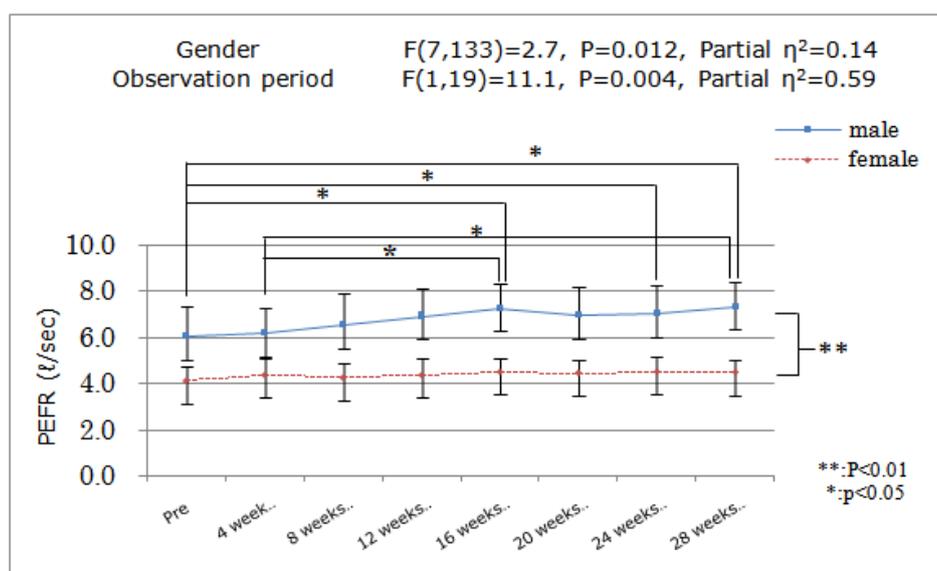


Figure 1. Chronological changes of the PEFR of male and female subjects. *Significantly different from pre-exercise value ($P < 0.05$)

4. Discussion

The mean PEFR value in male subjects at the first-time measurement was 6.05 ± 2.64 l/sec. This value is similar to that of sedentary elderly people (5.95 ± 1.68 l/sec), as

reported. [9] Although our subjects had been swimming for 2.6 times/month before participating in this study, their PEFR levels were similar to that of sedentary elderly people. This may indicate that a low frequency of swimming is insufficient to increase PEFR. When subjects increased the frequency of swimming to 4 times/month,

mean PEFR significantly increased to 7.32 ± 2.14 l/sec. These results suggest that swimming frequency is an important factor for increasing PEFR in elderly people, as evidenced by the increased PEFR in elderly male subjects who swam once a week. Interestingly, mean PEFR did not significantly increase in female subjects, despite swimming at the same frequency as male subjects. This suggests that the effect of swimming on PEFR may be gender-related.

Although the effects of swimming were not significant for female subjects, swimming increased PEFR in male subjects. There are several possible explanations for this. First, swimming could more effectively burden the cardiorespiratory system than land-based exercises due to the restricted ventilation volume caused by higher outside pressure against the human body. [10,11,12,13] Second, effective strengthening of the external intercostal muscles by swimming could represent a mechanism for increasing PEFR. Indeed, breathing occurs when the face is above water, and at that moment, ventilation volume increases to more than that during land-based exercises. Thus, external intercostal muscles are engaged during swimming. [14] Additionally, Ide et al. reported that aquatic respiratory exercises improve inspiratory muscle strength in elderly people more effectively than non-aquatic exercises. [6] This mechanism may also explain the differences seen in PEFR between male and female subjects. Although we could not identify the specific muscle mass associated with respiratory function, whole body muscle mass of male subjects increased to a greater extent than that of female subjects. Third, the expiration method may represent another mechanism for increasing PEFR during swimming, since it is necessary to exhale against pressure. It is necessary to minimally purse one's lips to prevent water from entering and exhale through the pursed lips. This results in exhaling through a small area, resulting in an exhalation speed faster than normal.

There are some limitations to this study worth noting. First, although we found that swimming once a week increased PEFR in elderly male subjects, we could not determine the optimal frequency since our subjects exercised only once a week. Future studies involving different frequencies should be performed to determine an optimal frequency for enhancing respiratory function. Second, we did not determine the optimal duration or intensity of swimming, since our subjects swam for 25 minutes at their preferred speeds. Thus, optimal conditions for enhancing respiratory function will also need to be determined in future studies.

5. Conclusion

PEFR in elderly males increased by swimming once a week for 28 weeks, while PEFR in elderly females did not significantly change throughout the study period. This may suggest that the PEFR increasing effect of swimming on elderly people is gender-dependent.

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Statement of Competing Interests

The authors have no competing interests.

References

- [1] "National Heart, Lung and Blood Institute," International Consensus Report on diagnosis and Treatment of Asthma, NIH Bethesda, Maryland 20892. *European Respiratory Journal*, 5 (5). 601-41. May. 1992.
- [2] Hirano, H., Enamido, K., Suzuki, N., "Examination of the peak flow level in the Shinjuku-ku asthma child swimming classroom participation child", *Information & Knowledge Database of Tokyo Women's Medical University*, 65 (9). 792-793. Sep. 1995.
- [3] Gelb, A.F. and Zamel, N., "Simplified diagnosis of small-airway obstruction", *The New England Journal Medicine*, 288. 395-398. Feb. 1973.
- [4] Kurokawa, T., and Ikegami, H., "Closing volume and lung volumes during swimming and bicycling", *The Japanese Society of physical Fitness and Sport Medicine*, 30. 220-227. Feb. 1981.
- [5] Matsui, T., Miyachi, M., Hoshijima, Y., Takahashi, K., Yamamoto, K., Yoshioka, A. and Onodera, S., "Effects of water immersion on systemic cardiovascular responses during recovery period following steady state land exercise", *The Japanese Society of physical Fitness and Sport Medicine*, 51 (3). 265-273. Feb. 2002.
- [6] Ide, M.R., Belini, M.A.V., and Caromano, F.A., "Effects of an aquatic versus non-aquatic respiratory exercise program on the respiratory muscle strength in healthy aged persons", *Clinics* [online]. 60. 151-158. 2005.
- [7] Sato, K., and Sakurai, T., "Effects of Water Exercise Compared to Land Walking on Cardiopulmonary Functions of the Elderly", *Journal of Physical Exercise and Sports Science* 18. 1-8. Dec. 2012.
- [8] Tanizaki, Y., Kitani, H., Okazaki, M., Mifune, T., Mitsunobu, F., Tanimizu, M., Honke, N., Kusaura, Y., Takatori, A., Okuda, H., and Kimura, I., "Bronchial asthma in the elderly, Ventilatory function in each clinical asthma type", *Annual Reports of Misasa Medical Branch, Okayama University Medical School*, 63. 44-49. June. 1992.
- [9] Iwamoto, M., Dodo, H., Ueda, Y., Yoneda J., and Morie T., "A Study of Pulmonary Functions in Elderly Men and Women by Flow-Volume Curve", *The Japanese Society for hygiene* 37(6). 886-891. Feb. 1983.
- [10] Town, G.P. and Bradley, S.S., "Maximal metabolic response of deep and shallow water running in trained runners", *Medicine Science Sports and Exercise* 23(2). 238-241. Feb. 1991.
- [11] American College of Sports Medicine, Resource manual for guidelines for exercise testing and prescription, Lea & Febiger, Philadelphia. 205-222, 1988.
- [12] Hotta, N., Ogaki, T., Kanaya, S., and Hagiwara, H., "Exercise Treatment to Low Physical Fitness Level's Patients in Water.", *Journal of Health Science* 15, 57-61.1993.
- [13] Holmer, I., Stein, E.M., Saltin, B., Ekblom, B. and Astrand, P. O., "Hemodynamic and respiratory responses compared in swimming and running", *Journal of Applied Physiology*, 37. 49-54. July. 1974.
- [14] Bachman, J.C., and Horvath, S.M., "Pulmonary function changes which accompany athletic condition program", *Research Quarterly*, 39. 235-239. May. 1968.
- [15] Japan Swim Federation, *Swimming instruction doctrine-Revised edition*. Taisyukan, Bunkyo-ku-Tokyo, 1-4. Mar 2011.