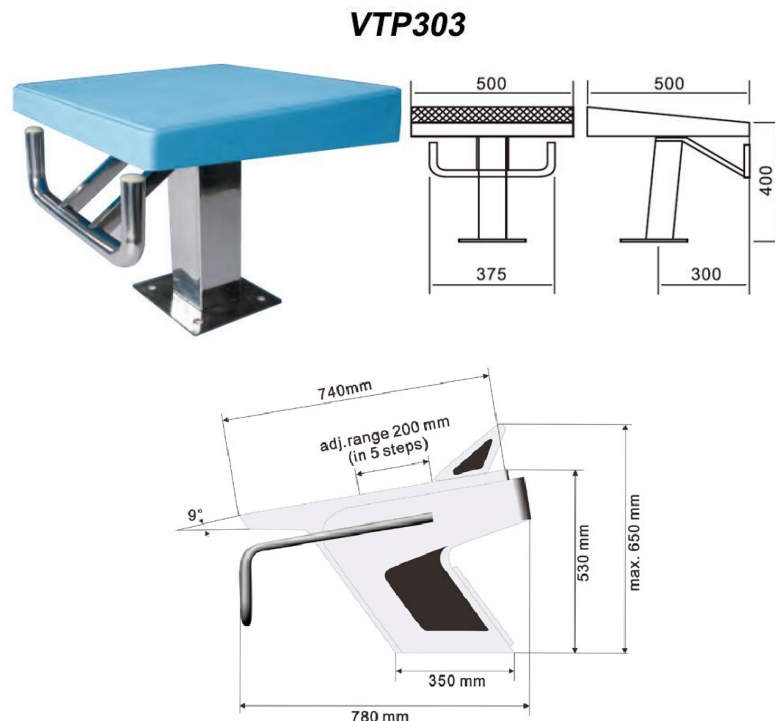


# How does the position of the wedge on a diving block affect the distance travelled off the dive?

## Abstract:

With swimming being an individual sport dependent on pure speed, every aspect of a race is important. The start phase refers to the speed of covering the first 15m of a race which largely includes reaction time, velocity off the block and distance covered in air. Athletes constantly look for ways to improve these minor details, as everything counts in swimming. The sport where Nathan Adrian was able to beat James Magnussen in the 2012 Olympics games 100 freestyle final by 0.01s swimming 47.52s and 47.53s.

Focusing on the start phase, this paper will be looking specifically at the dive of the block and how the position of the wedge on a diving block affects the distance travelled in the air. In the paper several studies will be analyzed, and the findings will be explained in terms of physical, biomechanical, and biological concepts such as muscle memory, which many believe to be a hoax. Finally the existence idea of a perfect ration of height to distance between the front foot and the wedge is an idea that will be touched upon.



## Introduction:

There are two diving techniques used to dive off the block: the block start (where both feet are placed at the front of the block) and the track start (where one foot is placed at the block of the block and the other near the back). It wasn't until recent research and comparisons made between the two, that people began to favor the track start. Prior to 2010, the blocks were flat. An introduction of a wedge, at a 30-degree elevation, on the Omega OSB11 (Swiss Timing, 2022), caused a shift in research to focus on comparisons between the traditional track start and the new 'slanted one,' with no reference to the grab start. Despite this, the area is still relatively new and should be a major area of constant improvement in the swimming world.

Through watching many recent Olympic Games and World Championship, it's safe to say that one thing they all swimmers have in common is that they always ensure that the wedge of the block is on a specific number; the one that works best for them. Whether this is purely about preference or is related to the biomechanical workings of the human body is difficult to say. Looking at the athlete's heights, body types, limb lengths and more, it would be very difficult to find a direct correlation between these biological factors and the 'perfect' wedge position. Although a ratio of these factors probably does exist and does play a major role in the distance they're capable of covering in the air off the block, it would be almost impossible to find with the provided resources and equipment and instead would require conducting an experiment with a very large sample of people and expensive technology. Through looking at the peak force and reaction times of swimmers at different wedge positions, the distances covered can be anticipated and compared as done below.

## **Findings:**

### **How different wedge positions affect the peak force produced by swimmers?**

The OSB-11 diving block wedge can be moved into 5 positions with 1 being the closest to the front edge and 5 being the furthest back. Through analysis of the findings of multiple well-respected scientists from the sports institution at Loughborough University, some of which have conducted an experiment on 32 elite British swimmers, including 17 males, with an average height of 182.28cm and average weight of 77.47kg, and 14 females, with an average height of 170.33cm and average weight of 65.63kg, it's evident that there is a trend between the peak force produced by a swimmer and the position of the wedge on a diving block. In this experiment only 3-5 were used as 1 and 2 would have been very unrealistic and uncomfortable for fully grown athletes to use when 'exploding' off the blocks (Swiss Timing, 2022).

As it turns out, the footrest position had a significant impact on output and performance. It was found that in positions 4 and 5, the horizontal take-off velocity was approximately 0.1m/s higher than in position 3. A similar trend was seen regarding peak force produced, as vertically positions 4 and 5 were around 0.05BW higher than position 3, whilst horizontally the difference between positions 3 and 4 was about 0.094BW and between positions 3 and 5 it was around 0.116BW (S.E. Slawson, 2011).

These trends can suggest that the swimmers were able to reach higher velocities and produce larger forces when the wedge was in positions 4 and 5 in comparison to position 3. Despite the

differences being quite small, it's still significant given the nature of the sport, where races are won or lost over 0.01 secs. Like when Phelps won the 2008 100m butterfly final against Milorad Cavic, over 4.7mm (1/6 of an inch).

### How different wedge positions affect swimmers' speeds and reaction times?

Another study carried out with 38 elite swimmers, 19 males and 19 females, with average heights of 179.1cm and 169.7cm and average weights of 73.4kg and 59.9kg respectively. Athletes primarily dived with their preferred wedge position, and then with the wedge placed closer and further back. Below are the tables of results from that experiment for both females and males respectively:

Variable	Wedge Position		
	Forward	Preferred	Backward
<b>15m start time (s)</b>	<b>7.351 ± 0.32</b>	<b>7.282 ± 0.33</b>	<b>7.306 ± 0.37</b>
<b>Reaction time (s)</b>	<b>0.165 ± 0.03</b>	<b>0.167 ± 0.03</b>	<b>0.158 ± 0.03</b>
<b>Hands take-off (s)</b>	<b>0.457 ± 0.09</b>	<b>0.441 ± 0.08</b>	<b>0.449 ± 0.08</b>
<b>Hands take-off: reaction time (s)</b>	<b>0.287 ± 0.08</b>	<b>0.269 ± 0.06</b>	<b>0.283 ± 0.08</b>
<b>Rear foot take-off (s)</b>	<b>0.641 ± 0.04</b>	<b>0.630 ± 0.03</b>	<b>0.618 ± 0.05 f</b>
<b>Rear foot take-off: reaction time (s)</b>	<b>0.475 ± 0.04</b>	<b>0.463 ± 0.03</b>	<b>0.460 ± 0.03</b>
<b>Front foot stand (s)</b>	<b>0.131 ± 0.02</b>	<b>0.140 ± 0.02</b>	<b>0.144 ± 0.02 f</b>
<b>Block time (s)</b>	<b>0.772 ± 0.03</b>	<b>0.769 ± 0.03</b>	<b>0.761 ± 0.05</b>
<b>Movement time (s)</b>	<b>0.607 ± 0.04</b>	<b>0.602 ± 0.03</b>	<b>0.603 ± 0.04</b>

Variable	Wedge Position		
	Forward	Preferred	Backward
<b>15m start time (s)</b>	<b>6.411 ± 0.47</b>	<b>6.331 ± 0.55</b>	<b>6.434 ± 0.49</b>
<b>Reaction time (s)</b>	<b>0.168 ± 0.04</b>	<b>0.175 ± 0.03</b>	<b>0.171 ± 0.03</b>
<b>Hands take-off (s)</b>	<b>0.452 ± 0.07</b>	<b>0.463 ± 0.08</b>	<b>0.445 ± 0.07</b>
<b>Hands take-off: reaction time (s)</b>	<b>0.279 ± 0.07</b>	<b>0.288 ± 0.08</b>	<b>0.276 ± 0.07</b>
<b>Rear foot take-off (s)</b>	<b>0.609 ± 0.04</b>	<b>0.615 ± 0.05</b>	<b>0.589 ± 0.05</b>

<b>Rear foot take-off: reaction time (s)</b>	<b>0.448 ± 0.05</b>	<b>0.440 ± 0.05</b>	<b>0.424 ± 0.04</b>
<b>Front foot stand (s)</b>	<b>0.109 ± 0.02</b>	<b>0.118 ± 0.02</b>	<b>0.130 ± 0.02</b>
<b>Block time (s)</b>	<b>0.718 ± 0.04</b>	<b>0.734 ± 0.05</b>	<b>0.719 ± 0.04</b>
<b>Movement time (s)</b>	<b>0.557 ± 0.05</b>	<b>0.558 ± 0.04</b>	<b>0.554 ± 0.05</b>

The tables above show that when the wedge was placed in the athletes preferred position, they completed the 15m start in a quicker time than when it was placed in other positions. This is despite the fact that they had slower reaction times in this position. With this slow reaction time, for the time to 15m to still be the quickest when the wedge was in the swimmers' preferred position, they must have travelled much faster and with much more power off the block to make up the lost time.

Whilst proving that there is a perfect distance for each athlete to dive the furthest distance in the quickest time possible, these results also complicate coming to a conclusion as they add the question: is it based on personal preference and consistence practice of that position or is it based on scientific findings? Although this isn't the question being answered, it's still relevant food for thought. Coming back to the focus, these findings prove that there is indeed a significant relationship between the position of the wedge and the 15m start time, which relates to the previous experiment.

### **How can these finding be explained?**

#### **Experiment 1:**

The diving movement is very similar to a squat jump, which is a much more deeply researched topic. Hence the data from another experiment, showing that the optimal knee flexion angle for jumping is between 87 and 107 degrees, (C. Christensen, 2020) can be used to explain this finding. When the elite swimmers' heights and large limb lengths are taken into account, it can be seen that when the wedge is placed further back (in positions 4 and 5), the angle of flexion in the back knee increased and falls within the range of optimal squat jump power. The front knee remains unaffected and so isn't considered in this analysis.

The Omega officially claims that the footrest enables the athlete to push-off with a rear knee angle of 90 degrees. This lies in the range of maximum vertical force production at a rear knee angle between 80-90 degrees which allows athletes to travel further in the air on their starts. Whilst knee angles between 100-110 degrees maximize the peak horizontal velocity experienced by the athletes (Yang, 2018). Looking at this, it is evident that the 'perfect' wedge position would depend on the angle a swimmer dives at as diving at a higher angle would mean that the athletes would need to focus on horizontal velocity. This is because diving at a high angle would mean that swimmers are in the air for a long time and need that propulsion to allow further travel

forwards. On the other hand, swimmers who dive at a flatter angle would need to increase their peak vertical force as they have the forward momentum pushing them forward but need more airtime to maximize its benefit.

### **Experiment 2:**

Muscle memory, which has only been deeply studied and understood recently, is the ability to reproduce a particular movement without conscious thought acquired as a result of frequent repetition of that movement. This concept can be used to explain why swimmers were able to get quicker 15m times when the wedge on the block was in the position they preferred as opposed to any other.

Some experts have said that it takes between 3000 and 5000 reps to build muscle memory whilst others have said that it takes between 40,000 and 50,000 (Born, 2021), which would depend on the movement. Based on fact that the experiment discussed was carried out on elite swimmers, it's safe to assume that they've performed the dives thousands of times and hence enough to build muscle memory. Since muscle memory "allows athletes to perform motor functions faster and with greater accuracy without having to think about them ... without requiring extra time to consciously react," (MasterClass, 2021) this is a valid explanation as to why these athletes' performance was significantly better in their preferred position.

This might not be the case though as the athletes could have chosen these 'preferred' positions based on what felt more natural for their bodies. This would in turn mean that the results could be unrelated to muscle memory and instead go back to the idea of a perfect height/limb length to wedge position ratio. With such limited information it's quite difficult to tell as more investigations would need to be carried out to prove either.

### **Limitations**

Both experiments were only conducted on less than 40 athletes, a relatively small group. This is evident in the lack of consistency within these results, especially across genders. Thus, these results are not fully reliable, but can be developed with other theories and experiments conducted on a wider demographic, in order to provide a more accurate conclusion. Furthermore, it's difficult to come to an explanation of experiment 2 as very limited information has been published and so it is unknown what position the swimmers 'preferred' and whether that is purely preference or relates back to the idea of a ratio.

### **Conclusion:**

From the previous data and analysis, it can be concluded that there is a statistical relationship between the position of the wedge on a diving block and the efficiency of the performer's dive. Gathering evidence from the recorded data in the table above, it can be inferred that a major contributing factor is the athlete's preference. Despite muscle memory being an under-researched topic, we can assume that it plays a major role in why athletes performed quicker and more explosive dives when starting from a preferred position. On the contrary, another major factor is the angle of flexion in the rear knee, which when in the range of 87-107 degrees, has proven to maximize the power output of the diver.

## **Writer Background:**

### **Why I chose this area?**

A swimming race consists of multiple contributing parts including but not limited to the turns, the strokes, kicking and pulling. One of the most significant aspects is the start (dive and underwaters). Being a competitive swimmer myself, I spend over 20 hours a week trying to master what could be as short as a 25 second race, the 50m freestyle, and over the course of such a short distance, every part of the swim proves to be crucial and can be the difference between first and tenth. With the goal always being to go faster, swimmers are always desperate to master old techniques or find new ones based on recent research. Having constantly experienced this, and witnessed my teammates and competitors use different methods to propel forwards, sparked an intrigue in me; hence I'm digging deeper into a topic of interest to me – diving blocks and race starts – in hope of finding the perfect diving position.

## **Appendix 1 – Muscle Memory:**

The idea of muscle memory refers to a phenomenon that suggests that after repeated practice, the body become able to perform physical tasks with increased accuracy and efficiency. This concept has been studied extensively in the fields of neuroscience, physiology and sports science and can be used to explain why athletes in experiment 2 were able to dive further using their preferred wedge position on the block.

A series of studies carried out by Ericsson (Ericsson, 1993), showed that repeatedly practicing a motor skill leads to changes in the brain's neural networks responsible for controlling movement. This process of neuroplasticity can be used explain these results as connections between the neurons become stronger and more efficient, leading to a smoother and more accurate execution of the movement. Later, the work of Rosenbaum (Carmel Mevorach, 2010) further supported this idea as it concluded that repetition of a specific movement led to changes in the neural activity in the primary motor cortex, a region of the brain responsible for motor control.

In addition to these neural changes, muscle memory is also associated with changes in the muscles themselves. Studies carried out by Dudley (G A Dudley, 1991) have shown that repeated exercise leads to an increase in the number and size of muscle fibers, as well as an increase in the number of myonuclei within the muscle fibers. These physical changes are believed to play a role in the muscle's ability to contract with more force and maintain a higher level of endurance.

Furthermore, feedback also helps in the development of muscle memory as found by Schmidt and Lee (Schmidt, 2011). They said that feedback provides important information about the accuracy of the movement and helps to reinforce the correct movement pattern. Relating back to diving off a block, it is feedback from teammates, coaches or internal feel that allow swimmers to improve and have effective muscle memory to assist their dives.

When referring to swimming dives it is clear that multiple repetitions of this movement has allowed many swimmers around the world to develop this area as they develop neuroplastic changes in the brain's neural network as well as changes in the muscles themselves. This repetition assisted with constant feedback could be used to explain the results of the second experiment.

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