THE TURNING MOTION AND FORCES INVOLVED IN THE BACKSTROKE FLIP TURN

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This study examined the backstroke turning motion. Twelve male and female subjects, including beginners and trained swimmers, performed backstroke flip-turns. The time taken from 5m turn in to 2.5m turn out ranged from 4.25sec to 6.31sec. There was a significant difference between the beginners and trained subjects during the preparation and beginning of turn phases. The forces during the push off phase ranged from 1040.6N - 321.9N. Values for trained backstroke swimmers were approximately equal to 50% of the values for trained crawl swimmers (Takahashi 1983), and 100% for semi-trained crawl swimmers (Goya 1997). This study revealed that the streamlined position after push off might be a very important factor influencing the magnitude of kick off force and direction.

KEY WORDS: backstroke turn images, underwater force plate, motion analysis, streamlined position

INTRODUCTION: Compared with studies on the analysis of the start and the stroke, few studies have been conducted on the turn motion in swimming (Nicol et al.,1979; Chow et al., 1984; Ulrich et al., 1988). The turn is not regarded as a swimming technique, and thus does not usually attract the attention of researchers and instructors. It has also been pointed out that further analysis of the turn should incorporate new methods and ideas (Hay 1988). We have been trying to examine the turning mechanism in swimming by use of images and an under-water force plate. In this study, we investigated how the swimmer should acquire the turn technique by comparing trained and untrained swimmers, using an under-water force plate connected to a high-speed (200fps) video camera system.

METHOD: The subjects consisted of 6 male & 6 female age group swimrners including 4 trained and 2 untrained swimrners in each gender group. Male and (female) characteristics are as follows; average age: 12.8 (14.0) years, height: 150.3 ± 14.3 (154.1 ±1 2.8) cm, weight: 40.8 ± 9.5 (47.0 ± 14.1) kg, and career: 3.0 ± 1.1 (2.9± 1.8) years. The turning motion was photographed by two high-speed VTR cameras synchronized with an under-water force plate, and later analyzed to obtain information on swimming form and center of gravity. Forces were calculated using Mac Lab 8 connected to a personal computer. The backstroke flip turn was divided into 4 phases:

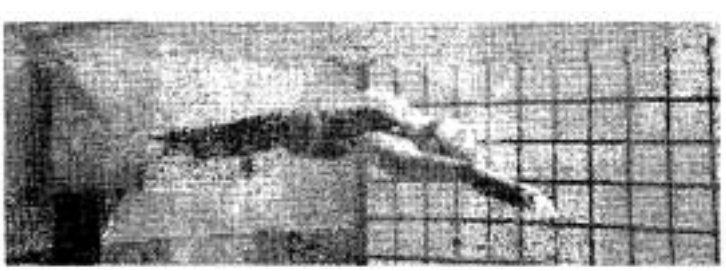

Figure 1- Experimental design for force plate measurement.

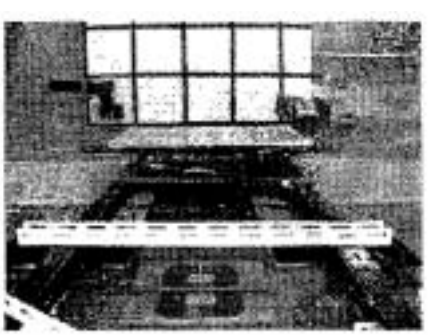

Figure **2** - Top view of under-water force plate.

1 Preparation: from 5m to 2.5m before the turn.
2 Approach: from 2.5m until feet touch the plate.
3 Drive: from when feet touch the plate to take off
4 Glide: from take off to 2.5m.

Preparation + approach is defined as "turn in time", drive + glide is "turn out time" and turn in + turn out time is defined as "total turn time".
Figure 1 shows the method used for measuring the under-water forces and recording images of the turning motion. Top view of the under-water force plate is shown in Figure 2.

RESULTS AND DISCUSSION: Table 1 shows the time differences between the trained and untrained swimmers at each phase. There were significant differences in the total turn times and times for each of the 4 phases recorded between trained and untrained swimmers, in both the male and female groups. Blanksby (1996) has reported that the 5m round trip time correlated significantly with peak force, wall contact time, swim resumption distance and peak speed in age group freestyle swimmers. In this study, the time differences of turn in could be due to the magnitude of swimming velocity and turning technique. On the other hand, the difference in turn

Table ▮ - Time differences between the untrained and trained swimmers.

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	Total	preparation	Approach	Drive	Glide
	Turn ın {Turn out@ @ @	@ @Turn ın		@ @ @	@ @Turn out
Male	Trained (4.25)	1.48	2.11	0.29	0.36
	Untrained (5.48)	2.02	2.55	0.25	0.62
Female					
	Trained (4.45)	1.57	2.15	0.34	0.38
	Untrained (6.31)	2.10	2.88	0.59	0.73

out times might also be due to the streamlined position and the direction of the kick off the wall. Figure 3 shows one of the forces sampled during turn in for trained and untrained swimmers. A trained swimmer's force curve has two peaks during contact with the wall. The former is to hold the body in position before kick off. The latter is the maximum force value, approximately 600 N, exerted during the moment of kick off. The untrained swimmers only exhibited simple force curves and low force values of around 200 N.

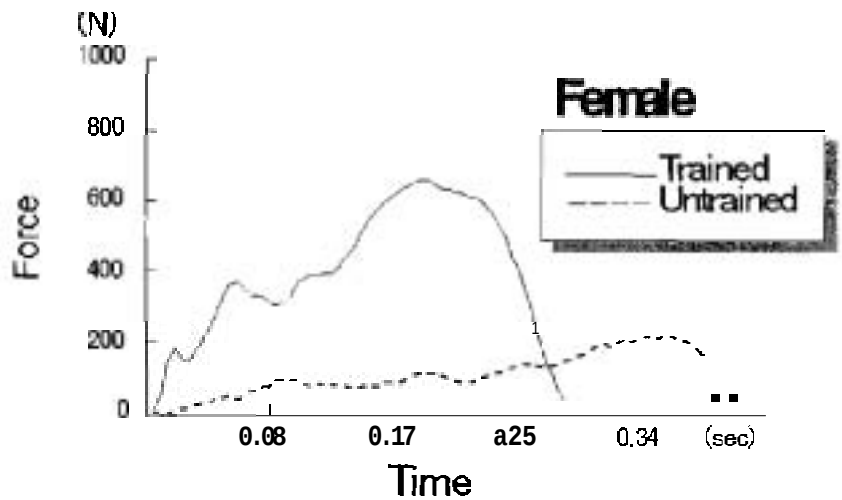

Fig.3 Forces during turn for female swir

Table 2 shows the magnitude of forces compared with a previous study. In 1979, Nicol and Kruger found that the maximum force exerted varied between 600 and 1,100 N during a freestyle swimming turn. This value was almost equivalent to the force observed in the case of un-trained crawl swimmers reported by Goya (1997), and Takahashi (1983), and also almost

Table **2.** Comparison between present and previous study in Force.

		Force	Force/Wt
		(N)	(N/Kgw)
Crawl	Untrained(Pre)	**532**	10.6
(Goya 1997	Untrained(Post)	**827**	16.5
Crawl	**Untrained**	1068	15.1
@(Takahashi1983)	**Trained**	1712	24.2
Breast	Untrained(Pre)	851	15.2
(GOYA1999)	Untrained(Post)	**944**	16.9
	Trained	**2087**	**29.8**
Back	**Male·Untrained**	363.3	**12.7**
(GOYA 2001)	**Male Trained**	**575**	**12.3**
	Female Untrained	227.7	**7.0**
	Female Trained	596.6	**11.0**

the same as untrained breaststroke swimmers reported by Goya (1999). Forces exerted divided by body weight (N / Kgw) exhibited the same values in both groups.

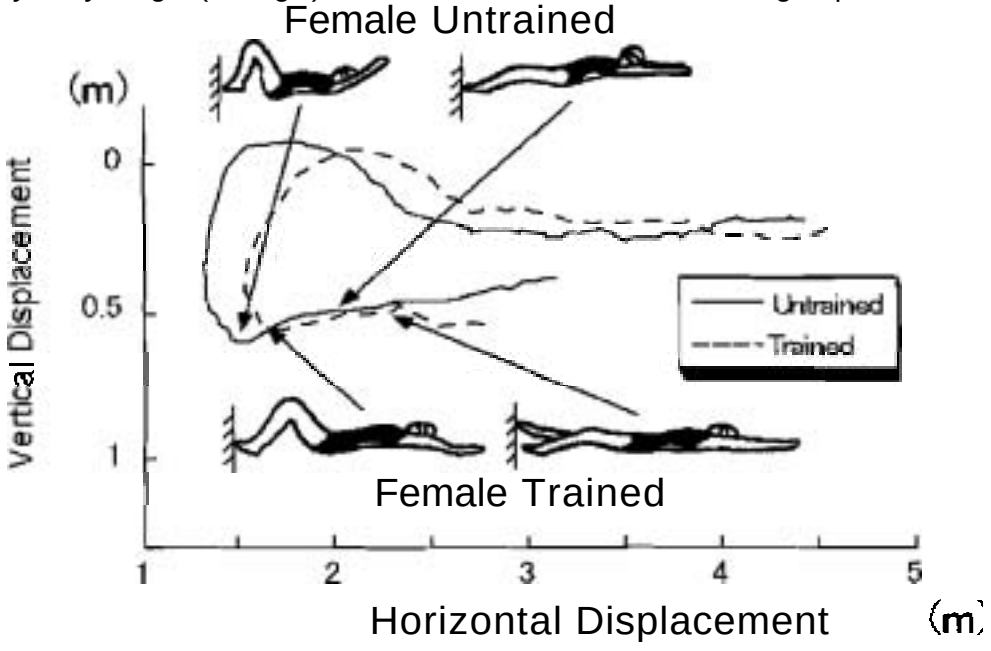

Fig.4 Changes in Locus of CG during Turn.

However, both trained crawl swimmers, reported by Takahashi, and trained breaststroke swimmers, reported by Goya, showed greater values. This suggests that the difference in the ability of the subjects is an important factor. Figure 4 shows the changes in the locus of the

center of gravity and the turn motion in both trained and untrained swimmers. The untrained swimmers rotated closer to the wall than the trained swimmers. After kick off, the untrained swimmers also went up to the surface more quickly.

Meanwhile, the angle of trajectory varied from 66 to 94 degrees in untrained, and from 89 to 91 degrees in trained swimmers. Almost the same results were observed in both trained and untrained male swimmers respectively. Hueelhorst et al (1988) has suggested that the streamlined position should' be assumed smoothly at the end of the push off phase. If the swimmer fails to assume the appropriate streamlined position this will cause a great deal of frontal resistance at this point in the motion. From the results of this study, it could be suggested that the swimmer should assume the streamlined position during the drive phase.

CONCLUSION: The purpose of this study was to provide some basic guidelines for swimming instruction. The results are as follows:

When teaching the back stroke flip turn:

1) The swimmer should have completed the twist and tuck motion before the feet touch the wall.
2) Assume the appropriate streamlined position as the feet touch the wall.
3) To evaluate the push off technique, it is necessary to monitor the push off direction as well as power and the speed.

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