Chapter II

REVIEW OF RELATED LITERATURE

Holmer\(^1\) investigated the energy expenditure of arm stroke, leg kick and the whole stroke of champion swimmers. Tests were completed in a swimming Hume where water velocity and temperature were controlled. For the freestyle tests, it was demonstrated that the highest energy output (\(V_o\)) by the swimmers during maximal swimming speed was 78\% for the arms alone and 87\% for legs, alone, respectively, as compared to the energy output for the whole stroke.

Bucher\(^2\) studied the influence of the leg kick and the arm stroke on the speed of the crawl stroke. Seventy six swimmers were divided into three sub-groups good, average and poor swimmers. The 15 meter speed tests included, arms alone, legs alone and arms and legs combined. His results


revealed, that the arm stroke, the speed/crawl speed ratio percentages were 91, 91 and 90 for good, average and poor swimmers respectively and 60, 59 and 62 for the leg stroke/crawl speed ratios.

Di Prampero et al. has contended that at slow velocities leg kick is inefficient as a positive source of swim propulsion, and is mainly used as a means to initiate leg lift, which results in a more horizontal body position. In response to swimming, the oxygen work requirement of the legs are high as compared with the arms because of the larger mass of active muscle, which mainly include the quadriceps, gastroenemius and the hamstrings. As a result of the greater oxygen requirements of the legs, the efficiency of swimming is impaired at slow speeds which is also associated with low body drag. He further contended that at higher speeds body drag increases. However, the rate of the leg kick can be reduced because the swimmer's body has assumed a more streamlined position in the water because of the increased efficiency of arm propulsion.

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Counselman⁴ studied the force which operated during swimming two types of crawl stroke. He used a harness in which the subjects were pulled at various speeds while in a glide position during which time they kicked their legs. He concluded that "when the swimmer was pulled at speeds greater than five feet per second, he did not only contribute anything to the speed at which he was being towed but, in same instances, actually created an increased drag as a result of his kicking." As a result of his findings, he concluded that the kick contributed nothing to the propulsion created by the arms when persons swim at specified fast speeds. He has contended that the principle role of the kick is that of a stabilizer and is a means by which the feet are kept in a high position which results in a more streamlined body position in the water. Also, if the kick is correctly coordinated with the corresponding arm action, it acts as a neutralising arm action, it acts as a neutralising force in order to counteract the negative drag resulting from the hips being forced downward in the water. This is because at the termination of the arm pull, the principle factors of force are counter productive to swim speed in that they are ineffectively pushing backward and upward.

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Tucker determined the relationship between relative muscular strength and personality in college males. The body cathexis scale, eysenik personality inventory and tennessee self-concept scale were employed to assess personality in 142 randomly selected subjects and relative muscular strength was measured during free weights in the bench press and squat. Because of the influence of body weight as muscular strength, body weight was controlled statistically. Person correlation, trend analysis, and partial correlations were computed and the results showed relative muscular strength to be a significant predictor of body cathexis, extraversion, neuroticism, and global self concept. Significant curilinear relationships were found between relative squat strength and neuroticism, and self concept. With the variance of body cathexis controlled the strength and self concept correlation increased threefold. In general relatively strong males were significantly more satisfied with their body parts and processes, less emotionally labile and auxious, more outgoing, sociable and impulsive, and more confident and satisfied with themselves than were their muscually weaker counterparts.

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Lean: Whitley determined the relationship between muscular force of a limb, under different starting condition and speed of movement. A horizontal adductive arm swing executed at maximal speed, and time at intervals of 150°, 90°, and 105° was studied under two experimental conditions. Although the movement completed was the same in both conditions the fundamental differences between the normal and pre-tensed arm movements was that in the latter condition the subject built up his arm strength maximally just prior to initiating the movement. Twenty trials under each condition were performed by 60 college men. All reliability coefficients were found to be high i.e. over .89.

In contradiction to expectations, the relationship between premovement strength and speed of movement at the first station (r = -.208) was lower than anticipated. However, the low correlations found between strength and speed of movement are in general agreement with the results of earlier investigators which have substantiated the predominance of neuromotor specificity.

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Albrecht includes 89 varsity swimmers from six different high schools in the South Sub-urban Conference as subjects. Measurements were taken of height, weight, upper arm length, lower and length, tarso length, bust height, arm spa..., chest normal, chest expanded, chest deflated, hand and food area measurement, body surface area, ankle flexion and hip flexion. Success was measured by a Coaches' rating and success (Percentage) determined by the State record for the event-divided by the time in the conference meet. No relationship was known between flexibility measure and swimming success.

Gross and Thompson found high and significant V/s between dynamic balance and speed in swimming, and dynamic balance and ability in swimming. Also, the ratios calculated between there same activities indicated that dynamic balance is not a chance factor and may be an important factor in speed and in ability in swimming.

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Mishra studied the relationship of selected Physical and Physiological Variables to performance in fifty meter front crawl swimming. The subjects were 25 professional male students of physical education studying in Lakshmibai National College of Physical Education, Gwalior. Datas were collected on Arm Strength (Roger’s Physical fitness Index), ankle flexibility (Ganometer) vital capacity (Spinometer) and body surface area (Du. Bios), performance was recorded in seconds, Product moment correlation was compared to special in fifty meter swimming. It was concluded that 1) there was a significant positive relationship between arm strength, ankle flexibility and vital capacity to swimming speed and 2) there was no significant relationship between body surface area and swimming speed.

The relationship between swimming and selected physiological, anthropometric, developmental and skill variables in 10-12 years old (x = 11.3) female competitive

Laljee Mishra, "Relationship of Selected Physical and Physiological Variables to Performance in 50 meter Front Crawl Swimming." (Unpublished Master’s Thesis, Jiwaji University, Gwalior, 1983).
swimmers was determined by Mathesen\textsuperscript{10}. Each also completed a 400 yards and 50 yards time trial. The data were initially examined by means of Pearson's matrix. Subsequently, the swimmers were classified into a top and bottom group. The two groups discriminant function analysis. The inter correlation matrix indicated that the best single predictors of swimming performance were height, aerobic capacity, and stroke efficiency. When the two classes of performance were compared, body size, skill, and exposure to swimming were the most significant groups of factors.

Fifty two college women who had attained at the maximum on intermediate level of swimming were selected as subjects by Hopper\textsuperscript{11} who tested them in Clark's Cebie Terminometer Tests for shoulder and hip extension strength, leightan's ankle flexibility test, and the Fox Power test. The only stroke tested was the front crawl. There was no significant relationship between shoulder extension strength or ankle flexibility and swimming efficiency. There was a


significant relationship, however, between hip extension strength and efficiency, and it was found that females derived more power from the arm stroke than from the leg stroke.

Relationship of selected physiological and psychological factors to the beginning swimmers ability to perform the crawl stroke was determined by Criteo\(^1\)\(^2\), who used 40 subjects from two beginning swimming classes. The beginning swimming classes met for 40 minutes twice a week. Prior to any swimming instruction, measurements were collected on shoulder rotation, shoulder extension strength, hip extension strength, body composition, swimming anxiety and swimming ability as measured by the Fox Power Test (revised). After five weeks of Crawl stroke instruction, measurements were again collected on swimming anxiety and swimming ability. Pearson Product Moment Correlation was used to \________ the date, It was found that 1) shoulder rotation, shoulder extension strength, hip extension strength and body composition were not significant factors in the performance of Crawl Stroke, and 2) a significant relationship was

\(^1\)\(^2\)Jersy Keith Criteo, "A Study of Selected Physiological and psychological Factor to Determine, the Relationship to the performance of the Crawl Stroke by Beginning Swimmers," Dissertation Abstracts International\(^3\)\(^\circ\) (October 1975): 2083A
indicated between swimming and anxiety and the ability to perform the crawl stroke.

Meardle\textsuperscript{13} Studied the effect of hyperventilation an artinal pco$_2$ and subsequent breathhold time have been used by swimmers and divers in an attempt to improve performance. In sprint swimming for example, it is undesirable from a mechanical viewpoint to roll the body and turn the head during the breathing phase of the stroke consequently, many swimmers hyperventilate on the starting blocks to prolong breathhold time during the swim. In spot diving, the intention of hyperventilation is the same as in competitive swimming to extent breathhold time. this sport, however, the results can be tragic. As the length and depth of the dive increase, the Oxygen content of the blood may be reduced to critically low values before artirial pco$_2$ reaches the level to stimulate breathing and signal ascent to the surface. This can cause the diver to lose consciousness before reaching the surface.

\textsuperscript{13}William D. Mcardle, Frank I. Kath and Victor L. Katch, "Hyperventilation and Breath-holding," Exercise Physiology. (Published in great Britain by Henry Kimpton publishers, London, printed in the United States of America):182
Grimston, etc. 14 developed a theoretical model to identify anthropometric variables relevant to success in swimming. Frontal areas, cross-sectional areas and lengths of body segments were measured on twelve members of a man's college team using a photographic procedure. Motion picture films were taken of the subjects competing in free style events and were analysed to determine the average stroke length, average stroke frequency, and average stroking speed. Corelation and multiple regression procedures were used to determine the relationships among the anthropometric variables and stroke length, stroke frequency and stroking speed respectively of the 21 anthropometric variables selected with the aid of the theoretical model. 6 were found to be significantly related to one or more of the measures of swimming performance when the influence of event distance was partialled out (p 0.05). The anthropometric variables characterising the subjects accounted for 89% stroke length 41% stroke frequency and 17% stroke speed of the various in the measured characteristics of their strokes. The axilla (USA) cross sectional areas was shown to have the largest influences on both stroke length and stroke frequency accounting for 57% of the various in the stroke length and

24% in the stroke frequency. There results suggests that although speed is little influenced by the physique of a swimmer, the combination of stroke length and stroke frequency used to attain a given speed is very much a function of his physique.

Councilman\textsuperscript{15} expressed his opinion that every athlete needs flexibility in a specific joint or in joints. As a free style swimmer needs ample flexibility to have exceptional good kick which will enhance the performance.

Lerson and Yocon\textsuperscript{16} also lend the supper to the possibility of improved performance through increased flexibility.

"The effectiveness of individual adjustment in many physical activity is determined by the degree of total body or single joint flexibility.

Cureton\textsuperscript{17} was of the opinion that a swimmer with


\textsuperscript{17}Thomas K. Cureton, "Flexibility as an Aspect of Physical Fitness" \textit{Research Quarterly} 12 (May 1941): 383.
relatively flexible ankle has possibility of more effective force for propulsion on every down beat of the kick in crawl stroke. Due to hyper extension of the ankle the water is driven backward and downward at more favourable angle which will lead to better performance.

Clarke\textsuperscript{18} pointed out that speed also depends upon strength. This is nearly an other way of saying that stronger man can lift more rapidly than can a weaker one or than the strength or motor limits the speed of an automobiles. If all these aspects are equal of an individual the stronger the individual faster he can run.

Sprague\textsuperscript{19} studied the relationship of certain physical measurements with swimming speed in male swimmers. Several ways of examining the relationship of swimming speed to physical measurements were investigated for all competitive strokes. They were free style, back stroke, breast stroke and butterfly stroke. The physical measurement were height, weight, sitting height, lower leg length, foot


\textsuperscript{19}Homes Allen Sprague, "The Relationship of Certain Physical Measurements to Swimming speed in Male Age Group Swimmers," \textit{Dissertation Abstracts International} 35 (January 975 : 4235-A.
length, forearm length, waist girth, ankle girth, hip width, shoulder width, chest thickness, triceps, skinfold, shoulder flexion, ankle flexion, vital capacity. The stepwise method of multiple regression was used in all analysis. The most consistent physical measure were foot length and biceps size. Each was found significant in at least one analysis for each of three strokes. In each case longer feet were associated with slower time and longer biceps were associated with faster time.

Scott studied that male S.H.S. (senior high school) swimmers who cattred or equal a time of 56 seconds for 100 metre crawl stroke were tested for the flexibility of ankle, knee, hip, trunk and shoulder, followed by strength test of knee, hip, shoulder, trunk, upon completion of tests. The students were timed for 100 yard swimming. It was concluded that certain flexibility measures were significantly related to swimming time. However, it was determined that knowledge of certain flexibility and strength measures could not be used to predict 100 yard crawl stroke time.

Matheson\textsuperscript{21} studied the relationship between swimming and selected physiological and anthropometric development and skill variables in 10-12 years old female competitive swimmers was determined. Forty girls were tested and measured over selected variables. Each also completed 400 yard and 50 yards time trials. Swimmer were classified into two groups,— Top and Bottom level group. The intercorrelation matrix indicated that best single predictors of swimming performance were height, aerobic capacity and stroke efficiency. Body size skill and exposure of swimming were most significant groups of factors in differentiating bewteen both.

Luthra\textsuperscript{22} conducted a study on ankle flexibility and swimming speed in breast stroke by whip kick. One hundred swimmers were subjected and tested. He concluded after study that there is no relationship exist between swimming speed and ankle flexibility.

\textsuperscript{21} Larilee Matheson, "Selected Physiological, Athropometric and Skill Variables Contributing to Success in 10-12 Years Old Female Competitive Swimming," \textit{Completed Research in Health, Physical Education and Recreation} \textbf{20} (1978) : 293.

\textsuperscript{22} R.P. Luthra, "Relationship between Ankle Flexibility and Speed of Breast Stroke by Whip Kick," (Unpublished Master's Thesis, Nagpur University,).
Bloomfield studied about the anatomical and physiological differences between varsity ability swimmers. One hundred twenty senior level swimmers who were divided into three groups on the basis of two criteria of the means from 39 test administered in the study in any three of comparisons did the means of national level group significantly surpass those of the high level varsity swimmers. In contrast the means of national level group were significantly higher than those of low level varsity swimmers. In nine instances. In no instance was the means of the high and low level swimmers significantly higher than those of the national level swimmers in any instance higher than those of either of the other two groups.

Albrecht conducted a relationship study of high school swimming successes to certain physique and flexibility measures involving height, weight, upper arm length, lower arm length, torso length, hand and foot measurement, body surface area, ankle flexion, hip flexion on 89 varsity


swimmers from six different high schools in South suburban conferences (Illinois). Success was measured by coaches rating and success percentage determined by the state records for the event divided by the time in the conference meet. No relationship was known between physique measures and swimming success. Coaches were in consistent in their subjective rating and conference meet success.

Johnson\textsuperscript{25} conducted a study and concluded that flexibility was a factor in determining the power in wage kick though it was not in the whip kick. Strength was not a significant factor for power where as flexibility had some significance. These recommendations were made while studying the relationship of hip strength and flexibility to breast stroke kicking power which enhances the performance of the swimmer.

Duana\textsuperscript{26} studied the relationship of physical factors of football performance. Players were measured in arm


\textsuperscript{26} Ellena Jack Duana, Relationship of physical Factors to Football Performance," \textit{Completed Research in Health, Physical Education and Recreation} 2(1960): 26
strength (push and pull), 50 yard dash, right grip, left grip, speed correlated 60 percent to total strength, 10 with the criterion both co relation were significant.

Hebelinck, carter and Degray\textsuperscript{27} undertook a study on anthropometric measurement of 66 male 16 M divers and 71 male water polo players participating in Mexico Olympic Games. Male divers were clearly leanest group (sametian of skinfold 20.0 m water polo players had larger absolute somatometric measures than male swimmers were proportionately somewhat broader but also were the leanest among most muscular.

Cureton\textsuperscript{28} has done a study on mechanics and kinesiology of swimming (crawl stroke flutter kick). He studied the co relation between flexibility and speed in crawl stroke. He has shown significant result between ankle flexibility and speed of swimming by crawl stroke and also shown a 23.6 percent superiority in ankle flexibility corresponds to speed advantage of 29.9 percent.


Mc Curdy and Larson\textsuperscript{29} compared the circulorespiratory measures of three groups of 60 Springfield University swimmers, 138 infirmary patients with respiratory infection and 10 national level American swimmers in their peak form. The latter had the highest vital capacity, followed by Springfield swimmers, with the infirmary patient last. Evidently the physical conditioning achieved by training was the cause of increased vital capacity.

Nelson\textsuperscript{30} studied the effect of ankle and hip flexibility on speed in running. He concluded that increased ankle and hip flexibility has not significant effect on running speed of sprinters.

Bosworth\textsuperscript{31} studied 107 college women who were tested

\begin{itemize}
\item \cite{31} James M. Bosworth, "Relationship Between the Vertical Jump of College Women and Selected Anthropometric Measurements and Strength Variables," \textit{Complete Research in Health, Physical Education and Recreation} 7 (1965): 63.
\end{itemize}
for leg strength and jumping ability (Vertical) anthropometric measurement and ratio were obtained from photographs. Correlation were computed between vertical jump and each of anthropometric variables. Leg strength, a multiple relationship of 0.612 was obtained with the criterion using leg left/weight, shape index, bi-iliac width, leg length, and foot width, lower trunk length and upper leg length. None of these variables which were selected were adequately related with vertical jump performance.

Cozen\textsuperscript{32} conducted a study of stature in relation of physical performance and indicated in his findings that height and weight apparently influencing sector to some extent in the matter of physical performance although correlation obtained were not significant.

Cristian\textsuperscript{33} conducted a study of identify the contribution of selected variables. Thirty subjects were the member of South Eastern State College football team. Each

\textsuperscript{32}Fredrick W. Cozen, "A Study of Stature in Relation to Physical Performance," Research Quarterly 1 (March 1930): 35.

subject was tested over 12 variables and stepwise multiple regression was determined to use. The ultimate criterion was the percentage of plays executed correctly in determining by grading the film of team 1973 regular season football games. It was found that the best predictor of game percentage was the lateral movement with a correlation .33 for the line best predictor of the game percentage score was bench steps with correlation of .33, when the back and line group were combined. The best predictor of game percentage score was vertical jump with correlation of .50. It was concluded that for total group vertical jump and 12 minute run were best predictors.

Bookwalter and his associates conducted a study on the relationship of body size and shape of physical performance on the basis of test scores of 1997 Indiana elementary school boys. It was concluded that size and shape seems to have an influence on physical performance. Obese boys were found to be poorer performer.

Adbo conducted a study on leg strength, height.


weight factors in relation to cardio-vascular efficiency of college women. Data collected from 198 subjects intercorrelated. The results indicated that excess weight had effect on cardiovascular efficiency while leg strength correlated positively with step test performance. The linear correlation between cardiovascular efficiency and ponderal index was significant. But regression line levelled for women with high cardiovascular efficiency.

Park\textsuperscript{36} determined whether there is any relationship between physical education activities in a normal school department. The activities used were those required of all major in physical education activities at the State Normal School Cortland, New York. Sixty five subjects were selected at random. The activities were swimming, gymnastics, dancing, plays games and athletes. The author concluded that all five correlation have low. There were lack of correlation between physical fitness index and athletic award. Athletic success for men depends on more strength than physical fitness.

Money and Whitley\textsuperscript{37} conducted two experiments on the

\textsuperscript{36}Bessie L. Park, "Relationship Between Physical Fitness and Success in Physical Education Activities," \textit{Research Quarterly} 6 (March 1935): 263

college men in which lateral arm movement of approximately 90 degrees involving about four feet of hand travel was made at maximum speed. The movement time, effective arm mass. The static dynamometer strength of muscle were measured for each subject. It was concluded that there is no significant correlation between stature strength and strength in action.

Dintiman\textsuperscript{38} studied that if the strength is improved along with flexibility and combined together. There is significant improvement in the running speed.

Stephen\textsuperscript{39} studied a comparison of relationship between running speed and agility. The subject speed was measured for the last 10 yard of the 100 yards dash and agility was measured with McCloy’s Zig Zag Run. 20 subjects were taken from freshman baseball team and tested. Adecau automatic performance analyser was used to time all the tests to 1/100th of a second. Running speed was found correlated.


Wear and Miller\(^40\) studied the relationship of physique and developmental level as determined by the Netzel gird. To performance in 15 tests of junior high school boys they found the subjects medium in physique and normal in development to be the best performers and subjects of heavy physique to be the poorest performer.

Hess\(^41\) found that though practicing progressive resistance exercises improved significantly in soccer kicking performance for distance in keeping with the strength improvement in legs.

Cureton\(^42\) studied vital capacities of high school boys to determine whether vital capacity could be used as strength test. A circulo-respiratory test or only a test of thorasic size. He concluded that strength was a small factor contributing to vital capacity and there was no significant relationship between athletic ability and vital capacity. It was concluded that vital capacity was a relation


\(^{42}\) Cureton, Research Quarterly, pp. 81-86.
predominantly in sizes as indicated principally through surface area height, weight and chest girth. No positive relationship could be claimed between vital capacity and organic condition.

Andrews 43 compared the mean cardiac output $\text{Vo}_2$ and PWC 170 of preadolescent swimmers as opposed to understand but healthy children at rest at two levels of exercise. Eight pairs of student ranging in age from 9-13 and matches for age, sex, body size were examined at a PWC 170. The swimmers D.C. $\text{Vo}_2$ was significantly greater. In the swimmers than non swimmers value to mean Q.C. and $\text{Vo}_2$ max at rest and at sub max exercise does not significantly differ. A strong relationship was found between stroke volume and heart rate at 300 kg m/m. for trained group. Swimmers demonstrated significant relationship between power and Q.C. 44

Carlin 44 studied the effect of body composition upon


the cast efficiency of water treading. Exercises were in
eight trained swimmers age ranging between 9-15 years.
Cardio-pulmonary responses of treading water was compared to
that of treadmill walking. Physical factors under analysis
were body surface area, height, weight, body density,
percentage fat, fat weight, lung capacity — and sinking
force of sat F.R.C. work included $V_{O_2}$ consumption,
ventilation of heart rate. Analysis indicated that efficiency
of treading water was best related with their body
height.

Grigor\textsuperscript{45} studied the effect of progressive weight
training programme on the performance of swimming 100 meter
crawl stroke of male and female competitive swimmers between
age 10 to 16 years. Forty subjects were divided into two
groups and were exposed to different trainings. The
experimental group was exposed to nine week of training in
competitive swimming and weight training programme. The
controlled group participated to an identical competitive
swimming programme. The groups were tested on 100 meter crawl
stroke and to evaluated weight training programme 16 cable
tension strength test was administered. It was concluded that

\textsuperscript{45}John G. Grigor, "Effect of Progressive Weight
Training Programme on the Performance of Swimming 100 yard
Crawl Stroke of Male and Female Competitive Swimmers Between
Age of Ten to Sixteen," Dissertation Abstracts International
35 (August 1974) : 869-A.
the subjects who participated progressive weight training programme significantly improved their performance in swimming 100 yard distance using crawl stroke.

Cunningham\textsuperscript{46} reported that effect of breathing height concentration oxygen on treadmill performance time. The post exercise and post exercise pulse were taken and relationship between excess lactic acid and oxygen debt were studied. The breathing of oxygen during maximal performance test improved performance of each test oxygen debt was significantly reduced for last minute of recovery and was found at peak during third minute of recovery. A linear relationship was observed between excess lactic acid and oxygen debt while breathing air of oxygen during test.

The study conducted by Saltin\textsuperscript{47} a vital capacity revealed that swimmers and divers possessed an enlarged lung capacity as a result of training. It indicated that training had resulted in increased vital capacity.


Rork\textsuperscript{48} conducted a study to determine the floating ability of women on a homogeneous group of 27 young adult women, all of whom were expert swimmers. Observations were made in an indoor fresh water swimming pool. The factors affecting floating ability were considered: the specific gravity of the body, its buoyancy, surface area, and vital capacity. The method used for obtaining the specific gravity of the body was based on Archimedes Principle and was calculated by dividing the weight of the body on land by the loss of weight in water. Similarly, the buoyancy was obtained by subtracting the force needed to float the legs from the weight of the body. Partial and multiple correlations between buoyancy and other factors were computed. The results obtained showed a high positive correlation between the multiple factors buoyancy, surface area, vital capacity, and specific gravity. On the basis of the findings the human floaters may be classified in two groups: (1) Those who have a small specific gravity due to either adiposity or a large pulmonary Volume or both; and (2) those who have a large surface area. Floating ability is greatest when all three attributes are simultaneously present.

Yacher et al. conducted a study on 25 male swimmers of varying ages to find out the value of power training and stroke training in determining the appropriate training procedures for competitive swimmers. Swimmers were tested on their strength, stroke, height, weight, segmental swimming and 50 yards swim. The required swimming velocity was acquired by measuring 5 yard interval times during the 50 yard sprints. Their swimming velocities were transferred into Froude numbers so that the swimmers could be compared independent of their length (standing height from floor to fingertips).

The results of the study suggested that: (1) strong-inefficient swimmers should emphasise more on stroke technique and not on further strength development. (2) Weaker-inefficient swimmers should train a combination of stroke technique and strength development.

Manly conducted a study on 11 varsity swimmers from Virginia Polytechnic Institute and State University and 10

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boys who were members of several Blacksburg and Virginia area AAU Youth Group Swimming Teams, to determine the relationship of selected metabolic, pulmonary and anthropometric factors to performance in 100 yards butterfly swimming event. It was concluded that maximal breathing capacity was the only predictor in the youth group swimming performance at the .05 level of confidence. The stepwise multiple regression revealed that strength, somatotype index, bitrochantric, oxygen debt and maximal vital capacity are contributing factors to performance in 100 yards butterfly swimming event. Further, a high multiple correlation was found among four variables namely maximum breathing capacity, vital capacity, chest debt and strength to performance in 100 yards butterfly swimming.

Relationship of selected physiological and psychological factors to the beginning swimmer's ability to perform crawl stroke was determined by Crites.\(^{51}\) He selected 40 subjects who were members of two beginning swimming classes which met for forty minutes twice a week. Prior to any swimming instruction, measurements were collected on shoulder rotation, shoulder extention strength, hip extention

\(^{51}\)Jerry Keith Crites, "A Study of selected Physiological and Psychological Factors to Determine Their Relationship to the Performance of the Crawl Stroke by Beginning Swimmers," Dissertation Abstracts International 36 (October 1975):2084-A.
strength, body composition, swimming anxiety and swimming ability as measured by the Fox Power Test (revised). After five weeks of crawl stroke instruction, measurements were again collected on anxiety and swimming ability. It was concluded that shoulder rotation, shoulder extention strength, hip extention strength and body composition were not significant factors in the performance of the crawl stroke but a significant relationship was found between swimming anxiety and the ability to perform the crawl stroke.

In order to study the effects of selected biological, psychological, and sociological factors on the learning rate of the Negro male beginning Swimmer Vanderstok conducted a study on 37 freshmen enrolled at North California Agricultural and Technical State University, Greensboro. The biological factors was limited to the floating ability of the subject as measured by the turtuleprone float combination. The sociological factors focused on the individual’s level of aspiration and certain family and environmental background data. The psychological factor of general anxiety was

measured by IPAT-8-Parallel Form Anxiety Battery, and a ten point fear rating scale, developed by the investigator for this study.

An initial period was used for preliminary tests and later there were five weeks of instruction during which the front crawl was taught according to the American National Red Cross Instructor's Manual. Classes met twice a week for thirty minutes each. Performance improvement was recorded at the end of the third, fourth and fifth week by measuring the distance the subject could swim the front crawl.

Analyses of variance and correlation were the statistical techniques employed. The .05 level of confidence was accepted as indicating significance. A descriptive analysis was used to describe the sample in terms of sociological factors such as previous swimming experience, family background and desire to learn to swim. A graphic presentation was included to show the relationship between selected sociological factors, as well as a pictorial presentation of the swimming improvement over the five weeks period.

The findings of the study indicated nonsignificant correlation between the floating ability and the rate of learning swimming. Differences in anxiety did not show a
statistical significant effect upon the learning rate. Fear seemed to be a an important aspect of the learning rate. As fear diminished, the swimming performance improved. Level of aspiration was found to be a highly significant indicator of quicker learning.

The statistical significance of crawl stroke swimming learning to percentage of body fat (\.401) and body density (-1.406) may be attributed to the fact that an individual's ability to float is largely affected by: (1) The ratio of fat to fat free body mass; (2) the ratio of volume to weight or density; and (3) the relative volume of the lungs. The lesser the density of the body composition, the more buoyant the performer. The size of lung volumes (residual volume as well as total lung volume), forming a bellows inside the chest, obviously affects buoyancy as more air make the trunk float much easier.53,54 This buoyancy is an important factor which contributes to ease and efficiency in the learning of


54 Higgins, Human Movement-An Integrated Approach, p.98.
swimming skills. Individuals with a low degree of buoyancy experience considerable difficulty in keeping the body horizontal in the water. Much of the force exerted by the legs may be utilized in plaining the body which may affect the rate of learning and efficiency of performance.