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Final Project Abstract

Mathematics of Record Breaking of Swimming  
Innovation and Time

***Introduction***

Can you think of a sport that does not involve numbers? There are not many that come to mind, especially if they are competitive sports. The common denominator between all competitive sports are that they are all timed. Performance is based on the number of the unforgiving clock. Historically, timekeeping in sports originates from the concept of timekeeping in the battlefield. The best fighters – wrestlers and sword fighters – were under time constraints to kill their opponents. The time of how long a fight lasted was an indicator of human ability, talent and survival. In modern history, timekeeping had become an essential part of in sports and the record keeping of sports.

The first stopwatches were used in the modern Olympic games of 1896. The OMEGA watch company has been keeping times for swimming races since the 1932 Los Angeles Games. OMEGA has served as the official timekeeper at the world's highest-profile swimming events and has also been responsible for the development of much of the most important equipment used to time competitive swimming. Some of the best known of these innovations are the Swim Eight-O-Matic Timer, the world's first semi-automatic swimming timer which was first used at the Olympic Games in Melbourne in 1956, and the famous "touch pads" placed at each end of the pool for timekeeping at swimming events, introduced at the Pan-American games in Winnipeg in 1967 and used at the Olympic Games a year later.<sup>1</sup>

The time keeping innovation of OMEGA technology is supported by Federation Internationale de Natation (FINA). This international swimming federations is a partner of the Olympic Swimming Committee and determines the rules for swimming, diving and water polo, applicable at Olympic Games and other international competitions. FINA is also responsible for

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<sup>1</sup> OMEGA Olympics History - <https://www.omegawatches.com/watches/specialities/olympic-official-timekeeper/>

verifying the world records and establish an official updated world records list. Every year, FINA approves of the time keeping technology and the swimmer's suits for the competitions at the Olympic Games.

FINA approved the Speedo LZR suits for the Beijing 2008 Olympics. The suits were made of high-technology swimwear fabric composed of woven elastane-nylon and polyurethane. During the Beijing 2008 Olympics games, the "rubber suit" was worn by all the swimmers. According to Speedo, 98% of the medalists at the 2008 Olympics were won by swimmers wearing the LZR suits. Speedo had contacted Michael Phelps to advertise the suit before the games and awarded him 1 million dollars for his success in the games. The suits helped with speed, adding buoyancy and reducing drag. The combined effects of the LZR, both compressing the body and trapping air for buoyancy, led to many competitors to wear two or more LZR suits for an increased effect. This led to some claiming that the LZR was in effect "technological doping"<sup>2</sup> As a result, sixty-six Olympic records were broken during the 2008 Olympic games and 70 world swimming records were broken in total throughout 2008.

FINA and the Olympic Swimming Committee decided to change the rules. It was concluded that some innovations would end up hurting competitive swimming because of the pace in which world records were being set were being challenged compared to the projected human ability of the athletes. In 2009, FINA released a statement and explained that all full size body suits would be banned from the 2012 London Olympics. The statement included that, "FINA wishes to recall the main and core principle that swimming is a sport essentially based on the physical performance of the athlete."<sup>3</sup>

The controversy at the time was around the new world records of the Beijing 2008 Olympics. The records achieved with the LZR suits were not dropped by FINA and Olympics organization. Instead, for the next game only "jammers" suits would be permitted. The suits would have to be kneecap to navel for men, and from the knee to shoulder for women. The fabric must be air permeable.

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<sup>2</sup> "Fina cracks down on hi-tech suits". BBC Sport. 14 March 2009. Retrieved 15 March 2009.

<sup>3</sup> FINA Opts to Ban All High-Tech Swimsuits, reachforthewall.com, 24 July 2009.

In 2008, Michael Phelps broke seven world records out of the eight events he was competing in. Innovation within swimming has conditions. For example, time keeping will continue to evolve. For example, at the Olympic Games in Beijing in 2008, only a hundredth of a second separated gold medallist Michael Phelps and silver medallist Milorad Cavic in the men's 100-metre butterfly. OMEGA Timing's high-speed video cameras confirmed that the results recorded by the company's electronic system had been absolutely perfect.

### ***Abstract***

Competitive swimming is a timed sport. Swimming records in the Olympics continues to be beat at a faster rate. During the 2008 Beijing Olympics, seventy world swimming records were broken in total throughout the year of 2008. Given this pace, when will swimmers stop breaking records? Why were the 2008 world records important? By looking at the world records of swimming in the butterfly, freestyle, and backstroke, this report will estimate when the rate of record breaking in swimming will also decrease compared to the rate of world records.

### ***Related Work***

In 2008, Paris-based researcher Geoffroy Berthelot looked at more than 3,000 world records from 147 sporting events in the Olympics. He used data that went back to 1896. When he plotted the records over time, he found an exponentially decaying rate—"a major global fading of [world-record] progression," he explained. Based on the analysis of 3,263 world record established for all quantifiable official contests since the first Olympic Games, Berthelot's team showed that world record progression rate follows a piecewise exponential decaying pattern with very high accuracy (mean adjusted  $r^2$  values= $0.91\pm 0.08$  (s.d.)).<sup>4</sup> The report concludes that two thirds of track-and-field events have stagnated since the early 1990s, and the rate has also slowed for other individual sports.

However, it seems like the swimming world records has not slowed down at the same rate. Over the past 30 years, swimming records have been continuously been set. For example,

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<sup>4</sup> Berthelot G, Thibault V, Tafflet M, Escolano S, El Helou N, Jouven X, et al. (2008) The Citius End: World Records Progression Announces the Completion of a Brief Ultra-Physiological Quest. PLoS ONE 3(2): e1552. doi:10.1371/journal.pone.0001552

Justin Lynch broke Michael Phelps’s 14-16 age group in the 100-meter butterfly race. Lynch was only 14 years old in the 2013 World Championship Trials. He is expected to break even more world records in the Rio Olympics this summer.

**Data:**

The data that Berthelot used does not differentiate between the different Olympic sports. This report will take into account different swimming strokes. Swimming has greatly evolved since 1896. Prior to 1933, there were only three competitive strokes, with butterfly yet to be invented. The butterfly was added in the 1952 Finland Olympics. The 50m freestyle, which measures speed ability the best, was not added to the Olympic schedule until the South Korea 1988 games.

The following data is from 1980 onward:

Swimming Olympic Records		
<b>Men 100m- Freestyle</b>		
Year	Time	Winner
London 2012	47.52s	Nathan A. USA
Beijing 2008	47.21s	Eamon S. AUG
Athens 2004	48.17s	Pieter H. NED
Seoul 1988	48.63s	Matthew B. USA
<b>Men 100m- Butterfly</b>		
Year	Time	Winner
London 2012	51.21s	Michael P. USA
Beijing 2008	50.58s	Michael P. USA
Athens 2004	51.25s	Michael P. USA
Moscow 1980	54.92s	Par A. SWE
<b>Men 100m- Backstroke</b>		
Year	Time	Winner
London 2012	52.16s	Mattew G. USA
Beijing 2008	52.54s	Aaron P. USA
Athens 2004	54.06s	Aaron P. USA
Seoul 1988	55.05s	Daichi S. JPM

In the data above includes 2012 “record breaking” numbers since different suits were used compared to 2008.  
 Source: <https://www.olympic.org/swimming>

### **Method:**

This report has slightly modified the model used by Berthelot's team. For the swimming data,  $\Delta$  is set as the annual ration at year T of the new world record number over the total number of the official swimming Olympics events since 1988. The data is analyzed through an exponential decay model. An exponential decay is defined as a population or group of something is declining and the amount that decreases is proportional to the size of the population. In exponential decay, the total value decreases but the proportion that leaves remains constant over time.

In the Berthelot study, the following function was used:

$$y_j(t) = \Delta_{WR} \cdot \exp^{-a_j \cdot t} + b_j$$

The  $\Delta_{WR} = WR_{i,j} - WR_{f,j}$  is an event indicator for the studied  $j$  period; it is positive for the chronometric events (with decreasing WR values) and negative for the non-chronometric ones (increasing WR values). In the calculations for the swimming, the data is analyzed by the results of the following formula:

$$Y = \alpha e^{-bt}$$

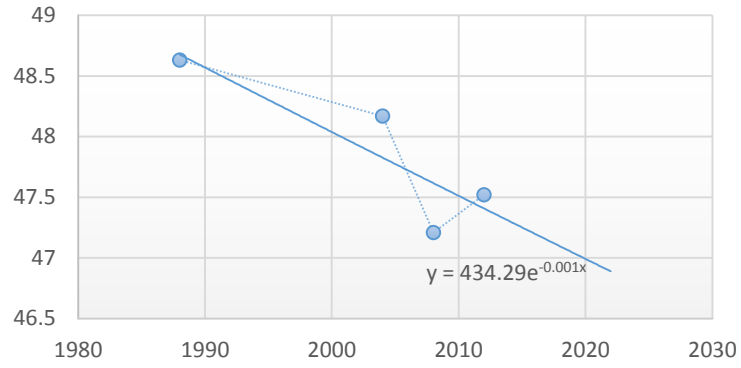
At  $t$  goes to infinity,  $e^{-bt}$  will eventually become zero. So, as the Olympic years continue, the number of records breaking will decrease because the time to finish a race will also decrease. Beta in this formula represents how fast records will be broken.

### **Results:**

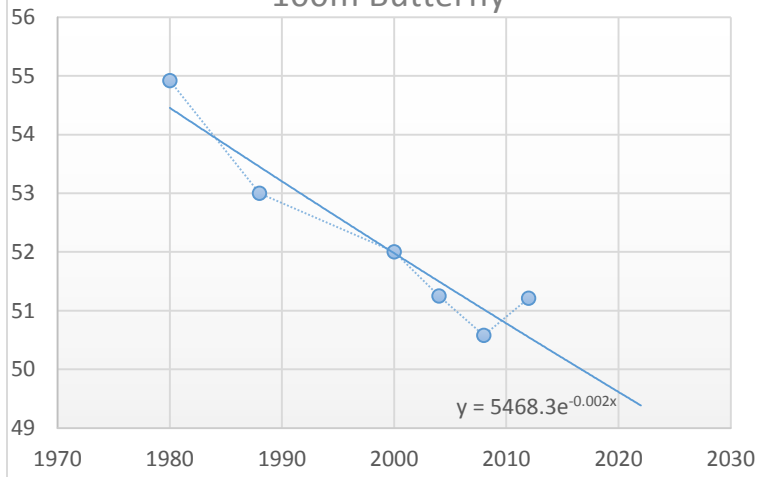
The swimming data for all three swimming events were plotted using the exponential decay model. Two charts were produced for each of the events. The first group includes the 2008 Olympic World Record numbers and the second group of charts excluded the Beijing 2008 numbers. When calculating the exponential decay for each swimming category and comparing it to when the 2012 world records, the rate of world records breaking would not last for more than eight more Olympic games. Approximately, 32 years from the 2012 Olympics games, the number of breaking world records would eventually stop for all three categories. Competitive sports cannot be achieved in zero seconds, therefore this will not occur.

## Group 1

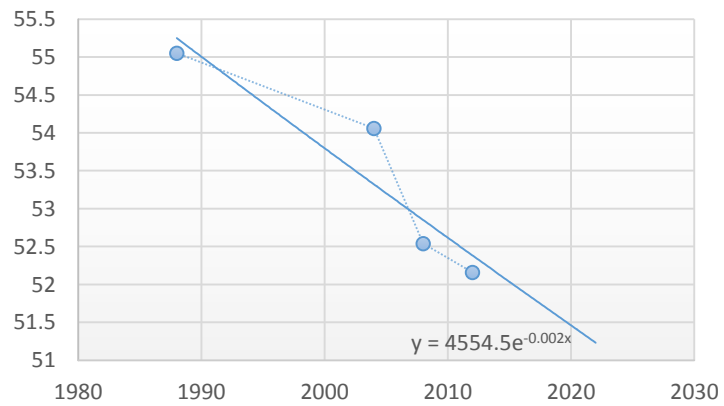
### 100m Freestyle



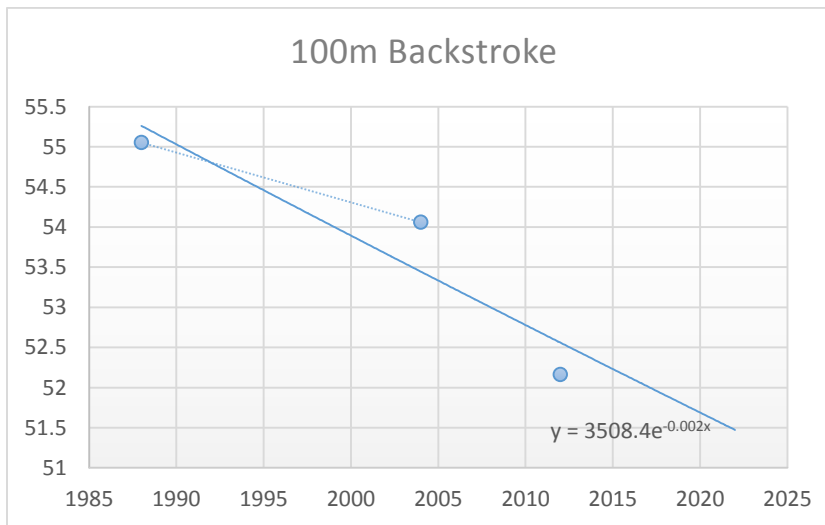
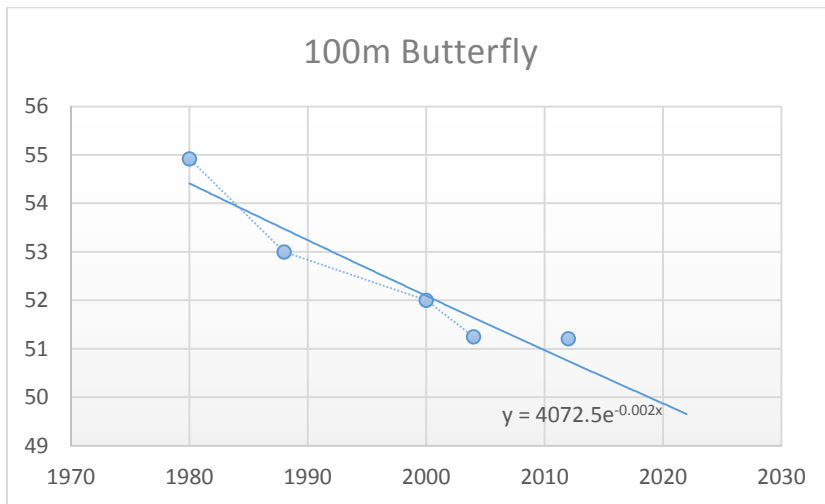
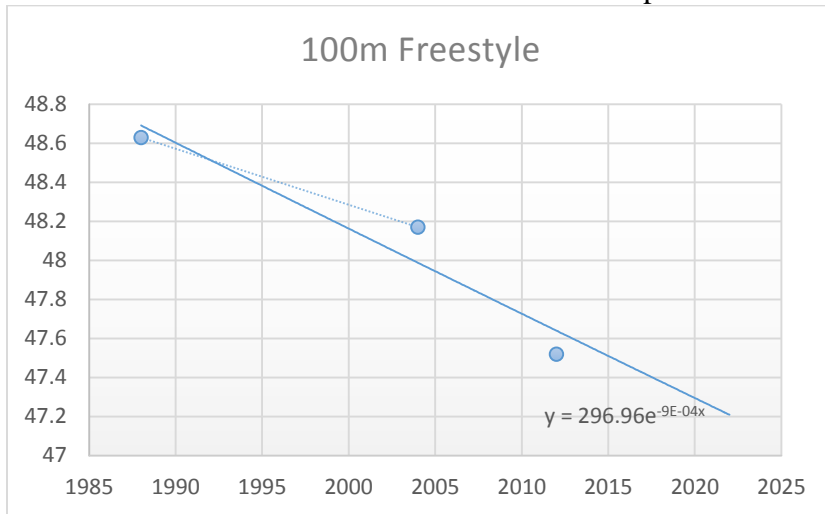
### 100m Butterfly



### 100m Backstroke



## Group 2



**Conclusion:**

FINA and Olympic Swimming committee will likely face another innovative challenge that will affect the world records in swimming. Overall, Olympic sports have evolved with technological innovation. (Cycling has a very interesting history.) The controversy around the LZR swimsuits can be justified. It had challenged the tradition of the competitive sport. Innovation in swimming for swimmers is slow. However, FINA does allow innovation when it comes to timekeeping. The clock is becoming more precise in world competitions and the swimming suit technology will eventually have to keep up. By looking at the charts of freestyle, butterfly, and backstroke in both of the groups, one thing is clear: records are slowing down. The prediction of Berthelot's study is true for swimming as well, even though swimming continues to be a young Olympic sport.