



International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

<http://gssrr.org/index.php?journal=JournalOfBasicAndApplied>



Dominant Physical Factors for Breaststroke Swimming Speed

Saharuddin Ita *

*Senior Lecturer of Department of Sport Science, Faculty of Sport Science, Cenderawasih University, Papua,
Indonesia*

Email: saharuddinita@yahoo.com

Abstract

Breaststroke swimming speed is influenced by certain physical exercises and focused on dominant physical factors, including having an ideal height, leg length, leg muscle strength, trunk flexibility, and good arm muscle strength in swimming breaststroke, speed will be obtained. In this study the researchers assumed that the determination of breaststroke swimming speed could be determined if a person had a standard height, ideal leg length and leg muscle strength, flexibility of the tool, and good arm muscle strength. This study uses multiple linear regression analysis method. The processed statistics result that the Standardized Coefficient Beta variable leg length is 0.992, the highest among other variables, followed by arm muscle strength (0.224), trunk flexibility (-0.143), leg muscle strength (-0,526) and height (-1,034). It signifies that the dominant physical factor determining the speed in a breaststroke is the length of the leg. With these findings, the combination of leg muscle strength and leg length in breaststroke swimmers is one of the concerns in fostering and training and teaching breaststroke swimming. In swimming breaststroke learning the problem of the legs both leg muscle strength and leg length are priorities that need attention.

Keywords: Height; Leg Length; Leg Muscle Stength; Arm Muscle Stength; Trunk Flexibility; Breaststroke Swimming Speed.

* Corresponding author.

1. Introduction

Sports is one form of efforts to improve the quality of Indonesian humanity which is directed at the formation of character, discipline and high sportsmanship, as well as an increase in achievement that can increase a sense of national pride. Sports activities include various kinds of branches such as athletics, water sports, gymnastics, games, martial arts, and others. Sports science is a cross-disciplinary applied science between related and relevant sciences, so that the implementation of sports coaching to achieve optimal or maximum performance needs to be addressed comprehensively and in an integrated manner.

Swimming is one of the 5 aquatic sports sub-branches namely swimming, beautiful swimming, diving, water polo and open water swimming. The swimming sports branch has its own advantages compared to other sports if you want to pursue the number of gold medals because swimming provides 40 gold medals.

In swimming competition, breaststroke is the slowest swimming style compared to the other 3 swimming styles, namely free style, back stroke and butterfly style. This is because the breaststroke has the biggest obstacles because of the relatively large water resistance during acceleration of both the arms and legs due to irregular body position [1].

Especially for the breaststroke as the tekhis swimming style the initial attention is the formation of a good basic swimming style skill based on the force style mechanics. This means that a breaststroke swimmer must have its own style according to the style mechanics in the breaststroke. Likewise in the form of training must pay attention to the principle of specificity, especially in certain physical conditions that can support the athlete's skills to achieve maximum performance [2]. Furthermore, Maglischo said that in the thousands of meters of total training given to breaststroke swimmers, 75-80% of the training program material was aimed at the legs, both in the form of endurance and speed [3].

Another expert, Counsilman, one of the swimming head coaches at UCLA in the United States said that to increase explosive power and muscular endurance, swimming athletes use weight training, because with weight training especially breaststroke swimmers will get power in the legs [4]. Furthermore, Luttgens and Hamilton said that to get a large boost strength and good breaststroke techniques, the strength of the leg muscles must be strong by weight training [5]. In line with this opinion, Bompa said that the first and foremost thing that must be addressed in exercising achievement sports is physical factors. If the physical condition of the athlete is good, then the others are techniques, tactics and strategies will follow. Conversely, if the physical condition of an athlete is not good, then others will experience the same thing. Because of the importance of physical exercise, in making training programs the problem of physical exercise should not be forgotten [6].

Aspects related to sports coaching according to Soeharsono include: (1) sports aspects; concerning physical issues: physical coaching, technical coaching, tactic coaching, competing maturity, trainers, training and evaluation programs, (2) medical aspects; concerning issues: the function of organs (heart, lungs, nerves, muscles, senses, etc.), nutrition, injury, and examination, (3) psychological aspects; concerning issues: mental endurance, self-confidence, self-mastery, discipline and fighting spirit, pressure, perseverance, and accuracy,

and motivation [7].

Biological or physical factors that are related to the structure, posture and genetically determined biomotor abilities are one of the determinants of achievement consisting of basic components, namely: strength, endurance, explosive power, speed, flexibility, agility, balance, and coordination which is still possible to be developed in accordance with the limits of existing biomotoric abilities in young athletes who are still growing and developing [8].

Anthropometry comes from the word anthropos and metry. Anthropos means body and metros means size. Anthropometry can be interpreted as body size or external size of body parts. In relation to physical measurement, anthropometry is a standard technical unit for systematic measurement of the body as a whole or body parts [9]. Anthropometry includes the quantity of body dimensions including body weight, body length and cross-sectional area or body parts. Comparison of each body organ gives a different appearance to each individual. The size of anthropometry is related to the type or shape of the body, it can also be used as a parameter to determine a person's nutritional status [10]. Anthropometry or body posture is quite influential on sports, especially for high achievement (sports achievement). In order to achieve high achievement, certain physical characteristics and body postures are needed in accordance with the demands of the sports branch he follows. While we know that the ratio is a comparison of body measurements. Correspondingly, Verducci stated that "the anthropometric ratio is a further measurement of the outer parts of the body". Anthropometric measurements include measurements of height and leg length.

Leg length can be said to be relatively long when viewed in terms of comparison with height. In normal posture, the length of the legs compared to the trunk in adults is balanced. But in reality, not all individuals have a balanced anthropometry size. There are individuals who have legs that are longer than trunk, and on the contrary there are also those that have longer trunks than their legs.

Variations in the size comparison of body parts occur due to certain reasons. One of the factors that are examined carefully is the growth rhythm factor and the time of maturity development. Individuals who mature quickly, in their adult years will have relatively shorter legs compared to their trunk. In individuals who are slow to mature will have legs that are relatively longer than the trunk, while the development of normal maturity has a balanced leg and trunk. This can be assessed from the characteristics of body growth that occur during growth.

Height is a person's height measured using a Stadiometer which is measured from the soles of the feet to the top of the head when standing with an anatomical erect posture. Body posture can be measured in front of a wall. Athletes do not shoe and stand on a flat surface to the right of a vertical pole or stadiometer board. The athlete stands upright and both heels must touch the floor. The head, back and buttocks also touch vertical poles. The position of the measuring instrument is parallel to the series of vertebrae. The head position should be such that the ear canal and the lower border of the eye cavity are in a horizontal line. The results of measurements of height are recorded in centimeters [11].

Discussing about height, can not be separated from the human frame. Where the human frame can be grouped

into two parts, namely the appendicular part and extremity. appendicular consists of; cranium, sternum, costae, vertebrae, shoulder bones, and pelvic bones. While part of extremity; arm bones (humerus, ulna, radius, carpal, metacarpal, phalanges), and leg bones (femur, patella, tibia, fibula, tarsal, metatarsal, phalanges) [12]. In this study, measurements of height will be measured in a standing upright position using a stadiometer.

One of the important components in sports performance is body posture and structure. Fox, Bowers [13] said that "professional sportsmen and teachers have a view of interest in body posture and structure as a relative understanding of body type in success in various sports". The ideal body shape or body portion in accordance with the sports it is practicing is one of the conditions that can affect sports achievement. Sajoto [14] stated that one aspect of achieving sports achievement is the biological aspect which includes the structure and posture of the body, namely 1) the height and length of the legs, 2) the size, width, and weight, and 3) somotype (body shape).

Physical conditions is one of the requirements that are needed in an effort to improve the performance of an athlete can even be said as a need that can not be delayed or bargained again. Thus, it can be stated that physical conditions are the most basic conditions in the effort to empower other aspects [14]. Physical conditions are the most important part in all sports, especially to support other aspects such as techniques, tactics and mental. Physical conditions are crucial in supporting the athlete's duties in the match so that they can perform optimally [15]. Physical conditions are one of the factors determining the success of athletes in certain sports. Athletes who have good physical quality, the quality of motion or motor skills tend to be good too. Setiawan said that in other cases physical conditions also play a role in improving physical fitness so that someone can achieve more productive work. Consideration of the physical condition must be developed based on the characteristics of the sports they are doing, because in certain sports it may require the overall physical condition component, while in other branches it may only be partially [15].

From the above theory, part method can be applied if the motion structure is rather complex so it is possible to obtain maximum results if the physical component is trained. Leg muscle power training, flexibility, and balance are important parts that must be possessed by all types of sports that use anaerobic energy systems such as 25 meters of short swimming. The physical condition or physical ability that can be known or measured in relation to this research are as follows: Every sport activity, muscle is the dominant and inseparable body component. All movements carried out by humans due to the presence of muscles, bones, joints, ligaments, and tendons so that movement can occur through muscle pulling movements and the amount of muscle fibers that are activated [15]. Strength is a component of physical conditions, which involves the problem of an athlete's ability to use muscle, receive a load in a certain work time. Muscle strength is the ability of the muscles or muscle groups to do work, by holding the weight they lift. Strong muscles will make the muscles work efficiently such as lifting, carrying and they will make a better body shape [14].

Strength is the ability of muscles to resist prisoners or load in carrying out activities, such as the movement of holding or moving loads. The term muscle is defined as a network that has a special ability to contract. The motion component that is very important for carrying out a very heavy activity is power, because it can determine how many people can run fast. All explosive maximum effort depends on power. To increase power

can be by increasing strength, increasing the speed of contraction, or increasing both, which increases the strength and speed of muscle contraction [16]. Flexibility is a person's ability in adjusting himself, to do all the activities of the body by stretching, especially the muscles, ligaments around the joints. Furthermore, with the ability of joints, ligaments and tendons around the joints, carry out the widest possible motion. According to Gallahue, there are two types of definitions; the first is static modification, namely the trunk's divergence in various directions, and the second, dynamic behavior, namely the ability of the muscles of various limbs, when contracting [14]. Flexibility is the ability to do movements in a wide range of joint motion [15]. While Wahjoedi [17] said that flexibility is the body's ability to do movements through joint space or maximum body space. According to Nagappa and Martin [18] Flexibility is defined as the range of motion of the joints or the ability of the joints to move freely. It also refers to the mobility of the joints. Swimmers who have good muscle flexibility will be able to direct more energy when doing all the movements both when moving their legs or arms. This is because, by having good muscle flexibility, the swimmer will be able to perform elastic movements during the race. Thus to get a good breaststroke, muscle flexibility must be good. Speed is the ability to travel distances quickly. The ability to move fast in a straight line is a component that is inseparable from the success of various sports. Straight lines running can be divided into three stages: acceleration, maximum speed achievement, and maximum speed maintenance [19]. There are two types of speed that are needed in sports, namely the reaction speed and moving speed. The speed of reaction is a quality that allows starting a kinetic answer as quickly as possible after receiving an stimulus, and moving speed is a quality that allows people to move or carry out the same or not the same movements as quickly as possible.

2. Materials and Methods

2.1. Description of the Study Area

This study uses multiple linear regression analysis method regression analysis. This research was conducted at the Tirta Abe Swimming Pool Jayapura.

2.2. Population and Sample

A total of 50 student at department of sport science, faculty of sport science, cenderawasih university, Papua were willing to participate in this study.

2.3. Inclusion Criteria

The inclusion criteria were male student of, of sport science, faculty of sport science, cenderawasih university, Papua.

2.4. Exclusion Criteria

The exclusion criteria were:

1. Student who cannot swim
2. Students who are sick or injured

2.5. Collecting Data and Procedure Intervention

The researcher makes a letter of approval, and the respondent must sign the contents of the report that the respondent is willing to be a sample of this research until the end of the study. Data collection was carried out directly by researchers by measuring height, leg length, leg muscle strength, muscle flexibility, arm muscle strength and breaststroke swimming speed.

2.6. Data Analysis

The collected data is analyzed using the analysis of the Multicollinearity Test to determine whether the independent variables in the regression equation are not correlated with each other, heteroscedasticity test.

To determine the occurrence of heteroscedasticity by looking at the presence of certain patterns in scatterplot that shows the relationship between Regression Studentised Residual and Standardized Regression Predicted Value.

Test for Normality, Linearity, Multiple Linear Regression Analysis, Regression Coefficient, Determination Coefficient, F Test (Simultaneous Influence), T Test (Partial Influence) All statistical tests performed computerized.

2.7. Ethical consideration and clearance

Ethical approval for this study was obtained from the Ethics Committee, Department of Sport Science, Faculty of Sport Science, Cenderawasih University, Papua, Indonesia.

3. Results

The F test is used to find out whether all independent variables together have a real or no effect on the dependent variable.

Based on table 2, the significance value for F test got $p = 0.003$ ($p < 0.05$), meaning that H_0 was rejected, so there was a significant effect between variables $X_1 = \text{Height}$, $X_2 = \text{Leg Length}$, $X_3 = \text{Leg Muscle Strength}$, $X_4 = \text{Arm Muscle Strength}$, $X_5 = \text{Trunk flexibility}$ Determination of the bound variable $Y = \text{Simultaneous Breaststroke Swim Speed}$.

The T test is used to determine the effect of each independent variable on the dependent variable. Based on table 2, the significance value for T test is leg length and arm muscle strength ($p > 0,05$) meaning that H_0 was rejected, so there was a significant effect between variables $X_2 = \text{Leg Length}$ and $X_4 = \text{Leg Muscle Strength}$ Determination of the bound variable $Y = \text{Simultaneous Breaststroke Swim Speed}$.

The processed statistics result that the Standardized Coefficient Beta variable leg length is 0.992, the highest among other variables, followed by arm muscle strength (0.224), trunk flexibility (-0.143), leg muscle strength (-0,526) and height (-1,034).

Table 1: Characteristics of Respondents

| No | Sample | H | LL | LMS | AMS | TF | BSS |
|----|--------|-----|------|------|-----|----|-------|
| 1 | A | 169 | 85 | 57 | 42 | 10 | 19,50 |
| 2 | B | 167 | 84 | 55,5 | 43 | 11 | 20,15 |
| 3 | C | 165 | 83 | 54 | 41 | 12 | 20,12 |
| 4 | D | 164 | 82 | 55,5 | 43 | 15 | 21,25 |
| 5 | E | 160 | 81 | 54 | 41 | 12 | 19,80 |
| 6 | F | 160 | 80 | 53,5 | 46 | 16 | 21,65 |
| 7 | G | 161 | 82 | 57 | 45 | 17 | 22,25 |
| 8 | H | 160 | 81 | 56 | 47 | 19 | 20,19 |
| 9 | I | 163 | 82 | 56 | 46 | 18 | 18,12 |
| 10 | J | 164 | 82 | 57 | 44 | 17 | 19,10 |
| 11 | K | 161 | 81 | 55,5 | 43 | 19 | 18,20 |
| 12 | L | 162 | 81 | 56 | 47 | 21 | 21,45 |
| 13 | M | 165 | 83 | 53,5 | 48 | 23 | 20,50 |
| 14 | N | 167 | 83,5 | 57 | 44 | 24 | 19,56 |
| 15 | O | 168 | 84 | 52,5 | 45 | 21 | 21,21 |
| 16 | P | 163 | 81,5 | 56 | 47 | 25 | 20,18 |
| 17 | Q | 160 | 80 | 56 | 42 | 20 | 18,90 |
| 18 | R | 160 | 80 | 57 | 45 | 21 | 19,80 |
| 19 | S | 161 | 80,5 | 55,5 | 43 | 22 | 20,10 |
| 20 | T | 160 | 80 | 58 | 46 | 21 | 18,45 |
| 21 | U | 164 | 82 | 57,5 | 47 | 25 | 18,20 |
| 22 | V | 165 | 82,5 | 58 | 48 | 23 | 17,89 |
| 23 | W | 166 | 83 | 56 | 46 | 24 | 19,45 |
| 24 | X | 168 | 84 | 53 | 43 | 26 | 20,10 |
| 25 | Y | 169 | 85 | 59 | 46 | 27 | 20,12 |
| 26 | Z | 166 | 83 | 57,5 | 48 | 30 | 19,50 |
| 27 | AA | 165 | 82,5 | 58 | 51 | 29 | 18,76 |
| 28 | AB | 163 | 82 | 57,5 | 50 | 28 | 20,12 |
| 29 | AC | 165 | 82,5 | 58 | 54 | 26 | 19,23 |
| 30 | AD | 167 | 84 | 58,5 | 52 | 28 | 18,45 |
| 31 | AE | 162 | 81 | 59 | 51 | 26 | 19,45 |
| 32 | AF | 164 | 82 | 57 | 50 | 19 | 19,12 |
| 33 | AG | 162 | 81 | 58,5 | 49 | 18 | 18,98 |
| 34 | AH | 160 | 80 | 54 | 48 | 18 | 19,90 |
| 35 | AI | 161 | 81 | 57 | 49 | 15 | 20,71 |
| 36 | AJ | 162 | 81 | 57 | 47 | 17 | 20,12 |
| 37 | AK | 165 | 82,5 | 56,5 | 51 | 19 | 20,34 |
| 38 | AL | 167 | 83,5 | 57 | 50 | 19 | 18,90 |
| 39 | AM | 168 | 84 | 56,5 | 51 | 27 | 20,45 |
| 40 | AN | 169 | 84,5 | 58 | 52 | 25 | 19,48 |
| 41 | AO | 170 | 85 | 59,5 | 51 | 26 | 20,49 |
| 42 | AP | 168 | 84 | 60 | 50 | 27 | 19,30 |
| 43 | AQ | 169 | 85 | 58 | 49 | 29 | 19,56 |
| 44 | AR | 162 | 81 | 57,5 | 48 | 29 | 19,76 |
| 45 | AS | 165 | 82,5 | 56,5 | 49 | 30 | 19,34 |
| 46 | AT | 168 | 84 | 57,5 | 50 | 31 | 19,36 |
| 47 | AU | 169 | 84,5 | 59 | 51 | 32 | 18,56 |
| 48 | AV | 170 | 85 | 58 | 50 | 32 | 18,40 |
| 49 | AW | 171 | 85,5 | 60 | 51 | 29 | 17,80 |
| 50 | AX | 169 | 84,5 | 60 | 50 | 29 | 17,65 |

Information : H=Height; LL=Leg Length; LMS=Leg Muscle Stength AMS=Arm Muscle Stength; TF=Trunk Flexibility; BSS=Breaststroke Swimming Speed

Table 2: Results of Calculating Multiple Linear Regression

| Model | $\hat{Y} = 34,419 - 0,317X_1 + 0,624X_2 - 0,297X_3 + 0,070X_4 - 0,025 X_5$ | | | | |
|---|--|--------|--------|-------|-------------------------|
| F test | 4,186 | | | | |
| F sig | 0,003 | | | | |
| Adj R2 | 0,245 | | | | |
| Variable | Coefisien Regression | Beta | T | p | Decision |
| Konstanta | 34,419 | | | | |
| Height (X1) | -0,317 | -1,034 | -1,502 | 0.140 | H ₀ Accepted |
| Leg Length (X2) | 0,624 | 0.992 | 1,495 | 0.142 | H ₀ Accepted |
| Leg Muscle Strength (X3) | -0,297 | -0.526 | -3.227 | 0.002 | H ₀ Refused |
| Arm Muscle Strength (X4) | 0,070 | 0.224 | 1.252 | 0.217 | H ₀ Accepted |
| Trunk Flexibility (X5) | -0,025 | -0.143 | -800 | 0.428 | H ₀ Accepted |
| Dependent Variable: Breaststroke Swimming Speed | | | | | |

4. Discussion

Speed is the ability to travel distances quickly. The ability to move fast in a straight line is a component that is inseparable from the success of various sports. Straight lines running can be divided into three stages: acceleration, maximum speed achievement, and maximum speed maintenance [20]. Speed is the ability to travel long distances quickly, the ability to move fast in a straight line is a component that is inseparable from success in various sports. A straight running line can be divided into three stages: acceleration, achieving maximum speed up to about 80 m [21].

There are two types of speed that are needed in sports, namely the reaction speed and moving speed. The speed of reaction is a quality that allows starting a kinetic answer as quickly as possible after receiving an stimulus, and the speed of movement is a quality that allows people to move or carry out the same or not the same movements as quickly as possible. The reaction speed can also be interpreted as an organism's ability to answer a stimulus as quickly as possible in achieving the best results. While the speed of movement is the ability of the athlete's organism to move as fast as possible in a motion that does not rotate. Speed is expressed by V (velocity), the distance traveled by D (distance), and the time needed to travel this distance with T (time). It can be formulated that speed is distance divided by the time taken and denoted by units of meters / second. Speed is one physical component that is very important in sports, or something to move places quickly.

The processed statistics result that the Standardized Coefficient Beta variable leg length is 0.992, the highest among other variables. This result is inline with Maglischo [22] that leg muscle strength plays a more important role in breaststroke swimming. This is still the same as the results of the study published by Marek Strzala, that the coordination index of foot and arm movements in relation to breaststroke sprints on young swimmers is very dominant [23].

Leg length affects the width of the kick, the wider the kick the greater the thrust produced. When you kick back,

the length of the leg is used as a board with water. If the legs are long, the board will be wider, so that the force given by the water to be pressed before it becomes endless, with great strength, the thrust will be greater in the future. This is related to Newton's law 3, which is the law of reaction action, that the greater the imposition of an object's force, the object will give the same force. So the conclusion is that with swimming techniques that are already good and supported by long legs, it will increase the thrust forward faster [24].

Thus, the dominant physical factor cannot stand alone but must get support from other conditions such as arm strength as the results of this study the next dominant physical factor after limb length is leg muscle strength. This means that even if the athlete has a good leg length but the leg is less then the speed for swimming is not achieved optimally, but if the length of the leg is good and then supported by good leg muscle strength, the speed will be achieved because of the collaboration between muscle strength and leg length. By knowing the dominant physical speed of breaststroke, in choosing athletes anthropometric factor breaststroke becomes a factor that must be considered first and then following other factors.

Swimmers who have good muscle flexibility will be able to direct more energy when doing all the movements both when moving their legs or arms. This is because, by having good muscle flexibility, the swimmer will be able to perform elastic movements during the race. Thus to get a good breaststroke, muscle flexibility must be good.

Strength is a component of a person's physical condition about his ability to use muscles to accept burdens while working. Likewise, leg muscle strength is also one of the factors affecting breaststroke swimming speed. Muscle explosive power or muscle endurance or muscle endurance has a relationship with the dominant factor, namely strength. Strength remains the basis or basis of muscle explosive power and muscle endurance. So muscle strength is a very important component in improving overall physical condition. Physical ability, especially leg muscle strength is the main forward driving force, in support of breaststroke swimming techniques for swimming speed of 50 meters breaststroke. Kicking in the breaststroke requires strength to produce forward thrust. The greater the power produced by the strength of the leg muscles, the faster the forward thrust produced so that the time taken will be faster. So the relationship between leg muscle strength and breaststroke swimming speed is directly proportional, because the greater the power produced, the faster the swimming speed [24]. The limitation of this study is that randomization was not carried out on the subject due to the small number of subjects. Another limitation is that it is difficult to determine which factors are most influential on breaststroke swimming speed, because there are some other factors not examined in this study, including the type of muscle fibers from swimmers. Fast twitch muscles are identical with speed and slow twitch is identical to endurance.

5. Conclusions

In conclusion, the dominant physical factor determining the speed in a breaststroke is the length of the leg.

6. Abbreviations

H=Height; LL=Leg Length; LMS=Leg Muscle Stength; AMS=Arm Muscle Stength; TF=Trunk Flexibility; BSS=Breaststroke Swimming Speed

7. Competing interest

The authors declare that they have no competing interest.

8. Recommendations

With these findings, the combination of leg muscle strength and leg length in breaststroke swimmers is one of the concerns in fostering and training and teaching breaststroke swimming. In swimming breaststroke learning the problem of the legs both leg muscle strength and leg length are priorities that need attention.

References

- [1]. Suryatna, E. and A. Suherman, *Renang Kompetitif alternatif untuk SLTP*. Jakarta: Depdiknas, Dikdasmen, 2001.
- [2]. Allen, M.B., *Sports, exercise, and fitness: a guide to reference and information sources*. 2005: Libraries Unlimited.
- [3]. Maglischo, E.W., *Is it Time to Consider a Different Way of Swimming Backstroke?* *Journal of Swimming Research*, 2014. **22**(1).
- [4]. Counsilman, J.E., *Competitive swimming manual for coaches and swimmers*. 1977: Counsilman Company Bloomington, IN.
- [5]. Hamilton, N.P., *Kinesiology: scientific basis of human motion*. 2011: Brown & Benchmark.
- [6]. Bompa, T.O. and C. Buzzichelli, *Periodization-: theory and methodology of training*. 2018: Human Kinetics.
- [7]. Harsono, M.S. and M.S. Drs, *Coaching dan Aspek-aspek Psikologis dalam Coaching*. 1988, Direktorat Jendral Pendidikan Tinggi: Jakarta.
- [8]. Åstrand, P.-O., et al., *Textbook of work physiology: physiological bases of exercise*. 2003: Human Kinetics.
- [9]. Malina, R.M., C. Bouchard, and O. Bar-Or, *Growth, maturation, and physical activity*. 2004: Human kinetics.
- [10]. Irianto, D.P., *Panduan gizi lengkap keluarga dan olahragawan*. Yogyakarta: Andi Offset, 2007.
- [11]. Anwar, M., *Memilih Atlet Untuk Menghasilkan Prestasi Prima Dalam Olahraga*. 1986, Simposium Olahraga. Surabaya.

- [12]. Rahmadini, Ilmu Otot Umum. Jakarta: FK UI. 2007.
- [13]. Fox, E.L., R.W. Bowers, and M.L. Foss, The physiological basis for exercise and sport. 1993: Brown & Benchmark.
- [14]. Sajoto, M., Peningkatan & pembinaan kekuatan kondisi fisik dalam olah raga. 1995: Dahara Prize.
- [15]. Harsono, Coaching dan Aspek-aspek Psikologis dalam Coaching. 1988, Direktorat Jendral Pendidikan Tinggi: Jakarta.
- [16]. Jensen, C.R., Applied kinesiology and biomechanics. 1983: McGraw-Hill College.
- [17]. Wahjoedi, Landasan Evaluasi Pendidikan Jasmani. Jakarta: PT Panjagra Sindo Persada, 2000.
- [18]. Nagappa, K.T. and K. Martin, Effect of flexibility on secondary school children. 2017.
- [19]. Lubis, J., Panduan Praktis Penyusunan Program Latihan Jakarta: PT Raja Grafindo Persada, 2013: p. 92.
- [20]. Lubis, J., Panduan praktis penyusunan program latihan. Jakarta: PT Raja Grafindo Persada, 2013.
- [21]. Bompa, T.O., G., Gregory Haff. Periodization Theory And Metodolgy Of Training, 2009.
- [22]. Maglischo, E.W., Swimming fastest. 2003: Human Kinetics.
- [23]. Strzala, M., et al., Intra-cyclic phases of arm-leg movement and index of coordination in relation to sprint breaststroke swimming in young swimmers. Journal of sports science & medicine, 2013. **12**(4): p. 690.
- [24]. Asa, A.M., Hubungan daya ledak otot tungkai, kekuatan otot tungkai dan panjang tungkai terhadap kecepatan renang 50 meter gaya dada pada atlet putra berprestasi klub renang metal sc metro tahun 2013. 2013.