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Effects of Physical Training and Mental Practice of In-clothes Swimming: Assessment by Physiological Parameters

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***Purpose*: This study examined whether a short-term physical or mental training reduces the physiological load and perceived exertion of the in-clothes swimming.**
***Methods*: The study included 24 male inter-collegiate competitive swimmers with no previous experience of the in-clothes swimming. Prior to the training, the subjects performed 200-meter swimming with two styles of swimming, namely the crawl and elementary backstroke, and the degree of perceived exertion in the Borg scale, heart rate, and blood lactic acid level were determined. Following this baseline determination, the subjects were divided into 4 groups with 6 individuals each. These four groups were Group A "in-clothes training", Group B "image training", Group C "swimsuit training", and Group N "no training". Group A and C were lectured on the in-clothes swimming and practiced 7.5 min-long in-clothes swimming per day for a week with the two swimming styles, with Group A subjects wearing daily clothes and Group C subjects in swimsuits. Group B received 15 min of non-physical mental practice primarily through viewing video recording of swimming performance everyday for a week. No training was given to Group N. At the completion of the training session, the subjects underwent the 2nd 200-meter swimming, and the physiological parameters were determined.**
***Results*: The 1st in-clothes swimming load test showed that the elementary backstroke swimming resulted in significantly lower values of heart rate, blood lactic acid level, and perceived exertion than the crawl. For Group N, no difference was observed in the physiological parameters between the 1st and 2nd load test with either the elementary backstroke or crawl. Upon the 2nd in-clothes load test with the elementary backstroke, all three parameters were lower for Group A, B, and C than those seen for the 1st load test, and these differences were statistically significant, except for blood lactic acid in Group A. The 2nd in-clothes load test with the crawl showed that both heart rate and blood lactic acid were lower than those of the 1st load test for all three groups, with the differences in heart rate and blood lactic acid in Group A and that in blood lactic acid in Group B reaching the statistic significance. With respect to perceived exertion, the Borg score determined after the in-clothes load test with the crawl was significantly reduced for Group A, B, and C. The score after the in-clothes load test with the elementary backstroke was significantly reduced only for Group A.**
***Conclusion*: The elementary backstroke, when practiced in-clothes, imposes a relatively less physiological load. The present training methods can reduce physiological load and/or perceived exertion of the in-clothes swimming. Thus, both image training and swimsuit swimming are equally effective as a training method of the in-clothes swimming.**

Key words : Mental practice, Survival swimming, Intervention study

INTRODUCTION

Reports from the Division of Life Safety, the Police Department indicate that the number of the dead or missing in water accidents in Japan remained unchanged at 1,200 to 1,400 per year for the recent 10 years [1, 2]. In terms of the activity engaged at the time of accident, a greater number of people died or went missing during fishing and/or

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catching fish or passing by the water than that occurred during swimming. It has been recognized that, in an in-clothes water accident, wet clothes hinder free movement of body and, as a result, even skilled swimmers are likely to lose their lives [1–3]. These analyses indicate that regular training of swimming is not sufficient to prevent the loss of lives in water accidents and a new training method of the in-clothes swimming has to be formulated.

Recently, the Japanese Government has been active in delineating safety and rescue measures for water accidents [4]. In addition to these measures, experiencing or receiving the training of swimming with clothes on, so-called "in-clothes swimming", will aid to further prevent water accidents.

In Japan, reports of basic studies have been published sporadically with a primary focus on the potential usefulness of the in-clothes swimming as part of the swimming training at school [5, 6], while even fewer studies appeared examining the training methods of the in-clothes swimming [7–9].

The present study evaluated the effect of a short-term in-clothes swimming practice by assessing the physiological parameters. In parallel, we also examined the effect of "mental practice", a type of non-physical training, which would be useful when the physical training of the in-clothes swimming cannot be exercised.

SUBJECTS AND METHODS

This study was conducted on 24 male members of the Inter-collegiate Swimming Club of Keio University who had no previous experience of the in-clothes swimming. Average age, height, and weight were 20.3 ± 1.6 years, 175.3 ± 6.6 cm, 67.5 ± 4.8 kg, respectively. A written informed consent on the purpose of the study was obtained.

Prior to the training, all subjects were asked to put on a T shirt, a sweat shirt, cotton trousers, socks, and jogging shoes, and underwent the 1st load test consisting of 200-meter swimming with the elementary backstroke, followed by a sufficient break, and finally another 200-meter swimming with the crawl. The subjects were told to perform this in-clothes swimming at a velocity that increases blood lactic acid level to 4 mmol/L after 30 min of swimming (T30) [10, 11]. Lap time was recorded for each swimming style and, both prior to and at the completion of each swimming, perceived exertion, heart rate, and blood lactic acid level were determined.

In order to determine the degree of perceived exertion, the table prepared by Onodera and Miyashita [12] corresponding to the scale by Borg [13] was shown to the subjects immediately after the 200-meter in-clothes swimming, and a value was chosen from 15 levels of the perceived exertion score ranging from 6 to 20. Heart rate was recorded on Heart Rate Monitor Vantage XL (Canon) both immediately before and after the 200-meter in-clothes swimming, and the highest value was used for analysis. Blood lactic acid was determined by Lactate Reader (Lactate-Pro, Kyoto Daiichi Kagakusha) in blood collected from a fingertip by needle puncture both immediately before and after the 200-meter in-clothes swimming.

Following the 1st load test, these 24 subjects were divided into 4 groups with 6 each. These four groups were assigned to the in-clothes training (Group A), the image training (Group B), the swimsuit training (Group C), or no training (Group N). Upon grouping the subjects, care was taken that these four groups be not different in body mass index (weight/height), total body surface area, or swimming ability. Swimming ability was determined as T30, which is the distance a swimmer covers when he swims for 30 min at a velocity that increases blood lactic acid to 4 mmol/L [10]. Since Araki, Nomura and others reported that increases in the load of clothing hinder swimming ability [3, 5, 8], total body surface area among the four groups was kept indistinguishable so as not to cause differences in the load of clothing. Total body surface area was calculated using the formula by Fujimoto and Watanabe, $\text{weight}^{0.44} \times \text{height}^{0.663} \times 88.83 \div 100$. Swimming ability and body surface area were statistically analyzed using analysis of variance, and no significant difference was found among the four groups. Values of body mass index, total body surface area, and swimming ability (T30) are summarized in Table 1.

This study was conducted at the 50-meter indoor swimming pool of Hiyoshi campus, Keio University. Mental training was performed at the meeting room of Inter-collegiate Swimming Club and the 50-meter

Table 1 Profiles of the Four Training Groups

	In-clothes Swimming	Image Training	Swimsuit Swimming	No Training
Number	6	6	6	6
Age (years)	19.8 ± 1.3	20.3 ± 1.7	20.8 ± 1.4	20.5 ± 1.9
Body Mass Index (kg/cm)	21.7 ± 1.6	21.6 ± 1.5	22.6 ± 1.2	22.2 ± 1.1
Total Body Surface Area (cm^2)	169.1 ± 11.0	179.5 ± 5.9	176.5 ± 8.4	171.6 ± 7.7
T30 (m)*	2,314.2 ± 234.6	2,330.0 ± 174.7	2,319.2 ± 108.7	2,236.7 ± 96.5

*The distance the subject covered by swimming for 30 min at a velocity that increases blood lactic acid to 4 mmol/L.

indoor swimming pool of Hiyoshi campus.

After the 1st load test, technical aspects of the in-clothes swimming were lectured to Group A, B, and C. The following day, the training was initiated. Group A subjects put on a T shirt, a sweat shirt, cotton trousers, socks, and jogging shoes as the load of clothing, and Group C subjects wore a swimsuit. Swimming was performed for 7.5 min per day at the subject's own, non-competitive pace.

Group B was given the image training formulated according to the non-physical training method described as one type of mental training by Volpert [14]. Detailed technical explanation of the in-clothes swimming was given in-door. Then, the subjects viewed a model performance on video to gain the image of the in-clothes swimming. Prior to the video viewing, the subjects were told to watch the swimmers on video as if the subjects themselves were swimming. To further enhance the image of the in-clothes swimming, the subjects watched a performance of the model swimming from the poolside. The performer of the model swimming put on the clothes that were used in the present study and, to help the subjects gain the image of the model swimming, performed the swimming at a low velocity. Before this session at the poolside, the subjects were again told to watch the model swimming imagining himself exercising the model swimming. Considering the length of time with which a single mental practice is most effective [15], the training session was 5 min each in total of 15 min, which was equal to that of the in-clothes swimming training.

For one week, Group N practiced no training and was kept in a situation where the subjects were not allowed to image the training. During the training period, Group A, B, and C were engaged also in regular practices. Training sessions were held for Group A and C at the same time and place everyday.

At the completion of the one-week training given separately to the 4 groups, the 2nd in-clothes load test was performed. Lap time for 200-meter in-clothes swimming with either the crawl or elementary backstroke, and the values of perceived exertion (the Borg score), heart rate, and blood lactic acid were determined both prior to and after 200-meter in-clothes swimming.

To help the subject swim the distance in the time required on the 1st load test and experience a similar level of physical load, the lap time of the 1st load test was indicated, and the subjects were told to achieve the same 25-meter lap. Swimming velocities scored in the 1st and 2nd load test were compared (Table 2).

Lap time, heart rate, blood lactic acid, and perceived exertion were all analyzed using Wilcoxon's signed rank test. When the P value was < 0.05, the difference was regarded statistically significant.

RESULTS

At the entry to the study, the values of heart rate and blood lactic acid were not different among the subjects. In the 1st load test, no significant difference was observed in 200-meter lap time recorded with the crawl or elementary backstroke among the subjects. Of note, the values of heart rate,

Table 2 Lap time for 200-meter in-clothes swimming before and after the training

		In-clothes Swimming	Image Training	Swimsuit Swimming	No Training
Crawl	Before	328.2 ± 56.7	296.7 ± 25.0	312.0 ± 58.9	339.5 ± 30.2
	After	325.8 ± 59.2	296.0 ± 22.7	303.7 ± 48.6	340.2 ± 203
Elementary	Before	325.3 ± 43.0	291.8 ± 33.9	303.8 ± 61.3	332.0 ± 56.1
Backstroke	After	324.8 ± 42.4	289.3 ± 28.9	307.0 ± 55.7	333.0 ± 55.4

Both before and after the training session, the subjects performed 200-meter in-clothes swimming with either the crawl or elementary backstroke at a velocity that elevates blood lactic acid to 4 mmol/L. The pre-training (Before) and post-training (After) values of lap time were compared.

Table 3 Pre-training values of physiological parameters after the first in-clothes load test with two swimming styles

	Crawl	Elementary Backstroke
Lap time (min)	319.1 ± 45.4	313.3 ± 49.3
Heart Rate (beating/min)	162.4 ± 14.2	153.7 ± 15.3*
Blood lactic acid (mmol/L)	6.5 ± 2.6	4.1 ± 1.9*
Borg score	15.3 ± 1.4	12.5 ± 2.3*

* $P < 0.01$ vs. crawl.

Table 4 Pre- and post-training values of physiological parameters determined in 200-meter in-clothes swimming with the elementary backstroke.

		In-clothes Swimming	Image Training	Swimsuit Swimming	No Training
Heart rate	Before	147.2 ± 13.0	158.5 ± 16.3	159.3 ± 9.4	149.7 ± 20.5
(beating/min)	After	133.3 ± 17.1*	140.5 ± 19.4*	144.7 ± 16.5*	141.2 ± 23.0
Blood lactic	Before	3.6 ± 1.8	4.6 ± 1.6	4.3 ± 1.8	4.1 ± 2.6
acid (mmol/L)	After	3.0 ± 1.4	3.7 ± 1.7*	3.3 ± 1.4*	4.0 ± 2.3
Borg score	Before	13 ± 2	13 ± 4	12 ± 1	12 ± 3
	After	12 ± 2*	11 ± 1	12 ± 1	13 ± 2

Both before and after the training session, the subjects performed 200-meter in-clothes swimming with the crawl. Heart rate, blood lactic acid, and Borg score were determined, and the pre-training (Before) and post-training (After) values were compared.
*$P < 0.05$ between the pre- and post-training values.

blood lactic acid, and perceived exertion were all significantly lower for the elementary backstroke than those for the crawl (Table 3).

To verify that the physiological conditions prior to the training session were not different among these four groups, physiological parameters obtained after the 1st load test were statistically evaluated. No difference was found among the four groups, indicating that prior to the training, physiological conditions of these four groups were not distinguishable.

Table 4 and 5 summarize the values of heart rate, blood lactic acid, and the Borg score as the measure of perceived exertion determined in the 1st and 2nd load test with either the crawl or elementary backsroke,

Table 5 Pre- and post-training values of physiological parameters determined in 200-meter in-clothes swimming with the crawl.

		In-clothes Swimming	Image Training	Swimsuit Swimming	No Training
Heart rate	Before	156.7 ± 19.0	161.3 ± 11.6	167.0 ± 7.2	164.7 ± 17.7
(beating/min)	After	142.2 ± 23.3*	149.2 ± 13.8	159.5 ± 10.7	159.7 ± 14.7
Blood lactic	Before	6.2 ± 2.5	7.1 ± 2.9	6.2 ± 3.3	6.7 ± 2.1
acid (mmol/L)	After	4.2 ± 2.2*	4.1 ± 2.0*	5.2 ± 2.4	6.0 ± 1.6
Borg score	Before	16 ± 2	15 ± 1	16 ± 1	14 ± 2
	After	12 ± 2*	11 ± 2*	14 ± 2*	14 ± 3

Both before and after the training session, the subjects performed 200-meter in-clothes swimming with the crawl. Heart rate, blood lactic acid, and Borg score were determined, and the pre-training (Before) and post-training (After) values were compared.
*$P < 0.05$ between the pre- and post-training values.

respectively. For Group N, no significant difference was observed in heart rate, blood lactic acid, or the Borg score for perceived exertion between the 1st and 2nd load test. For Group A, B, and C, heart rate and blood lactic acid determined after the in-clothes swimming with the elementary backstroke were both lower for the 2nd load test than those for the 1st load test (Table 4). These differences were statistically significant, except for blood lactic acid in Group A.

With respect to the physiological parameters following the in-clothes swimming with the crawl, heart rate and blood lactic acid after the 2nd load test were found lower in Group A, B, and C as compared to the values seen after the 1st load test (Table 5). However, statistical significance was found only in heart rate and blood lactic acid for Group A and in blood lactic acid for Group B.

Following the training session, the Borg score after the in-clothes swimming with the elementary backstroke was significantly reduced only in Group A. In contrast, the Borg score after the in-clothes swimming with the crawl was significantly reduced in Group A, B, and C.

DISCUSSION

In the current study, we evaluated the effects of short-term in-clothes training by assessing physiological parameters in inter-collegiate competitive swimmers. We chose inter-collegiate competitive swimmers for the study because physical load could be equalized among the subjects, specialized programs of swimming, such as T30, could be used, and little risk was involved. The distance was set at 200 meters for two reasons; 1) swimming ability required to survive in an in-clothes accident was assumed in the study, and 2) while the previous studies used either 25 or 50 meters, the subjects of the current study had such a high swimming ability that at least 200 meters of swimming was required to determine the effect of training method. As a training method that can be applied under the circumstances where the physical in-clothes swimming is hardly acceptable, we included mental practice, a type of non-physical training, and evaluated its effect relative to other in-clothes training.

Prior to the training, we first determined heart rate, blood lactic acid, and perceived exertion in the Borg score after swimming at a similar velocity with each of the two swimming styles. It was found that all physiological parameters were lower with the elementary backstroke than with the crawl (Table 3). Since the crawl requires the stroking arm to recover over the water, it enforces another physically demanding maneuver. In contrast, the elementary backstoke recovers the stroking arm through the water and, as a result, the recovery is more efficient. When practiced in-clothes, these differences in the arm recovery manuever and the physical demand become more apparent, emphasizing the fact that the elementary backstroke is more energy-efficient than the crawl. Taken together with these characteristics of the swimming styles, the present finding shows that when no particular in-clothes swimming training has been given, the elementary backstroke imposes less physiological load than the crawl. In keeping with this notion, previous reports indicated that the crawl is not suitable for the in-clothes swimming, whereas the elementary backstroke is [16, 17]. Thus, in order to prevent the water accident by reducing the load of the in-clothes swimming, the use of the elementary backstroke needs to be recognized.

We next examined the pre- and post-training values of heart rate, blood lactic acid, and perceived exertion determined after the in-clothes swimming with each of two swimming styles. For Group N with no training, no significant difference was observed in any of the physiological parameters between the 1st and 2nd load test. This finding indicates that a single session of the in-clothes swimming does not provide "getting-used-to" effect.

Upon the in-clothes swimming with the elementary backstroke, heart rate and blood lactic acid were both lower after the 2nd load test for Group A, B, and C than those after the 1st load test. These results suggest that for the elementary backstroke, either the image training or swimsuit training is effective in reducing the physiological load of the in-clothes swimming and, possibly, superior to the in-clothes swimming. Thus, the physical training of the in-clothes swimming is not essential to reduce the physiological load.

It has been described that the short-term image training alone is equally effective to the physical training, and the best effect is achieved when these two training methods are combined. Twining reported that in acquiring the learning skills through playing quoits, better results were seen with the subjects who practiced physical training after 15 min of mental rehearsal than those who underwent physical training alone [18]. Rawlings *et al*. described that mental practice by the image training and physical practice by actual exercise were similar in effectiveness in learning the rotary pursuit tracking [19]. In addition, Ulich concluded, from the study on the acquisition of physical abilities requiring skills, that the best learning was achieved when both physical and image training were given [20]. Although different approaches were used, the results of the present study are in agreement with these previous studies and further emphasize the effectiveness and importance of the mental practice.

Heart rate and blood lactic acid after the in-clothes swimming with the crawl was lower in the 2nd load test than in the 1st load test for Group A, B, and C, with statistical significance seen only in heart rate and blood lactic acid for Group A and blood lactic acid for Group B. These results raise the possibility that, in terms of reducing the physiological load of the in-clothes swimming with the crawl, the in-clothes training is more effective than the image training, and the image training is more effective than the swimsuit training. Therefore, unlike for the elementary backstroke, the in-clothes swimming training is most effective, while the image training has little effect to reduce the physiological load of the in-clothes swimming with the crawl.

In Japan, the elementary backstroke has not been accepted as a regular swimming style, and competitive swimmers are not familiar with this style. We speculate that this fact underlies the present findings that unlike for the crawl, swimsuit training and image training were more effective for the elementary backstroke. We also speculate that since competitive swimmers are well accustomed to the crawl, training methods other than the in-clothes swimming had minimum effects. The image training can be practiced anywhere and, as a training method of the in-clothes swimming, is far easier than the physical training. Furthermore, training with the elementary backstroke in swimsuit is not associated with risks that are found with the in-clothes swimming. In order to popularize the in-clothes swimming among the general public and to prevent the water accident, these training methods have to be effectively combined and the efficacy of the methods has to be studied in the general public.

Observations with the perceived exertion were slightly different from those with the physiological parameters. The Borg score after the in-clothes swimming in the elementary backstroke was significantly reduced only for Group A, whereas the score after the in-clothes swimming with the crawl was significantly reduced by the training for Group A, B, and C. When practiced at a similar swimming velocity, perceived exertion with the crawl is higher than that of the elementary backstroke, producing the effectiveness seen with all four training methods. Thus, it is suggested that these training methods reduces potentially present psychological load. Since the general public will experience higher perceived exertion than competitive swimmers when they face the load of the in-clothes swimming, various training methods will possibly be more effective for ordinary individuals.

As described above, the elementary backstroke is an instrumental swimming style in reducing the physiological load of the in-clothes swimming. We found that the physiological load and perceived exertion can be further reduced by various kinds of training. While the image training and swimsuit training are similarly effective as the methods of the in-clothes training, the effectiveness may vary depending on the level of the trainee's familiarity with the given swimming style. In hoping to prevent the loss of lives in water accidents, we will further investigate for the effective way to apply these training methods.

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REFERENCES

1) Mitsui, S.: The transition in accidents and disasters by water in a recent decade: Accidents and disasters by water increased in 1994. Monthly Swimming 227: 20–21, 1995.
2) Mitsui, S.: The transition in accidents and disasters by water in a recent decade: The circumstance of accidents and disasters by water worsened and the number of accidents and the deaths by water increased in 1997 from the year before. Monthly Swimming 265: 30–31, 1998.
3) The accidents and disasters by water. *In* "The first in-clothes swimming: The present circumstances around the water." Eds, Araki, A., and Sano, Y., Sankaido, Tokyo, pp. 8–35, 1993.
4) Hasegawa, K.: Studies on the prevention of accidents and disasters by water and the rescue procedures (part 2). The Japan Athletic Society 49: 489, 1998.
5) Nomura, T., *et al.*: Primary factors that affect the actions of children when they swim in-clothes. The Research Association for the Teaching Methods of Swimming 2: 1–8, 1991.
6) Takemine, R.: Studies on how clothing affects the swimming velocity. The Japan Athletic Society 49: 488, 1998.
7) Fuimoto, H.: Examples of the instructors who fail to care for the safe swimming for elementary school children. *In* "Guidance for Elementary School Children to In-clothes Swimming" Eds., Araki, A., Fujimoto, H., Reimei-shobo, Tokyo, pp. 56–57, 1988.
8) Nomura, T.: Experimental studies on the in-clothes swimming. The Research Association for the Teaching Methods of Swimming 1: 1–6, 1990.
9) Fujimoto, H.: Guidance to the in-clothes swimming. The Research Association for the Teaching Methods of Swimming 4: 16–24, 1994.
10) Olbrecht, J., Madsen, A, Liesen, A., and Hollman, W.: Relationship between swimming velocity and lactic acid concentration during continuous intermittent training exercise. International Journal of Sports Medicine 6: 74–77, 1985.
11) Olbrecht, J., Mader, A., Heck, H., Hollman, W.: Relation between lactate and swimming speed depending on the test conditions; pool length, before and after endurance training, AM versus PM, qualifications and finals, and relay or individual races. (Abstract) International Journal of Sports Medicine 9: 379, 1988.
12) Onodera, K., Miyashita, M.: Relationship between the whole body endurance and the intensities of perceived and objective movement: From the viewpoint of perceived exertion rating. Research of Physical Education 21: 191–203, 1976.
13) Borg: Psychological bases of perceived exertion. Medical Science of Sports and Exercise 14: 377–381, 1982.
14) Volpert, W.: Sensumotorisches Lernen. Limpret, Frankfurt, 1973.
15) "Sports Psychology Q&A: What are mental practice, image training, and mental rehearsal? How are they applied to sports?", Fumaido, Tokyo, pp. 60–61.
16) Kanagawa Lifesaving Association: Survival Swimming, pp. 4–5, 1993.
17) Riverfront Equipment Foundation: Familiarity with rivers and prevention of accidents by water: In-clothes swimming for water safety. pp. 119–121, 1992.
18) Twining, W.H.: Mental practice and physical practice in learning a motor skill. Research Quarterly 20: 432–435, 1949.
19) Rawlings, E., Rawlings, I.L., Chem, S.S., Yilk, M.D.: The facilitating effects of mental rehearsal in the acquisition of rotary pursuit tracking. Psychonomic Science 26: 71–73, 1972.
20) Ulich, E.: Some experiments on the mental training in the aquisition of motor skills. Ergonomics 10: 411–419, 1967.