The Sexual Differences of the Contribution of Physique to Crawl Swimming Performances in Competitive College Swimmers

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Abstract

To investigate the sexual differences in physique aspects and in the relationship between physique and swimming performance in well-trained competitive swimmers, a total of 257 Japanese male(age=19.9±1.07 yr) and female(age=19.7±0.96 yr) swimmers were employed in this study. Comparative and correlative analyses were done on 15 physique variables and 5 crawl swimming performances from 25m to 400m. As a result, male swimmers as compared with female swimmers were taller, heavier, less fat, and had larger body girths of chest and arm, greater body density, lean body mass, body surface area, and vital capacity. For male swimmers, significant correlations between swimming performances and many physique variables except for fat mass and skinfolds were found. For female swimmers, physique variables such as skinfolds and fat correlated significantly only to the 25m performance, and chest and arm girths to performances of longer than 200m. It was concluded that the contribution of physique to swimming performances differs between male and female swimmers.

Introduction

As early as 1939, Beall[2] found that successful women swimmers were heavier, had broader hands, hips and shoulders, deeper chests, and larger chest circumferences than unsuccessful swimmers. Cureton[8] and Hirata[20] determined that body types of sportsmen were different in each sport and even the same competitive swimmers possessed somewhat different body types in each stroke event such as crawl, breast, back and butterfly. Cureton[8] also found that champion athlete swimmers as compared with the other champion athletes had body density traits and a slightly different body composition, adding that Olympic swimmers possessed an unusually high breathing capacity for their height and weight. Pugh[32] reported that college swimmers were taller and heavier and had a greater body density than students of similar age.

Demura[15] studied physique traits for Japanese competitive college male swimmers, reporting that swimmers are higher in stature, heavier in body weight, larger in chest and limb girths, larger in vital capacity, thinner in skinfolds of arms and back, and longer in limbs than general people of similar

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age. Also results reported by some other researchers were almost consistent with the above results on the point that well-trained swimmers are taller and heavier[25)26)] or had larger lung capacity[24)] and greater body density[3)].

On the other hand, Demura and Matsuura[10)] and Demura[18)] determined that the growth of physique with age had a close relationship to the improvement of swimming speed. To swim fast, competitive swimmers would need more developed and longer limbs for producing greater propulsion in water. And although, in most sports, fat is a disadvantageous factor for its successful performance, it is not necessarily so in swimming, rather it would be an advantageous factor because of increasing buoyancy[21)28)]. It appears that each physique attribute is closely related to the achievement of speed swimming. Therefore, many researchers[6)9)12-18)22)30)33)34)35)36)] have studied relationships between swimming performance and physique from various standpoints although the results obtained were not necessarily consistent.

As above has been mentioned, until now, many comparative studies and correlative studies concerning physique trait for swimmers have been done. However, little has been studied as to whether sexual differences in physique aspects for well-trained competitive swimmers exist or whether relationships between physique and swimming performance differ between sexes.

The purposes of the present study were :(1) to compare physique attributes between swimmers and general people of similar age, and between male swimmers and female swimmers, (2) to determine the simple relationships of physique attributes to various swimming performances from 25m to 400m and their sexual differences, and (3) to examine the contributions of physique elements to performances and their sexual differences.

Methods

Subjects

A total of 166 male swimmers, ranged from 18.3 to 22.6 ys(mean age= 19.9 ys) and 91 college female swimmers, ranged from 18.3 to 22.3 ys(mean age= 19.7 ys) volunteered to be subjects for this study. There was no significant difference between the mean ages of both sexes($p<0.05$). They were well-trained, skilled Japanese swimmers and had experienced competitive swimming for at least more than five years.

Variables

Physique is generally divided into the following four elements: body linearity(BL), weight of body(WB), body girth(BG), and body width(BW). According to Demura et. al[11)], a close relationship exists between BG and BW. Therefore, 9 test items were chosen as representing the four physique elements: stature, arm length, and leg length from BL, body weight, arm skinfold and back skinfold from WB, and thigh, chest and upper arm girths from BG and BW. Vital capacity was also measured because this has a close relationship to physique attributes such as chest girth, chest width, stature, and so on. These tests were administered according to standard procedures [31)].

Besides, the following five physique indexes(composite variables)were calculated by using values of stature, body weight and

skinfolds of arm and back:body density[29], % body fat[4], body fat (% body fat x weight), body surface area(0.007245 x body weight$^{0.425}$ x stature $^{0.725}$), and lean body mass(weight-body fat).

To test the hypothesis that contributions of physique elements or attributes to swimming performances would vary with the extension of swimming distance, five crawl swimming speed tests from 25m to 400m were administered to all subjects. In 25m and 50m tests, the subjects started to swim from kicking the wall of the swimming pool in the water while in the other tests, they started with a general competitive starting method.

Statistical technique

Student's t-test was used to test differences between the means of swimmers and general people, and between the means of male swimmers and female swimmers. In addition, Pearson's product moment correlation and multiple correlation techniques were employed to determine the relationship between swimming performance and physique variables. A probability level of less than 5% was taken as indicating statistical significance.

Results and Discussion

Table 1 shows the means and standard deviations for all variables selected in this study for male and female swimmers. When values of stature, body weight, arm length, chest girth, upper arm girth, body surface area, skinfolds of arm and back and vital capacity for swimmers, were compared with standard values for the same age people, all values except for both skinfolds were relatively greater in swimmers. Arm skinfold was somewhat lesser in swimmers than in general people, while back skinfold did not differ between groups.

These results seem to be identical to those reported by previous studies[2)8)9-10)12-13)15)18)23)25)26)27]. That is, well-trained or skilled swimmers are higher in stature, heavier in body weight, larger in limb girth and chest girth, greater in body surface area and vital capacity than general people or nonathletes. In general, well-trained swimmers as compared with general people or non-athletes[1)15)32] have lesser body fat although some researchers [5)7)19] reported that body fat or % fat for swimmers varied even during swimming season.

From the results of both skinfolds obtained in this study, Japanease swimmers also seem to have lesser fat than general people. Further, it is inferred that swimmers have less fat in limbs rather than trunk or they have a somewhat different distribution trait of fat as compared with general people because only arm skinfold showed significant difference. Lesser fat of limbs for swimmers seems to be due to the reason that arms and legs are used entirely to produce propulsion in speed swimming although fat is not always a detrimental factor because it influences on increasing buoyancy.

In comparison between male swimmers and female swimmers, although values of both skinfolds, body fat, and % body fat for female swimmers were significantly greater and thigh girth was not found to differ between sexes, all the remaining variables including swimming performances for male swimmers showed significantly greater values.

Table 1. Means and standard deviations for all variables.

variable	male M	male SD	female M	female SD	
1. stature(cm)	171.3	5.37	159.0	4.88	>
2. body weight(kg)	65.8	5.99	55.3	5.86	>
3. arm length(cm)	76.0	3.33	68.8	3.12	>
4. leg length(cm)	92.9	3.88	86.6	3.58	>
5. thigh girth(cm)	53.8	2.73	54.3	3.33	
6. chest girth 1(cm)	97.1	4.39	89.4	3.98	>
7. chest girth 2(cm)	92.6	4.41	84.3	4.05	>
8. mean chest girth(cm)	94.8	4.29	86.8	3.95	>
9. upper arm girth	29.0	2.08	26.8	2.10	>
10. skinfold(arm)	9.8	2.56	14.9	3.25	<
11. skinfold(back)	12.4	2.90	14.7	3.21	<
12. body density(kg/ℓ)	106.1	0.60	104.9	0.74	>
13. lean body mass(kg)	55.0	4.59	43.3	4.17	>
14. body surface area(m^2)	178.6	9.79	157.1	9.67	>
15. body fat(kg)	10.8	2.20	11.9	2.49	<
16. % body fat(%)	16.3	2.44	21.3	3.02	<
17. vital capacity(cm^3)	5158.8	591.38	3449.1	460.01	>
18. 25m crawl swim(sec)	13.9	0.92	16.1	0.27	>
19. 50m crawl swim(sec)	30.6	2.30	36.0	2.77	>
20. 100m crawl swim(sec)	66.0	5.54	79.7	7.57	>
21. 200m crawl swim(sec)	151.4	15.79	177.7	22.06	>
22. 400m crawl swim(sec)	320.9	33.31	373.7	48.84	>
23. age(yrs)	19.9	1.07	19.7	0.96	

Note ; 1. Values of variable number 12 and 14 are multiplied by 100.
2. Chest girth 1 and 2 are values of maximum inspiration and expiration times, respectively and mean chest girth is their means.
3. > Values for male swimmers are significantly greater than those for female swimmers and < its revers.

From the above results, male swimmers are considered to have higher swimming speed abilities than female swimmers if they had almost the same swimming training experience. Besides, the sexual differences in physique aspects for swimmers seem to be almost the same as those in general people of the same age category[31]. Namely, although female swimmers possess more fat, male swimmers are taller, heavier, larger in body girth such as chest and arm, and greater in vital capacity, body surface area, lean body mass, and body density.

The sexual differences in physique aspects like the above-mentioned may produce also the difference in the relationships between swimming performances and physique attributes. Correlation coefficients between swimming performances and physique variables are shown in Table 2. For male swimmers, although physique variables such as skinfolds, body density and % body fat were not

Table 2. Correlation coefficients between swimming performances and physique variables.

	male					female				
No.	25m	50m	100m	200m	400m	25m	50m	100m	200m	400m
1.	-254*	-210*	-204*	-262*	-197*	-104	-108	-029	-138	-173
2.	-308*	-330*	-281*	-339*	-243*	132	012	043	-121	-168
3.	-187*	-161*	-157	-245*	-167*	-077	002	-092	-146	-169
4.	-182*	-129	-141	-221*	-175*	-171	-088	-109	-178	-183
5.	-174*	-196*	-175*	-220*	-137	216*	069	121	-002	-030
8.	-309*	-308*	-258*	-356*	-219*	145	028	-046	-181	-237*
9.	-258*	-333*	-351*	-362*	-293*	071	-042	-059	-220*	-243*
10.	-096	-119	-088	-153	-090	296*	106	050	-023	-027
11.	-017	-116	-024	-087	003	220*	054	090	-057	-061
12.	022	092	034	103	021	-266*	-083	-068	040	030
13.	-325*	-336*	-298*	-351*	-263*	036	-021	017	-127	-182
14.	-325*	-329*	-277*	-353*	-253*	058	-029	021	-139	-186
15.	-150	-209*	-130	-206*	-109	256*	064	074	-071	-090
16.	-020	-090	-024	-097	-016	267*	079	067	-037	-028
17.	-451*	-462*	-444*	-421*	-330*	122	068	082	019	-040

Note ; 1. Decimal point omitted.
2. Variable numbers correspond to those in Table 1.

found with any swimming performance, the other physique variables showed significant correlations with all or many swimming performances. However, for female swimmers, some physique variables such as thigh girth, skinfolds, body density, body fat, and % fat correlated significantly to the 25m swimming performances and only chest and arm girths to relatively longer performances (200m and 400m). In addition, the signs of correlation coefficients between 25m swimming performance and physique attributes of thigh girth, both skinfolds, body fat, and % fat were negative in males but positive in females.

As a whole, the present results were not entirely identical to those, especially in female swimmers, reported by Kita[22], using Japanese competitive swimmers as subjects. However, the subjects in Kita's study seem to be fairly inferior in swimming ability to those used in this study. As already stated, the results of previous studies concerning relationships between swimming performance and physique are not always the same. Namely, some researchers[15)22)33)] found that swimming speed related significantly to physique attributes such as stature and body weight, but others[30)36)] reported no significant relationships.

Probably, following factors may have affected the inconsistent results among previousely reported data: skill level, degree of training experience, group trait, and so on. However, as far as judging from the present results, a relationship of each physique attribute to swimming performances seems to differ in sexes. Namely, male swimmers have a greater influence of physique to swimming

Table 3. Multiple correlation coefficients of physique elements to various crawl swimming performances.

		25m	50m	100m	200m	400m
male	body linearity	.272*	.248*	.244*	.275*	.254*
	weight of body	.347*	.335*	.312*	.355*	.286*
	body girth	.347*	.363*	.370*	.405*	.314*
	whole physique	.444*	.425*	.439*	.462*	.395*
female	body linearity	.209	.199	.202	.186	.187
	weight of body	.305*	.120	.090	.132	.185
	body girth	.285	.184	.315*	.400*	.424*
	whole physique	.469*	.313	.394	.434*	.449*

Note ; *Significant at the 0.05.

performances than female swimmers. Especially, it may be noted that the way of relationship of physique attributes such as body density, skinfolds, and fat to 25m performance differ extremely in both sexes. Negative correlations in Table 2 can be interpreted as that the faster a swimmer swims the greater his physique value is because time was used as a unit of swimming performance. Therefore, it is considered that in female swimmers, the greater thigh girth they have, or the more fat they have, the slower they swim in 25m swimming, but, in male swimmers, such a trend does not exist.

It should also be noted that in male swimmers, lean body mass, body surface area, and lung capacity showed significant correlations with all swimming performances, but not in female swimmers.

Table 3 shows multiple correlations of physique elements to each swimming performance. In case of male swimmers, all physique elements or whole physique correlated significantly with all swimming performances. In contrast, for female swimmers, significant correlations were found only between weight of body and 25m performance, and between body girth and performances of longer than 100m. It is apparent that the sexual difference in contribution of physique elements to swimming performances exists although the point is somewhat different when compared to viewing from each physique variable like in Table 2. Both groups of male and female swimmers were the same in age and training experience although speed swimming ability was fairly different. Therefore, as the reason of the sexual differences obtained in this study, the following can be considered: in case of female as compared to male, physique itself is not always one of more important factors for limiting swimming performances, and physical elements such as muscular strength, flexibility and endurance rather than physique are closely related to the achievement of speed swimming. Or, physique with many other physical factors rather than by itself relates strongly to swimming performance. However, from the present results, in both sexes, the hypothesis that the contribution of physique to swimming performance would vary

with the change of swimming distance can not be comfirmed.

In summary, well-trained swimmers have greater values in many physique attributes except for arm skinfold than general people of the same age and there is a similar sexual difference in physique aspects between male and female swimmers as that of general people. Furthermore, the contribution of physique to swimming performance for male swimmers is generally higher than that for female swimmers and also a sexual difference in the way of its relationship exists.

References

1. Åstrand, P.-O., Engstrom, L., Eriksson, B., Karlberg, P., Nylander, I., Saltin, B., and Thoren, C.(1963) Girl swimmers with special reference to respiratory and circulatory adaptation and gynaecology and psychiatric aspects. Acta Paediatria 147,75.
2. Beall, E.(1939) The relationship of various anthropometric measurements of selected college women to success in certain physical activities. New York Bureau of Publications, Teacher's College, Columbia University.
3. Bloomfiled, J., and Sigerseth, P.(1965) Anatomical and physiological differences between sprint and middle distance swimmers at the university level. J. Sports Med. and Physical fitness 5, 76-81.
4. Brożek, J., Grande, F., Anderson, F.and Keys, A.(1963) Densitometric analysis of body composition: revision of some quantitative assumptions. Ann. N.Y. Acad. Sci 110,113-140.
5. Bruce, W.M. and Malina, R.M.(1985) Changes in body composition and physique of elite university-level female swimmers during a competitive season. J. Sports Sci. 3, 33-40.
6. Burdeshaw, D.(1966) Learning rate of college women in swimming in relation to strength, motor ability, buoyancy, and body measurements. Doctoral Dissertation. The Univ. of Texas.
7. Clarke, D.H. and Vaccro, D.(1979) The effect of swimming training on muscular performance and body composition in children. Res. Quart. 50-1, 9-17.
8. Cureton, T.K.(1951) Physical fitness of champion athletes, Urbana Illinois, University of Illinois Press.
9. Demura, S.(1983) The sex difference and grade difference in anthropometric characteristics, muscular strength, and flexibility -junior high school swimmers -. Jpn. J.Phy. Fitness Sports Med., 32-1, 8-16.(in Japanese)
10. Demura, S. and Matsuura, Y.(1983) The sexual difference of factorial structure of swimming ability in well-trained junior high school swimmers. Jap. J. Phys. Educ. 27-4, 287-299.(in Japanese)
11. Demura, S., Matsuzawa, J, and Nojima, T. (1984) Interrelationships between various physique-compositing elements. J. Educational Medicine 30-2, 29-35.(in Japanese)
12. Demura, S.(1984) Comparison of physique, muscular strength, flexibility, and neuromuscular function among different swimming strokes of swimmers. Jap. J. Phys. Educ. 29-1, 25-34.(in Japanese)
13. Demura, S.(1986) Sexual differences in physique, physical fitness and swimming skill in college swimmers. Jap. J. Phys. Educ. 31-2,151-162.(in Japanese)
14. Demura, S.(1987) Developmental change of crawl swimming performances with age in school age. Bull. Fac. Edu. Kanazawa Univ. 36, 273-282.(in Japanese)
15. Demura, S.(1988) Relationship of physique with crawl swimming performance in competitive college male swimmers. Bull. Fac. Edu. Kanazawa Univ. 38, 1-9.(in Japanese)
16. Demura, S.(1990) Contribution of physique and muscular strength to pull swimming force and swimming performance in school-boy swimmers.

Bull. Fac. Edu. Kanazawa Univ. 39, 187-196.

17. Demura, S.(1990) Effects of a six-month swimming training program on physique, muscular strength and swimming speed in school children. J. Educational Medicine 36-1, 44-52.
18. Demura, S.(1990) Factorial structure of swimming ability and its sexual difference in well-trained schoolchild swimmers. Jap. J. Phys. Educ. 35-3, 219-230.
19. Dickson, C.A.(1971) The effects of swimming instruction method on selected aspects of physical fitness. Doctoral dissertation, University of Texas.
20. Hirata, K.(1975) Evaluating Method of Physique and Physical Fitness and its Practical Application, Japan, Taiyosha Printing Company, 1st edition.(in Japanese)
21. Ikegami, H., Shigeeda, T., Kuyama, J., Nomura, T., Kurokawa, T. and Goto, S.(1983) Comparison of $\dot{V}O_2$ for buoyancy and propulsion during swimming between male and female. Jap. J. Phys. Educ. 28-1, 33-42.
22. Kita, I.(1984) Relationships of bouyancy, physique, and swimming performance. Master thesis, Kanazawa University.(in Japanease)
23. Lawther, J.D.(1956) Flexibility for what, Journal of Health, Physical Education, and Recreation 27,23.
24. McCurdy, J.H., and Larson, L.A.(1940) The validity of circulatory-respiratory measures as an index of endurance condition in swimming. Res. Quart. 11,3-12.
25. Medical Tribune.(1965) Individual capacity of sport determined by somatotype. Swimming Technique 2,76-77.
26. Medved, R.(1960) Body heat and predisposition for certain sports. J. Sports Med.
27. Monotye, H.J., Howard, G. E. and Wood, J.H. (1967) Observations of some Homo-camical and anthropometric measurements in athletes. J. Sports Med. 7,35-44.
28. Morehouse, L. E. and Rasch, P. J.(1963) Sports medicine for trainers.(2rd ed.) Philadelphia: W. B. Sounders.
29. Nagamine, S.(1975) Evaluation of body fatness by skinfold measurements. JIBP Synthesis, Physiological Adaptability and Nutritional Status of Japanese 4,16-20.
30. Patterson, W. R. (1965) The effects of competitive swimming training on girls in relation to selected anthropometrical and strength measurements. Swimming Technique 2, 14-15, 24.
31. Physical Fitness Laboratory Tokyo Metoropolitan University.(1982) Physical Fitness standards of Japanese people(3rd edn.), pp.22-104. Tokyo : Fumaido.
32. Pugh, L.G.C.(1960) A physiology and applied anatomy. Clinical Psychology 19,257-273.
33. Schockley, J.M.(1972) An analysis of performance of the swimmers in the 1971 NACAA university division championships with a discription of personal variables and training methods. Doctoral dissertation, Georgia University.
34. Sprague, H.A.(1976) Relationship of certain physical measurements to swimming speed. Res. Quart. 47-4,810-814.
35. Stollman,R.K.(1971) The relationship of body density and selected anthropometric measurs to the acquisition of beginning swimming skills. Doctoral Dissertation, Illinois University.
36. Stroup, F.(1964) Height, weight, and swimming time. Physical Educator 12,19.