Segment speed or segment force, which one is of more value in golf?

Historically in golf segmental speed (angular velocity) has been the accepted measurement of how the body segments (pelvis, ribcage, arm, hand and club) produce and apply speed and this has often been seen by some as the predictor of/correlation to driving distance/ball displacement. However we are now able to provide segment force values through the new information produced by the Bull3D software. This has revealed some fascinating and intriguing patterns and discoveries, one being that when it comes to its influence on driving distance and club head speed, what is of more value, segment speed or segment force? A brief definition of both is:

Speed – time/distance.

Force – mass x acceleration.

I was fortunate recently to test a world long drive champion and like most enthusiasts I was curious to see the values being produced in an attempt to best understand how they achieve such high club/ball speeds and driving distance. On investigation, what came back was very intriguing.

The peak body speeds being produced in the downswing were exceptionally low, however the peak segment forces being achieved and applied were outstanding. Therefore one such question this then prompted is 'what is the value of segment speed in golf?'

In an attempt to best answer this, I looked at all the players I had tested in the past six months and located the player that had the highest segment speeds, on finding these values what was staggering was this particular player produced relatively low club/ball speeds and classified themselves as a short hitter, ironically when I met them one of their main objectives was to achieve greater distance. However speed as an isolated measurement does not acknowledge the mass it is moving and the time it takes to achieve it. Therefore this is why segmental force is perhaps now of more value in golf than segmental speed as force is mass x acceleration (rate of change in velocity) whereas speed is time and distance. We acknowledge that there are many other influences that need consideration, such as the time difference between each segments peak speed, the peak speeds time to impact as well as how well the segments decelerate and interact to move elastic energy cross segment (more on this in the next article). Also, please refer to force definition at the bottom of this article to best understand exactly what we are (and are not) measuring.

The significant difference between these two players is their body mass, the high speed/short hitter weighed 56kg, whereas the long drive champion weighed 120kg, therefore had substantially more mass, plus accelerated it much quicker.

In this very short reflection, below are the speed and force values of these two players, plus the force application plots, you will see how the player who was self-described as a short hitter produces

significantly more peak segment speed than the long drive champion, but substantially lower peak forces. Also, in the force application plots, asides from the club the player with high speeds fails to apply the peak segment force with any segment on impact whereas the long drive champion achieves peak force with all segments on impact, with the slight exception of the thorax which happens just after impact.

This clearly requires significant more exploration and understanding and I will explore and investigate this in much more detail over time and share all findings, however it allows us to ask the question in advance, "in golf what is of more value, segment speed or segment force?" thankfully with the new data available, we are now able to best answer this.

Peak downswing segment speed.

High speeds/short hitter	**World long drive champion**
Pelvis rotation speed 524.8 d/s	Pelvis rotation speed 293.8 d/s
Thorax rotation speed 547.0 d/s	Thorax rotation speed 469.3 d/s
Lead arm rotation speed 883.9d/s	Lead arm rotation speed 654.6 d/s
Lead hand rotation speed 1781.2 d/s	Lead hand rotation speed 1549.2 d/s
Club rotation speed 3053.3 d/s	Club rotation speed 3067 d/s

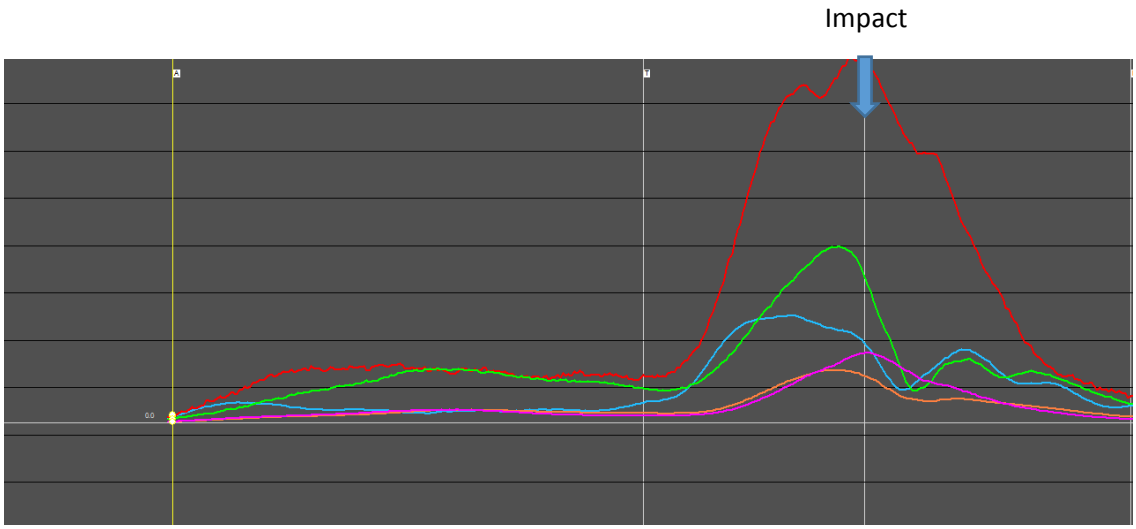
d/s degrees per second

Peak downswing segment force.

High speeds/short hitter	**World long drive champion**
Peak downswing resultant (net)force values	Peak downswing resultant (net)force values
Pelvis 5.5 kgf	Pelvis 9.1 kgf
Thorax 16 kfg	Thorax 21.9 kgf
Lead arm 7.0 kgf	Lead arm 15.0 kgf
Lead hand 2.1 kgf	Lead hand 3.4 kgf
Club 2.4 kgf	Club 4.2 kfg

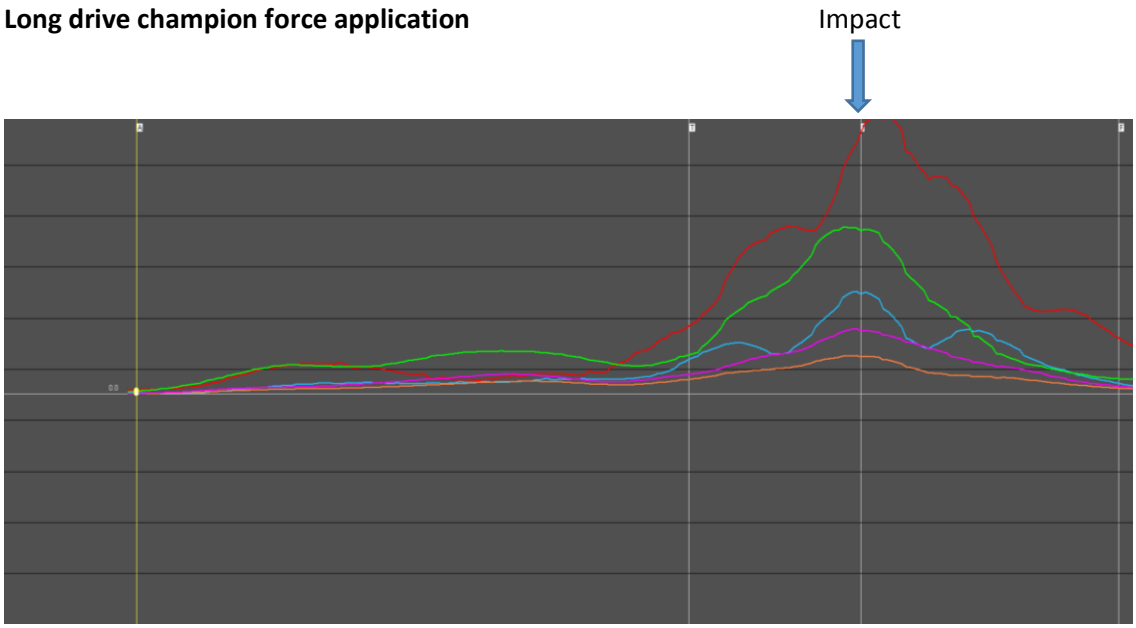
kfg – kilograms of force

High segmental speeds/low forces/short hitter force application



Purple – club, orange – lead hand, blue – pelvis, green – lead arm, red – ribcage

Long drive champion force application



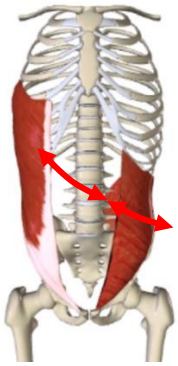
Purple – club, orange – lead hand, blue – pelvis, green – lead arm, red – ribcage

Segmental force definition (thank you to Dr Matt Bridge for his help in producing this definition)

Segmental net force is a measure of the sum of the instantaneous forces acting upon the segment. This includes internal myofascial forces generated both to accelerate the segment but also those that are acting to decelerate the segment. The first of these would increase the total net force and the second decrease it. Alongside this are external forces that act upon the segment such as gravity and air resistance. Adding all these forces together results

in the net segmental force.

It should be remembered that an internal muscular force that acts to accelerate a more distal segment of the body may at the same time apply a force to a more proximal that decelerates it. An example of this is the contraction of the obliques and pull on the associated fascia to accelerate the thorax which at the same time also decelerates the pelvis. This can be seen in the diagram below.



When we consider the force acting on the club the measurement takes into account not only the force that the wrist movement is imparting but also the centripetal force that keeps the club moving in a curved path, the golfer's pull on the club as well as gravity and air resistance.

The peaking of all segmental forces that we see at impact in good players shows the highest total force in the system occurs at that point. It is important to remember through that not all of this force will be applied to the club ball collision.

The net force is the sum of all the forces that may be acting on the body.

What is important to acknowledge is there are many restrictions around calculating force through the use of motion capture as some of the forces that influence segmental and club force we cannot measure through 3D. The mathematical model used to calculate each segments centre of mass is extremely robust however we fully accept and acknowledge there are many limitations around using 3D to calculate force. However based on what we can produce despite hardware limitations, these values provide a good understanding of the resultant force being produced by each segment.

Golf club force.

For the club the forces that are acting on it while in swing, it is important to understand what

forces the club is being subjected to:

1. Force applied by the player in accelerating the club. This force is due to moving of the hand.

2. The force due to gravity on the club mass.

3. The centripetal force responsible for keeping the club moving in a circular/ curved path.

4. The stress and shear on the club shaft.

5. The force/drag on the club due to air and viscosity.

Each of these forces can be acting on the club in different directions. The resultant or sum of these forces is responsible for the acceleration of the club. If all these forces sum to zero the club will not accelerate.

We only measure point one above.

Mark Bull

February 2016.