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# EFFECTS OF BODY SIZE AND BODY MASS ON THE SWIMMING PERFORMANCE OF PRESCHOOL CHILDREN *

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This research examined the relationship between body size and mass and the performance of 3- to 6-year-old children ($n = 117$) on two categories of swimming tasks: Locomotion: Front and Locomotion: Back. The major hypothesis was that body size and mass measurements would be good predictors of children's swimming performance. The function of age/gender also was examined. Stepwise multiple regression was used to select the best predictors of swimming performance after controlling for amount of aquatic training and child's apprehensiveness about water. Body weight was the best predictor of children's swimming performance on each category of tasks ($p < 0.01$). It accounted for at least 16% of performance variation when entered alone, and it accounted for 5% given age. Age was of little importance after body size and mass were taken into account. The major conclusion was that future research should incorporate more complex research designs to account for the network of influencing factors.

Many factors may influence the swimming performance of children. Previous motor development research has identified at least three important factors: aquatic training, physical growth, and child's attitude about water. Erbaugh (1986) reported that aquatic training significantly influenced preschool-aged children's performance on six categories of tasks over an 8-month period. McGraw (1939) observed that changes in the body proportions of Johnny and Jimmy between infancy

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and school-age altered their swimming behavior. Erbaugh (1981) found that a preschool child's apprehensiveness about the water had a negative influence on the performance of specific swimming tasks. The results of previous investigations of children's swimming behavior have provided scientific information about several of the important determinants; however, they have not provided information about their relative significance.

This research focused on the influence of body size and also body mass on the swimming performance of preschool children. It also examined age/gender differences in performance. The relationship between body size and body mass and physical performance of school-aged children is well documented. Body size has a moderate correlation with performance, and body mass or fatness has a low negative correlation (Malina 1975; Slaughter et al. 1980). In contrast, the relationship between physical growth and swimming performance in children is not very well understood. Only several well-designed studies have been completed on this topic. Matheson (1977) reported that several body size measurements were good predictors of performance in 10- to 12-year-old female swimmers. Results of stepwise discriminant analysis with control for age and maturity level indicated that three of the five best predictors were body size measurements: height, weight, and thigh girth (fat corrected). The other two predictors were measurements of skill efficiency and previous aquatic experience (Matheson 1977: 56). Kanitz and Bar-Or (1974) found that body size and maturity were related to the performance of young male swimmers, and Sprague (1976) found that the size of biceps was the most important influencing characteristic. These studies suggested that body size contributes significantly to the swimming skillfulness of elite school-aged performers; however, there is very little information about physical growth and the swimming performance of preschool-aged children.

Previous research also has indicated that swimming performance improves with age during the preschool years, and there is some evidence for gender differences (Erbaugh 1980, 1981). Erbaugh (1981) reported that 3- and 4-year-old girls performed Locomotion : Front tasks at a more advanced level than boys the same age; and that 4- and 5-year-old boys performed Locomotion : Back tasks at a less advanced level than their peers. One limitation of the completed swimming research is that individual differences associated with factors such as

physical growth and child's attitude about water were seldom analyzed; therefore, the effects of interest may have been masked. Motor development researchers are aware of this statistical problem; however, few of them have designed studies to overcome it. This research was designed to account for individual differences associated with several of the potential influencing factors; thus it should improve the level of knowledge about skill development in young children (Erbaugh 1984; Espenschade and Eckert 1980).

This study investigated the relationship between body size, and body mass and the swimming performance of preschool children. It also investigated the relationship among the selected physical growth variables, age, gender, and swimming performance. The four research questions were: (1) Will body size and body mass be related to swimming performance? (2) Will age and gender be related to swimming performance after body size and mass are taken into account? (3) Will age and gender be related to swimming performance given no information about physical growth? (4) What are the best predictors of swimming performance in preschool children? To answer these questions two additional factors were controlled statistically: amount of previous aquatic training, and degree of apprehensiveness about water. Previous research has shown that these two factors significantly influence the swimming skill development of preschool children (Erbaugh 1981, 1986; McGraw 1939).

## Method

### *Subjects*

The subjects were 56 boys with a mean age of 4.5 years ($SD = 1.0$ years), and 61 girls with a mean age of 4.3 years ($SD = 1.0$ years). Half of the children were enrolled in a development movement program in a Midwestern university community, and half were volunteers from the same community. Program participants received two 30-min swimming lessons per week for a 10-week period during the semester (Clifton 1970). Information about the family background and the previous swimming experience of children during the year prior to the study was obtained from parents by written questionnaire (Erbaugh 1981: 192–194). The family background variables included the age, occupa-

tion, and education of each parent, and family size. The mean age of parents was 30 years. Eighty percent of the fathers held professional or professional-academic positions. The majority of the mothers were housewives. Eighty percent of the fathers and 45% of the mothers had attended graduate, or professional schools. The average number of children per family was two. The children's swimming background variables included: amount of shower activity; amount of swimming in shallow water environment such as a wading pool; amount of swimming in a municipal pool or lake; and degree of apprehensiveness about water. Eighty-five percent of the children played in the shower, and 70% enjoyed weekly participation in wading pool activities during the summer months. Sixty percent of the children also swam at least once a week in their municipal pool or a nearby lake. Approximately 50% of the children occasionally feared water. A one-way analysis of variance of the frequency data for the family and swimming background variables indicated nonsignificant differences between the two groups of children. Thus the family characteristics as well as previous swimming experiences were not biasing factors in the present study. All parents were informed about testing procedure, and they consented to their child's participation.

*Data collection and analysis*

Children performed two categories of swimming tasks from the Erbaugh rating scale (Erbaugh 1978: 1180). The tasks within each category were arranged by order of difficulty. The simplest task was scored as 1 and the most difficult task was scored either 14 or 15 for the respective categories. The Locomotion : Front category had 14 tasks in which the child maintained a prone position and propelled self with or without the assistance of an examiner or flotation device. Level 7, for example, was:

> 'The child propels self *without* support a distance of at least 1.55 m. The child uses a human stroke. The examiner provides no assistance as he/she stands 1.5–2 m from the child. The *arm* movements are underwater paddling with *some* propulsive effects. The *leg* movements are a pedaling action with some supportive and propulsive effects. The *body* position is approximately 45°. The head is above the water' (Erbaugh 1981: 201).

The Locomotion : Back category had 15 tasks in which the child maintained a supine position and propelled self with or without the

assistance of an examiner or flotation device. Level 9, for example, was:

> 'The child propels self *without support* a distance of at least *1 m*. The examiner catches the child after he/she has travelled at least 1 m. The *arm* movements of finning and sculling provide some propulsive effects. They also help maintain a supine position. The *leg* action which is a rudimentary flutter kick provides most of the propulsive effects. The *body* position is 45° when the child begins to swim. The hips drop rapidly to a vertical position during the task. The *head* and ears are in the water' (Erbaugh 1981: 206).

Each child performed two trials of each test under standard conditions. A judge and an adult swimmer (examiner) tested children individually during a 20-min session. The examiner asked the child to perform, and the judge who sat on the pool deck rated the child's performance in each task category. The pool dimensions were 18.6 m $\times$ 9.3 m, and the depth was 1.24 m to 1.86 m. The temperature of the water and the room were 30°C and 32.2°C, respectively. The reliability of rating scale was reported in previous research (Erbaugh 1978). Intertrial reliability estimates were $\geqslant 0.98$ from the Locomotion : Front and Locomotion : Back tasks. Additional information about the scale and testing procedures has been reported elsewhere (Erbaugh 1978, 1980, 1981).

Physical growth measurements of height and weight were taken during a 10-min session scheduled just prior to the swimming test. Each child was dressed shorts and a short-sleeved shirt. The trained experimenter independently took two sets of measurements. Height was measured to the nearest millimeter, and weight, to the nearest half-pound. Pearson product–moment correlations which estimated reliability were $\geqslant 0.98$. Reliability estimates were similar to those reported by other researchers (Erbaugh 1984; Wilmore and Behnke 1974). Body mass was derived using the standard formula: weight (kg)/height$^2$ (m) (Falls 1984; Keys et al. 1972).

The child's apprehensiveness about the water was reported in a written questionnaire completed by the parent. The question was: Does your child fear the water? The three possible responses were: Yes, Occasionally, or No. Examination of the data lead the investigator to conclude that parents made accurate judgments. The number of previous semesters of aquatic training was taken from the program records of each child.

Standard statistical procedures were used to analyze the data. Descriptive statistics were used to screen the data, and to analyze bivariate

relationships between potential influencing factors and children's swimming performance. Stepwise multiple regression was used to select the best predictors of swimming performance and the Locomotion : Front and Locomotion : Back tasks. The predictors and covariates were forced into the regression equation in a fixed order in two separate analyses to provide maximum amount of information about the interrelationships among the predictors and swimming performance. Similar statistical procedures have been used by Erbaugh (1984), Falls (1984), and Slaughter et al. (1980).

## Results

Means and standard deviations of selected physical growth measurements and swimming performance are presented in table 1. The values for height and weight were compared to those Snyder et al. (1977) reported for a large United States sample. The values for Locomotion : Front and Locomotion : Back swimming performance were compared to those Erbaugh (1980) reported for a different sample with similar backgrounds. Means and standard deviations were very similar for each measurement.

Zero-order correlations for the selected dependent and independent variables are presented in table 2. This analysis focuses on the relation-

Table 1
Means and standard deviations of selected physical growth measurements and swimming performance of preschool children.

| | Boys | | Girls | | Sample | |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Swimming performance | | | | | | |
| Locomotion : Front | 6.2 | 4.4 | 6.8 | 4.2 | 6.5 | 4.3 |
| Locomotion : Back | 4.8 | 4.3 | 6.4 | 4.9 | 5.6 | 4.7 |
| Physical growth | | | | | | |
| Height (cm) | 104.9 | 7.2 | 104.3 | 9.1 | 104.6 | 8.2 |
| Weight (kg) | 17.6 | 2.6 | 17.1 | 3.2 | 17.3 | 2.9 |
| Body Mass Index (Wt [kg]/Ht$^2$ [m]) | 15.9 | 1.3 | 15.6 | 1.2 | 15.8 | 1.2 |
| Age (months) | 52.6 | 11.8 | 51.9 | 11.6 | 52.3 | 11.7 |

Table 2
Intercorrelations among selected dependent and independent variables. [a]

| | Locomotion: Front | Locomotion: Back | Age | Height | BMI |
|---|---|---|---|---|---|
| Age (mo) | 0.55 (0.51) | 0.52 (0.46) | | | |
| Height (cm) | 0.58 (0.56) | 0.60 (0.56) | 0.85 | | |
| Weight (kg) | 0.55 (0.60) | 0.55 (0.57) | 0.73 | 0.88 | |
| BMI (Wt [kg]/Ht$^2$ [m]) | 0.03 (0.16) | 0.01 (0.10) | −0.13 | −0.10 | |
| Gender (0–girl; 1–boy) | −0.07 (−0.05) | −0.17 (−0.15) | 0.03 | 0.04 | 0.11 |

[a] Zero-order correlations are given for selected variables; partial correlations with control for semesters of previous training, and degree of apprehensiveness about water are given in parentheses.

ship between children's performance of each category of swimming tasks and five preditors – age, height, weight, body mass, and gender. Two additional variables were included as covariates to account for individual differences in performance associated with amount of previous aquatic instruction, and apprehensiveness about water. The correlations between the covariates and the variables of interest, and also partial correlations are given in table 2. Correlations were interpreted according to Marascuilo (1971). Weight had a moderately strong correlation with Locomotion: Front and Locomotion: Back performance ($rs = 0.55$); thus, heavier children had a moderate tendency to perform at a more advanced level than lighter children. When the effects of the two covariates were partialed out the correlations between swimming performance and weight increased slightly ($rs = 0.60$, and 0.61, respectively). Height and age also had moderately strong correlations with swimming performance on each category of tasks. Correlations with Locomotion: Front, for example, were 0.58 and 0.55, respectively. Thus, older and taller children had a moderate tendency to perform at a more advanced level than younger and shorter children. Gender had a very weak correlation with Locomotion: Back performance, and gender and body mass index had very weak correlations with swimming performance given the two covariates.

In summary, zero-order and partial correlations indicated that three of the possible predictors had moderate relationships with swimming performance – weight, height, and age; and the other two – body mass and gender – had weak relationships with performance.

Stepwise multiple regression analyses of selected potential predictors of swimming performance on the Locomotion: Front and Locomo-

Table 3
Stepwise multiple regression analyses of selected predictors of preschool children's swimming performance.

| Source of variation | First analysis | | Second analysis | |
|---|---|---|---|---|
| | Step no. | $R^2$ change | Step no. | $R^2$ change |
| | *Locomotion: Front performance* [a] | | | |
| Previous aquatic training | 1 | 0.500 [c] | 1 | 0.500 [c] |
| Apprehensiveness about water | 2 | 0.044 [c] | 2 | 0.044 [c] |
| Weight | 3 | 0.165 [c] | 6 | 0.050 [c] |
| Body Mass Index | 4 | 0.004 | 7 | 0.000 |
| Age | 5 | 0.002 | 3 | 0.118 [c] |
| Gender | 6 | 0.004 | 4 | 0.002 |
| Gender × Age | 7 | 0.002 | 5 | 0.008 |
| | *Locomotion: Back performance* [b] | | | |
| Previous aquatic training | 1 | 0.370 [c] | 1 | 0.370 [c] |
| Apprehensiveness about water | 2 | 0.085 [c] | 2 | 0.085 [c] |
| Weight | 3 | 0.178 [c] | 6 | 0.059 [c] |
| Body Mass Index | 4 | 0.012 | 7 | 0.004 |
| Age | 5 | 0.001 | 3 | 0.114 [c] |
| Gender | 6 | 0.020 | 4 | 0.015 |
| Gender × Age | 7 | 0.015 | 5 | 0.033 [c] |

[a] Full model: $R^2 = 0.722$, overall $F(7, 109) = 40.37$, $p < 0.01$.
[b] Full model: $R^2 = 0.680$, overall $F(7, 109) = 33.17$, $p < 0.01$.
[c] $p < 0.01$.

tion: Back tasks are presented in table 3. The predictors and covariates were forced into the regression equation in a fixed order in each analysis. The levels for the first analysis were: (1) covariates; (2) weight, height, body mass; (3) age; (4) gender; (5) gender × age. The levels for the second analysis were: (1) covariates; (2) age; (3) gender; (4) gender × age; (5) weight, height, body mass. The results of previous research on swimming skill development of preschool children guided the selection of the variables included in the regression analyses (Erbaugh 1981).

The coefficient of determination ($R^2 \times 100$) for the five predictors and covariates was 72% for Locomotion: Front, and 68% for Locomo-

tion : Back. The overall relationship between the independent variables and swimming performance was statistically significant for each category of tasks ( $p < 0.01$). In the first analysis for each category of tasks, changes in the coefficient of determination were significant for only one of the five predictors of interest ( $p < 0.01$). Weight increased the explained variation in Locomotion : Front, and Locomotion : Back performance by 16.5% and 17.8%, respectively. Changes in the coefficient of determination also were significant for each of the two covariates – previous aquatic instruction, and fear of water; however, they were nonsignificant for the other predictors.

In the second analysis of Locomotion : Front data, when age was entered at step 3, changes in the coefficient of determination were significant for two of the predictors – age and weight ( $p < 0.01$). Age increased the explained variation in swimming performancy by 11.8%, and weight increased the explained variation by 5%. In the second analysis of Locomotion : Back data, three predictors were significant – age, weight, and gender × age. Age and weight increased explained performance variation by 11%, and 6% respectively, which was similar to the Locomotion : Front results. The gender × age interaction increased explained variation of performance of the Locomotion : Back tasks by 3.3% ( $p < 0.01$).

## Discussion

This is one of the first studies that has examined the relationship between body size and body mass, and the swimming performance of preschool children. The results of zero-order correlations indicated a moderate relationship between height and weight and the swimming performance of preschool children. Matheson (1977) reported similar findings for school-aged competitive swimmers. The results also indicated a weak relationship between body mass and swimming performance of preschool children. This finding was similar to other research in children's motor behavior. Analyses of normative fitness data for a large sample of children revealed low correlations between body mass and motor performance (Falls 1984: 37). One reason for the low relationship is that the height–weight ratio was not the best estimator of fatness. Future research in children's swimming skill development should include skinfold measurements to estimate body fatness (Erbaugh 1984; Falls 1984).

The results of the stepwise regression analyses provided important information about the factors which influence swimming performance in preschool children. First, weight was the best predictor of children's swimming performance, given information about children's amount of aquatic training, and their degree of apprehensiveness about the water. Weight accounted for at least 16% of children's performance variation on each task, and it also explained at least 5% of performance variaton given age and gender. One reason weight may have been so important in this research was that it has a strong relationship with buoyancy which enhances swimming skillfulness. Cotton and Newman (1978) found that weight which is an indicator of fatness had a correlation of 0.76 with 'buoyancy up' in children, ages 2 to 12 years. Another reason weight had a strong positive influence on children's swimming performance was that it may have provided for more stable body temperature (Bergh et al. 1978; Houston et al. 1978). Second, weight and age commonly accounted for 11% of performance variation in swimming by young children. This interrelationship may be more clearly understood by interpreting the zero-order correlations among the variables. The correlations between weight and age, and weight and swimming performance were 0.73 and 0.60, respectively (table 2). The heavier and possibly fatter children who were older than their peers had a moderate tendency to perform at more advanced level than the lighter thinner children who were younger. Third, the influence of body mass or relative fatness on children's swimming performance was nonsignificant given information about weight. This finding suggested that weight contained information about preschool children's fatness, and that the derivation of the body mass index provided very little additional information about fatness in the children as it related to their swimming performance. Additional research is needed to explain more clearly the significance of weight in children's swimming performance.

Fourth, the results also provided little evidence for gender differences in Locomotion : Front performance given previous training and attitude about water. This finding was not in agreement with previous research that reported gender differences in the development of Locomotion : Front skills in favor of the girls (Erbaugh 1981). The results of the present study suggest that gender differences reported in the previous research may have been associated with the two factors controlled in this research. Fifth, the Locomotion : Back results provided evidence of significant gender $\times$ age interaction given age (second

analysis). Examination of the mean Locomotion: Back scores of children in different age groups suggested that the 5- and 6-year-old girls performed at a more advanced level than boys the same age. Erbaugh (1981) reported similar gender differences, however, the explanation was unclear. The first regression analysis in this study provided new information because the gender × age interaction was nonsignificant given age, body weight, and mass. This means that gender differences in the Locomotion: Back performance of the older children may have been associated with differences in body size and mass. Future research on swimming development in young children should include gender as well as the other factors which may interact with it. Finally, amount of aquatic training and child's apprehensiveness about water influenced children's swimming performance. This finding was in agreement with previous research (Erbaugh 1981).

In conclusion, the swimming performance of preschool children is influenced by many factors. This research suggested that weight is the best predictor of swimming skillfulness given previous aquatic training and apprehensiveness about water. It also suggested that age is important especially if information about body size and mass are unavailable. Complex research designs are required to accurately determine the relative effects of important influencing factors. Future research in the swimming skill development of young children should include age, gender, amount of aquatic training, attitude about water, and body weight. It also should include other anthropometric, and body composition characteristics that may influence children's swimming performance (Cotton and Newman 1978; Matheson 1977; Meleski et al. 1982; Thorland et al. 1983).

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