Cardiff School of Sport  
**Dissertation Assessment Proforma:**  
Empirical

<table>
<thead>
<tr>
<th><strong>Student name:</strong></th>
<th>Declan Gosling</th>
<th><strong>Student ID:</strong></th>
<th>10001246</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Programme:</strong></td>
<td>SC</td>
<td><strong>Dissertation title:</strong></td>
<td>What effect do different feet positions have on backstroke start effectiveness?</td>
</tr>
<tr>
<td><strong>Supervisor:</strong></td>
<td>Ray Ponting</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Comments</strong></th>
<th><strong>Section</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Title and Abstract</strong></td>
</tr>
<tr>
<td></td>
<td>Title to include: A concise indication of the research question/problem.</td>
</tr>
<tr>
<td></td>
<td>Abstract to include: A concise summary of the empirical study undertaken.</td>
</tr>
<tr>
<td></td>
<td><strong>Introduction and literature review</strong></td>
</tr>
<tr>
<td></td>
<td>To include: outline of context (theoretical/conceptual/applied) for the question; analysis of findings of previous related research including gaps in the literature and relevant contributions; logical flow to, and clear presentation of the research problem/question; an indication of any research expectations, (i.e., hypotheses if applicable).</td>
</tr>
<tr>
<td></td>
<td><strong>Methods and Research Design</strong></td>
</tr>
<tr>
<td></td>
<td>To include: details of the research design and justification for the methods applied; participant details; comprehensive replicable protocol.</td>
</tr>
<tr>
<td></td>
<td><strong>Results and Analysis</strong></td>
</tr>
<tr>
<td></td>
<td>To include: description and justification of data treatment/data analysis procedures; appropriate presentation of analysed data within text and in tables or figures; description of critical findings.</td>
</tr>
<tr>
<td></td>
<td><strong>Discussion and Conclusions</strong></td>
</tr>
<tr>
<td></td>
<td>To include: collation of information and ideas and evaluation of those ideas relative to the extant literature/concept/theory and research question/problem; adoption of a personal position on the study by linking and combining different elements of the data reported; discussion of the real-life impact of your research findings for coaches and/or practitioners (i.e. practical implications); discussion of the limitations and a critical reflection of the approach/process adopted; and indication of potential improvements and future developments building on the study; and a conclusion which summarises the relationship between the research question and the major findings.</td>
</tr>
<tr>
<td></td>
<td><strong>Presentation</strong></td>
</tr>
<tr>
<td></td>
<td>To include: academic writing style; depth, scope and accuracy of referencing in the text and final reference list; clarity in organisation, formatting and visual presentation</td>
</tr>
</tbody>
</table>

---

1. This form should be used for both quantitative and qualitative dissertations. The descriptors associated with both quantitative and qualitative dissertations should be referred to by both students and markers.
2. There is scope within qualitative dissertations for the RESULTS and DISCUSSION sections to be presented as a combined section followed by an appropriate CONCLUSION. The mark distribution and criteria across these two sections should be aggregated in those circumstances.
CARDIFF METROPOLITAN UNIVERSITY
Prifysgol Fetropolitan Caerdydd

CARDIFF SCHOOL OF SPORT

DEGREE OF BACHELOR OF SCIENCE (HONOURS)

SPORTS COACHING

‘What effect do different feet positions have on backstroke start effectiveness?’

(Dissertation submitted under the discipline of Performance Analysis)

Declan Gosling

ST10001246
NAME: DECLAN GOSLING

STUDENT NUMBER: ST10001246

CARDIFF SCHOOL OF SPORT

CARDIFF METROPOLITAN UNIVERSITY
WHAT EFFECT DO DIFFERENT FEET POSITIONS HAVE ON BACKSTROKE START EFFECTIVENESS?
Cardiff Metropolitan University
Prifysgol Fetropolitan Caerdydd

Certificate of student

By submitting this document, I certify that the whole of this work is the result of my individual effort, that all quotations from books and journals have been acknowledged, and that the word count given below is a true and accurate record of the words contained (omitting contents pages, acknowledgements, indices, tables, figures, plates, reference list and appendices).

Word count: 9,681
Date: 10/03/2013

Certificate of Dissertation Supervisor responsible

I am satisfied that this work is the result of the student’s own effort.

I have received a dissertation verification file from this student

Name: _____________________________
Date: _____________________________

Notes:
The University owns the right to reprint all or part of this document.
1.

List of Tables

Table 1. The combined averages of all the foot positions tested .......................... 28
Table 2. The results of Swimmer 5’s starts...................................................... 30
List of Figures

Figure 1. Position for cameras 1 and 2 ................................................................. 19
Figure 2. Camera 1 and 2 set up on poolside ......................................................... 20
Figure 3. View over cameras 1 and 2 ................................................................. 20
Figure 4. Camera 3 set up on poolside ................................................................. 20
Figure 5. View from camera 3 ........................................................................ 20
Figure 6. The 1m scale .................................................................................. 22
Figure 7. The flight distance being measured .................................................. 22
Figure 8. The middle of the lane being indicated by a horizontal line ................. 23
Figure 9. The height gained by the swimmer being measured ......................... 23
Figure 10. The red circles indicate, when both feet leave the wall as well as the
time that the feet left the wall ........................................................................ 24
Figure 11. The red circles indicating where the swimmers feet are almost
completely in the water, as well as indicating the time, which this occurred. .......................................................... 24
Figure 12. Example of the table used to collect the analysed data from each swimmer ........................................................................................................ 24
Figure 13. How all the averages from all the swimmers were calculated and
recorded ..................................................................................................... 24
Figure 14. Participants foot positioning preference on backstroke starts
before testing and the results of what position was most effective in total
for participants .......................................................................................... 29
Figure 15. Flight time averages (s) for six of the participants ...................... 31
Figure 16. Height gained averages (m) ............................................................. 32
Figure 17. Distance gained averages (m) ............................................................ 33
Figure 18. Speed (m/s) for each foot position .............................................. 34
Figure 19. Speed (m/s) against Distance (m) .................................................... 35
Figure 20. Speed (m/s) against Time (s) ........................................................... 35
Figure 21. Speed (m/s) against Height (m) ......................................................... 36
Figure 22. Distance (m) against Time (s) ........................................................... 36
Figure 23. Height Gained (m) against Time (s) ................................................... 37
Figure 24. Distance Gained (m) against Height Gained (m) ......................... 37
Figure 25. Track start under the water foot position ........................................... C
Figure 26. Feet parallel under the water ......................................................... C
Figure 27. Feet together out of the water .....................................................D
Figure 28. Track start one foot in one out .....................................................D
ACKNOWLEDGEMENTS

I would like to thank my dissertation supervisor – Ray Ponting for his input and guidance throughout my dissertation. I would also like to thank both Emily Coe and Tim Middleton for giving up some of their time to help with the filming process.
Abstract

The purpose of this study was to determine the effect that different feet positions have on backstroke start effectiveness. The aims of this study were to discover how effective four different backstroke starts were. The four different feet positions that were considered; track start under the water, feet parallel under the water, feet parallel out of the water and track start one foot in the water one out, as well as four effectiveness variables: Flight Time (FT- the time from when the last foot leaves the wall, to where the last foot enters the water), Flight Distance (FD - the horizontal distance from the edge of the pool, to where the fingertips enter the water) Height (the vertical distance gained from the water surface, to the highest part of the back during the arc phase), were measured and Speed calculated (FD/FT).

Eight competitive university aged, male swimmers between 18 and 24 (average age 20.1 ±1.46) and an average height of 1.83m ± 0.052, participated in the study. Participants performed twelve starts using each foot position three times and these were filmed. Participants were familiar with the starts that were being tested and already had an individual foot preference on their start.

A one-way ANOVA was carried out to test for significant statistical difference between the starts. Results stated that there was no significant statistical difference between the starts. However across all the starts there were significant correlations found between: height gained and flight time, distance gained and height gained and speed and distance gained. There was also a significant negative correlation between speed and flight time. The results also showed that three of the participants produced better results on their non-preferred foot position.
Chapter One Introduction
Overview

Swimming is one of the world's greatest participatory sports which makes it one of few sports in which people in nearly every country take part (Wilkie & Juba, 1986). Competitive swimming has been significant within the sport since the first recorded race in 1844 which took place between two Native American Indians and an Englishman called Harold Kenworthy (Wilkie & Juba, 1986).

When evaluating a swimmer’s performance, several performance indicators have to be considered including final time, strategy, and technical components. Hughes and Barlett (2002) defined a performance indicator as “an individual or combination of variables that aim to define some or all aspects of performance”. Variables which have been investigated previously include speed, stroke mechanics, starting, turning, and finishing (Smith, Norris and Hogg, 2002). During training an emphasis is often placed on swimming a large overall distance, speed work, and stroke drills, leaving very little time for perfecting the starting technique (Maglischo, 2003).

Breed and Young (2003) suggested that having an effective start is an essential part of competitive swimming, predominantly in sprint races. According to Hoof (2007, pp 13-19) “most experienced coaches will agree that a swimmer with a poor start can save 0.1 second with an improved start”. The start needs to be effective, the faster and more efficient you are off the blocks, the more speed is carried into the first length of a race (Mills, 2005). Breed and Young (2003) suggested that a swimmer’s movement through the air and position after entering the water can help produce the greatest horizontal distance in the shortest interval of time. In 1998 Pearson, McElroy, Blitvich, Subic, and Blanksby stated “that regardless of swimmers start choice, the swimmer’s goal is to react quickly to the starting signal, leave the blocks rapidly generating as much horizontal velocity as possible, gain maximal flight distance while using an optimal projection angle on entry, and maintain a streamline position that will minimize the loss of horizontal velocity associated with drag on water entry”. The start is an area where minor but significant advantages can be made.
Research on swimming starts focuses on events that involve starting on the blocks, such as freestyle, butterfly and breaststroke. This is due to the constant debate of which start is more effective, when comparing the track and a grab start. In 1960, Eric Hanauer introduced and presented the grab start (Maglischo, 2003). Then in 1973, Fitzgerald presented the track start (Hong & Bartlett, 2008). The key difference between these two start techniques is the positioning of the feet on the starting block. In the track start, the starting leg is placed forward, at the front of the starting block, while the other foot is behind it. In the grab start, both feet are positioned at the front of the starting block (Maglischo, 2003).

However, the backstroke start is the only start that begins with the swimmer in the water. Hands grip the starting block handles, while the balls of the feet push against the pool wall. The options for feet positioning used in a backstroke start are similar to those used for events that start on the block. Swimmers can either have their feet in a track start position, where one foot is higher than the other, or they can have their feet parallel. Swimmers also have the choice to either place their feet on the wall, above the water surface or below the water surface. This is usually down to swimmers individual preference, although anecdotal evidence suggests that swimmers often choose to place their feet parallel to one another and at the same level horizontally, with both feet slightly less than shoulder width apart. When looking at a backstroke start, Mills (2005) indicated that the key to a powerful, explosive start was getting a good grip on the wall with the feet.

**Rationale of the research**

The study is a backstroke perspective to the existing research into block starts, to add to the non-existent research base, which is currently missing for backstroke starts. The study will help gain an understanding into the effect different feet positions have on backstroke starts. It also be provides an insight into the different feet positions that can be used on backstroke starts.
Aims of the study

The study aimed to discover how effective various forms of backstroke starts can be, by collecting data on the height, distance, time and speed of each form of start and therefore being able to see the effectiveness of each start.

Research Question

The research question investigated was ‘What effect do different feet positions have on backstroke start effectiveness?’

Hypotheses

The hypotheses of this study are:

1. Starts where the feet are under the water produce shorter distances and height than starts where the feet are above the water.
2. Having the quickest flight time will result in the participants having the shortest distance and height gained.

Limitations

The sample size was too small to generate a significant statistical difference between the variables, which meant it was hard to determine the effect different foot positions had on backstroke start effectiveness.

Delimitations

The study involved participants from various nations. By having this range of nationalities within this study, it therefore increases the generalisability, as the results can be used by others across the world. Another delimitation of this study was that it was only carried out on male swimmers of university age, therefore the results can only be applied to this group of swimmers outside of this study.
The findings of this study only show the effect that different feet positions have on a backstroke start, they do not show how efficient each foot position is to a set distance.

Glossary of terms

SD – Standard deviation measures dispersion. It is the square root of the variance. The coefficient of variation is based on the standard deviation, but it facilitates comparisons between two sets of data.

ISO speed – The ISO setting controls how sensitive the camera’s sensor is to the light that reaches it. It is one of the crucial factors which go into determining a photograph's exposure as well as the overall image quality. A higher ISO setting makes the sensor more sensitive to light, meaning that you can take photos in darker conditions without the need to use a flash or tripod. However, a high ISO also creates more noise, reducing the image quality (Photographymad, No Date)

F Stop - Is a camera's aperture setting which controls the area over which light can pass through the camera lens. A camera’s aperture setting is what determines a photo's depth of field (the range of distance over which objects appear in sharp focus). It is specified in terms an f-stop value, which can at times be counterintuitive, because the area of the opening increases as the f-stop decreases (Cambridgeincolour. No Date).
Chapter Two Literature Review
Overview

The start is an influential component of swimming, as it has been found to have a noteworthy impact on the overall race outcome. This is particularly true for sprint events, such as 50m when the start is believed to contribute up to 30% of the total race time. Mason and Cossor (2000) studied the results from the 1999 Pan Pacific Swimming Championships and found a significantly high correlation between start times and performances in most swimming events of various distances and strokes. Starts accounted for approximately 10% of total time in swimming events of 50m and for approximately 5% in those of 100m (Maglischo, 2003). Nutzel and Thoma (1986) believe that the start is the decisive aspect of swimming races up to 200m. Furthermore, Maglischo (2003, p. 265) states that “improving the start can, on average, reduce race times by a minimum of 0.10 s”. For this reason, numerous studies have examined the swimming start. The majority of studies have investigated events that start on top of the blocks, such as freestyle, butterfly, and breaststroke (Arellano, Garcia, Gavilan and Pardillo, 1996; Ayalon, Van Gheluwe, and Kanitz, 1975; Bowers and Cavanagh, 1975; Counsilman, Counsilman, Nomura, and Endo, 1988; Kirner, Bock, and Welch, 1989.)

The following sections examine block and backstroke starts, focusing on technique, style, biomechanics and feet positioning of the start. Recent research on the effect the introduction of the new style of blocks, with a back plate on, on a swimmers start is covered.

Block Starts

There has been extensive research that has focused on the different types of starts, which are used within swimming. Jorgić, Puletić, Stanković, Okičić, Bubanj and Bubanj (2010) performed a kinematic analysis of the track and grab start. The aim of their study was to determine the statistically significant differences in certain kinematic parameters between the grab and track start among competitive swimmers. The researchers looked at 8 key parameters within this study; Flight length (FL) - the distance from the swimming pool wall under the starting block to the
first contact of the swimmer's fingers with the water (in meters); Flight time (FT) - the time between the last contact of the feet with the starting block and the first finger contact with water (in seconds); angle of take-off; angle of entry; velocity of the centre of mass at take-off; Velocity of the centre of mass at take-off; velocity of head movement at take-off; Velocity of hand movement at take-off; Velocity of hip movement at take-off. They concluded that “there is no statistically significant difference between the grab and track start, except in the parameter AA (p=0.04) ascending angle. Therefore an advantage cannot be given to one of these start techniques. Therefore the regular and intensive drill of a chosen start technique should be applied” (p. 35). However this study did not use the same swimmers to perform both starts, only three swimmers performed a track and a separate three swimmers performed the grab start therefore the swimmers ability can have an effect on the results gained.

Research has been widely carried out from college level right through to elite competitors, which was the level Vantorre, Seifert, Fernandes, Vilas-Boas and Chollet (2010) focused their study on the biomechanical influences of Start Technique Preference for Elite Track Starters in Front Crawl. The aim of this study was to analyse the differences between preferential and non preferential start technique, and the inter-trial variability. It assessed the durations of the block flight, entry, glide, leg kicking and full swimming phases to the 15m mark. Each swimmer performed three repetitions using the track start and three using the grab start techniques. The first camera (50 Hz) was placed from the edge of the pool and videotaped the take-off and flight phases. Two other cameras (50Hz) were mounted on a specially designed support placed at the lateral wall 3m from the edge of pool deck (one above the water and the other kept underwater), videotaping the entry and underwater phases. Two lateral mobile cameras (50 Hz) were fixed on a trolley and were connected to double-entry visual mixing table. They found that the track start, as preferential technique, had shorter block and entry phases but similar flight phase. In the grab start, swimmers spent more time in reaction time and obtained higher vertical impulse values; moreover higher inter-trial variability was found for non-preferential technique suggesting lower efficiency. Once again this study suggested that there was no obvious advantage of using either of these starts as both have advantages that the other does not. It does although look at the durations
of the key indicators which contribute to an effective start, which can be useful to provide information to coaches.

However, a study that does indicate that one form of start has a significant advantage over another is the study by Galbraith, Scurr, Hencken, Wood and Graham-Smith (2008). This was another biomechanical comparison study, which aimed to compare the conventional track and a new one-handed track start in elite age group swimmers to determine if the new technique had biomechanical implications on dive performance. The results indicated that the conventional track start method was faster over 10m, and therefore may be seen as a better start after a short intervention. It was suggested that during training, swimmers and coaches should focus on the most statistically significant dive performance variables: peak horizontal force and velocity at take-off, block and flight time. This study provides valuable information to coaches and indicates that there is a significant difference in the forms of starts. However a factor that could have had an effect on the results was the participant group, as the female and male results were combined together. Female and male swimmers have different strength levels to one another which can effect on the performance of a start. This can reduce the reliability and validity of the study as when it came to comparing the results, the results gained could have been significantly different between males and females.

Sprint starts in track events in athletics use a starting block and research has previously reported that foot spacing where starting blocks are used affects speed (Henry, 1952; Sigerseth and Grinaker, 1962; Stock, 1962). In a previous study on swimming, LaRue (1985) reported that kinematic characteristics of a track start with a back plate were similar to those with a starting block for track sprint events in athletics.

Therefore, after the Beijing Olympics in 2008, FINA established a new rule for the starting blocks. They introduced the rule FR 2.7 which stated ‘the starting platform may have an adjustable setting back plate’ (FINA 2011). Therefore, new starting blocks were introduced with an adjustable back plate in competitions in the majority of countries. This enables swimmers to adjust the position of the back plate to suit their preference. As the rule, does not define the inclination of the back plate, its
position is variable, which can therefore affect the starting performance of swimmers that use the new starting platforms.

Various studies carried out since the new rule was introduced, tested the effect the new back plate starting blocks had on performance. Biel, Fischer and Kilbele (2010) reported differences in start times in swimmers using track starts when using conventional and the new starting blocks. Honda, Sinclair, Mason and Pease (2010) found that track starts, using the new back plate starting block, were significantly faster off the block, had shorter 5 and 7.5m times, had a higher horizontal velocity at take-off and had increased horizontal force on the block. However none of the studies investigated the effect of different positions and inclinations of the back plate on kinematic variables.

This created the need for Takeda, Takagi and Tsubakimoto’s study (2012). They studied at the effect of inclination and the position of the new swimming starting block’s back plate on track start performance. Takeda et al, (2012) had three research objectives: to investigate the effect of back plate inclination angle on start performance, to investigate the combined effects of take-off angle and back plate inclination and to investigate the effects of back plate position on start performance. The method that they used to conduct this study involved ten Japanese male college swimmers, all at national or international level. However as all the participants are of the same nationality, all at college level and around the same age, this reduces the generalisability of the results, as they cannot relate to a large percentage of swimmers across the world. The participants had a mean height of 1.77 m and a mean age of 21.1. The participants had a two-week familiarisation period, where they trained using a track start on the new starting block equipped with a back plate. Eight trials a day were performed for the two-week familiarisation period, which allowed the swimmers to familiarise themselves with the new starting conditions and the track start. By having a familiarisation period, it increases the reliability of the results gained, as all the swimmers have a chance to get used to the new back plate, therefore increasing the chances that the results are more effective. After the familiarisation period, the participants performed eight experimental starts, these included changes in the take-off angle and the position and inclination of the back plate. To allow for the potential fatigue of the participants, they only performed one
start for each condition. This also helps increase the reliability of the results, as it would help ensure that every start was performed and maximal effort.

The trials were videotaped above water at a frame rate of 125Hz and an exposure time of 1/250s using a high speed-camera, placed 2m from the front edge of the starting block. Motion analysis software was used to analyse the data. An issue with the camera positioning, is that they found it difficult to distinguish the swimmers right arm, therefore they assumed that both arms were symmetrical, by assuming the positioning of the swimmers arm, this can have a significant impact on the reliability and validity of the results gained.

The results from the study showed that the main effects of the take-off angle were on the vertical and resultant take-off velocities. Comparisons between the plate positions showed that the 5m time of the 0.29m condition was significantly longer, the take-off angle and vertical take-off velocities of the 0.59m condition were significantly lower. Rear foot take-off times were significantly longer in the ascending order: 0.29, 0.44 and 0.59m. They concluded that the use of the back plate did not improve starting performance a swimmer might be able to gain an advantage from the new starting block by modifying their start motion. They also suggested that the two week familiarisation period was not long enough to produce significant results. There was also a suggestion that there is a need to investigate why the use of a back plate did not create an advantage in terms of start performance.

Researchers have found that through consistent dive practice an elite swimmer can reduce their overall race time by a minimum of 0.10 s (Blanksby, Nicholson and Elliott, 2002; Maglischo, 2003). At the elite level, in a sprint event this improvement could signify the time difference between a first and third place (Thayer & Hay, 1984; Breed & McElroy, 2000; Breed & Young, 2003).
Backstroke Starts

Most evidence for backstroke swimming starts is either outdated or of limited relevance as many of the rules have changed over the years and due to the reason that nearly 90% of all swimming starts begin out of the water and research is heavily focused on those.

Graumitz and Kuchler (2007) concluded from their analysis of the Swimming World Championships in Melbourne, that at least in the woman’s races, the above water phase was a key factor in the sprint performance in backstroke.

The majority of studies carried out on backstroke starts, focus on the biomechanical and technique aspect. Tichy (1981) investigated ways to optimise the standing (no longer a legal start) and crouch backstroke starts via computer simulation. This research allowed computer simulation of the backstroke start to be used to improve individual start biomechanics.

An example of a study that investigates the biomechanics of the backstroke start is Hohmann, Fehr, Kirsten and Krueger (2006) study which biomechanically analysed the backstroke start technique in swimming. The study was based on a ‘complex 6-phase model of the swim start’ developed by Krueger, Kirsten, Hohmann and Wick, (2006, p.3) which measured the ‘time durations of the four phases of the above water phase, this included the reaction phase (from signal to the first movement), pressure phase (from first movement to hands off), jump phase (from hands off to feet off), flight phase (from feet off to hip entry) and of the first two phases of the underwater phase, this included the entry phase (from hip entry to the first maximum depth of the feet) and glide phase I (with the first dolphin kick from first to second maximum depth of the feet)’. The study identified the kinetic and kinematic parameters that are relevant in the backstroke start performance. Nine male German national swimmers took part, with an average age of 21.5yrs. Having all the participants of the same nationality reduces the generalisability of the study. The studies validity is reduced by the fact that the swimmers were given no familiarisation period in which to get used to the starts that they would have to perform during the study. Four trials of a start were performed over 7.5m for the kinematic measurement. A high speed video
analysis was used to record the overall start time at 125Hz before being split into reaction time, flight time and glide time. A 2-dimensional video movement analysis was carried out to determine the kinematic parameters. The parameters were calculated by motion analysis software (SIMI-Motion, SIMI Inc., Ger). Kinetic data was measured as 3-dimensional ground reaction forces, by a mobile water-proof force plate, mounted to the pool wall. A key parameter that the researchers did not control, which could have had a significant effect on the results gained, was the speed and power of the underwater phase to 7.5m that the swimmers performed, thus reducing the reliability of the results gained from the study. The results that were gained showed significant correlations between the times of hands off and take off, of the feet and between the times of hands off and hip entry. However the other parameters did not show any interrelations. To increase reliability, the inter-rater reliability of the system was tested. The researchers concluded that despite 7.5m is a short distance to measure start performance, the athletes exhibited notable differences in start times.

Green, Cryer, Bangerter, Lewis and Walker (1987) studied technique used in backstroke starts. They compared two methods of backstroke starting: conventional and whip. There were three aims to the study: to make a biomechanical analyses and a comparison of the conventional and whip starts using a computerised program designed to treat digitised cinematographic data. The second aim was to determine which of the two starts was faster under simulated racing conditions. The last aim was to discover the contribution of selected measures of flexibility and power to success in starting proficiency. Nine female and five male swimmers were selected for the study, with a mean age of 14.5 years. By having an uneven amount of females and males, this would not make the study gender specific, which would increase the generalisability of the study as the results would be able to be applied to both genders. However by having more females than males, it can affect the validity of the results as the results produced by each gender would not be comparable. The subjects were taught the two starts. The participants continued to train with their club throughout the course of the study and were asked not to spend any other time practicing backstroke starts. However there was no one monitoring the participants training sessions over this period, therefore this would reduce the validity of the results, as the researchers are unable to control this variable. The trials ran for a
duration of nearly seven weeks with approximately 100 trials performed for each start. The results showed that the primary differences between the two starts were that the whip start had a greater take-off angle, higher and longer flight path, steeper entry angle with less frontal resistance, faster entry velocity, greater underwater depth, longer submerged time, and a faster break-out velocity than the conventional start. The results of the time trials clearly show that with equal learning time, the whip start is faster than the conventional start. Ten of the 13 participants in the study had faster times with the whip start.

Currently there has been little research, on the different types of starts used in backstroke, as what there is, is mainly focused on the biomechanics and techniques used. Scheuchenzuber (1970) compared four types of backstroke starts with modifications to the handle height on the starting block; two were crouching starts while the other two were modified standing starts. Their results most notably demonstrated that the conventional crouch start was significantly less effective than the other starts in regards to the time it took to reach four metres from the starting wall. According to Scheuchenzuber, this may be due to the lack of underwater foot stability.

A key study that has researched the types of start used on backstroke was a comparison of two backstroke starts by Theut & Jensen (2006). It investigated the effect of a staggered or parallel foot placement on horizontal distance and velocity at which the swimmer moved away from the block to the point that the hands entered the water during a backstroke start. There hypothesis was that if backstroke swimmers began to use a start with staggered foot position, similar to the standing track start with one foot near the surface of the water and one foot at or below the level of the top foot’s heel, horizontal distance may increase along with velocity as compared to the standard backstroke start. They found that there was no significant difference \( p > 0.05 \) seen in average velocity or horizontal distance that the swimmer travelled when comparing both types of starts. A Chi squared analysis was carried out to check that there was no movement of the feet at the start, which found no significant differences. Although this study examined feet position, it only provided information on one performance indicator and also did not examine at the different foot levels in or out of the water.
Summary

As the above literature suggests, starts are an influential component to gaining a significant advantage in swimming. The type of block start used has been heavily researched and debated to try and enhance swimmers’ performance, despite the large amount of research that has been carried out on block starts, that looks at the effect different feet positions have on starts, there has been very little research into the type of starts used in backstroke. Backstroke swimmers and coaches would benefit from the type of research that has been carried out on block starts, as it can help improve performance. This therefore creates an obvious need and demand to be researched.
Chapter Three Method
Introduction

The purpose of this study was to determine the effect that different feet positions have on backstroke start effectiveness. Four different feet positions were considered and three effectiveness variables; the height, distance and flight time of the start, were measured to achieve the purpose of the study.

Participants

Eight competitive university aged, male swimmers between 18 and 24, with an average age of 20.1 (SD±1.46) and an average height of 1.83m were studied. Within this group, there were two GB national standard backstroke swimmers, one of whom swam in the 50m backstroke 2012 Olympic Trials. The swimmers also came from a range of nationalities and therefore potentially different coaching backgrounds: two of the swimmers were from Wales, five were from England and one was from Spain. This group was used, as in the authors view, male swimmers in this age group are generally more powerful and their starts are more advanced and perfected than those of a younger age. In the authors opinion they are able to gain more height on their backstroke starts, which provided part of the data, which was used to analyse the effectiveness of different feet positions. The standard of swimmers was chosen so that the starts performed were likely to be more consistent because of the swimmers experience. The participants volunteered for this study. After reading an information sheet about the study and what was involved, they gave informed consent and filled out a questionnaire, which helped identify their suitability for the study. The questionnaire asked questions on their age, current competing level, preferred stroke and preference of feet position on the backstroke start. (See Appendix 1)
**Equipment**

1 x JVC HD Everio video camera (Henceforth referred to as video camera)
1 x Samsung WB100 Bridge Camera (Henceforth referred to as Bridge Camera)
1 x HP Photosmart R967 Camera (Henceforth referred to as Camera)
1 x Hama Star 61 Camera Tripod
1 x Cannon Tripod
1 x Tape Measure
2 x Starting block’s
1 x Dartfish Teampro 6 software
1 x Microsoft Excel 2010
1 X IBM SPSS Statistics Software 20

**Operational Definitions**

Operational definitions needed to be precise and clear, to enable effective analysis of the data collected. Without this, the validity and reliability of the data can be compromised. Reliability in performance analysis relates to the extent to which the data collected, reflects what happened in the game i.e. an estimate of the accuracy (validity) (James and Taylor *et al* 2007). Reliability is concerned with the consistency or repeatability of a measure. Reliability is determined when a certain experiment is performed on more than one occasion and the data ends up being the same each time (Morrow and Jackson *et al* 2005). Flight Time (FT)—the time from when the last foot leaves the wall, to where the last foot enters the water. Flight Distance (FD) the horizontal distance from the edge of the pool, to where the fingertips enter the water (Galbraith, Scurr, Hencken, Wood & Graham-Smith, 2008). Height – the vertical distance gained from the water surface, to the highest part of the back during the arc phase. Speed – flight distance ÷ flight time.
Pilot study

A pilot study was carried out before the study was performed to collect data. The pilot study enabled the camera positioning and settings to be established, before data was collected.

Camera Set Up

Three cameras were set up on the poolside. The video camera was set up on the Hama tripod, with a frame width of 1280 pixels and a frame height of 720 pixels and a frame rate was at 50 frames a second. This camera was set up on the side of the pool 9.80m horizontally to the left of the starting block (see figure 1-3) to be able to record all of the swimmers starts.

The Bridge Camera was set up on a block for support, underneath and slightly in front of the video camera tripod (see figure 1-3). The camera was set to take burst shots, by using the motion capture setting on the camera, which takes 5 photographs per second, while the capture button is held down. The dimensions used were 640x480 pixels, with the F-stop at f/4.8, the cameras exposure time was set at 1/33rd of a second, with an ISO speed of 100, the focal length was at 21mm. This camera was set on the burst setting to capture the phases of the swimmers starts as well as providing a different aspect from the video camera.

Figure 1. Position for cameras 1 and 2

Figure 2. Camera 1 and 2 set up on poolside
The third camera used was on the cannon tripod, 1.83m to the right of the starting block, opposite the other cameras (see figures 4 and 5). This camera was positioned on poolside and was focused on the swimmers feet, to record the feet positions. The camera was set up on its video setting, with a frame width and height of 640x480 pixels, the frame rate was set to 24 frames per second.

To enable the swimmers start height and distance to be analysed, a scale was set up on the poolside. A tape measure was set out on poolside measuring exactly 1metre, with the start point next to the block (see figure 4).
Procedure

Four different feet positions were used by the participants; feet split in a track start under the water, feet parallel under the water, feet parallel above the water surface and the final position being feet in a track start with one foot half in the water and the other out of the water. (See appendix 2 for photographs of the feet positions used.) As all of the participants already had a preferred foot position, each participant was allowed a 10-minute familiarisation period in which they were allowed to practice all four of the feet positions, before the testing began. After the 10-minute familiarisation period, participants began the testing period in which they performed starts with each foot position three times, with no rest in between each start, apart from the time it took the swimmer to get back from where they finished their start. The testing was carried out in the following order; feet split in a track start under the water, feet parallel under the water, feet parallel above the water surface and the final position being feet in a track start with one foot half in the water and the other out of the water. By getting the participants to perform each foot position three times and working out an average, this helped reduce the chance of anomalies occurring within the results, therefore increasing the validity of the overall results.

The variables that were measured to determine the efficiency of each position included; height gained, distance gained and time in flight. All 12 starts from each swimmer were recorded on a video camera and two still cameras were used to take images of the start aswell.

Data Analysis

Three different variables were measured by using the analyser view of Dartfish TeamPro6 software; Flight time, flight distance and height. To enable the flight distance and height to be measured effectively, the distance tool was used to set the 1m scale up on the software by overlaying the 1m point that was measured out during testing, however this a parallax (See Figure 6).
After the scale had been set up in the software, the same distance measurement tool was used to measure the FD, from the wall to where the fingertips of the swimmer entered the water (See figure 7).

The next variable that was measured was the height gained. To work this variable out effectively, the middle of the lane, where the swimmer started from had to be worked out. To do this the distance tool was used to measure the distance between the wall at the side of the lane and the top of the lane rope, this distance was then divided by two to work out the middle, the line tool was then used to draw a line from this point to where the swimmers feet were placed on the wall (See figure 8).
Figure 8. The middle of the lane being indicated by a horizontal line.

The height gained by the swimmer was then measured by measuring the height from the horizontal line (middle of the lane); to the middle part of the swimmers back during the highest part of the arc phase (See Figure 9).

Figure 9. The height gained by the swimmer being measured.

The final variable that was measured from the swimmers starts was the time in flight. This was measured by taking note of the time (on screen) that the swimmers feet left the wall and then taking note of the time when the swimmers feet enter the water. The initial time was then taken away from the final time, to give the flight time. (See figure 10 and 11 below)
**Figure 10.** The red circles indicate, when both feet leave the wall as well as the time that the feet left the wall.

**Figure 11.** The red circles indicating where the swimmers feet are almost completely in the water, as well as indicating the time, which this occurred.

The data from each swimmer was entered into a table on a Microsoft Excel 2007 spread sheet (see figure 12).

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>泳</td>
<td></td>
<td></td>
<td>飞行时间</td>
<td></td>
<td></td>
<td>平均</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>平均</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>平均</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>手趾下水</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>脚平行下水</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>脚平行出水</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>全脚进入</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 12.** Example of the table used to collect the analysed data from each swimmer.
The data collection table was designed so that data could be entered on each variable, from every individual start for the four different feet positions. An extra column was added at the end of each variable so that the swimmers averages for the height gained, distance gained and flight time could be worked out. This was done by entering a formula which added up each variable for every start performed on that foot position and then dividing it by three, e.g. to work out the average of the flight time on the track start under the water, the following formula would be used: \( G5 = \frac{(D5 + E5 + F5)}{3} \).

To enable a comparison of the starts to determine the effectiveness of each position and therefore justify what effect each foot position had on backstroke starts. All the average’s from each individual swimmer, from each variable was then added up and then divided by eight to give an overall average (see figure 13). The combined results were then put into graphs to present the data.

<table>
<thead>
<tr>
<th>R</th>
<th>S</th>
<th>T</th>
<th>U</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight time average</td>
<td>Height gained average (M)</td>
<td>Distance gained average (M)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>track start under the water</td>
<td>(D5 + E5 + F5) / 3</td>
<td>(G5 + H5 + I5) / 3</td>
<td>(J5 + K5 + L5) / 3</td>
<td></td>
</tr>
<tr>
<td>feet parallel under the water</td>
<td>(M5 + N5 + O5) / 3</td>
<td>(P5 + Q5 + R5) / 3</td>
<td>(S5 + T5 + U5) / 3</td>
<td></td>
</tr>
<tr>
<td>feet parallel out of the water</td>
<td>(V5 + W5 + X5) / 3</td>
<td>(Y5 + Z5 + A5) / 3</td>
<td>(B5 + C5 + D5) / 3</td>
<td></td>
</tr>
<tr>
<td>Track start one foot in one out</td>
<td>(E5 + F5 + G5) / 3</td>
<td>(H5 + I5 + J5) / 3</td>
<td>(K5 + L5 + M5) / 3</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 13.** How all the averages from all the swimmers were calculated and recorded.

**Statistical Testing**

Statistical testing was carried out on the results by using IBM SPSS Statistics 20 software. An analysis of variance (One-way ANOVA) test was carried out. An ANOVA test is a statistical procedure concerned with comparing means of several samples, which is an extension of the \( t \)-test for two independent samples to more than two groups. The following assumptions are required for the ANOVA test; (1) the observations are independent of one another. (2) The observations in each group come from a normal distribution. (3) The population variances in each group are the same (KCL, No Date). The test was carried out to see if there was any statistical difference for each variable.
Issues occurred/dealt with

As the data collection was not able to be carried out on the same day, issues occurred with regards to the camera positioning. During one data collection session, which involved the recording of two participants starts, the camera that was used to collect the main data, was positioned at the wrong angle. This was not apparent until data analysis, when the footage was at a different angle, therefore giving misleading data. Due to insufficient pool time, the participant’s data was not able to be recollected.

Another issue that was dealt with was that some of the swimmers were not able to perform the starts effectively enough to analyse some of the variables that were being studied. Therefore within the results the data shown for swimmer 1 and 4 on FT and on height gained was set to 0. Therefore within the results section the overall averages will only be divided by 6 as swimmers 1 and 4 data is not being included. However the data collected for their distance gained will still be analysed and compared, to describe their effectiveness (See Appendix 4).
Chapter Four Results
**Introduction**

This section of the study presents the findings from the data that were collected and analysed. The aim of this section is to firstly look at all the variables presented as a whole to indicate which foot position is most effective overall. It will then look at the participant’s preference of foot positioning on the start before presenting each participants results. It will then go into more depth by presenting and describing the overall averages for each variable which was looked at; flight time, height gained and the distance gained. The speed of each foot position is also presented and analysed.

**Summary of Results**

**Table 1.** The combined averages of all the foot positions tested.

<table>
<thead>
<tr>
<th>Foot Position</th>
<th>Flight time average (s)</th>
<th>Height Gained average (m)</th>
<th>Distance Gained Average (m)</th>
<th>Speed (M/S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>track start under the water</td>
<td>1.22 ± SD 0.30</td>
<td>0.26 ± SD 0.11</td>
<td>2.74 ± SD 0.10</td>
<td>2.33 ± SD 0.89</td>
</tr>
<tr>
<td>feet parallel under the water</td>
<td>1.35 ± SD 0.25</td>
<td>0.27 ± SD 0.10</td>
<td>2.79 ± SD 0.11</td>
<td>2.14 ± SD 0.46</td>
</tr>
<tr>
<td>feet parallel out of the water</td>
<td>1.32 ± SD 0.27</td>
<td>0.32 ± SD 0.11</td>
<td>2.82 ± SD 0.12</td>
<td>2.23 ± SD 0.53</td>
</tr>
<tr>
<td>Track start one foot in one out</td>
<td>1.26 ± SD 0.23</td>
<td>0.27 ± SD 0.10</td>
<td>2.79 ± SD 0.13</td>
<td>2.27 ± SD 0.47</td>
</tr>
</tbody>
</table>

Table 1 gives the means for all participants and starts. The green coloured cells indicate values that are either the fastest or furthest and red coloured cells indicate values that are either the slowest or shortest. The feet parallel out of the water position has two of the best averages overall, the furthest distance was gained and also the highest average was gained on this foot position, the results gained from this foot position needs to be considered further and discussed. Another foot position, in which the results need to be considered and discussed, is the track start under the water position, as this foot position has the quickest flight time average and the fastest speed; however it also has the shortest height and distance gained. This maybe because the variables being measured may interact with one another and lead to such results being gained. This all needs to be looked at further and discussed.
Participants feet preference on the start

Figure 14. Participants’ foot positioning preference on backstroke starts before testing and the results of what position was most effective in total for participants.

Figure 14 shows the foot positioning preference of the participants before the study was carried out. With the most preferred foot position being feet parallel out of the water, with three out of the 8 participants preferring it. The least preferred foot position being track start under the water. Figure 14 also indicates that the swimmers preference of foot position is not always the most effective starting position. Before testing only two swimmers preferred using the feet parallel out of the water position, but the results indicate that the feet parallel out of the water position was most effective for five out of the six participants.
Participants results

Table 2. The results of Swimmer 5’s starts.

<table>
<thead>
<tr>
<th></th>
<th>Flight time</th>
<th>Height</th>
<th>Distance Gained</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1  2  3</td>
<td>1  2  3</td>
<td>1  2  3</td>
</tr>
<tr>
<td>track start under the water</td>
<td>1.43 0.47 1.56</td>
<td>0.24 0.28 0.26</td>
<td>2.65 2.57 2.59</td>
</tr>
<tr>
<td>feet parallel under the water</td>
<td>1.51 1.7 1.58</td>
<td>0.26 0.27 0.27</td>
<td>2.60 2.68 2.7</td>
</tr>
<tr>
<td>feet parallel out of the water</td>
<td>1.55 1.61 1.61</td>
<td>0.3 0.32 0.35</td>
<td>2.65 2.67 2.73</td>
</tr>
<tr>
<td>Track start one foot in one out</td>
<td>1.49 1.45 1.64</td>
<td>0.32 0.31 0.34</td>
<td>2.70 2.61 2.7</td>
</tr>
</tbody>
</table>

Table 2 shows the results that were gained from swimmer 5’s starts. Table 2 shows that for swimmer 5, the track start under water foot positioning had the shortest flight time but also had the least height and distance gained. We can also see that the feet parallel under the water had the longest flight time. Table 1 also shows that the feet parallel out of the water foot position had both the furthest height and distance gained out of the starts. The rest of the swimmers results can be found in Appendix 3.
Flight time

![Figure 15](image)

**Figure 15.** Flight time averages (s) for six of the participants

The flight times given in figure 15 only show insignificant differences, with the longest 1.348s being for feet parallel under the water. The shortest flight time was achieved when participants performed the track start foot position under the water, with a time of 1.216s. The difference between the quickest and slowest flight time was 0.132s (SD± 0.059s). The flight times were marginally different, but there was no significant statistical difference on the one-way ANOVA test carried out for flight time p=0.444.
The heights gained given in figure 16, only show insignificant differences, with the highest 0.322m being for feet parallel out of the water. The shortest height gained was achieved when participants performed the track start under the water, with a height of 0.258m. The difference between the highest and shortest height gained was 0.064m (SD ± 0.028m). There was no significant statistical difference on the one-way ANOVA test carried out for height gained p=0.264.
Distance Gained

Figure 17. Distance gained averages (m)

The distances gained given in figure 17, only show insignificant differences, with the furthest 2.824m being for feet parallel out of the water. The shortest distance gained was achieved when participants performed the track start under the water, with a distance of 2.744m. The difference between the shortest and furthest distance was 0.08m (SD ± 0.033m). There was no significant statistical difference on the one-way ANOVA test carried out for distance gained p=0.232. (The distance gained for the two participants that was excluded from the final results can be found in Appendix 4.)
Figure 18. Speed (M/S) for each foot position

Figure 18 indicates that of all the starts, the track start under the water position results on average 2.33m/s the fastest start speed. This is likely to relate to the foot positioning having the shortest flight time average overall, as well as the shortest distance average. Therefore these factors will have had an impact on the speed calculations used. The slowest speed 2.14m/s can be found on the feet parallel under the water foot position, this could be explained as this position has the slowest flight time and the second shortest average distance gained. The difference between the fastest and slowest speed was 0.19m/s. Therefore there was no significant statistical difference on the one-way ANOVA test carried out for speed p=0.504.
**Speed V Distance**

*Figure 19.* Speed (m/s) against Distance (m)

**Speed V Time**

*Figure 20.* Speed (m/s) against Time (s)
Speed V Height

**Figure 21.** Speed (m/s) against Height (m)

Distance v Time

**Figure 22.** Distance (m) against Time (s)
**Height v Time**

![Height Gained (m) v Time (s)](image)

*Figure 23. Height Gained (m) against Time (s)*

**Height v Distance**

![Distance Gained (m) v Height Gained (m)](image)

*Figure 24. Distance Gained (m) against Height Gained (m)*
Summary of Variable Results

Figure 19 indicates a correlation between speed and distance, there is a slight increase in speed as the distance increases. These results are as expected.

Figure 20 indicates a significant negative correlation, between speed and flight time, as flight time increases, the speed significantly decreases. The feet parallel under the water position has produced more variable results compared to the other foot positions. If this foot position was on its own, it would be said to have a positive correlation. Figure 20 is also implying that the feet parallel under the water position results in further distance gained compared to the other feet positions. However Figure 17 clearly indicates that the feet parallel under the water position did not produce the most distance gained.

Figure 21 suggests that a slight decrease in speed occurs when the height gained increases. This could be due to the fact that the measurement of speed is horizontal speed, not vertical speed. This suggests that the more height participant’s gain on the start will reduce the speed during flight.

Figure 22 indicates that there is a slight decrease in distance gained when the flight time increases. This could be related to the height of the individual participants.

Figure 23 indicates a significant correlation between height gained and flight time. The more time in flight results in more height gained by the participants.

Figure 24 indicates a small correlation between distance gained and height gained. There is a slight increase in distance gained with height gained. However the low consistency of the results does reflect starts that are more up and down as well as starts which go further horizontally than others.
Chapter Five Discussion
Introduction

Within swimming it is important to analyse the impact a certain variable has on race performance, as it is vital to the process of coaching. This process assists coaches in understanding the impact of specific factors, and of any changes, on a swimmer's performance, enabling them to set realistic performance goals and to provide correct emphasis on individual race elements within training (Thompson et al., 2004). Therefore within this section the following aspects and results will be discussed further and compared to previous research. The results gained could have an impact on the way a swimmer practices starts within training and racing; foot preference, flight time, distance gained, speed and track start under the water and feet parallel out of the water.

Foot Preference

Jorgić, et al. (2010, p.35) stated that “the regular and intensive drill of a swimmers preferred chosen start technique should be applied”. However results gained from this study showed that foot preference does not always lead to the most effective start, 3 out of the 6 participants gained results suggestive of a better start on their identified non-preferred start technique. However these results support those of Galbraith, et al, (2008), whose study suggested that during training, swimmers and coaches should only focus on the most statistically significant dive performance.

Therefore within an elite training environment athletes and coaches should aim to only focus on practicing and repeating the most statistically significant foot position. While in relation to the results gained from this study, although there was no statistical difference and it did not focus on elite swimmers, 5 participants achieved better results on the feet parallel out of the water foot position, for 3 out of 5 participants this was not their preferred position. If athletes and coaches were to focus on this foot position, researchers have found that through consistent dive practice, an elite swimmer can reduce their overall race time by a minimum of 0.10 s (Blanksby, Nicholson and Elliott, 2002; Maglischo, 2003). At the elite level, in a sprint event this improvement could signify the time difference between a first and third
place (Thayer & Hay, 1984; Breed & McElroy, 2000; Breed & Young, 2003). For example at the recent London 2012 Olympic Games, in the men’s 100m backstroke event the difference in time between 2nd and 3rd place was 0.05s and between 2nd and 4th place 0.15s. In the men’s 50m freestyle event there was 0.07s between 2nd and 4th place and in the 100m freestyle event, there was 0.01s between 1st and 2nd place (London 2012, No date). Such small differences in times, frequently are the difference between winning a medal or not. These slight differences between times of competitors and therefore placing’s of competitors clearly support the statements made by Blanksby, et al. (2002) and Maglischo (2003), that swimmers should focus on the most statistically significant start and foot position whilst in training and that by doing this significant time can be dropped.

**Flight Time**

Though there was no significant difference in the flight times achieved by participants in this study, a similar study by Hohman et al, (2006) showed significant correlations between the times of hands off and take off of the feet, as well as the times of hands off and hip entry. The study concluded that the athletes exhibited notable differences in start times. Therefore this creates the need for this study to be replicated, but involving a larger number of participants, to see if the results gained are then comparable to the results gained by Hohman et al, (2006).

**Distance Gained**

The statistical results gained from this study for distance gained, give no significant difference (p= 0.232) when comparing the different types of foot positions. These results are similar to the results gained by Theut and Jensen (2006), who also found that there was no significant difference (p > 0.05) seen in horizontal distance that the swimmer travelled when comparing both staggered or parallel foot placement on backstroke starts.
**Speed**

Although there was no significant difference in the speeds gained by participants whilst in flight, the results gained for speed indicate a relationship between the flight time and distance gained. They also suggest that swimmers, who gain less distance in flight, have a shorter flight time which resulted in the speed of the start being the quickest. Thus this research suggests that the most effective start would be on a track start under the water position, however it needs to be questioned if the lack of height and distance gained can effect on the underwater phase, this cannot be discussed as these variables were not examined or considered within this study.

**Summary**

Although the fastest flight time and speed were achieved when participants performed a track start under the water, this start also had the shortest distance and least height gained. However, this may merely shot that the participants were unable to gain as much height or distance, compared to the other start positions, therefore they were not in the flight phase for as long, which resulted in the shortest average flight time.

Whilst this start produced the shortest flight time and speed, it does not mean it would be the most effective or efficient start. Other variables which were not measured within this study must also be considered, such as the impact the height and distance gained has on the entry velocity, speed under water and break-out velocity. These variables were measured by Green, et al, (1987) where results showed that the differences between the two starts studied, were that the whip start had a greater take-off angle, higher and longer flight path, steeper entry angle with less frontal resistance and faster entry velocity, all of which resulted in the participants having greater underwater depth, longer submerged time, and a faster break-out velocity than the conventional start, as a result of this also being the faster start. Based on Green et al.’s findings in relation to the current study, where the feet parallel out of the water position gave the most distance and height gained, suggesting this to be the most effective foot position. However this would need to be tested for other values and factors that must be taken into account and also with larger numbers of participants as the current study did not.
Chapter Six Conclusions
The System

Although this study produced no significant statistical differences for the four variables, there were several relationships and correlations between the variables, which reinforced and inter-linked with previous research carried out. The study reinforced the Blanksby, et al, (2002) and Maglischo (2003) statements, that swimmers should focus on the most statistically significant foot position whilst in training. With the results from this study showing that three participants achieved better results on a non-preferred start. This suggesting that swimmers need to be made more aware of the types of feet positions that they can use, as well as suggesting that swimmers should be tested more often in relation to feet positions in swimming to help improve performance that has been proven by Blanksby, et al, (2002) and Maglischo, (2003) to make a vital difference between medal positions at the elite level.

In relation to the research question ‘What effect do different feet positions have on backstroke start effectiveness?’ and in relation to the hypotheses of this study; starts where the feet are under the water produce shorter distances and height than starts where the feet are above the water and, it can be said that different feet positions have no significant statistical effect on the distance and height of backstroke starts. However the results have given an insight into the effect different feet positions have on the variables within a backstroke start. Suggesting that by performing a track start under the water, can result in the shortest distance and height gained therefore resulting in a short flight time, but the fastest speed, which supports the hypotheses. With regards to the hypotheses that starts where the feet are under the water are less effective than starts where the feet are above the water, this cannot be concluded, due to the fact that the track start under the water position does have the fastest speed (m/s), however previous research has shown that if more height and distance is gained during flight, it will lead to a higher velocity and speed during the underwater phase, this suggesting that the feet parallel out of the water position would therefore be more effective, due to the fact that the most height and distance was gained on this position.
In relation to the results gained within this study, they may have been impacted by several influences throughout the study, for example the data collection was not able to be carried out all in one session, whilst it is not believed this affected the results, the camera position/angle may have changed slightly because of this. Another factor that could have led to there being no significant statistical difference could have been related to the small sample size in the study, a bigger sample size may have led to there being a significant statistical difference on the variables.

**Future Research**

Future research to help enhance the results gained from this study, to gain a better understanding on the effect of different feet positions on backstroke starts, could look at the effect the foot position has on speed to 15m, which would be able to determine efficiency of the start. Another aspect of the start that could be looked at in conjunction with the feet position used would be the type of hand position and arm start technique used on the start as well. This would enable athletes and coaches to be able to determine which start is more effective overall on backstroke.

In order to enhance the results achieved in this study and to help understand the fact that three participants achieved better results on a non-preferred foot position, it may be beneficial if the participants were given a longer familiarisation period in which participants would be able to practice their non-preferred start’s and then the testing procedure to be repeated, to see if the results were then similar to previously.
Chapter Seven Reference List


Mason, B., & Cossor, J. (2000). What can we learn from competition analysis at the 1999 Pan Pacific Swimming Championships? In R. Sanders & Y. Hong (Eds.). *The XVIII international symposium on biomechanics in sports—Applied session: Application of biomechanical study in swimming* (pp. 75-82). Hong Kong: Chinese University of Hong Kong.


Appendix

Appendix 1 – Participant Questionnaire ....................... Pg B
Appendix 2 – Pictures of the four different feet positions ....... Pg C
   Appendix 3 – Participants Results ................ Pg E
Appendix 4 – Participant 1 and 4 excluded results ............. Pg F
Appendix 1

UWIC PARTICIPANT QUESTIONNAIRE FORM

Participant Name: ...............................................

1. Age (Please circle)
   18  19  20  21  22  23  24  25  26  27+

2. What level do you currently compete at? (Please circle)
   Club  County  Regional  University  National

3. On a scale of 1 to 4, with 1 being your best or preferred stroke, what is backstroke? (Please circle)
   1  2  3  4

4. What type of feet position do you prefer when performing a backstroke start? (Please circle)
   Feet together under the water
   Feet together above the water level
   One foot higher than the other (track start) under water
   One foot out of the water and one foot under the water (track start)
   Other (please specify)
Appendix 2

Figure 25. Track Start under the water foot position

Figure 26. Feet parallel under the water
Figure 27. Feet together out of the water

Figure 28. Track Start one foot in one out
### Appendix 3

<table>
<thead>
<tr>
<th>Swimmer 2</th>
<th>Flight time</th>
<th>Height</th>
<th>Distance Gained</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>Average</td>
</tr>
<tr>
<td>track start under the water</td>
<td>1.48</td>
<td>1.68</td>
<td>1.58</td>
<td><strong>1.580</strong></td>
</tr>
<tr>
<td>feet parallel under the water</td>
<td>1.54</td>
<td>1.58</td>
<td>1.66</td>
<td><strong>1.593</strong></td>
</tr>
<tr>
<td>feet parallel out of the water</td>
<td>1.55</td>
<td>1.57</td>
<td>1.55</td>
<td><strong>1.557</strong></td>
</tr>
<tr>
<td>Track start one foot in one out</td>
<td>1.56</td>
<td>1.43</td>
<td>0.97</td>
<td><strong>1.320</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Swimmer 3</th>
<th>Flight time</th>
<th>Height</th>
<th>Distance Gained</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>Average</td>
</tr>
<tr>
<td>track start under the water</td>
<td>0.9</td>
<td>0.94</td>
<td>0.96</td>
<td><strong>0.933</strong></td>
</tr>
<tr>
<td>feet parallel under the water</td>
<td>1</td>
<td>1.02</td>
<td>1</td>
<td><strong>1.007</strong></td>
</tr>
<tr>
<td>feet parallel out of the water</td>
<td>0.99</td>
<td>0.96</td>
<td>0.89</td>
<td><strong>0.947</strong></td>
</tr>
<tr>
<td>Track start one foot in one out</td>
<td>1.02</td>
<td>1.05</td>
<td>1.03</td>
<td><strong>1.033</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Swimmer 5</th>
<th>Flight time</th>
<th>Height</th>
<th>Distance Gained</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>Average</td>
</tr>
<tr>
<td>track start under the water</td>
<td>1.43</td>
<td>0.47</td>
<td>1.56</td>
<td><strong>1.553</strong></td>
</tr>
<tr>
<td>feet parallel under the water</td>
<td>1.51</td>
<td>1.7</td>
<td>1.58</td>
<td><strong>1.597</strong></td>
</tr>
<tr>
<td>feet parallel out of the water</td>
<td>1.55</td>
<td>1.61</td>
<td>1.61</td>
<td><strong>1.590</strong></td>
</tr>
<tr>
<td>Track start one foot in one out</td>
<td>1.49</td>
<td>1.45</td>
<td>1.64</td>
<td><strong>1.527</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Swimmer 6</th>
<th>Flight time</th>
<th>Height</th>
<th>Distance Gained</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>Average</td>
</tr>
<tr>
<td>track start under the water</td>
<td>1.22</td>
<td>1.38</td>
<td>1.48</td>
<td><strong>1.360</strong></td>
</tr>
<tr>
<td>feet parallel under the water</td>
<td>1.36</td>
<td>1.34</td>
<td>1.28</td>
<td><strong>1.327</strong></td>
</tr>
<tr>
<td>feet parallel out of the water</td>
<td>1.28</td>
<td>1.26</td>
<td>1.38</td>
<td><strong>1.307</strong></td>
</tr>
<tr>
<td>Track start one foot in one out</td>
<td>1.26</td>
<td>1.26</td>
<td>1.22</td>
<td><strong>1.247</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Swimmer 7</th>
<th>Flight time</th>
<th>Height</th>
<th>Distance Gained</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>Average</td>
</tr>
<tr>
<td>track start under the water</td>
<td>1.18</td>
<td>1.28</td>
<td>1.2</td>
<td><strong>1.220</strong></td>
</tr>
<tr>
<td>feet parallel under the water</td>
<td>1.34</td>
<td>1.67</td>
<td>1.42</td>
<td><strong>1.477</strong></td>
</tr>
<tr>
<td>feet parallel out of the water</td>
<td>1.34</td>
<td>1.67</td>
<td>1.42</td>
<td><strong>1.477</strong></td>
</tr>
<tr>
<td>Track start one foot in one out</td>
<td>1.47</td>
<td>1.25</td>
<td>1.56</td>
<td><strong>1.427</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Swimmer 8</th>
<th>Flight time</th>
<th>Height</th>
<th>Distance Gained</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>Average</td>
</tr>
<tr>
<td>track start under the water</td>
<td>1.02</td>
<td>1.02</td>
<td>1.1</td>
<td><strong>1.047</strong></td>
</tr>
<tr>
<td>feet parallel under the water</td>
<td>1.07</td>
<td>1.08</td>
<td>1.17</td>
<td><strong>1.107</strong></td>
</tr>
<tr>
<td>feet parallel out of the water</td>
<td>1.16</td>
<td>0.98</td>
<td>0.97</td>
<td><strong>1.037</strong></td>
</tr>
<tr>
<td>Track start one foot in one out</td>
<td>0.99</td>
<td>1.01</td>
<td>1.07</td>
<td><strong>1.023</strong></td>
</tr>
</tbody>
</table>
### Appendix 4

<table>
<thead>
<tr>
<th>Track Start</th>
<th>Flight Time</th>
<th>Height</th>
<th>Distance Gained</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>track start under the water</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>feet parallel under the water</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>feet parallel out of the water</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Track start one foot in one out</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Track Start</th>
<th>Flight Time</th>
<th>Height</th>
<th>Distance Gained</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>track start under the water</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>feet parallel under the water</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>feet parallel out of the water</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Track start one foot in one out</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Track Start</th>
<th>Distance Gained Average (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>track start under the water</td>
<td><strong>3.021666667</strong></td>
</tr>
<tr>
<td>feet parallel under the water</td>
<td>3.05</td>
</tr>
<tr>
<td>feet parallel out of the water</td>
<td><strong>3.021666667</strong></td>
</tr>
<tr>
<td>Track start one foot in one out</td>
<td><strong>3.096666667</strong></td>
</tr>
</tbody>
</table>

**Bar Chart:**

- track start under the water
- feet parallel under the water
- feet parallel out of the water
- Track start one foot in one out

**Distance Gained Average (m):**

- 3.021666667
- 3.021666667
- 3.096666667