Biomechanics and biofeedback are transforming our understanding of the golf swing as well as our approach to instruction, practice and physiotherapy. With the help of some extraordinary new 3-D technology, **Dominic Pedler** gave his golf game the ultimate MOT.

What are the VITAL STATISTICS of your golf swing

It's ironic that for all the frantic emphasis on science and technology in so many areas of the golf industry, golf instruction remains widely perceived as an art.

Equipment companies blind us with science, while elaborate launch monitors measure our balll speed down to the last m.p.h. as well as every last RPM of spin and degree of launch angle as the ball leaves the clubface.

Yet few of us ever think of measuring the various components of our actual golf swing, the biomechanical movements of the body that, rather fundamentally, deliver the blow in the first place.

OK, so much of today's golf instruction may look high-tech – and video analysis is obviously a start with slow-motion replays, coloured lines and overlays certainly helping the learning process.

But in terms of the true science of what is really going on in our swing – and especially the vital elements that generate power and consistency – most traditional instruction methods do not give us the true picture.

For as many experts acknowledge, the dynamics of the golf swing are such that many of the most important positions, sequences, speeds and timing nuances cannot be appreciated with the naked eye and, in some cases, even slow-motion video.

"The fundamentals of Hogan states that the kinematic sequence of the golf swing cannot be seen on video and can only be measured in three dimensions," says David Leadbetter, referring to the timing of the unwinding of the lower body, upper body and hands which ultimately deter-

mines clubhead speed.

Hence the rise of cutting-edge, three-dimensional swing analysis technology that uses the principles of biomechanics to address these issues.

"Even the very best teachers cannot accurately assess, using their eyes alone, subtle movements and body orientations during the golf swing," says Rob Neal, whose Golf Biodynamics system is the subject of this feature. "As well as speeds and timing, the bending, tilting and rotation of the pelvis and shoulders, along with head thrusting and hip turn, are just some of the crucial elements that are hard to spot."

Having intrigued a range of top tour stars, including Nick Faldo, Angel Cabrerra and Camillio Villegas, Neal's fascinating system is steadily revolutionizing golf instruction.

As far back as 1985, Neal was among the first golf 'scientists' to recognize that 3-D was the key – not merely viewing the swing in three dimensions but measuring, numerically, the relevant angles, distances and speeds involved for all the relevant positions and movements.

Going far beyond the principles of Alastair J. Cochran's groundbreaking 1968 tome, *The Search For The Perfect Swing*, Neal completed and published his Masters thesis that pioneered biomechanical swing analysis, initially using high-speed film cameras and number crunching that took eight hours to process each player.

Twenty years on, the process has been considerably refined using electromagnetic measuring principles and software that, incredibly, measures your movements in real time and prints out a highly enlightening report for immediate analysis.

As *Golf International* found over the course of two detailed sessions, Golf Biodynamics makes a highly accurate biomechanical assessment of your swing which it presents in terms of several crucial parameters, both static and dynamic. It is not for sale commercially – not least because it requires the careful operation and data interpretation of a skilled teaching professional.

Already in operation at leading US golf schools (including the Jim McLean academies) and golf unions worldwide, it is currently only licensed in the UK to Total Golf Analysis under the guidance of teaching pros, Stewart Corstorphine and Mark Bull.

While currently based at Croydon Driving Range, the portability of the technology means they regularly travel to corporate days and other private sessions, by appointment.

"Biodynamics breaks down the kinematic chain of a player's golf swing, highlighting any inconsistencies in the timing sequence of pelvis, torso and hands necessary to provide the optimal energy transfer through impact," summarises Stewart Corstorphine. "In doing so it also identifies the player's physical limitations, allowing the instructor to devise the training programmes to achieve peak performance."

Once the pro has identified and isolated the areas to work on, the on-board biofeedback facility allows the player to practice by literally 'feeling' the correct positions and movements, in effect turning the system into a glorified training aid [see Biofeedback sidebar].

The accompanying case studies illustrate a typical session on the Golf Biodynamics system under the guidance of Stewart Corstorphine, while we continue below with a detailed look at the technology, how the system was developed and what insights it provides into the nature of the golf swing.

SO HOW DOES THE SYSTEM WORK?

The system effectively creates a computer-generated 3-D model of your golf swing by capturing data on your body positions and movements by means of a simple network of sensors. These are hidden in three lightweight Velcro straps that you wear around your body including one secreted in a headband.

For such an advanced analytical and training tool, the 3-D hardware is surprisingly modest, consisting of just a laptop, a couple of small boxes and a few wires.

A small transmitter mounted behind the golfer creates a weak electromagnetic field which is distorted as you move, allowing your swing to be tracked and mapped according to the path and orientation of the sensors throughout the time from address to follow-through.

Via a larger wire (that forms a tethered 'tail' that unobtrusively links the golfer to the hardware), the sensors feed a 'smart box' that converts the information into numerical data that the Golf Biodynamics software then interprets and compares to an ideal 'model' swing.

The figures (as well as slow-motion, 3-D robot images viewable from any angle) appear immediately on the laptop screen for instant analysis by the instructor.

WHICH PARTS OF THE SWING DOES THE SYSTEM MEASURE?

As shown by the various data boxes in the case studies, the system covers a full checklist of vital statistics for everything from your alignment at address, through to the crucial rotations on your backswing, and the movement of hips, shoulders and hands on the downswing.

Meanwhile, the 3-D nature of the system is ideal for more subtle torsional dynamics between the hips and trunk, including the mysterious X-Factor and X Factor 'Stretch' that instructors acknowledge are among the secrets to distance (see below).

WHAT ARE THE 'CORRIDORS' REFERRED TO FOR EACH SWING PARAMETER?

When comparing your swing to the ideal model for your age and sex, the system allows a margin error for each parameter according to the acceptable average range, or "corridor", of the tested data collected in the databank over the years.

This was compiled initially measuring the swings of some 75 top pros on the Australasian and European Tours. Six of the leading Australian coaches and teaching professionals were then asked to rank these golfers on their ball-striking ability. The averages of the top-10 male and female golfers were used as the starting point in an 'optimization' software programme, written by Rob Neal and adjusted to maximise power and consistency while also minimizing injury risk.

The resulting 'corridors' reflect the average variability of the data of the ten best ball-strikers and confirm that, in practice, there is no 'perfect swing' in terms of precise numerical values for every element of the swing, but rather an acceptable range.

Golf Biodynamics has now measured over 250 pros worldwide and found that 75 per cent of them fall within these corridors. Meanwhile, their experience with 5,000 amateur golfers confirms that, the better the player, the closer they are to the stated corridors.

WHAT DOES THE SYSTEM REVEAL AS TO THE NATURE OF THE SWING?

Rob Neal's research has helped him identify the key characteristics required for an efficient golf swing, and helped him home-in on the most important factors that distinguish tour pros from amateurs.

In particular, he has devised the software to make the distinction between *positional* parameters, which capture physical positions and rotations; and the dynamic, *kinematic* variables, that cover the speed and acceleration of the various body segments.

Starting with the positional parameters (such as a well-rotated body at impact), Neal explains that 3-D analysis confirms that the swings of top players invariably feature a good X-Factor and X-Factor 'Stretch'.

THE MYSTERIES OF X-FACTOR AND X-FACTOR 'STRETCH'

These terms have cropped up in our instruction pages over the years but, given that they can only be measured in 3-D, are worth reviewing again here.

First used by US instruction legend, Jim McLean, in the early 1990s, they refer to the relative rotation of the shoulders and the hips, specifically the amount by which the shoulders rotate *beyond* the hips.

"Research shows that the size of this angular differential is significant at two particular points in the swing," explains Neal. "Firstly, at the top of the backswing when the hips complete their rotation; and, secondly, when that differential attains its maximum [which, in good golfers, occurs about halfway through the downswing]."

Hence, X-Factor and X-Factor 'Stretch' are the values at these two points, with a high figure for the latter (as typically found in good players) reflecting the amount of 'lead-out' that the hips gain on the shoulders as the swing unwinds.

BIOFEEDBACK THE ULTIMATE TRAINING AID?

As well as analyzing your swing and instantly identifying the areas to work on, the Golf Biodynamics system also includes a novel audio biofeedback feature that greatly speeds up the learning process by ingeniously helping you 'feel' the correct positions and movements.

The coach first chooses a particular swing parameter and assigns a range of values that represents an appropriate margin of error within which to work.

The golfer then uses this to move himself into the correct positions as confirmed by a constant audible 'beep' tone from the computer. Moving outside this 'corridor' will interrupt the signal, with the silence immediately alerting the golfer that he has deviated from the desired position or movement.

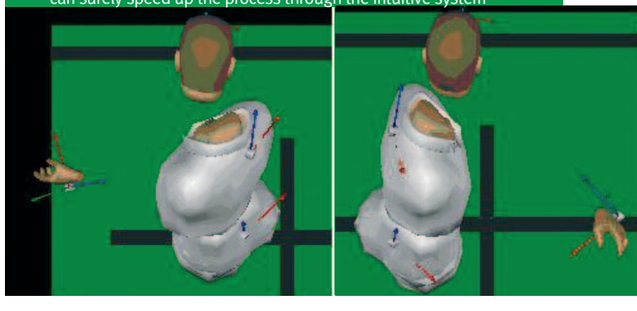
As mentioned in our case studies, Jake and I used it to work on several areas, in both a static (address) and dynamic (backswing and downswing) context. It instantly cured my open-shoulder stance and pelvic tilt at address, as well as the extra head-sway needed when loading up on the backswing. It also gave me a clear indication of my tendency to lower my head through impact and a guide to the acceptable margins.

The same device can be directed to even the more subtle swing elements, with Jake, in particular, able to improve his backswing hip turn and appreciate the more aggressive angle of hip *tilt* required through impact.

Sure, there are a proliferation of 'feel'-related training aids on the market these days, ranging from huge circular swing-plane wheels, to mirrored floors and laser-equipped visors. But the beauty of this type of biofeedback is that you can assign it to any part of the swing at the touch of a button.

The only downside is that, being an integral part of the Golf Biodynamics package, which requires expert guidance, you can't take it home with you.

The saying goes that it takes 10,000 repetitions to achieve muscle memory and make a move automatic. But biofeedback can surely speed up the process through the intuitive system



THE IMPORTANCE OF THE 'TRANSITION' PHASE

Such nuances have led Neal to call for a standardisation in the way we view the different phases in the golf swing. While most of us talk of backswing, downswing and follow-through, Neal likes to include a 'transition' phase that captures some of the most subtle secrets of power.

His point is that the shift from backswing to downswing does not occur at one instant in time, but over a phase between the top of the backswing (as defined by the point when the hips reach their maximum rotation) and the start of the downswing (when the clubhead changes direction).

[NOTE: Neal actual refers to "minimum" [rather than maximum] rotation to refer to this point when the hips are most 'closed', or turned to the right in a right-handed golfer.]

"The shoulders are often still rotating at this point," he says introducing the notion of 'Stretch'. "While the hips further increase the differential with the shoulders as they start to accelerate rapidly towards the target and initiate the weight transfer. Only then do the shoulders begin their rotation as the downswing starts, thereby closing the gap with the hips".

BEYOND THE X-FACTOR: SPEED, ACCELERATION AND TIMING

While the X-Factor figures emerge as important parameters in the quest for power and distance, they are not in themselves the Holy Grail of extra yardage.

"Just having large X-Factor numbers is no guarantee of great distance," warns Stewart Corstorphine. "There are plenty of very flexible golfers with high X-Factors who don't necessarily hit the ball a long way. It's about creating that differential at the most efficient point in the swing - and, equally, being physically able to 'close it down' efficiently. That's what maximizes power."

This brings us to the second main area that Golf Biodynamics can quantify. The efficiency of a golfer's kinematic sequence in terms of the speed, acceleration and timing of the hips, shoulders and hands on the downswing.

These factors are impossible to grasp without a quantitative measuring device, but this system now gives an immediate insight into the mechanical efficiency of the body movements, as well as the power produced during the downswing.

"These higher order kinematic variables help us quickly distinguish tour pros from their amateur counterparts, while the body's ability to recoil after stretch is an important part of the picture, too," says Neal, referring to his latest research into the contraction of the trunk's rotational muscles (which we hope to bring you in due course).

BIOMECHANICS AND A GOLFER'S PHYSICAL LIMITATIONS

Talking of physiological factors in the quest for power, such 3-D systems demonstrate how biomechanics is also transforming our understanding of physiotherapy, training and injury prevention.

"A person's optimal swing is dictated by their levels of strength, flexibility, power, control and coordination," says Neal. "It makes no sense for a player to be told to move in a certain way if they do not have the physical capability."

Biomechanics therefore helps instructors identify why a player cannot perform a certain element of the golf swing properly.

The principle was an important point of discussion during the case studies for both myself and Jake Ulrich, who were both recommended for the full musculoskeletal screenings devised by the *Golf Athlete* concept, a complete physio treatment and exercise plan customised for golfers.

Indeed, in following this up, I was suitably impressed by the *Golf Athlete* CD ROM, and an initial discussion with PhysioActive, in South East London, with whom Total Golf Analysis work closely.

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HITS AND MYTHS

By measuring precisely what a golfer does throughout this swing, biomechanical swing devices have helped dispel many myths about the nature of the golf swing and thereby settle a few scores (even between golf teachers).

In particular, the Golf Biodynamics corridors based on closely observed 'perfection' have proved a wake-up call for the few eccentrics who still insist, for example, that the head does not move during the swing; or that the address position closely resembles the impact position; or that the upper body initiates the transition to the downswing; or that the spine angle remains constant during the swing.

Golf magazines, in particular, better be on their guard.

"I read recently that an average golfer could immediately get an extra 20 yards by using their arms and hands to initiate the downswing – rather than the legs and proximal body parts," says Neal. "This idea is incorrect since the greatest amount of energy and consistency is generated by the large muscles of the body, not the small ones," he corrects.

One day, such 3-D biomechanical analysis systems will probably be commercially available – especially given the training benefits of the biofeedback facility that would surely revolutionise home practice.

Currently, though, the system requires a high degree of skill and training to both operate and interpret the information.

Meanwhile, as with any revolutionary development, there is inevitably scepticism in some quarters, with some club pros apprehensive about any new technology which demands a steep learning curve to offer effectively to their pupils.

Yet, as Stewart Corstorphine confirms, biomechanics is ultimately not about altering the fundamentals of golf instruction, merely a way of taking it to a new level by refining our information about a player's swing.

"We are not trying to replace existing coaching skills or methods – merely to complement them, and help pros deliver a 21st Century teaching service".

FOR FURTHER INFORMATION:

Golf Biodynamics is among the technology used by Total Golf Analysis, based at Croydon Golf Driving Range,

CASE STUDIES

...using the Golf Biodynamics system
WITH TOTAL GOLF ANALYSIS

The case studies involved both myself and fellow golf technology enthusiast, Jake Ulrich, as willing subjects under the guidance of PGA pros, Stewart Corstorphine and Mark Bull of Total Golf Analysis, (currently the sole UK licensee of the Golf Biodynamics technology).

The following summaries are examples of what to expect from a typical 1.5-hour session, consisting of an introductory analysis and lesson – even if our particular swing highlights (and lowlights) will obviously differ from your own. Indeed, while Jake and Dominic are both mid-handicappers, their respective reports illustrate how each have their own individual swings, and needed to work on different areas.

Setting Up

After an introductory chat about our game and our goals we were wired up in turn to the system by means of three lightweight Velcro straps which contain the sensors which transmit the data to the computer.

This takes just a couple of minutes, and while you are then tethered via a thick wire 'tail' to the hardware, it provides virtually no restriction and within a few swings you are oblivious to it.

After a few more 5-iron shots to get re-focused, the computer was then recalibrated and ready to 'read' the data coming from each shot. Half-a-dozen agreed decent strikes are usually sufficient to compile the first report which Stewart and Mark use to complement and their conventional coaching expertise.

For those with arithmophobia, each report is rather like a full blood count on BUPA, with a numerical value for each swing component listed with reference to a range (or "corridor") representing acceptable extremes based on a pre-calibrated 'model' golf swing for your age and sex.

Reports were prepared for both the initial assessment and then again after some instruction and biofeedback work, allowing for the following 'before and after' comparisons.

TECHIE TRIVIA: SYSTEM ACCURACY AND 'DEGREES OF FREEDOM'

When measuring a player's swing, Golf Biodynamics claims that their numbers are accurate to 1 degree and 1 centimetre, enough to enable a meaningful analysis in every parameter.

The future of such systems is surely 'wireless', offering the player total freedom of movement rather than the 'tethered' design we are focusing on. But wireless systems are currently mostly only accurate to some 5 cms – a margin of error which can make all the difference between a good and a bad movement, especially on the more subtle parameters like head sway and hip rotation.

Similarly, as the market for such biomechanical devices increases, it is important is to ensure that the 3-D system you choose operates within a spatial field of six 'degrees of freedom of movement' – and not just three.

Technically-minded golfers will appreciate the vital distinction.

To capture the full dynamics of the golf swing in 3-D requires the measurement of both linear movement (i.e. the position of the relevant body part within the three axes of a typical XYZ coordinate scale); and also its orientation in terms of how this same body part rotates about these same axes.

These six parameters (three translations and three rotations) are known as the 'degrees of freedom of movement' (DOF)

The Golf Biodynamics system is capable of measuring all six DOFs, while some 'wireless' systems (with sensors using rival technology like gyroscopes, magnetometers, accelerometers and inclinometers) do a good job of measuring only the three rotational DOF.

Of course, by ignoring the linear movement of the sensor they also crucially, fail to capture any forward/backward, up/down and sideways movements of the body.

Polhemus, the company that produces the 'tethered' version of the Golf Biodynamics system, is currently working on a portable, six DOF wireless version of its electromagnetic system, capable of working in virtually all environments (see www.polhemus.com).

Meanwhile, this magnetic field principle is just one of the methods being explored by biomechanics-based golf swing scientists.

Rival systems include the light and laser principles of Biomeca, and Taylor Made's MATT-i (Motion Analysis Technology).

While these are undoubtedly impressive alternatives that readers should also consider, the beauty of the Golf Biodynamics is its simplicity of set up, its flexibility and portability that allows it be used anywhere, indoors or outdoors.

GOLF BIODYNAMICS
swing excellence through 3D technology

NAME: JAKE ULRICH OCCUPATION: BUSINESS EXECUTIVE
AGE: 52 MASS: 205 LBS HEIGHT: 72" HANDICAP: 16 CLUB: THE WISLEY, SURREY

CASE STUDY 1

INITIAL ASSESSMENT

Despite the many positive areas of his swing, Jake admits to an inconsistent shot pattern and a relatively weak ball trajectory. This is caused by an angle of approach that is too steep, with an out-to-in swing path and an incorrect timing sequence in his downswing resulting in poor energy transfer.

In his attempt to solve this problem, Jake aligns his lower body to the right of his intended target [hips some 2-degrees closed] to enable a greater turn of his torso and a 'flatter' hand path and shaft plane. This limits his ability to load his weight sufficiently into his right side in his backswing, and to initiate his downswing with the optimum sequencing.

The transition should ideally be initiated from the ground up, with the feet leading the knees and hips, followed in turn by the torso, arms, hands and, finally, clubhead.

In Jake's case, the hips are loaded too much into his left side in his backswing, and they then move away from the target (instead of slightly towards it) in transition. In effect, a 'reverse pivot' of the lower body.

As a result of Stewart and Mark's analysis, Jake was prescribed the following plan, which he started in the same session.

STRATEGY FOR JAKE

1. Biofeedback work on lower-body alignment and forward bend of the pelvis.
This would help control his hand-path and arm/body connection in his backswing and encourage a better trunk rotation. While Jake immediately felt the correct position and made improvements during the session, this was the only area in which he 'reverted to type' during the final data collection [hips still closed (-2 to -4 degrees) and pelvic tilt too high at 21 degrees].

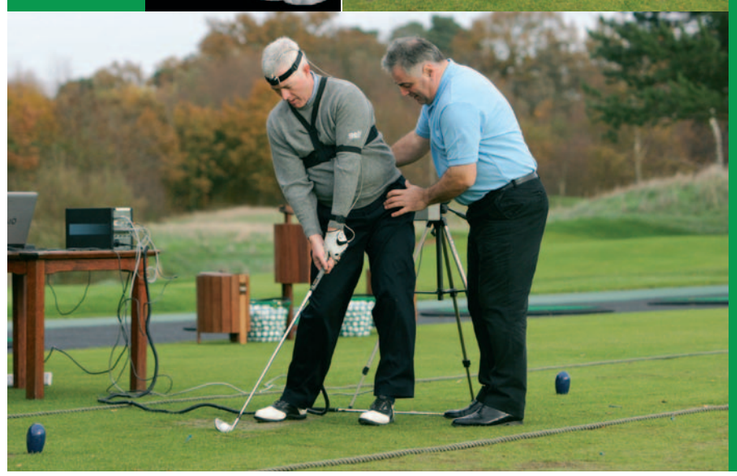
2. Biofeedback work on head sway
Jake needed another two inches of lateral movement during the backswing to promote a better loading of weight into the right side. The second report confirms an immediate improvement from 2.5 inches [outside the corridor] to 4 inches [comfortably inside]. There is also a welcome increase in X-Factor 'Stretch', suggesting an improvement in distance potential.

3. Biofeedback work on hip tilt
A correct lower-body separation in transition is vital, with a small lateral lower-body 'bump' helping to trigger the downswing. This should prompt a shallower hand-path and allow the clubhead the correct attitude at impact.

Indeed, Jake's hip tilt improved dramatically during the session, from a low 5 degrees to an excellent, mid-corridor 12 degrees. It was also accompanied by improvements in the downswing rotations of hip, shoulder and head.

Similarly, his second report shows a dramatic improvement in body speeds – for each of hips, shoulders and hands – and a corrected timing

3D GOLF BIODYNAMICS SWING ANALYSIS



BEFORE

1. Jake you have some very sound set up foundations, a touch less forward bend off your pelvis is needed
2. We need to establish what range of trunk flexibility you have but around 2 inches more head sway is needed in your backswing
3. Your body is under rotating through impact, biofeedback work on your hip tilt will assist you in this.

SETUP FOUNDATIONS

Alignment	Corridor	You
Hips	0 to 8°	-2 Closed
Shoulders	5 to 12°	6 Open

Hips slightly closed

Bending	Corridor	You
Hips	12 to 20°	21 Forward
Shoulders	35 to 45°	40 Forward
Head	30 to 50°	43 Forward

Pelvis too tilted upwards, forming an arch in the lumber spine that restricts backswing rotation

Tilting	Corridor	You
Hips	0 to 3°	0 Right
Shoulders	7 to 13°	8 Right
Head	0 to 10°	0 Right

BACKSWING

Rotations	Corridor	You
Hip Turn	-40 to -52°	-49 Closed
Shoulder Turn	-85 to -95°	-92 Closed
X-Factor	-40 to -50°	-44 Closed
X-Factor Stretch	-10 to -25°	-4 Closed
Head Turn	-20 to -40°	-15 Closed

Stability	Corridor	You
Head sway	3 to 4.5"	2.5 Away
Head lift	-1.5 to 0.5"	-1.4 Down
Head thrust	-0.5 to 0.5"	0.4 Forward
Head drop	-1.5 to 0.5"	-1.4 Down

ALL STABILITY AT ADDRESS TO TOP

Two inches of additional head sway needed to load up right side

DOWNSWING

Impact Zone	Corridor	You
Hip Turn	25 to 45°	18 Open
Shoulder Turn	25 to 50°	9 Open
Head Turn	10 to 40°	-12 Closed
Hip Tilt	10 to 45°	5 Right

Spine Angle Control	
Head Drop	-2.5 to 0.5" -1.2 Down
Head Thrust	-0.5 to 0.5" 0.2 Forward

Body and head under-rotated implying low weight transfer and insufficient turn through impact
Hip tilt too low (left hip not high enough for effeciant weight shift).

Body Speed	Corridor	You
Hips	380 to 550°	370
Shoulders	480 to 700°	590
Hands	17.9 to 21.5°	24.7

Hip speed too low due to insufficient hip 'lead out' on the downswing.

Timing Sequence
ORDER THAT PEAK SPEEDS OCCUR IN DOWNSWING

	Hips	Shoulders	Hands
Ideal	1	2	3
5-Iron	1	3	2
Driver	0	0	0

Incorrect timing sequence: the shoulders should lead the hands

AFTER

1. Jake, some awesome improvements in such a short space of time.
2. Head sway/pelvic tilt/hip speed and timing sequence are much improved, well done.
3. You still need to allow your head to rotate the target through impact.

SETUP FOUNDATIONS

Alignment	Corridor	You
Hips	0 to 8°	-4 Closed
Shoulders	5 to 12°	7 Open

Bending	Corridor	You
Hips	12 to 20°	21 Forward
Shoulders	35 to 45°	37 Forward
Head	30 to 50°	36 Forward

Needs further biofeedback to 'feel' the correct position

Tilting	Corridor	You
Hips	0 to 3°	0 Right
Shoulders	7 to 13°	10 Right
Head	0 to 10°	0 Right

BACKSWING

Rotations	Corridor	You
Hip Turn	-40 to -52°	-50 Closed
Shoulder Turn	-85 to -95°	-91 Closed
X-Factor	-40 to -50°	-42 Closed
X-Factor Stretch	-10 to -25°	-7 Closed
Head Turn	-20 to -40°	-15 Closed

Improved head sway has also helped increase X-Factor Stretch

Stability	Corridor	You
Head sway	3 to 4.5"	4.0 Away
Head lift	-1.5 to 0.5"	0.1 Down
Head thrust	-0.5 to 0.5"	-0.4 Forward
Head drop	-1.5 to 0.5"	-1.0 Down

ALL STABILITY AT ADDRESS TO TOP

Much improved head sway following biofeedback

DOWNSWING

Impact Zone	Corridor	You
Hip Turn	25 to 45°	33 Open
Shoulder Turn	25 to 50°	21 Open
Head Turn	10 to 40°	-10 Closed
Hip Tilt	10 to 45°	12 Right

Spine Angle Control	
Head Drop	-2.5 to 0.5" -4.1 Down
Head Thrust	-0.5 to 0.5" 0.3 Forward

Much improved body position at impact (more open) - though head still hanging back.
Hip tilt greatly improved and now in corridor

Body Speed	Corridor	You
Hips	380 to 550°	431
Shoulders	480 to 700°	604
Hands	17.9 to 21.5°	23.9

Body speeds much improved

Timing Sequence
ORDER THAT PEAK SPEEDS OCCUR IN DOWNSWING

	Hips	Shoulders	Hands
Ideal	1	2	3
5-Iron	1	2	2
Driver	0	0	0

Timing sequence now corrected

KEY BLUE : WITHIN THE CORRIDOR | YELLOW: JUST OUTSIDE THE CORRIDOR | RED : WELL OUTSIDE THE CORRIDOR

GOLF BIODYNAMICS
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CASE STUDY 2

NAME: DOMINIC PEDLER OCCUPATION: GOLF JOURNALIST
AGE: 47 MASS: 180 LBS HEIGHT: 72" HANDICAP: 12 CLUB: ROEHAMPTON, LONDON

INITIAL ASSESSMENT

Given his history of back trouble, Dominic's prime issue is the efficiency of his swing in terms of minimizing the pressure on his neck and lumbar spine. His body speeds are sound, as are his timing sequences; but it is important that he does not put his lumbar and neck under excessive strain.

The initial assessment showed Dominic's torso to be aligned some 8-degrees too far too far left of target (open), and tilted too much to his right. His pelvis was also 'tucked under', making him some 3-degrees too upright and losing the neutral curves of his lower spine.

In the backswing, his torso did not move into his right side sufficiently, with his head staying very still.

In transition, however, there was a large loss of head height, restricting his stretch, pelvic tilt and body rotations through impact.

STRATEGY FOR DOMINIC

1. Biofeedback on shoulders position and pelvic bend

Our first task was to develop a more neutral position in which to initiate his backswing. With biofeedback Dominic immediately 'felt' the correct positions and, by the second report, had retained his 'squared up' shoulders (in both planes) and similarly adjusted his spinal tilt [from 9 to 13 degrees] into the correct corridor.

2. Biofeedback on head sway

Like Jake, Dominic needed to increase his head sway by around two inches, to put his body in a better position to start the downswing and also reduce strain on his lower back. He, too, made an immediate improvement into the corridor [from 1.8 to 4.1 inches].

3. Biofeedback to monitor head height

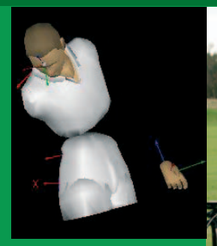
Dominic was dropping his head by some 5.7 inches in the downswing. Reducing this by a couple of inches would help him clear his hips and trunk more efficiently through impact.

It would also increase his pelvic tilt and minimise the compression in the lower back through impact when the forces are at their greatest.

The slight improvement at the end of the session [5.1 inches] is a start, but not enough, and requires further work.

Dominic also needs to work on head roatation. The initial improvement from -9 to -12 degrees was encouraging, but only takes him to the lower end of the ideal corridor.

3D GOLF BIODYNAMICS SWING ANALYSIS



BEFORE

1. Dominic, you have some great attributes to your swing, however you need to pay more attentionto the alignment of your shoulders which at present are too open and your pelvic bend where you need to be slightly more butt out.
2. Biofeedback work will assist you in increasing your head sway in your backswing. This will allow you to create a more effecient weight transfer in your downswing and place your lumbar spine under less pressure.

SETUP FOUNDATIONS

Alignment	Corridor	You
Hips	0 to 8°	3 Open
Shoulders	5 to 12°	17 Open

Shoulders too open

Bending	Corridor	You
Hips	12 to 20°	9 Forward
Shoulders	35 to 45°	38 Forward
Head	30 to 50°	42 Forward

Pelvis too tucked under. Needs to be more neutral to allow effecient rotation.

Tilting	Corridor	You
Hips	0 to 3°	0 Left
Shoulders	7 to 13°	14 Right
Head	0 to 10°	8 Right

Shoulders tilted too far to the right

BACKSWING

Rotations	Corridor	You
Hip Turn	-40 to -52°	-44 Closed
Shoulder Turn	-85 to -95°	-92 Closed
X-Factor	-40 to -50°	-47 Closed
X-Factor Stretch	-10 to -25°	-4 Closed
Head Turn	-20 to -40°	-25 Closed

Stability	Corridor	You
Head sway	3 to 4.5"	1.8 Away
Head lift	-1.5 to 0.5"	0.6 Up
Head thrust	-0.5 to 0.5"	1.2 Forward
Head drop	-1.5 to 0.5"	-0.3 Down

ALL STABILITY AT ADDRESS TO TOP

Head too central. Need extra 2 inches of lateral sway to help load weight into right side.

DOWNSWING

Impact Zone	Corridor	You
Hip Turn	25 to 45°	34 Open
Shoulder Turn	25 to 50°	27 Open
Head Turn	10 to 40°	-6 Closed
Hip Tilt	10 to 45°	8 Right

Head under-rotated. Needs to follow hips and shoulders for effecient release and to reduce pressure on lower back.

Spine Angle Control		
Head Drop	-2.5 to 0.5"	-5.7 Down
Head Thrust	-0.5 to 0.5"	-1.8 Backward

Too much head drop. Needs consistent height to allow spine to be more neutral relative to pelvis

Body Speed	Corridor	You
Hips	380 to 550°	429
Shoulders	480 to 700°	601
Hands	17.9 to 21.5"	25.5

Good body speeds - if anything hands too fast

Timing Sequence
ORDER THAT PEAK SPEEDS OCCUR IN DOWNSWING

	Hips	Shoulders	Hands
Ideal	1	2	3
5-Iron	1	2	2
Driver	0	0	0

Correct timing sequence

AFTER

1. Dominic, since your last visit you have made some great improvements in hip bend, shoulder alignment, body tilts and head sway. However, in acheiving this your hips have become slightly closed.
2. You are standing a touch too far from the ball at address with your torso and head excessively forward bent. Just stand a touch closer and taller.
3. To allow your body to clear more effectiently we need to perform biofeedback work on your head height. Presently you are losing over 5 inches of height through your torso in transition. Allow your head to rotate more freely through impact.

SETUP FOUNDATIONS

Alignment	Corridor	You
Hips	0 to 8°	-3 Closed
Shoulders	5 to 12°	8 Open

Much improved shoulder alignment. though correction has slightly closed the hips

Bending	Corridor	You
Hips	12 to 20°	13 Forward
Shoulders	35 to 45°	46 Forward
Head	30 to 50°	50 Forward

Pelvic tilt much improved now at lower end of correct scale.

Tilting	Corridor	You
Hips	0 to 3°	2 Right
Shoulders	7 to 13°	11 Right
Head	0 to 10°	3 Right

Squaring up torso (above) has also returned body tilt to the correct corridor

BACKSWING

Rotations	Corridor	You
Hip Turn	-40 to -52°	-45 Closed
Shoulder Turn	-85 to -95°	-98 Closed
X-Factor	-40 to -50°	-54 Closed
X-Factor Stretch	-10 to -25°	-5 Closed
Head Turn	-20 to -40°	-29 Closed

Stability	Corridor	You
Head sway	3 to 4.5"	4.1 Away
Head lift	-1.5 to 0.5"	1.1 Down
Head thrust	-0.5 to 0.5"	-0.2 Forward
Head drop	-1.5 to 0.5"	-0.3 Down

ALL STABILITY AT ADDRESS TO TOP

Improved head sway allows greater loading into right side for effecient weight transfer

DOWNSWING

Impact Zone	Corridor	You
Hip Turn	25 to 45°	27 Open
Shoulder Turn	25 to 50°	22 Open
Head Turn	10 to 40°	10 Closed
Hip Tilt	10 to 45°	11 Right

Much improvement: yet now only at very lower end of corridor

Spine Angle Control		
Head Drop	-2.5 to 0.5"	-5.1 Down
Head Thrust	-0.5 to 0.5"	-1.8 Backward

Slight improvement though still outside corridor. Needs further biofeedback

Body Speed	Corridor	You
Hips	380 to 550°	416
Shoulders	480 to 700°	602
Hands	17.9 to 21.5"	24.9

Timing Sequence
ORDER THAT PEAK SPEEDS OCCUR IN DOWNSWING

	Hips	Shoulders	Hands
Ideal	1	2	3
5-Iron	1	2	3
Driver	0	0	0

KEY BLUE : WITHIN THE CORRIDOR | YELLOW: JUST OUTSIDE THE CORRIDOR | RED : WELL OUTSIDE THE CORRIDOR