BODY COMPOSITION AND HIP FLEXIBILITY OF SYNCHRONIZED SWIMMERS

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INTRODUCTION

Public interest in synchronized swimming has increased as a result of the 1984 Summer Olympics, however, there has been very little research completed to date on this sport. The information presented in this paper is the result of the first year of a five year longitudinal study to determine body composition and hip flexibility characteristics of intermediate and elite synchronized swimmers.

SUBJECTS

The subjects for this study were 20 members of the nationally ranked Santa Clara Aquamaids Synchronized Swimming Team. The means for age, height, and weight of the subjects were 17.35 years, 164.05 cm, and 563.19 Newtons, respectively (Table 1).

METHODS

Body Composition

Two techniques were utilized in order to predict percentage of body fat. Hydrostatic weighings were conducted in a shallow (5 feet) tank. The subjects were suspended from a Chatillon 15 kg scale in a seat made of 4 inch canvas webbing. A weight belt was placed around the subject's waist to aid in submersion. The weight of this belt was determined prior to submersion of the subject and subtracted from the subject's underwater weight. Subjects were hydrostatically weighed 5 to 10 times until 3 readings agreed within 20 grams. The maximum of those 3 readings was used to calculate body density. Body density was calculated from the formula of Brozek, Grande, Anderson, and Keys, (1963) and body composition according to the formula of Siri (1956).

Lung volumes were determined using a helium dilution technique. The procedures given in the Collins R/S Unit Spirometer manual were followed. Subjects breathed quietly into a closed system filled with helium, oxygen, and room air. Oxygen was added as needed. After helium equilibrium was reached the subject inhaled maximally and exhaled maximally. Two tests were taken and the average of the test results was used. Both residual volume and hydrostatic weighing were administered to subjects in the same postural position (i.e., sitting).

Skinfold measurements were taken at four sites (triceps, calf, suprailium, thigh), as indicated in Wilmore and Behnke (1969), and Sloan, Burt, and Blyth (1962). According to the methods of Wilmore and Behnke (1969), two independent measurements were taken at each site. Whenever the difference in the two measurements at a site was greater than 1%, a third measurement was taken. The mean of the first two measurements or the mean of the closest measurements was accepted as the representative value for the site. All measurements were taken by a single, trained technician with a Harpenden caliper that was calibrated with a Vernier caliper according to the methods of Lohman, Pollock, Slaughter, Brandon, and Boileau (1984). Three equations were used to predict body density: a) Jackson, Pollock, and Ward (1980), b) Sloan, Burt, and Blyth (1962), c) Mayhew, Piper, Koss, and Montaldi (1983). These equations are specifically for prediction of body density/composition of women. The mean obtained from these three equations was utilized for each subject's analysis.

Hip Flexibility

Hip abduction was determined according to the method of Atwater (1984). With the subject lying in a supine position, the legs were fully abducted at the hips. The distance was measured from lateral maleolus to lateral maleolus. Next the distances from greater trochanter to greater trochanter (hip width) and from greater trochanter to lateral maleolus (leg length) were measured. Utilizing these known distances the angle of abduction was determined with trigonometry (Figure 1).

Hip medial rotation was also determined according to the method of Atwater (1984). The subjects were kneeling on a table with the knees directly under the hips. The hips were then internally rotated, and the distance measured from ankle to ankle. By measuring the distances from knee to knee (knee width) and from knee to lateral maleolus (shank length), the angle of medial rotation could be determined with trigonometry (Figure 2).

Both right and left hip flexion were measured with the subject in a supine position on a low table. With the pelvis tilted posteriorly, the subject was asked to maximally flex one leg at a time. Measurements were taken utilizing a goniometer. Symmetry in hip flexion was merely the difference between values for the right and left legs.

Performance Rankings

The swimmers were ranked by their coaches on the basis of their performances for the entire 1984 season and the 1985 season through April 15, 1985. Unfortunately, between the time the data collection began in August, 1984 and it was completed in October, 1984, there were some major changes within the Santa Clara Aquamaids Synchronized Swimming Team, resulting in a loss of some of the team members. Therefore, the number of subjects varies for the different variables which were analyzed.

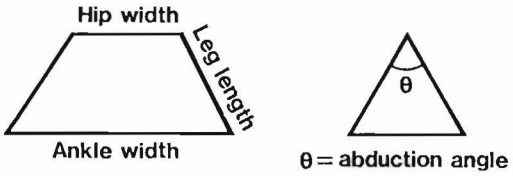

Figure 1. Technique utilized for calculation of the abduction angle.

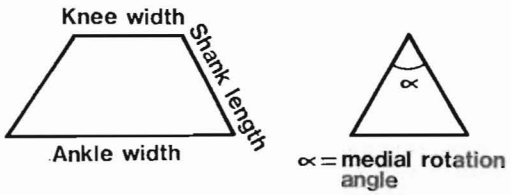

Figure 2. Technique utilized for calculation of the medial rotation angle.

Analysis of Data

In order to investigate the relationships between the variables for which data were quantified and the coaches' rankings of performance, Spearman rank correlations (rho) were calculated. Based on the definition given by Weber and Lamb (1970), a coefficient of $\geq .70$ indicated a high correlation.

RESULTS AND DISCUSSION

Body Composition

The means for percentage of body fat and lean body weight (LBW) were 22.27% (hydrostatic) and 44.19 kg (hydrostatic), respectively (Table 2). Moffat, Katch, Freedson, and Lindeman (1980) studied 15 members of the University of Michigan Synchronized Swimming Team. They reported means of 20.9% for body fat and 45.0 kg for LBW. Kirkendall, Delio, Hagerman, and Fox (1982) investigated the body composition of 90 intermediate and 100 elite synchronized swimmers. Their results were 20.56% body fat and 22.09% body fat for the elite and intermediate swimmers, respectively. The LBW was 43.77 kg for the elite swimmers and 41.07 kg for the intermediates.

Roby, Buono, Constable, Lowdon, and Tsao (1983) reported body composition data for 13 champion synchronized swimmers. They found the mean for body fat to be 24% and for LBW to be 42.3 kg. The most probable reason for the higher value of 24% was the discrepancy in ages among the samples studied. The average age in the Roby, et al. (1983) study was 20.1 years, whereas for the

Table 1

DESCRIPTIVE STATISTICS SUMMARY

	N	Mean	Standard Deviation
Height	20	164.05 cm	5.74
Weight	20	563.19 N	7.33
Age	20	17.35 yrs.	3.03

Table 2

BODY COMPOSITION SUMMARY

	N	Mean	Standard Deviation
Body Fat (Hydrostatic)	20	22.27%	6.19
Body Fat (Skinfolds)	20	19.70%	4.05
Lean Body Wt. (Hydrostatic)	20	44.19 kg	4.14
Lean Body Wt. (Skinfolds)	20	45.82 kg	4.63

other three studies reported it was 17.35 years (current study), 17.39 and 15.86 years (Kirkendall, et al., 1982), and 19.7 years (Moffat, et al., 1980).

It has been hypothesized that body composition variables, particularly percent body fat and LBW, might be used to predict success for various athletes (Girandola, 1978). It was the belief of the investigators that relatively increased fatness might be beneficial in synchronized swimming in order to produce maximal buoyancy. The rank order correlations between percent fat (hydrostatic) and ability were $r = -.22$ and $r = -.76$ for the 1984 and 1985 seasons, respectively (Table 3). The significant relationship found for the 1985 season should be noted with caution due to the smaller number of subjects in 1985 ($n = 11$) than in 1984 ($n = 19$). Moffat, et al. (1980) found a correlation of $r = -.31$ between percent fat and an ability ranking. Since all three of the correlations reported to date are negative, it would appear that relatively increased fatness may be beneficial in synchronized swimming, however, a great deal more research in this area is necessary. It also should be stressed that in terms of aesthetic appeal, increased body fat may be a detrimental factor.

The correlations for LBW (hydrostatic) and performance rankings were $r = -.04$ and $r = -.50$ for the 1984 and 1985 seasons, respectively (Table 3). Moffat, et al. (1980) reported an $r = .18$ between ability ranking and LBW. Since none of these values are significant, there does not appear to be a predictable relationship between LBW and success in synchronized swimming.

Table 3

SPEARMAN RHO SUMMARY

(Y VARIABLE = COACHES' RANKINGS)

	N	Season	Rho
% Fat (Hydrostatic)	19	1984	-0.22
% Fat (Hydrostatic)	11	1985	-0.76 *
%Fat (Skinfolds)	19	1984	-0.13
%Fat (Skinfolds)	11	1985	-0.70 *
LBW (kg) (Hydrostatic)	19	1984	-0.04
LBW (kg) (Hydrostatic)	11	1985	-0.50
LBW (kg) (Skinfolds)	19	1984	-0.21
LBW (kg) (Skinfolds)	11	1985	-0.67
Hip Abduction	7	1984	0.11
Hip Abduction	8	1985	0.19
Hip Medial Rotation	7	1984	0.29
Hip Medial Rotation	8	1985	0.33
Right Hip Flexion	7	1984	0.67
Right Hip Flexion	8	1985	0.59
Left Hip Flexion	7	1984	0.71 *
Left Hip Flexion	8	1985	0.71 *
Hip Flexion Symmetry	7	1984	0.37
Hip Flexion Symmetry	8	1985	0.33

* = High Relationship ($\geq$ .70)

Hip Flexibility

The means for right and left hip flexion were 117.25° and 105.5° , respectively (Table 4). The greater flexibility in the right hip was probably due to the fact that a majority of the swimmers were right-legged, thereby using their right legs more for such synchronized swimming skills as ballet legs.

The mean for hip abduction was 88.86° (Table 4), which was close to the mean of 93.11° found by Atwater (1984) when she tested 21 synchronized swimmers at the National Team Trials. Since the mean was slightly greater for the higher caliber swimmers measured by Atwater, this might be an important area for further investigation.

The mean for medial rotation was 83.94° (Table 4), which was considerably higher than the mean of 63.4° reported by Atwater. The reasons for this discrepancy are still open to question, however some possibilities might be a slightly different protocol, the fact that the swimmers in the current study were younger (mean = 17.35 years) than those in the Atwater study (mean = 19.8 years), or the difference in skill level. Clearly, this difference dictates the necessity for further investigation.

Table 4

HIP FLEXIBILITY SUMMARY

	N	Mean	Standard Deviation
Abduction	8	88.86°	7.51
Medial Rotation	8	83.94°	13.12
Right Hip Flexion	8	117.25°	12.15
Left Hip Flexion	8	105.5°	13.82

The only significant correlations found for hip flexibility were between the performance rankings and left hip flexion for both the 1984 and 1985 seasons (r = .71). Due to the small number of subjects, further research is definitely indicated (Table 3).

SUMMARY

The results of the first year of this five year longitudinal study indicate that the average swimmer tested was 17.35 years of age, 164.05 cm tall, weighed 563.19 N, and was 22.27% fat (hydrostatic). In terms of hip flexibility, the means for abduction, medial rotation, right hip flexion, and left hip flexion were 88.86° , 83.94° , 117.25° , and 105.5° , respectively.

Significant correlations were found between rankings of performance and: a) percent body fat (1985) and b) left hip flexion (1984 and 1985).

In addition to the continuation of the current study over the next four years, the authors are also investigating selected anthropometric characteristics of younger synchronized swimmers (8 - 14 years). It is the hope of the investigators that these results will help add to the body of knowledge in order to improve performance in the sport of synchronized swimming.

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