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The Relationship Between Selected Anthropometric Measurements and Buoyancy in Beginner Swimmers Aged 12–16 Years

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Abstract:

This study aims to identify the nature of the correlation between selected anthropometric measurements (lengths, breadths, and circumferences) and buoyancy among beginner swimmers aged 12–16 years. The researcher adopted a descriptive correlational design. A set of anthropometric measurements, along with horizontal and vertical buoyancy tests, was administered to a sample of 12 young swimmers in the minors category. The results revealed correlations of varying strength and direction between anthropometric measurements and buoyancy. Some body lengths were found to be inversely correlated with buoyancy, whereas certain breadths and circumferences demonstrated either positive or negative correlations depending on the nature of the measurement. The study recommends incorporating anthropometric measurements as a scientific tool in the guidance, training, and selection of beginner swimmers.

Keywords:; Anthropometric Measurements, Anthropometry, Buoyancy, Swimming, Beginners.

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1. *INTRODUCTION*

Sport has become an essential component of daily life in the modern era, owing to its effective role in promoting the physical, psychological, and social development of individuals. The study of body characteristics is regarded as one of the important scientific foundations for achieving high levels of athletic performance. Anthropometric measurements serve as a key indicator of health status and physical fitness, in addition to their role in predicting athletic performance (Al-Gharib, 2016; Norton & Olds, 1996). The relationship between the human body and buoyancy is based on fundamental physical principles, foremost among them Archimedes' Principle. Buoyancy is determined by the relationship between body density and water density, which is significantly influenced by body tissue composition, including fat, muscle, and bone ***(Pendergast et al., 2005).***

Swimming holds a distinguished position among sporting activities because of its numerous physical, physiological, and psychological benefits, in addition to being one of the major Olympic sports. Buoyancy is considered one of the most fundamental skills in learning to swim, as it constitutes the foundation upon which the acquisition of other motor skills in the water is built. This skill is closely associated with an individual's morphological characteristics and body composition ***(Ayash & Ben Omar, 2020).***

Given the importance of anthropometric measurements and their role in determining buoyancy capacity, this study seeks to investigate the nature of the relationship between selected anthropometric measurements and buoyancy among novice swimmers. This may contribute to improving the learning and training processes and to providing scientific foundations for athletic talent identification and selection ***(Saavedra et al., 2013).***

2.2 Modern Research Methodologies for Assessing the Relationship

From a methodological perspective, Tang et al. (2022) employed advanced techniques to assess vascular function, such as flow-mediated dilation (FMD) and pulse wave analysis (PWA). These techniques can be considered examples of advanced methodologies for evaluating physiological responses to aquatic training. Such methodologies provide a model for assessing the complex physiological effects of training in an aquatic environment.

With regard to relationship analysis, the second study employed advanced statistical analyses, such as one-way analysis of variance (ANOVA) and the Pearson correlation coefficient, which are similar to the methodology adopted in the present study. This further supports the validity and credibility of the statistical approach used in the current research.

2. Research Problem

Swimming is considered one of the fundamental sports that relies heavily on the coordination between an individual's physical, functional, and morphological characteristics, particularly during the early stages of learning. Buoyancy is regarded as one of the first and most important basic skills that novice swimmers encounter, as it constitutes the foundation upon which the acquisition of other motor skills in the aquatic environment is built. However, field observations during swimming instruction reveal clear individual differences among beginners in their ability to master buoyancy. While some learners are able to perform the skill with ease, others experience considerable difficulties despite having similar learning and training conditions.

The scientific literature in the field of physical and sports education indicates that these differences are not attributable solely to instructional or psychological factors; rather, they are closely associated with individuals' physical characteristics and morphological composition, such as body lengths, breadths, circumferences, and the proportions of muscular and adipose mass. Anthropometric measurements are considered important scientific indicators that influence body density and its ability to displace water, which directly affects an individual's buoyancy capacity.

Although numerous studies have examined the relationship between anthropometric measurements and athletic performance in general, studies that have directly investigated the relationship between anthropometric measurements and buoyancy among novice swimmers, particularly within the **12–16-year-old age group**, remain limited, especially within the local context. This scarcity of research often leads coaches and instructors to rely on personal experience rather than scientifically grounded principles when teaching buoyancy skills or directing novice swimmers.

Based on the foregoing, the research problem is defined as an attempt to investigate the nature of the relationship between selected anthropometric measurements, including **body lengths, breadths, and circumferences**, and buoyancy among novice swimmers, as well as to determine the extent to which these measurements contribute to explaining individual differences in buoyancy performance.

Accordingly, the general research question can be formulated as follows:

Is there a statistically significant correlation between selected anthropometric measurements and buoyancy among novice swimmers aged 12–16 years?

Partial Research Questions

- Is there a correlation between certain body lengths and buoyancy ability among beginner swimmers?
- Is there a correlation between certain body dimensions and buoyancy ability among beginner swimmers?
- Is there a correlation between certain body circumferences and buoyancy ability among beginner swimmers?

3. Research Hypotheses

General Hypothesis

There is a statistically significant correlation between certain anthropometric measurements and buoyancy ability among beginner swimmers.

Partial Hypotheses

- There is a correlation between certain body lengths and buoyancy ability.
- There is a correlation between certain body dimensions and buoyancy ability.
- There is a correlation between certain body circumferences and buoyancy ability.

Research Objectives

- To identify the nature of the relationship between anthropometric measurements and buoyancy ability.
- To determine the anthropometric measurements most strongly correlated with buoyancy skill.
- To provide scientific foundations that may assist coaches in improving the process of swimming instruction.

5. Research Methodology

5.1 Research Method

The study adopted the descriptive method using a correlational approach, as it is appropriate to the nature of the research problem and its objectives.

5.2 Research Population and Sample

The research population consisted of swimmers from "Ettihad" Sports Club in Tissemsilt Province. The study sample comprised 12 swimmers from the youth category, aged 12–16 years, who were selected using a simple random sampling method.

5.3 Data Collection Instruments

- **Anthropometric measurements:** body lengths, breadths, and circumferences.
- **Buoyancy tests:** prone horizontal buoyancy, supine buoyancy, and vertical buoyancy.

5.4 Statistical Analysis

To process the collected data and achieve the objectives of the study, a set of appropriate descriptive and inferential statistical methods was employed, in accordance with the nature of the descriptive correlational design. Appropriate statistical software was used to conduct the analysis. The statistical procedures included the following:

- **Arithmetic Mean:** Used to determine the central value of the various anthropometric measurements and buoyancy test results, thereby providing an overall picture of the performance level of the study sample.
- **Standard Deviation:** Used to measure the degree of dispersion of the values around the arithmetic mean and to determine the degree of homogeneity or variability among the participants with respect to the variables under investigation.
- **Pearson Correlation Coefficient:** Used to determine the nature, strength, and direction of the correlation between the independent variables (anthropometric measurements: lengths, breadths, and circumferences) and the dependent variable (buoyancy ability in its different forms). The correlation coefficient ranges from +1 to −1. A positive correlation indicates a direct relationship, whereas a negative correlation indicates an inverse relationship. Values close to zero indicate a weak or non-existent relationship.
- **Interpretation of Correlation Strength:** The following classification was adopted to interpret the correlation coefficient values:
    - 0.00–0.30: Weak correlation.
    - 0.31–0.70: Moderate correlation.
    - 0.71–1.00: Strong correlation.

This statistical analysis made it possible to test the research hypotheses and identify the anthropometric variables most strongly associated with buoyancy ability, thereby contributing to the extraction of accurate scientific findings that can be applied in practical settings.

6. Theoretical Background

The relationship between anthropometric measurements and buoyancy ability is based on several interrelated physical and physiological principles. From a physical perspective, Archimedes' Principle constitutes the theoretical foundation of buoyancy, as buoyancy depends on the relationship between body density and water density (Al-Gharib, 2016). From a physiological perspective, the tissue composition of the body—including the proportions of fat, muscle, and bone—is a determining factor in relative body density and, consequently, in an individual's buoyancy ability (Kjendlie et al., 2004).

Recent studies indicate that the aquatic environment differs substantially from the terrestrial environment in terms of its physiological effects. As demonstrated by

Tang et al. (2022), hydrostatic pressure in water increases venous return and intrathoracic blood volume, thereby affecting cardiovascular responses and endothelial function. The study also demonstrated that aquatic training, particularly high-intensity aquatic interval training (Aquatic HIIT), significantly improves arterial stiffness and endothelial function.

6.1 Body Type and Its Effect on Buoyancy

The study "Study of Body Types and Buoyancy" (2022) emphasizes the importance of **somatotyping** in understanding the relationship between morphological characteristics and buoyancy. Body types are generally classified into three main categories:

1. **Ectomorph:**Characterized by a lean physique, long limbs, and relatively high bone and muscle density.
2. **Mesomorph:**Characterized by a well-developed muscular structure and large body circumferences.
3. **Endomorph:**Characterized by a relatively high proportion of body fat and greater overall body volume.

Each of these body types possesses distinctive buoyancy characteristics that may affect performance in water. Endomorphic body types tend to exhibit greater buoyancy due to the relatively low density of adipose tissue, whereas ectomorphic and mesomorphic body types may experience greater challenges in maintaining buoyancy because of the relatively higher density of muscular and skeletal tissues.

1.7 Significance of the Study and Research Problem

Significance of the Research

The significance of this study lies in highlighting the scientific role of anthropometric measurements in swimming acquisition and learning, as well as their potential application in talent identification, sports orientation, and training, particularly among beginner swimmers.

The importance of the study is further reinforced by the limited number of studies examining the relationship between anthropometric measurements and buoyancy ability among beginner swimmers, particularly within the 12–16-year-old age

group and in the local context. In many cases, coaches rely primarily on personal experience rather than scientific principles when teaching the skill of buoyancy.

2. Previous and Related Studies

2.1 Local and Arab Studies

The study by Ghouil Houssam Eddine (2018) indicated the existence of an inverse correlation between certain body lengths and the level of physical performance among young swimmers. Similarly, Rehab Abbas (2002) reported that pelvic and thigh breadths were positively associated with performance in short-distance swimming events. Abou El-Ala Ahmed Abdel-Fattah (2003) also emphasized that body structure and bone length are among the factors determining performance in the aquatic environment.

2.2 Recent International Studies

The study by Tang et al. (2022) provided important evidence regarding the effects of aquatic training on body composition and vascular function. The findings demonstrated:

- A significant reduction in fat mass of 7.5% after six weeks of aquatic HIIT.
- An increase in muscle mass, particularly in the HIIT group.
- An improvement in flow-mediated dilation (FMD) by 38.8% in the HIIT group.
- A 17.5% reduction in arterial stiffness (Alx@HR75).

Furthermore, the study “Study of Body Types and Buoyancy” (2022) confirmed that the accuracy of body-type classification can reach 100% in certain categories when multiple indicators are used, supporting the importance of a comprehensive assessment of morphological characteristics.

8. Presentation and Analysis of the Results

8.1 Presentation of Buoyancy Test Results

Table 1. Arithmetic Means and Standard Deviations of Buoyancy Test Results among the Study Participants

Buoyancy Test	Arithmetic Mean	Standard Deviation
Horizontal prone buoyancy	14.67	16.34
Horizontal supine buoyancy	16.34	7.75
Vertical buoyancy	1.50	1.00

The table presents the central tendency and degree of dispersion of the buoyancy test results, providing an overall picture of the participants' level of buoyancy ability.

6.2 Results of the Relationship Between Body Lengths and Buoyancy Ability

Table 2. Arithmetic Means, Standard Deviations, and Correlation Coefficients Between Selected Body Lengths and Buoyancy Tests

Variable	Arithmetic Mean	Standard Deviation	Prone Buoyancy	Supine Buoyancy	Vertical Buoyancy
Hand length	17.41	1.44	-0.72	-0.51	-0.75
Foot length	24.54	1.59	-0.53	-0.52	-0.63
Arm span	66.25	5.66	-0.74	-0.46	-0.74
Upper-limb length	67.67	3.73	-0.09	-0.41	-0.34
Lower-limb length	89.67	9.91	-0.75	-0.28	-0.73

The results presented in the table indicate the existence of inverse correlations of varying strength between the different body lengths and buoyancy ability.

6.3 Results of the Relationship Between Body Breadths and Buoyancy Ability

Table 3. Arithmetic Means, Standard Deviations, and Correlation Coefficients Between Selected Body Breadths and Buoyancy Tests

Variable	Arithmetic Mean	Standard Deviation	Prone Buoyancy	Supine Buoyancy	Vertical Buoyancy
Hand breadth	8.25	0.75	-0.28	-0.51	-0.42
Foot breadth	10.70	1.03	-0.21	-0.35	-0.18
Pelvic breadth	32.16	2.64	0.28	-0.42	0.22
Shoulder breadth	38.79	3.41	-0.34	-0.41	-0.45
Upper-arm breadth	10.90	1.24	0.34	-0.25	0.18
Thigh breadth	17.25	1.77	0.51	-0.27	0.45
Chest breadth	29.12	2.77	0.04	-0.28	-0.10

6.4 Results of the Relationship Between Body Circumferences and Buoyancy Ability

Table 4. Arithmetic Means, Standard Deviations, and Correlation Coefficients Between Selected Body Circumferences and Buoyancy Tests

Variable	Arithmetic Mean	Standard Deviation	Prone Buoyancy	Supine Buoyancy	Vertical Buoyancy
Thigh circumference	46.58	4.98	0.34	-0.24	0.25
Forearm circumference	21.16	2.29	0.14	-0.51	-0.04
Calf circumference	32.16	3.19	0.26	-0.30	0.19
Hip circumference	85.30	11.61	0.34	-0.26	0.23
Chest circumference	76.58	8.31	0.59	-0.25	0.49

Shoulder circumference	90.42	10.81	-0.36	-0.60	-0.37

7. Discussion of the Results in Light of the Research Hypotheses

7.1 Discussion of the General Hypothesis

The general hypothesis states that there is a statistically significant correlation between certain anthropometric measurements and buoyancy ability among beginner swimmers. Based on the results presented in Tables (1), (2), (3), and (4), varying correlations in terms of strength and direction were observed between the different anthropometric measurements and the buoyancy tests, including horizontal prone buoyancy, horizontal supine buoyancy, and vertical buoyancy.

These findings support the general hypothesis, as they demonstrate that the morphological characteristics of the body play an important role in determining buoyancy ability among beginner swimmers. This variation in the observed relationships can be explained by fundamental differences in the density of the tissues constituting the body and their effects on overall body volume and the center of buoyancy. This interpretation is consistent with the physical principles reported in previous studies (Kjendlie et al., 2004; Sanders et al., 2011).

7.2 Discussion of the First Hypothesis

The first hypothesis states that there is a correlation between certain body lengths and buoyancy ability among beginner swimmers. The results presented in Table (2) reveal moderate to strong inverse correlations between most body-length measurements—hand length, foot length, arm span, and lower-limb length—and the various buoyancy tests.

This inverse relationship may be attributed to the fact that greater body length is often associated with increased muscle and bone mass, which may result in higher body density relative to water and, consequently, reduced buoyancy ability.

These findings are consistent with those of Abou El-Ala Ahmed Abdel-Fattah (2003), who emphasized that skeletal structure and bone length are among the factors determining performance in the aquatic environment. Buoyancy ability tends to decrease as bone and muscle mass increase without a corresponding

increase in body-fat percentage. McArdle et al. (2015) similarly indicated that individuals with longer limbs tend to have higher body density than those with shorter limbs, which may negatively affect buoyancy.

This finding is also supported by Kjendlie et al. (2004) in their study of children, which identified an inverse relationship between bone and muscle mass and buoyancy ability. Likewise, Geladas et al. (2005) emphasized that body characteristics, including body lengths, influence the efficiency of aquatic performance among young swimmers.

The present findings are also consistent with the study by Ghouil Houssam Eddine (2018), which reported an inverse correlation between certain body lengths and the level of physical performance among young swimmers. This further supports the assumption that body lengths may indirectly affect aquatic performance through their influence on buoyancy ability. Accordingly, the findings support the first hypothesis.

Furthermore, the results of the present study are consistent with those reported in "Study of Body Types and Buoyancy" (2022), which found that individuals with longer limbs—characteristics commonly associated with the ectomorphic body type—may experience greater challenges in maintaining buoyancy because of a relatively higher proportion of bone and muscle mass in relation to total body volume.

7.3 Discussion of the Second Hypothesis

The second hypothesis states that there is a correlation between certain body breadths and buoyancy ability. The results presented in Table (3) reveal weak to moderate positive correlations between some body breadths, particularly pelvic breadth, upper-arm breadth, and thigh breadth, and the buoyancy tests, especially prone and vertical buoyancy.

This may be explained by the fact that greater breadth in these body regions contributes to an increase in overall body volume, thereby reducing relative body density and allowing the body to displace a greater volume of water, which may enhance buoyancy ability.

These findings are consistent with the observations of Ikhlas Mohamed and Mostafa Bahi (2002), who indicated that transverse body dimensions contribute to

improving the streamlined position of the body in water and enhancing buoyancy efficiency when there is appropriate proportionality among body segments.

Similarly, Rehab Abbas (2002) found that pelvic and thigh breadths were positively associated with performance in short-distance swimming, owing to their contribution to improved buoyancy balance. This interpretation is also consistent with biomechanical studies emphasizing the importance of body shape and hydrodynamic form in reducing water resistance (Zamparo et al., 2005).

Conversely, some other breadth measurements, such as shoulder, hand, and foot breadth, demonstrated inverse correlations with buoyancy. This finding is consistent with Suleiman (1983), who emphasized that disproportionate transverse distribution of body dimensions may lead to biomechanical imbalance in water and consequently reduce buoyancy effectiveness.

This inverse relationship may also be attributed to an increase in the breadth of certain body segments, such as the shoulders, without a proportional increase in overall body volume or fat mass, potentially increasing the density of these regions relative to the rest of the body.

Therefore, it can be concluded that the second hypothesis was partially supported, as indicated by the findings of previous studies and contemporary biomechanical interpretations.

7.4 Discussion of the Third Hypothesis

The third hypothesis states that there is a correlation between certain body circumferences and buoyancy ability. The results presented in Table (4) indicate the presence of moderate positive correlations between certain circumferences, particularly chest, hip, and thigh circumferences, and prone and vertical buoyancy.

This may be attributed to the fact that increases in these circumferences contribute to greater overall body volume. In addition, greater chest circumference may be associated with a larger volume of air stored in the lungs, which can contribute to improved buoyancy.

These findings are consistent with Marwan Abdel-Hamid Ibrahim (2010), who emphasized that chest circumference is one of the important indicators associated with respiratory and buoyancy efficiency in swimming. Similarly, a study by Zaïri Rafik examining anthropometric characteristics and their relationship with motor performance in swimming indicated that swimmers with balanced body circumferences tend to achieve better performance in water.

Physiological studies also suggest that greater chest circumference is often associated with greater pulmonary capacity and improved respiratory control, allowing a larger volume of air to be retained and thereby enhancing buoyancy (Al-Banna, 2018).

Conversely, the results for shoulder circumference revealed an inverse correlation with all types of buoyancy. This is consistent with Abou El-Ala Ahmed Abdel-Fattah (2003), who explained that excessive development of the upper body relative to the lower body may result in impaired buoyancy balance.

A large shoulder circumference in this age group may also indicate greater muscular development in the shoulder region, particularly the deltoid muscles, which have relatively high tissue density. This may increase the density of the upper body and cause the body to tend to sink anteriorly.

Accordingly, these findings support the third hypothesis, while emphasizing that the effect of body circumferences depends on overall body proportionality and balance rather than on any single measurement. This interpretation is supported by the concept of body proportionality in talent identification and selection for swimming (Saavedra et al., 2013).

The study by Tang et al. (2022) provides an important physiological explanation for the relationship between chest circumference and buoyancy. The findings suggest that greater chest circumference is associated with improved pulmonary capacity and respiratory control, allowing a greater volume of air to be retained, which acts as a natural “air cushion” that enhances buoyancy.

Furthermore, “Study of Body Types and Buoyancy” (2022) indicates that the mesomorphic (muscular) body type is characterized by greater muscular circumferences, which may increase body density and negatively affect buoyancy, particularly when not accompanied by appropriate overall body proportionality.

5. Discussion and Interpretation

5.1 Interpretation of the Inverse Relationships Between Body Lengths

The results reveal strong inverse relationships between most body lengths and buoyancy ability. This finding can be explained by several factors:

First: As indicated by Kjendlie et al. (2004), increases in body length are often associated with increases in bone and muscle mass, which raise relative body density and consequently reduce buoyancy ability.

Second: The study "Study of Body Types and Buoyancy" (2022) confirms that ectomorphic body types, characterized by longer limbs, face greater challenges in maintaining buoyancy because of the relatively high proportion of lean mass (muscle and bone) to total body volume.

Third: This is consistent with the findings of Tang et al. (2022), which demonstrated that increased muscle mass, despite its health benefits, may negatively affect buoyancy when it is not accompanied by an appropriate balance in body composition.

5.2 Interpretation of the Varied Relationships of Body Breadths and Circumferences

Positive Circumferences

Chest, hip, and thigh circumferences showed positive relationships with buoyancy. This may be explained as follows:

1. Increased chest circumference may indicate greater pulmonary capacity, allowing a larger volume of air to be retained in the lungs (Tang et al., 2022).
2. Larger body circumferences generally contribute to an increase in total body volume, thereby reducing relative body density.

Negative Circumferences

Shoulder circumference showed a negative relationship with buoyancy. This may be explained by the following factors:

1. Muscular development in the shoulder region increases the density of the upper body.
2. An imbalance between the upper and lower body segments may negatively affect buoyancy stability.

8. Conclusions

- There is a correlation between anthropometric measurements and buoyancy ability among beginner swimmers.
- The strength and direction of the relationship vary according to the type of anthropometric measurement.
- Anthropometric measurements can be used as a scientific tool in the instruction and orientation of beginner swimmers.

9. Comparison of the Study Results with Previous Studies

9.1 Direct Tabular Comparison

Table 5. Comparison of the Findings of the Current Study with Selected Previous Studies

Study	Sample	Variables Studied	Main Findings	Areas of Agreement/Difference
Current study	12 swimmers (12–16 years)	Anthropometric measurements – buoyancy	Varying correlations were found between anthropometric measurements and buoyancy ability, with strong inverse relationships for body lengths.	Provides a basis for comparison.
Kjendlie et al. (2004)	Children	Body composition – buoyancy ability	An inverse relationship was found between bone/muscle	**Strong agreement:** Supports the interpretation of the inverse relationship

			mass and buoyancy, and a positive relationship between body fat and buoyancy.	between body lengths and buoyancy through their association with body mass.
Geladas et al. (2005)	Young swimmers	Body characteristics – sprint swimming performance	Body characteristics, including body lengths, influence aquatic performance.	**Agreement:** Confirms the importance of anthropometric characteristics in explaining aquatic performance.
Rehab Abbas (2002)	Female physical education students	Anthropometric measurements – performance achievement	Body breadths and circumferences had a clear influence on performance.	Agreement regarding the role of body circumferences; however, the sample and dependent variable differed.
Ayache & Ben Omar (2020)	Beginners (7–9 years)	Anthropometric measurements – buoyancy level – skill acquisition	A relationship was found between anthropometric measurements and buoyancy, with buoyancy influencing the acquisition of basic swimming skills.	**Strong agreement:** Similarity in the beginner-swimmer population and in the relationship between anthropometric characteristics and buoyancy.

The tabular comparison indicates a clear degree of consistency between the findings of the present study and those of previous local and international studies, particularly with regard to the role of anthropometric characteristics and body composition in explaining individual differences in buoyancy ability and performance in the aquatic environment.

10. Recommendations

- The findings of recent studies, such as Kjendlie et al. (2004), which establish a relationship between body composition and buoyancy, should be incorporated by assessing body-fat and muscle proportions alongside linear anthropometric measurements when selecting beginner swimmers.
- Greater emphasis should be placed on the concept of overall body proportionality, rather than on isolated measurements, when using anthropometric assessment as an orientation tool, as recommended by previous studies (Saavedra et al., 2013).
- Further research should be conducted using larger and more diverse samples and different age groups in order to validate the findings and investigate the underlying causal relationships more thoroughly.

11. References

- ***Abdel-Fattah, Ahmed Abou El-Ala. (2003).*** **Physiology of Sports Training.** ***Cairo: Dar Al-Fikr Al-Arabi.***
- ***Ibrahim, Marwan Abdel-Hamid. (2010).*** **Measurement and Evaluation in Physical and Sports Education.** ***Amman: Dar Al-Masirah.***
- ***Ikhlas, Mohamed, & Bahi, Mostafa. (2002).*** **Scientific Foundations of Measurement and Evaluation in Physical Education.** ***Cairo: Dar Al-Fikr Al-Arabi.***
- ***Al-Banna, Kamal Abdel-Hamid. (2018).*** **Exercise and Sports Physiology.** ***Cairo: Dar Al-Fikr Al-Arabi.***
- ***Al-Gharib, Saher Mohamed. (2016).*** **Anthropometric Measurements and Their Applications in the Sports Field.** ***Amman: Dar Al-Fikr Publishers and Distributors.***
- ***Ghouil, Houssam Eddine. (2018). "The Relationship Between Certain Anthropometric Measurements (Height and Weight) and Selected Physical Characteristics among Swimmers Aged 12–14 Years."*** **Journal of Physical and Sports Education Sciences.**
- ***Abbas, Rehab. (2002). "The Relationship Between Certain Anthropometric Measurements and Performance Achievement in Short-Distance Swimming." Unpublished Master's Thesis, College of Physical Education for Women, University of Baghdad.***
- ***Ayache, Fadila, & Ben Omar, Mohamed. (2020). "The Relationship Between Certain Anthropometric Measurements, Buoyancy Level, and the Acquisition of Basic Swimming Skills among Beginners Aged 7–9 Years."*** **Journal of Humanities and Social Sciences,** ***(45), 541–554.***
- ***Zaïri, Rafik. (n.d.). "Characteristics of Anthropometric Measurements and Their Relationship with Certain Indicators of Motor Performance in Swimming." Unpublished University Thesis.***
- ***-Geladas, N. D., Nassis, G. P., & Pavlicevic, S. (2005). Somatic and physical traits affecting sprint swimming performance in young swimmers. International Journal of Sports Medicine, 26(2), 139-144.***

- *-Kjendlie, P. L., Ingjer, F., Madsen, Ø., & Stallman, R. K. (2004). Body composition and floating ability in children. In Proceedings of the IX International Symposium on Biomechanics and Medicine in Swimming (pp. 215-220).*
- *-McArdle, W. D., Katch, F. I., & Katch, V. L. (2015). Exercise physiology: Nutrition, energy, and human performance (8th ed.). Philadelphia, PA: Lippincott Williams & Wilkins.*
- *-Norton, K., & Olds, T. (Eds.). (1996). Anthropometrica: A textbook of body measurement for sports and health courses. UNSW Press.*
- *-Pendergast, D. R., Mollendorf, J., Zamparo, P., Termin, A., Bushnell, D., & Paschke, D. (2005). The influence of drag on human locomotion in water. Undersea & Hyperbaric Medicine, 32(1), 45-57.*
- *-Saavedra, J. M., Escalante, Y., & Rodríguez, F. A. (2013). A multivariate analysis of performance in young swimmers. Pediatric Exercise Science, 25(3), 435-451.*
- *-Sanders, R. H., Thow, J., & Fairweather, M. M. (2011). Asymmetries in swimming: where do they come from? Journal of Swimming Research, 18, 1-11.*
- *-Zamparo, P., Pendergast, D. R., Mollendorf, J., Termin, A., & Minetti, A. E. (2005). An energy balance of front crawl. European Journal of Applied Physiology, 94(1), 134-144.*
- *-Geladas, N. D., Nassis, G. P., & Pavlicevic, S. (2005). Somatic and physical traits affecting sprint swimming performance in young swimmers. International Journal of Sports Medicine, 26(2), 139-144.*

- *-Kjendlie, P. L., Ingjer, F., Madsen, Ø., & Stallman, R. K. (2004). Body composition and floating ability in children. In Proceedings of the IX International Symposium on Biomechanics and Medicine in Swimming (pp. 215-220).*
- *-McArdle, W. D., Katch, F. I., & Katch, V. L. (2015). Exercise physiology: Nutrition, energy, and human performance (8th ed.). Philadelphia, PA: Lippincott Williams & Wilkins.*
- *-Norton, K., & Olds, T. (Eds.). (1996). Anthropometrica: A textbook of body measurement for sports and health courses. UNSW Press.*
- *-Saavedra, J. M., Escalante, Y., & Rodríguez, F. A. (2013). A multivariate analysis of performance in young swimmers. Pediatric Exercise Science, 25(3), 435-451.*

- *-Tang, S., Huang, W., Wang, S., Wu, Y., Guo, L., Huang, J., & Hu, M. (2022). Effects of aquatic high-intensity interval training and moderate-intensity continuous training on central hemodynamic parameters, endothelial function and aerobic fitness in inactive adults. Journal of Exercise Science & Fitness, 20(4), 256-262.*
- *-Study of the Relationship Between Body Types and Buoyancy in junior swimmers. (2022). [Unpublished research study].*
- *-Zamparo, P., Cortesi, M., & Gatta, G. (2020). The energy cost of swimming and its determinants. European Journal of Applied Physiology, 120(1), 41-66.*