PERFORMANCE OF THREE START TECHNIQUES OFF THE OSB11 STARTING BLOCK OVER 15M

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A thesis submitted in fulfilment of the requirements for the degree

MA (Sport, Recreation and Exercise Science)

In the department of Sport, Reaction and Exercise Science

University of the Western cape

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23 October 2019

DECLARATION

I hereby declare that **"***performance of three start techniques off the OSB11 starting block over 15m"*, is my own work, that has not been submitted before any other degree or examination at any other university, and that the sources I have used have been indicated and acknowledged as completed references.

Lynne Reagon **Date**

Signed____________________________

DEDICATION

This study is wholeheartedly dedicated to my parents. Sharon Reagon and Rene Reagon, thank you for your unconditional love, unwavering support and the sacrifices made to provide me with opportunities that you never had.

ACKNOWLEDGEMENTS

This study would have not been possible without the contribution, support and guidance from the following people:

First and foremost, I would like to thank God Almighty for giving me the strength, knowledge and opportunity to undertake this research study and to persevere and complete it satisfactorily. None of this would have been possible without his blessings.

I would like to thank Vineyard swimming club for allowing me to use their swimmers and Stellenbosch University for allowing me to conduct my testing at their facility.

I would like to acknowledge the financial assistance of the National Research Foundation (NRF) for the scholarship I was awarded with. It is important to note that the opinions and conclusions arrived at are those of the author and not that of the NRF.

To the Department of Sport, Recreation and Exercise Science (SRES) and the University of the Western Cape, thank you for affording me the opportunity to complete a Master's degree and for the ongoing support from the academic and administrative staff.

Finally, a special thank you to my supervisor, Dr. Barry Andrews, for his support and encouragement on this journey.

ABSTRACT

Background: In swimming, a swimmer's performance is mostly determined by the time spent on starts, stroking and turning. The start of a swimming races, especially sprint races, can account for almost a quarter of race time.

Aim: The aim of this study was to analyse the biomechanics and performance of three start techniques off the OSB11 starting platform over 15-meters to determine which of the three is most effective when looking at the three parts that constitute the start: block time, flight time and underwater time.

Methods: A Quasi-experimental cross over trial-based study design was used to determine which of three starting techniques (Grab, Track & Kick) was the most effective off the OSB11 starting block. Ten Swimmers who qualified for junior nationals from Vineyard Swimming Club participated in the study. Each participant acted as their own control and were required to perform each start once. All trials were filmed and analysed on Dartfish pro suite 10. The following variables were analysed: shoulder angle, hip angle, knee angle, reaction time, movement time, total block time, flight distance, flight time, flight velocity, entry angle, underwater time, underwater distance, time to 15-meters.

Results: Results showed that although shoulder angle analysis, that the Track and Kick start could produce the greater angular momentum than that of the Grab start, when performed off the OSB11 starting block. It was also showed that the Kick starts had a significantly faster reaction time (p=0.03), longer flight distance (p =0.0005), and smallest angle of entry (p=0.025) than that of the Grab and Track start. The track start was shown to be significantly faster than that of the Grab Start, when performed of the OSB11 starting block. In summary, the Kick start also had a faster block time, greatest velocity and furthest underwater distance and fastest 15-meter start time.

Conclusion: In conlcusion, the current study proved that the Kick Start is the more superior start technique off the OSB11 starting block. However, swimmers, together with their coaches, need to adapt to the new starting block and choose the technique best suited for the individual while taking advantage of the new block. During training, swimmers should focus on those variables that were proved to be statistically significant for perfromance.

Keywords: Biomechanics, Grab start. Track start, Kick start, OSB11

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LIST OF ABBREVIATION

BT	Block Time
CoM	Centre of Mass
FT	Flight Time
FD	Flight Distance
GS	Grab Start
KS	Kick Start
MT	Movement Time
RT	Reaction Time
ST	Start Time
TS	Track Start
TOV	Take-off Velocity
UT	Underwater Time

DEFINITION OF TERMS

Biomechanics:

Centre of Mass: It is the average position of all the parts of a system, weighted according to their mass

Reaction Time: The time elapsed between the starting signal and the swimmers first visible movement on the block.

Movement Time: The time elapsed between the first and the starting signal and the when the swimmer is no longer in contact with the block.

Block Time: Total time the swimmers spend on the starting block after the starting signal. This made up of Reaction and Movement time.

Flight Time: The time the swimmer spends in the air before contacting the water

Flight Distance: The distance a swimmer travels before contacting the water

Total Start Time: The time elapsed between the starting signal and when the swimmers head reaches 15-meters

Underwater Time: The time from the swimmers pends underwater, before their head emerges to start the free swim

CHAPTER ONE

INTRODUCTION AND BACKGROUND TO THE STUDY

1.1 INTRODUCTION

This Chapter introduces the study conducted by the researcher. It includes the background and rationale of the study, purpose of the research, aims, objectives and hypotheses. Thereafter, an outline of each chapter is presented towards the end of this chapter.

1.2 BACKGROUND

"The starts in swimming are an important time saver" (Lyttle, 2011, pg. 427).

Before swimming became a competitive sport, the focus of swimming was for enjoyment and pleasure, perused at popular riversides, at the seaside and municipal baths (Parker, 2001). Competitive swimming was first introduced in the early 1800's in Britain and came into prominence with its inclusion in the Modern Olympics (Love, 2008). The lack of controlled swimming environments was a challenge during the first few Olympic Games. For example, at the 1900 Paris Olympics swimmers raced in the Seine River and during the 1904 games, they competed in a lake. With the creation of the International Swimming Federation (FINA), Federation Internationale de Natation, the international federation recognized by the International Olympic

Committee for administering international competition in water sports, in 1908 swimmers competed in a specially built 50-meter swimming pool (Kehm, 2007). At first only males could compete in the modern Olympics, however, in 1912 FINA convinced the International Olympic Committee (IOC) to include woman's events. In 1909, the South African Amateur Swimming Union was formed (SAASU), which was an exclusively white organization, however after the first racial policy on sports was introduced during the Apartheid era, SAASU was expelled from FINA and the Modern Olympics up until 1992. Since then South Africa has had several male and female swimmers winning gold.

All swimming events, except the backstroke, start outside of the water on a starting block. A swimming race can be broken up into four contributing components: the start, free swimming, turns and the finish (Cossor & Mason, 2001). The swimming start is the first component of a swimming race and although it accounts for a small fraction of the entire race, it has a large influence on the outcome of the race (Cossor, Slawson, Justham, Conway & West, 2010). For shorter races, such as 50-meter races, the swimming start, i.e. time to 15-metesr, can have a significant impact on total race time (Slawson, Conway, Cossor, Chakravoti, Le-sage & west, 2011). Its performance is quantitatively measured by the time elapsed between the start signal and the moment when the swimmers head crosses an imaginary 10-meter (Arellano, 2001) or 15-meter mark (Cossor & Mason, 2001). Contributing to anywhere between 0.8% and 26.1% of the total race time (Lyttle & Benjanuvtra, 2005).

The swim start is broken down into three phases:

i. block,

ii. flight, and

iii. underwater.

Since the block phase is the first phase of the start, it is beneficial for swimmers to master their take-off parameters on the starting block (Mason, Alcock, & Fowlie, 2007). The most commonly used and well researched starting techniques are (i) the Grab and (ii) the Track, with the main difference between the two being the foot placement on the block (Barlow, Halaki, Stuelcken, & Greene & Sinclair, 2014). With the introduction of the new Omega OSB11 starting block, approved by FINA in 2008, including an adjustable back plate, research has shifted towards comparing the traditional track and the newly developed variation, the Kick start (Nomura, Takeda & Takagi, 2010), in an attempt to determine the advantages the new block offers in the swimming start.

The requirements for a successful start include, but are not limited to, fast reaction time; jumping power; and a high take-off velocity (Thanopoulos *et al*, 2012). In previous studies, in order to highlight the differences or advantages of one start technique over another, the analysis of various kinematics was done (Bojan, Puletic, Stankovic, Okicic, Bubanj & Bubanj, 2010). Thus far, the following kinematics parameters have been measured: flight time, block time, start time for 5m, 7.5-meter, 10-meter and 15--meter, start reaction, start time that involves flight time and block time, flight length, angle of take-off, angle of entry, take-off velocity, the centre of mass velocity (Welcher, 2008; Takeda & Nomura, 2006; Issurin & Verbitsky, 2003;

Nikodelis & Kollias, 2003; Kruger, Wick, Homann, El-Bahrawi & Koth 2003; Miller, Allen & Pein, 2003; Blanksby, Nicolason & Elliot 2002). Therefore, the purpose of the study is to determine which of the three starting techniques is most effective off the Omega OSB11 starting block by analysing various kinematics.

1.3 STATEMENT OF THE PROBLEM

Since the OSB11 starting block has become the standard at all major swimming events, it is essential to gain a better understanding of how to optimize performance when diving from this block. To date, existing literature has investigated the Grab Start (GS) and Track Start (TS) and have recently included the newly developed Kick Start (KS). Of these studies, some researchers have found the GS to be superior to the TS (CousilmanCoulsiman, Nomura & Endo, 1988; Zatiorksy, Bulgakvo & Chapplinsky 1979; and Aylalon, Van Cheluwe & kanitz, 1975). While other researchers have shown the TS to be more superior (Issurin & Verbitsky, 2002; Holthe & Mclean, 2001; Juergens, Rose, Smith & Pearse, 1999, & Allen, 1997). These results leave an uncertainty as to which technique would be best. Furthermore, the newly developed KS off the OSB11 starting block has also been investigated, comparing it to both the TS and the GS. Biel, Fischer & Kibele (2010) compared the TS and KS off the OSB11 starting block and found that swimmers were 0.2 seconds faster to 7.5-meters, had shorter block times and increased horizontal take-off velocity from the OSB11. This study did not include the comparison of the GS.

Considering existing literature and the uncertainty regarding which start is most superior, and that very few studies have compared all three starting techniques

(Grab, Track & Kick) off the new OSB11, the purpose of this study was to analyze the differences in kinematic variables of three starting techniques off the Omega OSB11 starting block to determine which starting technique is most effective.

1.4 SIGNIFICANCE

The focus of this study was on which of three swimming start techniques (Grab, Kick and Track) was most effective off the new Omega OSB11 starting block.

The swimming start is the shortest and fastest phase of a swimming race and is of utmost importance for competitive success, particularly in sprint events. The swimmer invests about 0.8s of the total race time into its performance, producing the fastest velocity that they will achieve during a race (Mason & Cossor, 2000; Kennedy, 1990). Researchers have found that in sprint events, especially, total race performance has undoubtably been linked to the start performance (Mason, Alcock & fowlie 2007; Nikodelis & Kollias, 2003). It has been suggested that an improvement in start performance could reduce total race time by at least 0.10s over 50-meters (Maglischo, 2003). As world records continue to be broken in many swimming events, an effective start is one of the necessary skills that has become extremely important for success (Yang, 2018).

Several different starting techniques have been used by swimmers over the years. Specific attention has been given to two of the most commonly used (GS and the TS) with the main different between the two being position of the feet on the block (Barlow, Halaki, Stuelcken, Greene & Sinclair, 2014). However, since the newly designed starting block by Omega (OSB11, Corgémont, Switzerland) was approved by FINA (Takeda, 2012), a new technique known as the Kick Start (KS) technique was developed. The KS is essentially modified TS which allows the rear foot to be raised and placed onto the back plate, which is a plate fixed at an angle of 30° at the rear end of the starting block (Honda, Sinclair, Mason & Pearse, 2012).

Since there is no consensus on which start is more superior, Chueh-Yu and Thanopoulos et al (2012) suggested that the coach, together with each swimmer individually, should decide which start is most suitable. Several authors also concluded that the best starting technique would be that most practiced by the individual (Thanopoulos et al , 2012; Jorgic et al, 2010; Vantorre, Seifert, Fernandes, Vilas -Boas & Chollet, 2010; Mason, Alcock & Fowlie, 2007; Blanskby, Nicholson & Elliot, 2002). Therefore, this study attempted to establish which of the three starting techniques (Track, Grab and Kick) is most effective off the Omega OSB11 starting block. Although the study had some limitations, coaches and swimmers could still benefit from the results provided by this study.

1.5 AIM

The aim of this study was to analyse the biomechanics and performance of three start techniques off the OSB11 starting platform over 15-meters to determine which of the three is most effective when looking at the three parts that constitute the start: block time, flight time and underwater time.

1.6 OBJECTIVES

The objectives of this study were to:

1. Determine the difference in biomechanics of the starting position between the three starting techniques

2. Determine the block time of the Grab, Track & Kick start technique off the OSB11 starting block

3. Determine the flight time of the Grab, Track & Kick start technique off the OSB11 starting block

4. Determine the underwater time of the Grab, Track & kick start technique off the OSB11 starting block

5. Determine which start Technique has the fastest 15-meter Start time

1.7 RESEARCH HYPOTHESES

It was hypothesized that:

1. The main difference between the starting position biomechanics will lie in the foot placement on the block.

2. The Kick start technique off the OSB11 starting platform will produce the fastest block time

3. The Kick start technique off the OSB11 starting platform will produce the fastest flight time

4. The Kick start technique off the OSB11 starting platform will produce the fastest underwater time

5. The Kick start technique will produce the fastest 15-meter start time

1.8 CHAPTER OUTLINE

This research is presented in five chapters:

Chapter 1 introduces the study and includes the background to and rationale for the study, aims and objectives as well as the hypotheses, and definitions to all abbreviations used in this study.

Chapter 2 is the literature review and includes information on competitive swimming, the importance of the swimming start, an explanation of the deterministic model used for technique analysis in biomechanics, the benefits of video analysis and feedback.

Chapter 3, the methodology is outlined and included the research design. The population sampling and selection as well as the research methods used are presented. Data collection and analysis, reliability, validity and ethical considerations are discussed.

Chapter 4 includes the results in accordance to the objectives and hypotheses of the study. Data is organized, analyses and interpreted in order to draw a conclusion.

Chapter 5, the results, conclusions and limitations of the study are discussed, followed by recommendations for future research.

The **Appendices** provide important information regarding data collection, analysis and replication of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents a review of literature with regards to swimming start performance. The history and origin of swimming and the development of the freestyle stroke are explored. Thereafter, literature pertaining to the evolution of competitive swimming worldwide is discussed. Followed by a discussion on the evolution of swimming in South Africa. The significance of the swimming start on overall race performance is discussed, followed by the last evolution in swimming, and the introduction of the OSB11 starting block. Finally, the biomechanics of the swimming start, and the deterministic model for technique analysis is explained towards the end of this literature review. Published and unpublished journal articles, theses and academic transcripts will be illustrated in this literature review, for this study.

2.2 HISTORY OF SWIMMING

Swimming is one of the oldest arts, if we are to form an opinion from the fact that no trace of its origin, discovery, invention or improvements are found in any of the ancient writing (Wilson & Mariono, 1883).

2.2.1 The origins of swimming

Ancient Assyrian, Greek, Egyptian and Roman civilisation archaeology prove that swimming has been practiced from as early as 2500 BC. Ancient Egyptian cave paintings and art show figures practicing breaststroke, dogpaddle or what could have been the front crawl. Other art from ancient Middle East, Italy and Mexico also feature swimming scenes (Khem, 2007). Furthermore, a few references to swimming are found in the Old Testament and can be ranked among the earliest references to swimming (Colwin, 2002). In Greece and Rome, swimming was part of martial training and was, like the alphabet, also part of elementary school for males. In the Orient, swimming dates back to the 1st century, there being some evidence of swimming races. In the Encyclopaedia of Swimming, written by Bestford (1976), it states that the Japanese had early history of competitive swimming too, with formal races taking place as early as 36BC. Although literature suggests competitive swimming has its origin in Japan, due to its “closed country” status competitive swimming was largely attributed to the English (Bestford, 1976). During the middle ages, water and swimming lost its popularity. It was thought that water may have been a source of sickness and disease and that swimming may spread infection (Brio, 2015). It was not until the 19th century that swimming as both recreation and sport began to gain popularity again (Brio, 2015).

2.2.2 Development of the front crawl – Freestyle

In 1844, a small revolution occurred at a London Swimming meet, competing in the races were some Native Americans. While the British swimmers swam breaststroke, the Native Americans surged ahead using an unusually fast style of swimming, in which their legs kicked up and down and their arms moved like "windmills" (Brio, 2015). The splashing produced by the Native Americans' form of the front crawl was vicious to British gentlemen, who liked to keep their heads above water. As a result, British swimmers continued to stick to the Breaststroke and the sidestroke, which had emerged in the 1800s (Brio, 2015).

In the 1870s, however, the front crawl was reintroduced to England by a man names J. Arthur Trudgeon. Impressed by the style used by Native Americans, Trudgeon began teaching the stroke which became known as the "Trudgeon". It was like the front crawl we know today, but with scissor kick, rather than the flutter kick (Kehm, 2007). Meanwhile, in the 1880s, Frederick Cavill, an English swimmer who had settled in Australia, witnessed the young men from the South Sea Islands using a flutter kick with the crawl. In fact, the native people of America, West Africa and some Pacific islands had been using this stroke for thousands of years. Cavill taught his son this stroke, who soon went on to break world records using it in competition. The stroke gained worldwide fame as the Australian crawl. In the 1960s it became known simply as the front crawl (Kehm, 2007).

2.2.3 Chronology of competitive swimming

At the end of the 18th century, great historical events took place which promoted swimming as a competitive sport.

1875, 25 August: England's Matthew Webb became the first person to cross the English Channel, completing the course from Dover to Calais in just under 22 hours swimming only breaststroke (Lohn, 2010). Internationally, competitive swimming came into prominence with its inclusion in the modern Olympics.

1896, 6-15 April: The first modern Olympics took place in Athens which only included the following men swimming events: 100m Freestyle, 400m Freestyle and 1 500m Freestyle (Lohn, 2010). Relationships amongst European countries were formed to undertake the task of organising competitions. These relations formed the National Swimming federation, which entailed the creation of an International Swimming organisation (Brio, 2015).

1908, 19 July: The Federation Internationale de Natation (FINA) was founded in London and became the world governing body for swimming, diving, waterpolo, synchronized swimming and open water swimming (Lohn, 2010). Olympic events were originally for men only, however, in 1912 FINA had convinced the International Olympic Committee (IOC) to have womans events in all future Olympic swimming races. FINA is structured with a council of 22 members, including the president and 5 vice presidents (one per continent). Under its control, five continental organizations were created, one of them being the Confederation Africaine de Natation Amateur, under which south africa was represented (Nauright, 2012).

2.2.4 Swimming in South Africa

In 1909, the South Africa Amateur Swimming Union (SAASU) was formed but remained an exclusively white aquatic organisation during the apartheid era (Nauright, 2012). In 1909, South Africa was accepted as a member FINA. In 1912, G. A. Godfrey was the first swimmer to represent South Africa at the Olympic Games held in Stockholm. In 1956, South Africa had formed its first racial policy on sports, the policy stated that the privilege of representing South Africa would be restricted to whites only. This resulted in SAASU being banned from competing at the Olympics. The IOC banned SAASU until “an integrated single governing body was constituted”. SAASU was also expelled from FINA as the ruling states: “If any national body practices discrimination on the grounds of race, religion or political associations, it shall be ineligible for admission. If any FINA member practices such discrimination after investigation and subsequent substantiation, it shall be expelled. After 1990, when the discussion to end Apartheid started, South Africa was invited to compete in the 1992 Olympic Games (Desai, 2010).

2.3 THE SWIMMING START

2.3.1 Background and relevance

Swimming events are broken up into four contributing components: the start, the first component of any swimming race, followed by the free swim, turns and the finish (Cossor & Mason, 2001). The start of all swimming events, except the backstroke, begin on an elevated platform, called the starting block, which is situated at the edge of the pool (Alexandar, 2012). The swimming start performance is measured by the time elapsed between the start signal and the instant the swimmers head crosses the 10-meter or 15-meter mark (Issurin & Verbitsky, 2002; Cossor & Mason, 2001;).

The swimming start performance has been quantitatively evaluated in relation to the free swim, turn and finish to assess its overall contribution (Vilas-Boas, Cruz, Sousa, Conceicao, Fernandes & Carvahlo, 2003; Lyttle & Benjanvuatra, 2005). This means researchers have assigned a numerical value on the overall contribution of the swimming start on total race performance. It was found that the start time can account for anything between 0.8% - 26.1% (Lyttle & Benjanvuatra, 2005) or, as suggested by Slawson (2011), can make up as much as 30% of a swimming race and has a substantial impact on total race time (the latter percentage representing that of sprint events). During the world championships held in Barcelona (2013), in the 50-meter events, the start accounted for 1.10% and 0.69% of total race time for males and females, respectively (Arguelles-Cienfuegos & De la Fuente-Caynzos, 2014). Maglischo (2003) suggested that an improvement in the swimming start performance can, on average, reduce race time by 0.10s. Regardless of the small contribution to overall race time, an effective swimming start performance is crucial, since the goal of any swimming race is to complete the required distance in the least amount of time (Blanco, 2016). At the 2017 Budapest World Swimming Championships, in the 50-meter freestyle final events, race performance was within 21s and the ranking was determined by milliseconds (Cossor, Slawson, Shillabeer, Conway, & West, 2011).

The relevance of the swimming start in overall race performance has led to several biomechanical studies analysing advantages and disadvantages of various starting techniques, with the objective of finding which is most effective (Blanco, 2016). In 1966, Gentile conducted the first experimental study in which he included an analysis of the swimming start. The technique analysed in the study was that which is now known as the Conventional Start (CS) (Figure 2.1) (Blanco, 2016). In this technique, the swimmer's feet are placed shoulder width apart, parallel to each other, at the edge of the starting block. The knees and hips are slightly flexed, with the head and neck tucked downward towards the flexed knees. The arm placement in this technique could be in one of two positions:

i. extended backward in line with the spine
ii. hung out in front of the starting platform or

In both positions, the arms would either swing forward or backward respectively.

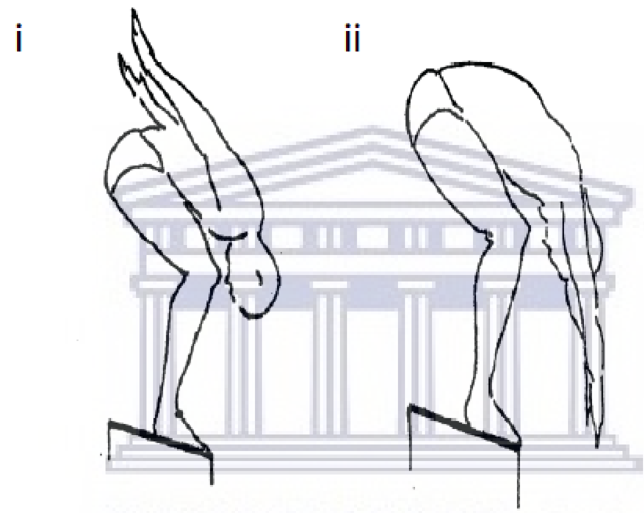


Figure 2. 1: Arm positioning for the conventional start technique (Lewis, 1980).

In 1967, Eric Hanauer introduced a different start technique, the Grab start (GS) (Figure 2.2a) (Hanauer, 1967). The GS has both feet at the front of the starting block, like that of the conventional start, but differs slightly in that the swimmer's hands grab the front edge of the block. After this introduction, several studies were conducted to determine the advantages and disadvantages of the two different starting techniques. Holthe and Maclean (2001), compared the CS and GS and found that the GS offers greater performance advantages over the CS. In previous studies, researchers found the GS to be much faster in several variables namely; reaction time, movement time and block time. Reaction time is defined as the time elapsed between the starting signal and the first movement on the block; Movement time, the time elapsed time from the first visible movement to the time the feet leave the block and Block time, total time spent on the block (Ayalon, Van Gheluwe & Kanitz, 1975; Bloom, 1978; Bowers & Cavanagh, 1975; Lewis, 1980; Roffer, 1972). It was first thought that swinging the arms when performing the CS was benficial. However, It was found that it actually increased the time the swimmer spent on the block and did not add any advantage (Bowers & Cavanagh, 1975; Disch, Holser, & Bloom, 1978; Lewis, 1980). Due to the advantage the GS had over the the CS, soon the CS was no longer being used in competitive swimming.

In 1973, Fitzgerald introduced the Track start (TS) (Figure 2.2b) (Fitzgerald, 1973). The TS is a variation of the GS with one foot at the front edge of the block and the other foot placed to the rear end of the block, with the same hand placement. In a study done by Chueh-Yu (2012), comparing the GS and TS, no significant difference was found between the two. Due to no one start being more advantageous over another, both techniques have been used in competitive swimming for more than forty years (Blanco, 2016).

Figure 2. 2: Comparison of the Grab Start (a) and Track Start (b).

In 2010 FINA, the governing body for swimming, approved the Omega OSB11 starting block (Swiss Timing, Corgémont, Switzerland) (Barlow, Halaki, Stuelken, Greene & Sinclair, 2014).

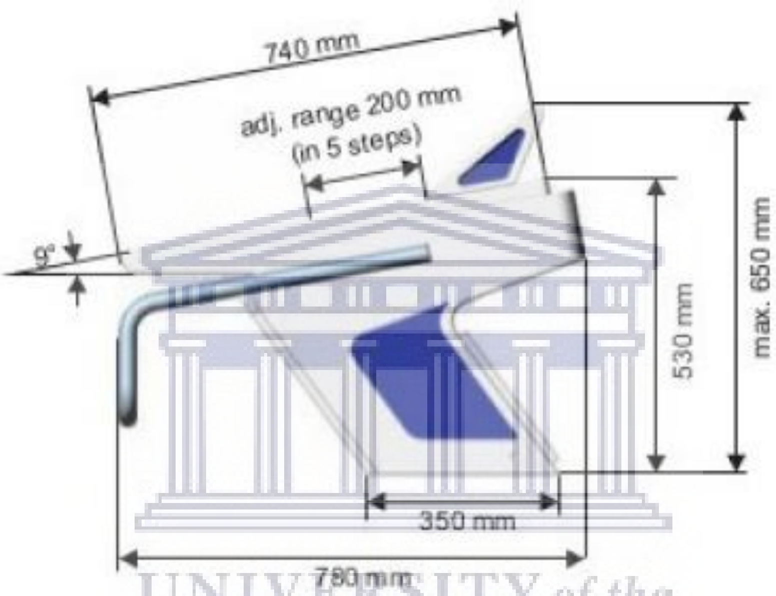


Figure 2. 3: Omega OBS11 Starting Block (HTS Group Ltd, 2000)

This starting block made its first appearance at the Olympic Games in London 2012. The OSB11 is characterized by the addition of an adjustable incline footrest towards the rear of the block angled at 30° which can be moved between five different locations along the length of the block (Barlow, 2014).

2.3.2 The Omega OSB11 Starting Block

The introduction of this new starting block allowed for the development of the Kick start (KS). Essentially, the KS is a modified TS and allows for the rear foot to be raised off the block and placed upon a back plate (Honda, 2010). The new KS has been adopted by most swimmers performing at international competitions because of the large advantage researchers found when compared to that of the TS and GS (Blanco, 2016). Many researchers agree that the KSs' main advantage falls on the block phase of the swimming start. Benefits of using the back plate is two-fold; force generation is increased which reduces time invested on the block, and an increase in horizontal velocity the instant the swimmer leaves the block (Blanco, 2016).

Analysis has shown that the swimming start technique most efficient off the new starting block remains debtable among coaches, swimmers and researchers (Yang, 2018). Researchers have compared the TS from the traditional starting block, which does not have a back plate, and the New OSB11, with and without the use of the back plate (Nomura, Takeda & Takagi, 2010; Petryaev, 2010). In all three studies, there was a consensus that start performance from the OSB11 platform was faster than that off the traditional starting block. Reiterating, the benefits of the newly introduced starting block on start performance. In a study done by Chueh-Yu (2012), who performed a biomechanical analysis comparing the GS and TS off the OSB11 starting block, found no difference between flight time and velocity between the two techniques. However, the KS was found to have a shorter block time. Welcher, Hinrichs and George (2008) it was found that the rear-weighted TS position was found to have a better combination of time to 15m and velocity than the front-weighted TS position. A study done by Barlow *et al.* (2014) echoed these results when comparing neural, rear and front weighted KS off the OSB11. Results indicated that the neutral and rear-weighted positions produced faster times to 15m when compared to the front-weighted position (Barlow, 2014). These findings suggest that starting positions in either a rear or neural-weighted position would be most suitable for improving start performance.

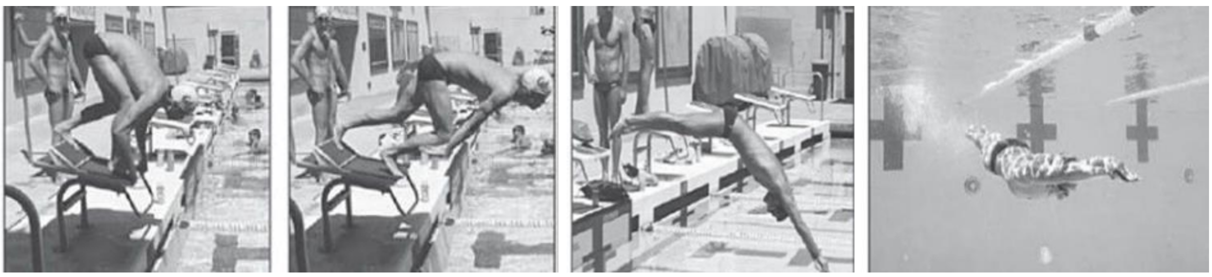
Honda (2010) reported shorter 5-meter and 7.5-meter times with the KS technique compared to that of the TS technique, when comparing the two off the OSB11 Starting block. However, other researchers reported no significant difference in performance between these two techniques (Takeda, Takagi, & Tsubakimoto, 2012) with this all, these studies have been inconclusive on which start is most superior., suggesting that swimmers should use the KS or the TS over the GS on the new starting block (Vint, Mclean, Hinrichs & Mason, 2009; Murrell & Dragunas, 2012;). Consequntly, different studies showed greater values for horizontal velocity, vertical velocity and acceleration when the swimmer leaves the block using the KS rather than for that of the TS. Indicating that the KS may possibly be superior.

Chueh-Yu (2012) suggested that coaches and swimmers should decide which start is most appropriate for use in competition. Due to similar findings, Thanpoulos (2012) also suggested that the coach, together with each swimmer individually, should decide which start is most appropriate. Several authors concluded that the best starting technique would be that most practiced by the individual and have not prioritized one above the other too (Thanopoulos, 2012; Vantorre, Seifert, Fernandes, Vilas -Boas & Chollet, 2010; Jorgic , 2010; Mason, Alcock & Fowlie, 2007; Blanskby Nicholson & Elliot, 2002).

2.4 BIOMECHANICS OF THE SWIMMING START

2.4.1 Phases of the Swimming start off the starting block

According to Researchers (Vilas-Boas et al., 2003; Cossor & Mason, 2001; Schnabel & Kuchler, 1998; Guimaraes & Hay, 1985), the start made out of the water is divided into three distinct phases (Figure 2.4). The first phase, called the block phase, includes movements made by the swimmer on the starting block, after the starting signal. This phase is defined as the time between the starting signal and the time when the swimmer's feet are no longer in contact with the block (Tor, Pease & Ball, 2014). The second phase, called the flight phase, begins once the first phase is completed and ends when the hands enter the water. The third phase, called the underwater or glide phase, is defined as the interval between hand contact with the water and the head re-surfaces to commence free swimming (Tor, Pease & Ball, 2014). Each of these consecutive phases are characterised by essential variables influencing the effectiveness and the speed of its performance (Formicola & Rainoldi,

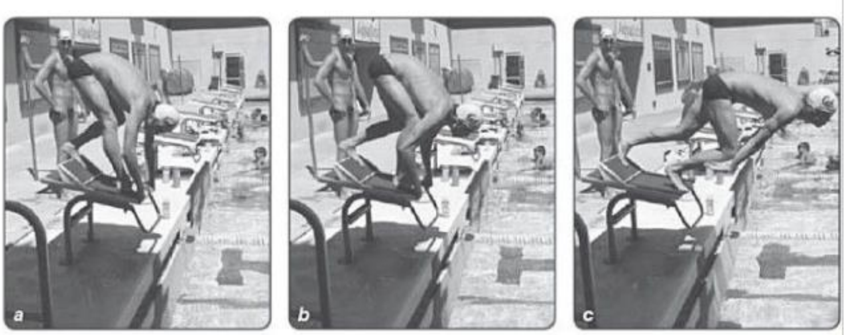


2015).

Figure 2. 4: Phases of the swimming start (Hannula, 2018)

2.4.1.1 The Block Phase

During the block phase (Figure 2.5) the swimmer takes up the preferred starting position and remains motionless. At the starting signal, swimmers pull on the block using their arms, rapidly propelling themselves towards the direction of the water,



dropping downward and forward before the swimmer performs an explosive leg extension and leaves the block (Formicola, 2015). It has been proposed a rapid Reaction Time (RT) is important for start performance (Vantorre et al., 2010; Bloom et al., 1978;). This is the time elapsed between the starting signal and the first visible movement by the swimmer on the block. Minimizing RT has been found to be a relevant factor for final success. Researchers have also shown a positive correlation between increased TOV generation during swimming start performance of this phase (Young, 2003). Therefore, RT needs to be as brief as possible but Block Time (BT), the total amount of time spent on the block before take-off, needs to be long enough to maximize impulse generation (Dragunas, 2015; Young & Breed, 2003). The block phase affects the performance in succeeding phases of the start and, therefore, it is beneficial for swimmers to master their take-off parameters on the starting block (Mason, Alcock, & Fowlie, 2007).

Figure 2. 5: Block phase of the swimming start (Hannula, 2018)

2.4.1.2 The Flight Phase

The flight phase (Figure 2.6) is characterized by an aerial trajectory where the swimmer needs to jump as far as possible and travel the maximum distance at the high velocity generated during the block phase (Hubert, Silveira, Freitas, Pereira & Roesler 2006; Sanders & Byatt-Smith, 2001). In a study done by where they analysed kinematic parameters of the swimming start, it was reported that there is no correlation between Flight Time (FT) and swim start performance. However, time to 15-meters was significantly correlated with Flight Distance (FD) (r=-0.482) (Ruschel, 2007). Another study, showed similar results and proved that in the 200-meters medley and 400-meters freetsyle, the further the distance covered in the flight phase, the faster the time to 15-meters (Cossor, 2001). Therefore flight distance is an important factor in swim start performance and time to 15-meters.

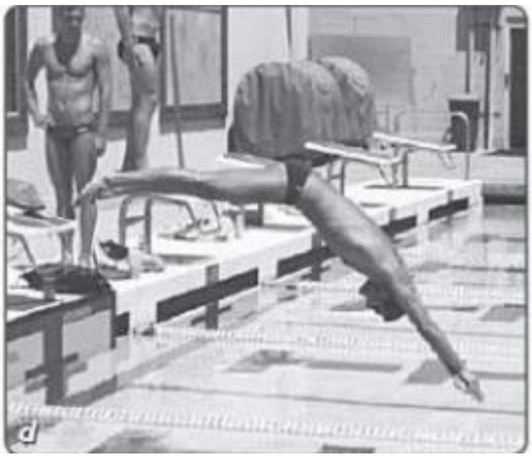


Figure 2. 6: Flight phase of the swimming start (Hannula, 2018).

2.4.1.3 The Underwater Phase

Following the flight phase, is the underwater or glide phase (Figure 2.7). This has been defined as the moment when the swimmer's hands enter the water and ending when the head emerges out (Counsilman, Counsilman, Nomura, & Endo, 1988). After water entry, swimmers need to maintain a streamlined position for as long as possible to preserve the velocity attained in the block and flight phase (Vantorre, 2014). The streamlined position is one of the most fundamental skills necessary for competitive starts and turns and although it is a basic skill, it requires mastering multiple elements (Havriluk, 2005).

A complete description of an effective streamline position included the following: arms completely flexed at the shoulders, and extended at the elbows and wrists, upper arms are in contact with the sides of the head, one hand on top of the other, head is positioned so that the swimmer is looking down, ankles together and feet are in plantar flexion (Havriluk, 2005). Sanders (2002) emphasized that great deliberation should be given to the underwater phase, as when analysing swimming start performances at the 2000 Olympic Games, Cossor and Mason (2001) found a negative correlation between underwater distance and time parameters with total start time. Therefore, as the distance covered in the underwater phase increases, the 15m start time should decrease. This reiterates that if the swimmer maintains the velocity achieved in the preceding phases and covers as much distance under water as possible, the faster their total start time.

Figure 2. 7: Streamlined position during the underwater phase (Hannula, 2018).

In conclusion, a good start requires a fast reaction time, excellent jumping power, flight and glide distance (Maglischo, 2003). Each of these three phases need to be skilfully executed to obtain maximal start performance. Targovet and Ionescu-Bondac (2014) recommended that the start analysis should focus on these three phases as they have essential variables used to determine spatial-temporal parameters.

2.5 PERFORMANCE ANALYSIS AND FEEDBACK

2.5.1 The Deterministic Model

The Deterministic model is a modelling paradigm that determines the relationship between a movement outcome measure and the biomechanical factors that yield such a measure (Chow, 2011). The inarguable pioneer of the deterministic model, Dr. James G. Hay, first discovered this concept when working on his dissertation on high jumping (Hay, 1987). He struggled to keep the variables he was using clear in mind and started to draw block diagrams to clarify things (Chow, 2011).

Over the years, the deterministic model approach in biomechanics research has been used in several sports especially swimming (Guimaraes & Hay, 1985), and athletics (Hay, 1978). Guimaraes and Hay (1985) used the deterministic model approach to test performance results of the swim GS time. They used several different variables to determine block, flight and underwater time of the GS in its entirety. Using the sum of the block, flight and underwater times in the swimming start, Guimaraes and Hay (1985) also identified several mechanical characteristics that contribute to a faster start (Guimaraes, 1985). Furthermore, a study done on relay starts also used the deterministic approach to determine which of four starts techniques is most efficient during a relay event (Mclean, 2000). Another study used the deterministic model approach to determine swimming speed of the four competitive strokes, butterfly, backstroke, breaststroke and freestyle. Therefore, the use of the deterministic model assists the researcher to defining variables which contribute to a specific movement.

In the development of a deterministic model, Hay and Reid (1988) suggested that the researcher firstly, Identify the primary goal or outcome of the technique being investigated and secondly, identify those factors that produce the required result. Once key factors of the specific technique are identified, it is important to question their relative importance to one another (Chow, 2011). This is established by correlating variables adjacent to one another. All factors included should normally

be mechanical quantities, where possible, and each factor should be completely determined by those factors that are linked below (Hay, 1988).

Figure 2. 8: The deterministic model (Hay, 1988).

2.5.2 Dartfish – Performance analysis

Modern techniques of sports performance analysis enable sports scientists, coaches and athletes to objectively assess, and therefore improve upon, sporting performance (O'Donoghue, 2010). Dartfish is the world's leading video analysis software company, providing skill analysis as well as game film breakdown modules. Used by over 90% of the national governing bodies of sport in the USA, athletes who train with Dartfish software accounted for 372 medals at the Beijing Olympic Games.

Several studies have made use of Dartfish software to analyse sports movements (Barlow et al, 2014; Tarvoget & Ionescu-Bondoc, 2014; Seifert, Vantorre, Lemaitre, Chollet, Toussaint & Vilas-Boas, 2010). The concurrent validity has been investigated, and test-retest reliability of 2D video Analysis using Dartfish software and proved Dartfish to be a valid and reliable tool for 2D angle analysis in swimming (Norris & Olsen, 2011).

2.5.3 The benefit of video feedback on swim start performance

Several studies examining the use of video feedback on swim start performance has, been administered. Fischer and Kibele (2010) made use of video feedback to teach swimmers the flat and pike entry. Their intervention study included a single session of video feedback concerning the take-off and entry of the swimming start. Results show that swimmers take-off anlge, velocity and entry angle improved significantly after feedback. Similar results were found in a study where they used video feedback to support swimmers in learning and practicing the handle or track start technique. Swimmers performed two to four sessions a week and were then tested once they had completed 14 sessions. Results showed that swimmers improved in start perofrmance in all techniques and suggested that resgular start practice should be included in swimmers training programmes. These studies show that the use of video feedback is an effective method of improving swiming start performance (Blanskby, Bickolson & Elliot, 2002).

2.6 CHAPTER SUMMARY

In summary, the addition of the kick plate is a new feature to the starting block which lead to the development of the kick start technique, the last evolution of swimming. The most effectient start off the OSB11 starting block remains debatable.

Researchers have not prioritised one above the other. The purpose of the study is to determine if there are differences in certain performance variables between the GS, TS and KS off the new OSB11 starting block in order to determine which of the three starts is the most efficient.

CHAPTE THREE

METHODOLOGY

3.1 INTRODUCTION

This chapter gives an outline of the research methodology and describes the quantitative approach used in this study. The researcher describes the research design chosen and reasons for this choice. In addition, information pertaining to the research setting and study participant is also included in this section. Furthermore, the tools used, and procedure followed for data collection for this study is included, along with a discussion of the methods used to analyse collected data. Finally, ethical considerations are also discussed in this chapter.

3.2 RESEARCH METHOD

Leedy and Ormrod (2001) stated that quantitative research is specific in its surveying and experimentation, as it builds upon existing theories. A quantitative approach is one in which the researcher primarily uses previous claims for developing knowledge (i.e., cause and effect thinking, hypotheses and questions, to test theories) and employs strategies of inquiry, such as experiments or surveys, to collect data on predetermined instruments which yield statistical data. Quantitative research begins with a problem statement and involves the formation of a hypothesis, a literature review, and a quantitative data analysis (Creswell, 2013). A quantitative approach was considered the most appropriate design for this study as it allowed the researcher to conclude findings, through the systematic creation of a hypothesis and subjecting it to an empirical test.

3.3 RESEARCH DESIGN

The aim of the study was to determine which of the three starting techniques (Grab, Track and Kick) was the most effective off the OSB11 starting block by comparing several kinematic variables. A Quasi-experimental cross-over design using a quantitative approach was utilised to conduct this study.

The Quasi-experimental cross over is a trial-based study design. In this type of study design, the participant serves as his/her own control, which allows for a smaller sample (Byron & Kenward, 2003). The researcher chose this study design as it allowed for each of the participant to complete all three starting techniques. The participant would act as their own control, allowing the researcher to determine the best starting technique for each individual swimmer rather than only considering them as a group.

3.3.1 Quantitative approach to technique analysis

A model (graphical description) can be used to as a basis of theoretical understanding of a system or process in research. The deterministic model serves such a purpose in biomechanics (Chow, 2011). This is used as a basis for quantitative analysis of a specific sports technique, especially swimming, athletics and gymnastics (Hay & Reid 1982).

Since the development of this model, it has become one of the most comprehensive models for quantitative analysis. As previously mentioned in Chapter 2, for a Deterministic Model to be valid, it needs to include mechanical quantities and all factors at the lowest level should directly affect the factors at the next highest level (Hay, 1987).

In this study, the mechanical quantities used were time and performance variables that affect time in each phase of the swimming start, as presented in Chapter 2.

The objective of performing a swimming start is to achieve the fastest start time possible. For this study, the start time was divided into three phases namely:

1. Block time,
2. Flight time and
3. Underwater time

Each of these phases' performance are determined by several specific variables, namely: reaction time, movement time, flight distance, and underwater distance.

The following variables were chosen for analysis based on previous literature (Targovet & Lonescu-Bondoc, 2014; Ruschel, Araujo, Pereire, Roesler 2007; Blansky, 2002) and the traditional Deterministic Model (Hay,1987). This model identifies which variables are important in a technique and the factors that contribute to the outcome of its performance (Sanders, 2002). For this study, the researcher has modified the Deterministic Model using the following variables to determine performance outcome of three different starts (Figure 3.1). Table (3.1) provides a detailed description of each of the variables used in the deterministic model.

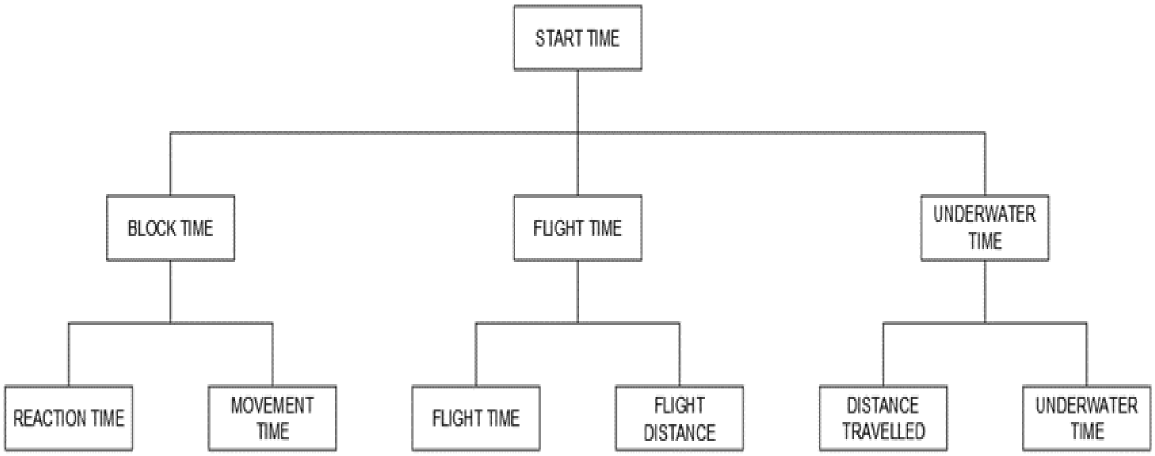


Figure 3. 1: Modified deterministic model of swimming start technique.

Table 3. 1: Performance variables for each phase of the swimming start.

Variable	**Unit**	**Description**
Block Time	Seconds	Sum of reaction and movement time
Reaction Time	Seconds	Time elapsed between starting signal and first distinct movement
Movement Time	Seconds	Time elapsed between first movement and when the toes leave the block
Flight Time	Seconds	Time spent in the air before first point of contact with the water
Flight Distance	Meters	Distance travelled from the wall till the first point of contact
Underwater Time	Seconds	Distance travelled over time
Underwater Distance	Meters	Distance travelled underwater
Start Time	Seconds	Sum of block, flight and underwater time

3.4 RESEARCH SETTING

The setting used to conduct this study was the Maties Gymnasium swimming pool. This swimming pool is situated that Stellenbosch University, Stellenbosch, Western Cape, South Africa. The pool is 50m in length, 25m in width and has 10 lanes. The pool is equipped with the OSB11 starting block and is registered and capable of hosting regional, national and international swimming championships. The swimming pool meets all the requirements according to the FINA Facilities Rules. Since the Maties swimming pool is equipped with the OSB11 starting block and meets the specifications of FINA facilities rule, is the reason for this swimming pool being chosen for this study (Appendix C: 2017-2021 FINA Facilities Rule).

3.5 POPULATION AND SAMPLING

The aim of quantitative sampling is to draw a representative sample from the population, so that the results of the study can be generalised and depends on the aim of the study (Marshall, 1996). The population, in this case, refers to swimmers in the Western Cape. Although there are multiples clubs, all swimmers come together and compete at swimming galas together. The competitions are held at swimming pools such as the Maties swimming pool that meet the specifications of FINA rules. This means they would all compete in the same pool using the same starting block and are required to meet the same qualification times, regardless of the coaching received or the club they belong to which means, any swimmer would be considered part of the population. With all of this, the sample chosen would need to accurately represent the population.

In the Western Cape there are several swimming clubs who have swimmers competing at either a national or international level. All swimming clubs are required to be registered with Swimming South Africa (SSA), the only authority that has sole jurisdiction for the administration and control of Aquatics in South Africa. The researcher initially decided to use participants from the Maties swimming club, who were registered with SSA, and situated at Stellenbosch University.

Due to the concerning lack of interest from the Maties Swimmers, the researcher approached another reputable and registered swimming club, named Vineyard Swimming Club. Vineyard Swimming Club is based in Bergvliet, Southern Suburbs of Cape Town and is also registered with SSA. This means that for swimmers to participate in the current study they needed to travel approximately 60km to the Stellenbosch situated pool.

The date of testing was arranged to coincide with the Grand Prix Gala that took place at Maties swimming pool. The Grand Prix Gala is a swimming gala attended by swimmers not only within South Africa but international swimmers too. The reason for this was because the swimmers who attended this gala met the inclusion criteria for the study that is highlighted in section 3 below.

3.5.1 Sampling Criteria

A sample frame is the group of individuals who can be selected from the target population and sampling is the process through which individuals are selected from the sampling frame (Martines-Mesa, 2015). Swimmers from Vineyard Swimming Club were selected and invited by the club Manager and the researcher to participate in the study. The researcher gathered the data for this study.

3.5.1.1 Inclusion and exclusion criteria

The inclusion criteria are defined as "the key features of the targets population that the investigators will use to answer their research question" (Patino & Ferreria, 2018, pg. 84). Inclusion critiera usually inlcude demographics or geographic charatcteristics. While exclusion critieria are additional characteristics, that could interfer with the success of the study, presented by those who meet the inclusion crirteria. (Patino & Ferreria, 2018).

Participants were included in the study if:

I. They were between 16 and 22 years of age,

II. If they met the SA National Qualifying times in 50m Freestyle for their age group (Appendix D: Age Group SA Jnr QT).

Participants were excluded in the study if:

I. They had any acute or chronic injuries

II. They did not meet the SA National Qualifying times the 50m Freestyle in their age group

III. They were below the ages of 16 years

3.6 PILOT STUDY

A pilot study was used in the research process as is allows the researcher to gain clarity to the feasibility of their method of data collection. This information will allow for relevant modifications, if necessary, so that the researcher is able to collect the best quality data (De Vos, 2011). A pilot study was completed to ensure the calibration of plane of motion for filming procedure, filming quality and software analysis.

The swimmer who was tested for the pilot study and was excluded from the study's sample but was appropriate for the pilot study as they met all other inclusion criteria. Once the pilot study was completed, no alternations were needed.

3.7 DATA COLLECTION AND ANALYSIS

3.7.1 Participants

To carry out the objectives purposed in this study, 10 swimmers, who met the inclusion criteria, from Vineyard Swimming Club (age: 16 ± 20 years) volunteered to participate in the study. As previously mentioned, only Vineyard swimmers were used in the study.

3.7.2 Testing procedure

Before proceeding with testing, the greater trochanter of the left femur was identified and marked with an “X” using a black water-proof marker (Figure 3.2. This measurement was used to measure shoulder and hip angle to analyse the angular parameters of the different starting positions on the block (Barlow et al, 2014). For practice and feedback purposes, the centre of mass was defined as a fixed point such as the hip (Luttegens & Hammilton 1992).

Figure 3.2: “X” marking of the greater trochanter

Once all markings were completed, participants performed a warm up – as prescribed by the swimming coach. Warmups are fundamental as it delivers oxygen to the muscles which will be used during testing. Since the swim start is an explosive activity, a proper warm up is understood to prevent injury. After the warmup, participants were instructed to perform all three starts, with maximal effort to just beyond 15-meters of the starting block.

For this study a standardized starting procedure was used. The starting procedure was done as follows:

I. Participants mounted the block and assumed the required starting position, either Grab, Track or Kick start position.

II. When ready, the start was initiated by an audio signal.

III. Participants would then perform the start to their best of their ability.

Participants were required to dive, glide and swim with maximal effort. After water entry, the participant was required to hold their best streamlined position with no stroking or kicking to eliminate the difference in aptitude. Once the participant emerges from the water, they are required to sprint to just beyond the 15m mark (Takeda, 2012). No feedback was given to participants on the start and swim motion in order to exclude any coaching effect on performance (Fischer, 2016). False starts were disregarded, and the trial was repeated. A start is considered false if the swimmer leaves the block before the starting signal is let off (Barlow, 2014). Due to potential fatigue, participants only performed one trial of each technique. If they felt they were unable to achieve their maximum effort, they were permitted to perform the trial again. All trials were filmed and analysed using Dartfish for data collection.

3.7.3 Filming procedure

All trials were captured on a GoPro Hero 3 (Woodman labs,USA) . The GoPro is an action camera that can capture photographs and videos. The video resolution used to film the starts was set at 1080 pixels, which is suggested to be the best mode when the camera is mounted on a stable object (gopro.com, 2019). The National Television System Committee (NTSC), which is the encoding system that affects the visual quality of the content view, was set at 30. This means that 30 frames are transmitted each second.

The GoPro was positioned and mounted above water, perpendicular to the plane of motion on the left side of the swimming pool. This position provided a clear view of the starting block and 15-metre line. This means the field of view of the GoPro captured the participants start from beginning until they passed the 15-meter line. The light emitting diode (LED) attached to the reaction light starting system that illuminated with the sound of the starting signal was also in the field of view of the GoPro. This allowed the researcher to capture the exact time of the start on film because sound was not used in the analysis.

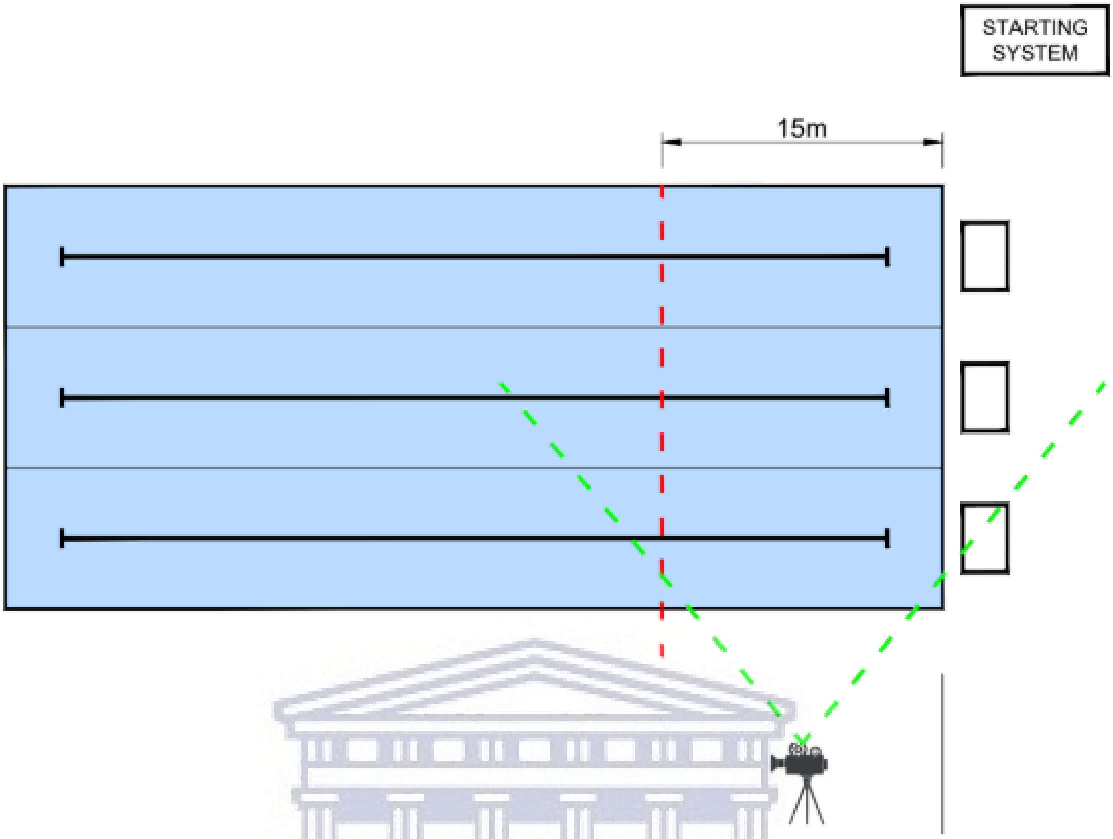


Figure 3. 2: Filming set-up of the GoPro and starting system.

3.7.4 Dartfish Analysis

All raw data needed for statistical analysis was collected by analysing all starting techniques for each participant. The captured video footage was analysed using Dartfish 10 (pro suite, Switzerland). Dartfish is a software system that enables users to view, edit and analyse videos. This software has been shown to be a valid and reliable tool for 2D analysis (Norris & Olson, 2011) and has been used in previous studies (Seifert et al, 2010; Barlow et al, 2014; Tarvoget & Ionescu-Bondoc, 2014).

The following variables were chosen for analysis based on previous literature and the deterministic model (Targovet, 2014; Ruschel, 2007; Blansky, Nicholson, Elliot 2002). The analysis protocol used for collecting raw data in this study was as follows:

Table 3. 2: Angular variables for analysis

Shoulder angle

Measurement was taken as the angle between the hip, shoulder and elbow

Hip Angle

Measurement was taken as the angle between the shoulder, hip and knee

Knee Angle

Measurement was taken as the angle between the hip, Knee and ankle

Table 3. 3: Performance variables analysed during block phase

Reaction Time

A frame by frame analysis was performed to find the time interval between the starting signal and the first distinguishable movement

Movement Time

Using frame by frame analysis the time interval between the first distinguished movement and when the participant was no longer in contact with the block

Block Time

The total sum of the reaction time and movement time

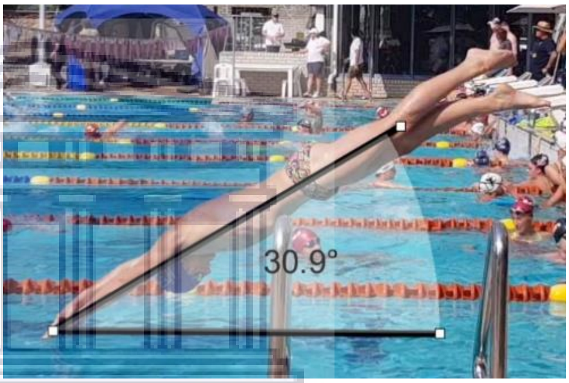
Table 3. 4: Performance variables analysed during the Flight phase

Flight Distance

Horizontal distance was calculated by the distance between the wall and the participant's first point of contact with the water.

Entry Angle

The angle measurement at the first point of contact with the water



Flight Time

The total amount of time spent in the air before the participant makes contacts the water.

Table 3. 5: **Performance variables analysed during the Underwater Phase**

Underwater Distance

Using frame by frame analysis, the distance between the point when the participants head entered the water and when their head emerges

Underwater time

The total amount of time spent underwater from the point when the participants head entered the water until the head emerges for the free swim

The images in Tables 3.2 – 3.5 are screengrabs from the participants of the study and video analysed on Dartfish

3.8 STATISTICAL ANALYSIS

All raw data was compiled in and analysed in Microsoft Excel 2010. Descriptive statistics (means & Standard deviations) were determined. The researcher then performed a one-way ANOVA to determine statistical significance, for each performance variable between the three starting techniques. Since the One-way ANOVA is used to determine whether there are any statistically significant differences between three or more groups, this was the most appropriate test to use to compare differences between the three starting techniques. A post hoc Test is an integral part of an ANOVA because it does not indicate which groups are different, if a statistically significant difference is found Therefore, the Tukey Kramer Post Hoc test was performed on those variables which showed a statistical significance, to determine exactly where the difference lies. Level of significance was set at ($p < 0.05$).

3.9 RELIABILITY AND VALIDITY

Reliability is defined as the extent to which results are consistent over time and an accurate representation of the total population under the study and if the results of a study can be reproduced under a similar methodology. Also, Validity is defined as whether the research measures that in which it was intended to. This study instrument can be considered reliable as it has been adopted from a previous study done by Barlow et al (2014). This should yield similar results in the current study.

3.10 ETHICS CONSIDERATION

Ethics clearance and permission to conduct the study was obtained from the Biomedical Research Ethics Committee University of the Western Cape, Ethics reference number BM 18/1/7. Permission was also sought from the Vineyard swimming club to make use of their swimmers as well as the University of Stellenbosch, to make use of their facilities. Once identified, all the participants were informed about the study verbally and via the information sheet (Appendix A: Information Sheet).

The information sheet clearly explained the aim of the study and the procedures followed during testing. Participants who consented to participate in the study were screened against the sampling criteria. Eligible participants received a consent form (Appendix B: Consent Form) to sign concerning their involvement in the study. Participants under the ages of 18 were required to provide signed consent from their parents/guardians. Participation in the study was voluntary, and participants were made aware that they could withdraw from the study at any stage with exemption. Each participant was assigned a number to ensure confidentiality. All trails were filmed and analysed to collect raw data. Videos and all personal information obtained from the study were kept confidential, and only the researcher and the supervisors had access to this information.

All data containing information about the participants was stored securely in a locked filing cabinet in the Sport Recreation and Exercise Science (SRES) department office, until the study report was completed. All the data collected will be kept for a minimum period of five years in the Sport Recreation and Exercise Science (SRES) department and thereafter, it will be destroyed. The information collected was used for research purposes only. The outcome of the study was made available to all research participants. The researcher acted ethically, responsibly and professionally always ensuring the safety of participants. Participants were not harmed in any way.

3.11 CHAPTER SUMMARY

This chapter outlined how a quantitative approach was most appropriate for this study, in capturing and analysing the variables that define the performance of the swim start. The procedure for analysing quantitative data and data verification was also outlined.

In this chapter, the research setting, and research design was described in detail. The sampling and population procedure as well as the method of data collection was explained. The next chapter presents the research findings

CHAPTER FOUR

RESULTS

4.1 INTRODUCTION

This chapter provides an overview of the findings in the context of research objectives and hypotheses of the study. Data is organised, analysed and reported to determine if either one of the analysed starting techniques are found to be superior to the others. The results for the starting position biomechanics are presented first, followed by the results of the block phase, flight phase and underwater phase.

4.2 SAMPLE DEMOGRAPHICS

Vineyard swimming club swimmers were chosen to participate in this study. As this study had a cross over design, each participant acted as their own control and were required to perform each of the three starting technique, once. All swimmers were from the same swimming club, received the same coaching and met the qualifying times for Junior Nationals in their specific age group (Appendix C: Age Group SA Jnr QT). Therefore, all participants were considered as equals. Ten swimmers volunteered to participate in this study. Each swimmer aged of 19 and over provided a signed a consent form and those aged of 18 and under where required to provide parental consent prior to any testing being conducted. To ensure anonymity, each participant was randomly assigned to a letter. This letter was used in all future analysis of the swimmer and not their name.

4.3 ANALYSIS OF DATA

The results of the analysed data are presented five parts, namely; body position characteristics, block phase, followed by the flight and underwater phases and lastly the total start time.

4.4 BODY POSITION CHARACTERISTICS

This segment will focus on three different angular parameters, namely; shoulder, hip and knee angle. These were analysed to determine the differences between starting techniques concerning the body position. Knee angle was only measured at starting position on the block, while shoulder and hip angle were measured at three different points in time. These points include the starting position on the block, take-off and water entry.

As presented in Chapter 3, the shoulder angle was measured as the angle between the hip, shoulder and elbow. The hip angle was measured as the angle between the hip, shoulder and knee. The knee angle was measured as the angle between the hip, knee and ankle. For those starting techniques, such as the Track start (TS) and Kick Start (KS) with a more asymmetrical stance, hip and knee measurements were taken on the rear leg.

These angles, as previously mentioned Chapter 3, were measured at three different points in the swimming start. The first point, the starting position, was when the participant was mounted on the block, before any movements were made. The second point, the take-off, was when the participants was no longer in contact with the starting block and lastly, the third point was the first point of contact with the water (Figure 4.1).

Figure 4. 1: Angular measurement points in swimming start (1-3).

Table 4. 1: Comparison of angular variables between starting techniques

The table below displays the means, standard deviations, and significant level for each of the analysed angular variables at three points in the start

Position	Variable	Grab start	Track Start	Kick Start	P-value
Starting Position (º)	Shoulder angle	107.19±7.70	102.70±5.09	101.97±6.18	0.28
	Hip angle	23.91±4.11	30.71±5.09	31.20±5.65	0.03*
	Knee angle	119.03±5.32	88.04±13.36	67.07±6.87	0.00*
Take-off (º)	Shoulder Angle	158.64±6.69	143.36±12.34	144.31±7.19	0.00*
	Hip angle	150.00±7.11	157.49±11.44	170.47±6.94	0.00*
Entry (º)	Shoulder angle	163.99±43	167.44±9.20	157.33±11.95	0.18
	Hip angle	162.2±5.71	169.04±12.34	170.44±5.43	0.18

**Significance set at p<0.05*

Table 4.1 represents the results for the angular variables analysed at three points in the start for each for each of the starting techniques. A one-way ANOVA was conducted to compare the difference in variables and each of the three points.

No significant difference was found between techniques for shoulder angle at the starting position (*p* = 0.28) or entry (*p* = 0.18). Nor was there any difference between hip angle at entry (*p* = 0.18). As expected, due to difference in the position of the feet on the starting block, there was a significant difference in hip and Knee angle at starting position at *p* = 0.03 and *p* = 0.001. A statistically significant difference was also found for shoulder and hip angle at take-off at $p<0.01$ (*p* = 0.001) for both.

The Tukey Post Hoc test results reveal that there was a statistically significant difference in the average scores for hip and knee angle at the starting position between the GS, TS and KS. On the other hand, the average hip angle at take-off for the KS was found to be significantly greater than that of TS, and GS respectively.

4.5 BLOCK PHASE

This section will focus on the first phase of the swimming start; the block phase. This phase includes movements made by the swimmer on the starting block, after the starting signal. Results for Reaction Time (RT), Movement Time (MT) and Block Time (BT) are presented.

Table 4. 2: Comparison of performance variables of the block phase between starting techniques

Variable	Grab Start	Track start	Kick Start	P-value
Reaction time (s)	0.24±0.17	0.09±0.11	0.06±0.01	0.03*
Movement time (s)	0.57±0.06	0.56±0.06	0.51±0.31	0.83
Block time (s)	0.80±0.19	0.66±0.11	0.58±0.31	0.16

**Significance set at p<0.05*

Table 4.2 depicts the results of the performance variables in the block phase of each of the three starting techniques. A one-way ANOVA was conducted to compare the difference in time between techniques for each performance variable on the block phase. There was no significant difference in MT and BT. However, there was a significant difference in RT at p= 0.03. Post Hoc comparison using the Tukey HSD test indicated that the mean score for RT for the GS (0.24s) was significantly different from that of the KS (0.06s). However, the BT for the KS did not significantly differ from the GS or the TS technique of the OSB11 starting block. Taken together, even though the results suggest that the RT for the Kick start was a lot faster than that of the Grab start, there was no significant difference in the total Block Time between starting techniques.

4.6 FLIGHT PHASE

This section will discuss the findings of the second phase of the swimming start. Results for Flight Time (FT), Flight Distance (FD) and Angle of Entry (AE) are presented.

Table 4. 3: Comparison of performance variables during the flight phase between starting techniques

Variable	Grab Start	Track Start	Kick Start	P-Value
Flight time (s)	0.20±0.05	0.22±0.05	0.20±0.05	0.527
Flight Distance (m)	2.64±0.10	2.74±0.20	3.06±0.20	0.001*
Angle of entry (º)	35.07±1.11	36.30±1.39	33.93±1.83	0.025*

**Significance set at p<0.05*

Table 4.3 illustrates the results for the performance variables in the flight phase for each of the three techniques. As proved by the ANOVA, there was no statistically significant difference in FT between techniques. On the other hand, FD and AE was significantly different between techniques at $p<0.05$ respectively ($p = 0.02$) and ($p = 0.00$). The Tukey Post Hoc performed on both FD and AE revealed the following; mean Scores for FD for the KS (3.06) were significantly greater than the TS (2.74) and GS (2.64). The results for AE for the TS (36.30°) was significantly greater than that of the KS (33.96°). This displays that the kick start has the longest FD and smallest AE compared to that of the GS and TS, with no significant difference in FT.

With the average result of FT and FD, we were able to calculate the average velocity for each of the three starting technique off the OSB11 starting block. Velocity is calculated as distance/time. Table 4.4 represents the average velocity achieved for each starting technique.

Table 4. 4: Difference in average velocity between starting techniques during the flight phase

Start technique	**Average Distance**	**Average Time**	**Average Velocity**
Grab start	2.64m	0.20s	13.2m/s
Track Start	2.74m	0.22s	12.5m/s
Kick Start	3.06m	0.20s	15.3m/s

The table above illustrates the results for the calculation of average velocity for each start technique based on the results achieved for FT and FD during the flight phase of the swim start.

4.7 UNDERWATER PHASE

This section will discuss the findings of the third and final phase of the Swimming start. Results for Underwater Distance (UD), Underwater Time (UT) are presented. The underwater phase is described as the time elapsed between first contact with the water and when the swimmers head resurfacing to start the free swim (Yang, 2018).

Table 4. 5: Comparison of performance variables during the underwater phase between starting techniques

Variable	Grab Start	Track Start	Kick start	P-Value
Underwater Time (s)	2.73±0.15	2.79±0.08	2.69±011	0.28
Underwater Distance (m)	2.93±0.27	3.00±0.12	3.09±0.11	0.30

**Significance set at p<0.05*

Table 4.5 shows the results for the variables analysed for the underwater phase for each of the three techniques. The one-way ANOVA proved that there was no statistical difference between UT and UD between starting techniques. Although insignificant, the KS was found to be have a faster UT and a greater UD than the TS and GS.

4.8 TOTAL START TIME

This section will describe the findings of the total Start Time (ST) between the three starting techniques. The start time is typically defined as the time from the when the start is initiated by the starting signal to when the centre of the swimmer's head reaches the 15m (Cossor & Mason, 2001).

Table 4. 6: Comparison of Start time to 15m between starting techniques. Mean± standard deviation.

Performance Variable	Grab Start	Track Start	Kick Start	P-value
Time to 15 M (s)	7.19±0.38	6.96±0.32	6.67±0.34	0.03*

**Significance set at p<0.05*

The table above displays the mean scores for total start time (time to 15-meters) for the three starting techniques. The Tukey Post Hoc test proved that the KS was significantly different to that of the GS only.

4.9 CHAPTER SUMMARY

This chapter has reported on the findings of several angular, kinematic and temporal performance variables in three different phases of the swimming start, between the Grab start, Track start and Kick start technique.

Through the analysis of angular variables, the kick start and Track start proved to have shoulder and hip angles more favourable to increasing swim start performance. Therefore, it can be said, with relation to important angular variables, that the kick and Track could most likely produce greater angular momentum OSB11 starting block.

Results from the block phase proved that there were ultimately no differences between starting techniques in total block time. However, The Kick start had a significantly faster reaction time, which has been proved to be a very important factor contributing to start performance.

Analysis on the flight phase, proved that although the Grab start had the more favourable angle of entry. The kick started presented a combination of variables that contributed to superior flight performance, including horizontal velocity.

The underwater phase proved that both UT and UD were not different between starting techniques. Lastly, the total start time proved that the Kick start is the more superior start of the three techniques when performed off the OSB11, as a quick time to 15-meters is the main objective of a good swimming start.

Chapter 5 will discuss the above findings in relation to current and previous research along with concluding factors of the study. The limitations of the current study and recommendations for future studies will be provided.

CHAPTER FIVE

DISCUSSION, CONLCUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

In this chapter, the results are critically assessed and discussed, according to the hypothesis of the study as it is in Chapter 1. Thereafter the conclusions, recommendations and study limitations. The focus of this study was to determine which of the three starting techniques was most efficient off the Omega OSB11 starting block.

5.2 DISCUSSION

The findings of the study were used to evaluate the following hypotheses:

Hypotheses 1: Staring position biomechanics

In order to understand the advantage one start may have over the other, it is important to understand the difference in the biomechanics of each starting technique. The GS has a symmetrical stance with both feet placed towards the front of the starting block with the toes curled over the front edge and the TS technique has one foot placed at the front edge of the block with the other towards the rear (Murrell, 2012). With the approval of the OSB11 starting block, which is equipped with a back plate, the KS was developed. This technique is very similar to that of the TS except the rear foot is positioned on the back plate (Honda, 2010). The swimming start is influenced by the way the swimmers is positioned on the block, therefore, it is essential to understand its influence on performance (Milanese, 2014).

although the time spent on the block needs to be as brief as possible, it also needs to last long enough to generate sufficient force. From a biomechanical point of view, the hip and knee play an essential part in force development through muscle contraction. When swimmers push off the block, hip and knee extention activates both the quadraceps and glutes, allowing the swimmers to dive forward off the block. In this regard, angular momentum is achieved through and explained by Newston 1st law and 3rd law of motion. First of all, the swimmer would need to push on the block with their legs in order to move as newtons 1st law states that an object at rest stays at rest and Secondly, the more force excerted onto the block, the greater the reactive force. Swimmers therefore need to react to the starting by pushing onto the block and have a hip and knee angle that assists in optimal muscle contraction in order to excert force. This, in turn, assists in the development of angular momentum.

The current study found the average hip and knee angle between starting techniques to be significantly different at the starting position, although the results of the current study are not in line with current literature. Slawson (2012 & 2013) found that a rear knee angle of approximately 75º - 85º to be the most effective angles for shorter block times and take-off velocity. He also stated that angles above 85º or below 75º would most likely affect force production and consequently angular momentum. Similar findings were reported by Blanco (2015) who found that a decrease in knee angle, resulted in lower angular momentum. The GS had greatest average knee angle and the KS had the smallest knee angle. In this regards, the TS presented an angle closest to that of the optimal range. This means that swimmers need to find a position on the block in which they can achieve an optimal rear knee angle (75 º - 85º) in order to increase force production and ultimately angular momentum. This can be achieved by shifting their centre of gravity forward or backward depending on the start technique used. Swimmers performing the track start would need to shift their centre of gravity more forward, raising the hips or, alternatively, shifting their centre of gravity backward and dropping the hips when performing the TS may assist in achieving a knee angle between the suggested range. Based on knee angle, the GS seems to be inferior to that of the TS and KS.

Hypotheses 2: Block Time

*"*The Kick start technique off the OSB11 starting platform will produce the fastest block time"

The block phase is the first of the three phases of the swimming start and affects the performance in succeeding phases, therefore, it is beneficial for swimmers to master their take-off parameters on the starting block (Mason, Alcock, & Fowlie, 2007). The block phase requires a compromise between time and force (Yang, 2018). In other words, there needs to be balance between spending too much time on the block, with the intention of creating more force, and spending too little time on the block to minimize the time deficit (Lyttle, 1999). So, for swimmers to take advantage of the decreased resistance compared to that of the water, the start performed off the block needs to be effective enough to propel swimmers into the water as quick and as far as possible (Yang, 2018).

In order to determine the difference in block time, the results of the angular and temporal variables that influence block time were analysed. As presented in Chapter 4, the study findings partially support the first hypothesis. Although the KS was not found to be significantly faster than that of the GS and TS, it was found to be the faster of the three.

Angular variables

Studies indicate that an essential component of the starting technique is the geometry of the body at the starting position in terms of block position and, in particular, "optimal" joint angles. (Bradshaw, 2007). The angular variables analysed in the current study were shoulder, hip and knee angle. These measuremets were taken at three positions namely; the starting position, at take-off and at water entry (Fischer, 2017; Seifert, 2010; Vantorre, 2010). Knee angle was only measured at starting position on the block.

The difference in shoulder angle between starting positions and take off indicate the forward arm displacement of the swimmer during the start (Blanco, 2015). This refers to the movement of the arm in a forward direction away from the midline of the body, through the coronal plane. With this being said, a higher shoulder angle, an angle closer to 180 **°,** was related to the arm position as a continuation of the body and smaller values were associated with forward displacement (Vantorre, 2014). On the current study, the difference in shoudler angle between starting position and take off was an angle a lot smaller than 180 **°** and was considered as forward arm displacement.

Knee and Hip angles were measured as research suggests that they are important variable in determining block performance as it is directly associated with the ability to develop force (Slawson 2013; Beretic, 2012; Nomura, 2010; Slowinski, 2012), which ulltimately assists in the development of angular momentum. Angular momentum can be defined as a mechanical factor that makes an athlete rotate in a particular direction (Dapena, 2000). Angular momentum is important during the swimming start because the swimmer needs to rotate their body into a biomechanicaly effecient position to enter the water. Since the main objective of the swimming start is to leave the block as quick as possible, developing greater angular momentum is essential.

Although the current study did not measure angular momentum, the variables measured could assist in determining the potential angular momentum that could have been developed when performing each of the three techniques. As previously mentioned, shoulder angle from the starting position to take off demonstrates forward arm displacement. It was found that the GS had the greatest change in shoulder angle between starting position and take-off when compared to that of the TS and KS. This means that the GS presented greater forward arm displacement that that of the TS & KS. Blanco (2015) found there to be an association between lower forward dispalcement and angular momentum values at take off. These results are consistant with the findings of Vantorre et al. (2010) who proved that smaller shoulder angles facilitated rotation and subsequently increased angular momentum. Angular momentum is achieved when an object rotates and is maintined when all body segments are closer to the axis of rotation rather than further away. With this being said, larger forward arm movements during take off would negatively affect angular momentum. Therefore, the GS could have poetntially produced the least amount of angular momentum during the block phase between the three starting techniques. This means that swimmers should avoid extending their shoulders too much during take-off. The angular momentum achieved during the block phase determines the performance of the flight and underwater pahse therefore it is essential that swimmers manage the change in degree of shoulder angle between the starting position and take-off for optimal performance. This suggests that the TS and GS could be superior to that of the GS.

Temporal variables

The temporal variables analysed for the block phase of the swimming start were RT & MT. In order to obtain the best start performance, it is suggested that swimmers need to react quickly to the starting signal, i.e. leaving the block speedily (Guimaraes & Hay, 1985). The BT, defined as the sum of the RT and MT, is one of the most influential variables to obtain the best start performance (Blanco, 2018).

Block time is an important variable in swim start performance as it directly influences the generation of horizontal velocity. Velocity at take-off is dependent on impulse and impulse is produced by greater force and generally longer blocks times. However, since the main objectives of the swimming start is to leave the block as quick as possible, swimmers need to find a balance between force production and time spent on the block. According to the results in chapter 3, there was a detectable difference in RT between techniques. The KS was found to be, on average, 0.12s faster than that of the GS and 0.08s faster than that of the TS. The foot placement during the KS allows swimmers to lift their rear foot onto the back plate of the startng block. This stance puts the swimmer in a more horizontal position, moving CoM forward, allowing the swimmer to exert force in the direction in which they are required to move, allowing swimmers to move forward quicker. Honda et al. (2015) explained that because of the asymmetrical stance of the KS, swimmers can generate more force on the OSB11 starting block without increasing the block time. These results are in accordance with previous studies which state as a consequence of the asymmetrical position of the KS, it is possible that swimmers are able to reduce response time to the starting signal compared to that of the TS (Biel & Ozeki, 2012) and GS (Taladriz, Blanca, & Arellano 2017). Sakurai, Taguchi and Takise (2012) also suggested that the back plate used in the KS may contribute to a faster RT and MT and ultimately BT by allowing swimmers to lean forward more quickly. These results prove that the KS is more superioir than that of the TS and GS when performed off the OSB11.

In conclusion, based on the results of the angular and temporal variables when analysisng block time.The TS & KS prove to be superior to that of the GS when perfromed off the OSB11 block, therefore only partially supporting the first hypothesis as the KS was not significantly faster during the block phase than that of the TS and GS.

Hypotheses 3: Flight Time

“The Kick start technique off the OSB11 starting block will produce the fastest flight time”

The flight phase is the period between when the swimmer's feet leave the starting block and when the hands make contact with the water, during which swimmers need jump as far as possible and travel the maximum distance with the velocity developed in the block phase (Hubert, 2006). Researchers have found the the longer the time invested in the air supposes a shorter time to 15m (Seifert et al. & Vantorre, 2010). As the air poses a lot less resistaince than the water, longer time in the air allows swimmers to maintain the velocity achieved during the block phase, consequanently performing a more efficient start technique (Vantorre, 2010). In addition to this, Cossor and Mason (2001) observed a significant correlation between FD and time to 15m. The same trend was observed in a study done by Ruchel, Araujo, Pereira and Roesler (2007), who stated that higher values of FD was assiciated with shorter start times.

Along with the flight time and distance, the entry angle is an important factor in start performance. At water entry, the body progressively begings to touch the surface of the water, untimately increasing the drag force. The entry angle will either negatively or positively influence the drag force and average velocity in the underwater phase (Elipot, Hellerd, Taiar, Boissiere, Rey, Lecat & Houel, 2009). Drag or Hydrodynamic drag if the force that swimmers need to overcome to maintain movement through the water (Kjendlie & Stallman, 2008). Mclean, Holthe, Vint, Beckett and Hinrichs (2000) and Vantorre (2010) proved that swimmers must generate enough angular momentum to make a smooth entry into the water. This means they would need sufficient time in the air to rotate in order to enter the water through a small hole as entry angle has a direct impact on the performance of the swimmer underwater and the depth of the gliding during the underwater phase (Elipot, 2009)

Although the Hypothesis is directly related to time, there are a number of other variables in the flight phase that are beneficial to overall start performance and time to 15m. Angular, kinematic and temporal variables in the flight phase which could affect overall start time are discussed. As presented in chapter 4, the findings of the current study do not support the hypothesis.

Angular variables

The angular variables analysed for the flight phase were shoulder, hip and angle of attack. Although angular variables are not directly related to time of the swim start, they influence flight phase of the swimming start. The take-off angle, although not measured in the current study, and entry angle are the most used angular variables to describe the difference in start techniques (Blanco, 2015). These angles determine the body position relative to the water surface.

Since smaller entry angles are associated with a higher CoM, it would result in a higher entry angle and ultimately a smaller entry hole. According to our findings, the average entry angle for the GS was found to be the highest (35.07º) while the KS was the lowest (33.93º). When the swimmer enters the water through a small entry hole, it means the swimmer is in a more vertical position to the water surface than those starts with a smaller entry angle. This means that when performing the GS, swimmers would enter the water with more velocity due to gravity. We can then assume that the entry hole for that of the GS was significantly smaller than that of the

KS. Since this is determined by the entry angle. Therefore, those who enter at a smaller hole would need to rotate into a more horizontal position for the streamline position and then back into vertical position until they break of out the water. This type of rotation during the underwater phase would cause a higher resistance and ultimately decrease momentum (Vantorre, 2014), making the GS a less beneficial starting technique. It could then be suggested that the KS would be more beneficial because the swimmer would be entering the water at a smaller angle, with a larger entry hole. This would mean that the swimmer would already be in a horizontal position and would require less underwater rotation, resulting in less resistance. This is in line with the suggestion of Seifert & Vantorre (2010) on managing angular momentum achieved in the block phase, as previously mentioned. This implies that a flatter starts, such as that achieved by the KS, would be beneficial for shorter swim start times.

The Hip angle has proved to be relevant to the entry into the water (Fischer 2014 & Ozeki 2008). Like entry angle, the hip angle represents the body posture at first contact with the water. In the current study, it was found that the KS (170.47º) and TS (169. 04º) had larger average hip angles than that of the GS (162.2º), although not significantly different. This means that along with a larger entry hole and a flatter trajectory, the KS also proved to have a greater hip angle. These results are in line with the findings of Kibele and Fischer (2011) who indicated that the hip angle at entry is important to start performance as it will affect the underwater phase. They proved that larger hip angles and bigger entry holes at water entry appeared to minimize loss in horizontal velocity (2014). With this, it was found that larger hip angles allow the swimmer to prepare for a powerful dolphin kick after the feet enter the water, which assists in managing velocity loss. Although participants in the current study were prohibited from kicking during the underwater phase, during competition conditions it is essential. Previous studies suggested a similar entry angle effect between the KS, TS (Beretic, Durovis &Okicic; Ozeki, 2012). All together, it can be concluded that a smaller entry angle, larger hip angle and bigger entry hole may allow swimmer to manage the loss in velocity achieved during the block an flight and perfom better during the underwater phase. This making the KS , a more superior start when analysing aerial variables of the flight phase.

Kinematic and Temporal Variables

The kinematic variable analysed for the flight phase of the swimming start were FT and FD. In the current study, no significant difference was found between average FT between start technques. The KS (0.20s±0.05) & GS (0.20s±0.05) mean scores were the same, and slightly shorter than that of the TS (0.22s±0.05). On the other hand, there was a significant difference in the average FD between the three starts. It was found that the mean scores for FD in the KS (3.06m±0.20) was significantly greater than both the TS (2.74m±0.20) and GS (2.64m±0.10). This means that the FD when using the KS off the OSB11 was on average 0.37-meters and 0.42-meters further than the TS and GS resepectively. This means that when the participants used the KS they travelled further in the same amount of time or less. As mentioned earlier in this chapter, the KS was could have potentially developed more angular momentum when leaving the block and had a flatter trajectory. With greater angular momentum and jumping forward rather than upwards, as presented by that of the GS, swimmers can travel further before contacting the water.

With the average FT and FD for all three starting techniques, we were able to calculate the average velocity during the flight phase for each technique. The ability to generate velocity when performing an activity, in this case jumping, or direction change is a determinate of performance in any sport activity (Giroux, Rabita, Chollet & Gulhem, 2015). The current study found that the KS (15.3m/s) had the greates velocity when compared to that of the TS (12.5m/s) and GS (13.2m/s).

In conclusion, the KS was found to have the smallest entry angle, larger entry holes, furthest FD and greatest velocity making this the more superior start when analysing aerial, kinematic and temproal variables of the flight phase of the swimming start. Although superior, it does not support the hypotheisis of having the fastest FT.

Hypotheses 4: Underwater Time

"The Kick start technique off the OSB11 starting platform will produce the fastest underwater time"

The current study partially supports the hypothesis that the KS would have the fastest UT. The results, although not significant, showed that the KS had a slightly faster UT than that of the TS and GS start technique.

As previously mentioned in chapter 3, the underwater phase is defined at the time elapsed between the first point of contact with the water and when the swimmers head re-surfaces to start the free swim. The performance of this phase relies heavily on the previous phases (Vantorre, 2010). Although, all underwater phases differ between swimming styles, for those perfomed from outside the water, the 15-meter mark is the maxmimum distance swimmers are allowed to travel underwater before break-out (Cossor, 2001). The performance of this phase is determined by variables such as water entry as well as hip, knee and shoulder actions (Tor, 2015; Elipot, 2009; Cossor J. S., 2011). Unfortunately, the current study prohibited any underwater kicking and undulation, this could be the reason that's there were no differences between starting techniques for UT or UD. As mentioned earlier in this chapter, a higher hip angle compared to that of the trunk during entry prepares the swimmer for a powerful dolphine kick when the feet submerge. In competition conditions, this powerful dolphin kick would be essential to maintain the velocity achieved during the flight phase. Since the TS and KS producded a flatter start when entering the water, it could be suggested that with a powerful dolphin kick and less velocity loss, these starts could potentially produce fast UT and travel further than that of the GS. Essentially, the swimmer needs to mimize water resistaince and maximize propulsion by performing a longer distance in a shorter time (Cossor, 2001). Additionally, a low resistance postion when gliding underwater would mimize the loss of horizontal velocity and increase propulsion during this stage and can assits in a superior start (Honda, 2010; Breed, 2003).

Hypotheses 5: Total Start Time

*"*The kick start technique will produce the fastest 15-meter start time"

The swimming start has been defined as the time between the starting signal and when the swimmers head reaches 15-meters (Thanopoulos, 2012; Issurin, 2002; Cossor, 2002). The current study supports the hypothesis that the KS would produce the fastest 15-meter start time.

The KS produced a significantly faster 15-meter start time than the GS technique off the OSB11 starting block. Since each phase relies on the performance of the suceeding phases, it is evident why the KS has the fastes 15-meter time. Quick movements on the block, greater flight distance, greater horizontal velocity and smaller entry angle all contributed to the final perfomance of time to 15-meters. Since the UT and UD were not significantly different , it is difficult to determine the underwater phase's contribution to time to 15-meters.

5.3 CONCLUSION

A comparison between the Grab start, Track start and Kick start were made with the aim of understanding which of the three provide the best start performance and is better suited off the OSB11 starting block. Based on the results of this study the findings suggest that the Kick Start is more superior, when comparing variables, compared to that of the Track Start and Grab Start. In addition, the results of this study suggest that it is essential to execute each phase of the start with precision, as the performance of the succeeding phase effects the subsequent phases. The block time, flight distance and entry angle are all important factors to be observed by swimmers and coaches. During training, swimmers and coaches should focus on these variables in order to improve the proper execution of the swimming start.

5.4 STUDY LIMITATION

The study consisted of numerous limiting factors; however key limiting factors are discussed below:

The sample size used was too small due to the limitation of skill level and inclusion criteria. All swimmers who were of the correct age and able to participate in the study, may not have qualified for Junior Nationals.

The study considered start performance as the time between the starting signal and the 15-meter mark. Several important variables that contribute to the performance of the start performance, other than time could were not included.

Familiarity of one start over the next could have contributed to the results obtained for the track or kick start as these swimmers were not taught nor were, they allowed to practice the Grab start technique. Since performance is based on best times, the familiarity of being able to execute one start better than another, could have skewed the results in favour of the starting techniques they were more familiar with and could perform with me accuracy.

A Gopro was used to film the starts. A high-speed camera synced with an underwater camera would have recorded the starts at a higher quality and could have assisted in the accuracy of smaller movements when analysed on Dartfish.

Lastly, the participants could have performed more than one trial of each technique. This would have allowed the researcher to use the best results of each starting technique and disregard those starts that were not excused correctly.

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5.5 RECOMMEDATIONS FOR FUTURE RESEARCH

Based on the findings of the study, the following recommendations are offered:

- The use of a larger sample size. This will allow for a greater representation of the population being samples, more accurate and reliable statistics and smaller margin of error. This would mean that the accuracy of the data received would truly reflect that of the population.

- The use of the best results. As performance is considered as best results and, in this case, best time to 15-meters. Each swimmer should perform each starting technique multiples times, with enough rest in between, and the best of each should be used for statistical analysis to g block. ensure that the best starts are analysed because the aim of the study is to evaluate which is the best starting technique when performed of the new starting block.

- The back plate on the starting block was held constant for all trials. The back plate should have been adjusted to suit the swimmer. As the swimming start performance is defined at time to 15-meters, swimmer should be allowed to adjust the ciliation of the block to ensure they are able to perform each start optimally

- Skill acquisition was not considered; however, as participant acted as their own control, single subject analysis permitted us to evaluate performance of everyone. The study used participants who qualified for Junior Nationals which imply that's the results are only suitable for those who are more experienced. Future research should include several levels of skill in order to evaluate the advantages of one start over the next in other populations.

- Total start performance is measured on time between the starting signal and the 15-meter mark. Due to the influence of force production, angular momentum, water entry and water resistance has on time to 15-meters, these should be analysed to provide a more in-depth understanding of what factors influence performance outcome of various start techniques.

- More attention should be given to the underwater phase, further analysis of the different body positions, hands entry, and underwater undulation would be required to determine the advantage of each on underwater performance. This is essential as it would then simulate the start performed during competition.

- Participants should be taught and give an opportunity to practice all three starting techniques prior to testing to minimize the familiarity contribution towards results. Many of the swimmers were not familiar with the Grab start as it is not popular any longer, this could have led to poor performance when using this technique. If swimmers were able to execute each starting technique with precision it would have given a true reflection on which is more superior.

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Appendix A: Information Sheet

UNIVERSITY OF THE WESTERN CAPE

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INFORMATION SHEET

Project Title: Performance of three start techniques off the OSB11 starting platform over 15m

What is this study about?

This is a research project being conducted by Lynne Veronique Reagon at the Maties gymnasium swimming pool, Coetzenberg Sport complex, Stellenbosch University. We are inviting you to participate in this research project because this will be a good opportunity to gain an understanding of your own swim start performance related to various kinematics and possibly improve it using the given results.

The purpose of this research project is to determine which of the three starting techniques (grab, track & kick) is the most efficient off the OSB11 starting block.

.**What will I be asked to do if I agree to participate?**

1. You will be asked to, in conjunction with your coach, practice all three starts four weeks prior to testing. On the day of testing, you will be required to perform all three starts twice.

2. A standard warmup protocol will be administered by the coach before the testing commences.
3. A standardized starting procedure will be used.
4. Participants must mount the blocks and assumed the required position. When ready, a tester will give the command ‘‘take your mark”, a whistle will be blown to signal the start of the trial.
5. False starts will be disregarded, and the trial will be repeated.

Testing will take place at the Maties Gymnasium swimming pool, Coezenberg Sports Complex, Stellenbosch University.

Would my participation in this study be kept confidential?

The researcher undertakes to protect your identity and the nature of your contribution. To ensure your anonymity, your name will not be included on the surveys and other collected data; a code will be placed on the survey and other collected data; use identification key, the researcher will be able to link your survey to your identity; and only the researcher will have access to the identification key.

To ensure your confidentiality, we will store the collected data in safe place. Only the researchers will have access to this. Your identification will be given a code and no names will be used.

If we write a report or article about this research project, your identity will be protected.

What are the risks of this research?

There may be some risks from participating in this research study.

All human interactions and talking about self or others carry some amount of risks. We will nevertheless minimise such risks and act promptly to assist you if you experience any discomfort, psychological or otherwise during the process of your participation in this study. Where necessary, an appropriate referral will be made to a suitable professional for further assistance or intervention.

What are the benefits of this research?

The benefits to you include the following:

1. Results, discussion and recommendations on all kinematic analysis will be shared with the coach and swimmer
2. Practice and become familiar with all three starting techniques. Provides you with an opportunity to identify which suits you best and yields the best results

Do I have to be in this research and may I stop participating at any time?

1. Your participation in this research is completely voluntary.
2. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time.
3. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify.
4. Should you pick up an injury of any sort that will prevent you from taking part in the study you will be excluded from the study. This is to prevent you from injuring yourself further.

What if I have questions?

This research is being conducted by Lynne Veronique Reagon, a student in the Department of Sport and Exercise Science at the University of the Western Cape.

If you have any questions about the research study itself, please contact Lynne Veronique Reagon (Tel.: 072 852 3817, email: 3043830@myuwc.ac.za).

Should you have any questions regarding this study and your rights as a research participant or if you wish to report any problems you have experienced related to the study, please contact:

Head of Department:

Dr. Marie Young

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Private Bag X17, Bellville 7535

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BIOMEDICAL RESEARCH ETHICS ADMINISTRATION

Research Office

New Arts Building,

C-Block, Top Floor, Room 28

This research has been approved by the University of the Western Cape's Research Ethics Committee (REFERENCE NUMBER: BM18/1/7)

APPENDIX B: CONSENT FORM

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa

Tel: +27 21-959-3688, Fax: 27 21-959-3137

E-mail: bandrews@uwc.ac.za

Title of Research Project:

Performance of three start techniques off the OSB11 starting platform over 15m

The study has been described to me in language that I understand. My questions about the study have been answered. I understand what my participation will involve, and I agree to participate of my own choice and free will. I understand that my identity will not be disclosed to anyone. I understand that I may withdraw from the study at any time without giving a reason and without fear of negative consequences or loss of benefits.

I hereby give consent for my performances to be video recorded: Yes ☐ No ☐

Participants name

Participant's signature Date

BIOMEDICAL RESEARCH
ETHICS ADMINISTRATION
Research Office
New Arts Building,
C-Block, Top Floor, Room 28
Consent Form Version Date: April 2015

APPENDIX C: 2018 AGE GROUP – SA JNR QUALIFYING TIMES

SAAG18A STANDARDS Sa Jnr Ag Group Long Course Meters

200 Free	2:21.40	2:36.20	2:55.13
400 Free	4:55.96	5:29.14	
800 Free	10:06.97		
50 Back			41.74
100 Back	1:13.72	1:22.11	1:31.84
200 Back	2:37.36	2:56.63	3:17.57
50 Breast			44.37
100 Breast	1:21.62	1:32.46	1:43.42
200 Breast	2:56.45	3:18.30	3:41.80
50 Fly			39.53
100 Fly	1:10.37	1:19.25	1:28.64
200 Fly	2:38.95		
200 IM	2:39.97	2:58.70	3:21.37
400 IM	5:37.86		

Women 14-14

	SANJ	LEV3	LEV2
50 Free			33.74
100 Free	1:03.93	1:09.30	1:17.49
200 Free	2:18.74	2:30.28	2:48.03
400 Free	4:50.37	5:16.67	
800 Free	10:06.97		
50 Back			41.12
100 Back	1:13.22	1:19.07	1:28.19
200 Back	2:36.30	2:50.09	3:09.72
50 Breast			44.00
100 Breast	1:21.07	1:29.04	1:39.31
200 Breast	2:55.26	3:10.96	3:32.99
50 Fly			37.96
100 Fly	1:09.90	1:16.31	1:25.11
200 Fly	2:38.95		
200 IM	2:38.90	2:52.03	3:13.37
400 IM	5:37.86		

Women 15-15

	SANJ	LEV3	LEV2
50 Free			32.58
100 Free	1:03.54	1:07.12	1:14.76
200 Free	2:17.89	2:25.55	2:42.11
400 Free	4:48.60	5:06.70	
800 Free	9:44.69		
50 Back			39.70
100 Back	1:12.74	1:16.63	1:25.15
200 Back	2:35.27	2:44.86	3:03.18
50 Breast			43.89
100 Breast	1:20.54	1:26.30	1:35.89
200 Breast	2:54.11	3:05.08	3:25.65
50 Fly			36.65
100 Fly	1:09.44	1:13.96	1:22.18
200 Fly	2:30.51		
200 IM	2:37.85	2:46.70	3:06.70
400 IM	5:29.13		

Women 16-16

	SANJ	LEV3	LEV2
50 Free			32.58

SAAG18A STANDARDS Sa Jnr Ag Group Long Course Meters

100 Free	1:02.78	1:07.12	1:14.76
200 Free	2:16.26	2:25.55	2:42.11
400 Free	4:45.18	5:06.70	
800 Free	9:44.69		
50 Back			39.70
100 Back	1:11.81	1:16.63	1:25.15
200 Back	2:33.29	2:44.86	3:03.18
50 Breast			43.89
100 Breast	1:19.51	1:26.30	1:35.89
200 Breast	2:51.89	3:05.08	3:25.65
50 Fly			36.65
100 Fly	1:08.55	1:13.96	1:22.18
200 Fly	2:30.51		
200 IM	2:35.84	2:46.70	3:06.70
400 IM	5:29.13		

Women 17-17

	SANJ	LEV3	LEV2
50 Free			
100 Free	1:02.78	1:07.12	
200 Free	2:16.26	2:25.55	
400 Free	4:45.18	5:06.70	
800 Free	9:44.69		
50 Back			
100 Back	1:11.81	1:16.63	
200 Back	2:33.29	2:44.86	
50 Breast			
100 Breast	1:19.51	1:26.30	
200 Breast	2:51.89	3:05.08	
50 Fly			
100 Fly	1:08.55	1:13.96	
200 Fly	2:30.51		
200 IM	2:35.84	2:46.70	
400 IM	5:29.13		

Women 18-18

	SANJ	LEV3	LEV2
50 Free			
100 Free	1:02.78	1:07.12	
200 Free	2:16.26	2:25.55	
400 Free	4:45.18	5:06.70	
800 Free	9:44.69		
50 Back			
100 Back	1:11.81	1:16.63	
200 Back	2:33.29	2:44.86	
50 Breast			
100 Breast	1:19.51	1:26.30	
200 Breast	2:51.89	3:05.08	
50 Fly			
100 Fly	1:08.55	1:13.96	
200 Fly	2:30.51		
200 IM	2:35.84	2:46.70	
400 IM	5:29.13		

SAAG18A STANDARDS Sa Jnr Ag Group Long Course Meters

400 Free	4:58.68	5:22.77	
1500 Free	19:32.46		
50 Back			38.72
100 Back	1:12.22	1:18.33	1:23.78
200 Back	2:35.89	2:50.40	3:02.46
50 Breast			41.27
100 Breast	1:19.57	1:27.53	1:33.62
200 Breast	2:56.91	3:09.70	3:22.88
50 Fly			36.24
100 Fly	1:09.39	1:15.39	1:20.63
200 Fly	2:35.32		
200 IM	2:38.79	2:51.84	3:05.06
400 IM	5:33.74		

Men 14-14

	SANJ	LEV3	LEV2
50 Free			30.71
100 Free	1:00.33	1:04.93	1:09.32
200 Free	2:11.19	2:23.40	2:33.10
400 Free	4:43.04	5:04.46	
1500 Free	19:32.46		
50 Back			36.45
100 Back	1:08.69	1:13.98	1:18.88
200 Back	2:28.28	2:41.13	2:51.80
50 Breast			39.92
100 Breast	1:15.69	1:22.67	1:28.15
200 Breast	2:48.27	2:59.16	3:11.02
50 Fly			34.12
100 Fly	1:06.00	1:11.20	1:15.92
200 Fly	2:35.32		
200 IM	2:31.03	2:42.22	2:54.25
400 IM	5:33.74		

Men 15-15

	SANJ	LEV3	LEV2
50 Free			28.78
100 Free	57.60	1:02.00	1:06.88
200 Free	2:05.25	2:16.93	2:29.87
400 Free	4:30.24	4:50.72	
1500 Free	17:24.44		
50 Back			34.69
100 Back	1:05.32	1:10.72	1:16.16
200 Back	2:21.01	2:34.02	2:45.87
50 Breast			37.99
100 Breast	1:11.97	1:19.02	1:25.11
200 Breast	2:40.02	2:51.80	3:04.44
50 Fly			32.47
100 Fly	1:02.76	1:08.06	1:13.30
200 Fly	2:20.49		
200 IM	2:23.63	2:35.01	2:48.24
400 IM	5:07.21		

Men 16-16

	SANJ	LEV3	LEV2
50 Free			28.78
100 Free	56.25	1:02.00	1:06.88

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200 Free	2:02.30	2:16.93	2:29.87
400 Free	4:23.88	4:50.72	
1500 Free	17:24.44		
50 Back			34.69
100 Back	1:04.47	1:10.72	1:16.16
200 Back	2:19.17	2:34.02	2:45.87
50 Breast			37.99
100 Breast	1:11.04	1:19.02	1:25.11
200 Breast	2:37.94	2:51.80	3:04.44
50 Fly			32.47
100 Fly	1:01.95	1:08.06	1:13.30
200 Fly	2:18.66		
200 IM	2:21.76	2:35.01	2:48.24
400 IM	5:03.22		

Men 17-17

	SANJ	LEV3	LEV2
50 Free			
100 Free	55.93	1:02.00	
200 Free	2:01.61	2:16.93	
400 Free	4:22.38	4:50.72	
1500 Free	17:24.44		
50 Back			
100 Back	1:03.28	1:10.72	
200 Back	2:16.60	2:34.02	
50 Breast			
100 Breast	1:09.72	1:19.02	
200 Breast	2:35.01	2:51.80	
50 Fly			
100 Fly	1:00.80	1:08.06	
200 Fly	2:16.10		
200 IM	2:19.13	2:35.01	
400 IM	4:57.61		

Men 18-18

	SANJ	LEV3	LEV2
50 Free			
100 Free	55.93	1:02.00	
200 Free	2:01.61	2:16.93	
400 Free	4:22.38	4:50.72	
1500 Free	17:24.44		
50 Back			
100 Back	1:03.28	1:10.72	
200 Back	2:16.60	2:34.02	
50 Breast			
100 Breast	1:09.72	1:19.02	
200 Breast	2:35.01	2:51.80	
50 Fly			
100 Fly	1:00.80	1:08.06	
200 Fly	2:16.10		
200 IM	2:19.13	2:35.01	
400 IM	4:57.61		