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Golf performance a review of resent researches

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Abstract:

Golf is seen as a good candidate for the increasingly widespread sport-health approach. It is a sport where one comes alternately to perform phases of endurance and dynamic. Indeed, on a course, the golfer must walk about 10 km in 4 hours and achieve a variable number of swings depending on the technicality and skills of the golfer. Swing, the key movement of golf, is made to cover long distances to the ball, generally in the order of 200 m for a first shot. To analyze it, it is common to break it down into 4 phases: the address, the preparation phase of the movement, the backswing when you arm the club backwards, the downswing phase where you accelerate the club to impact and the follow-up phase through which one comes to slow down the club.

Keywords: Golf, swing, performance, club

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Introduction

Golf is a very popular sport worldwide: approximately 60 million people play it regularly (Farally et al. 2003).

Despite this aspect, more than 1,200 people are listed as professional players in France and play in international tournaments. The motivations of these two populations are not the same: a simple hobby for some, it is a profession for others. However, many have this desire to improve their performance. The challenge is to support them so that this is not done to the detriment of their health.

In many ways, golf is seen as a good candidate for the increasingly popular sport-health approach. Since the French government authorized doctors to prescribe sport as a therapeutic means, the problem is now to identify which sport is to be prescribed and to whom. And despite numerous scientific and medical studies on the subject, learned societies still seem far from having solved this problem. **(Bouchareb, 2018.p88)**

Golf is a sport where you come to alternately perform endurance phases and dynamic phases. Indeed, on a course, the golfer must walk about 10 km in 4 hours and perform a variable number of swings depending on the technicality and skills of the golfer. The swing, a key movement in golf, is performed to make the ball travel long distances, commonly around 200 m for a first shot. To analyze it, it is common to break it down into 4 phases: the address, the movement preparation phase, the backswing when you arm the club backwards, the downswing phase where you accelerate the club until the impact and the follow-through phase where we come to slow down the club. The swing is crucial: losing a few meters will force the golfer to make an extra shot but also to have a lack of orientation. At this distance, a 5° orientation error on impact leads to a deviation of almost 20 m from the target. Thus, concentration during the movement, self-control, but also proprioception become essential for the proper execution of this movement. We can see the execution of a golf course, completed in 3-4 hours, as a succession of



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endurance phases then dynamic phases requiring power as well as concentration and proprioception. In short, a complete sport.

A complete sport that has aroused the interest of the scientific community

Golf and injuries

In their review of the literature, Murray et al. showed that practicing golf improved the physical and mental health of players (Murray et al. 2016). Beyond the purely physical aspect of sport, the interactions between players, habits, encounters, etc., also have a positive role in mental health and well-being.

Some doctors recommend playing golf after chronic low back pain (**Ribaud et al. 2013**), or even for resuming physical activity after a total hip prosthesis operation (**Swanson et al. 2009**).

However, a recent study by Perron (Perron et al. 2016) showed, in a French population, that an injury or pain appeared every 500 hours of play, mainly in the lower back. These pains are the leading cause of career interruption for professional players (McHardy et al. 2016). This type of pain can appear following a lower range of motion in the lumbar region (Gluck et al. 2007) but also in the hips (**Lindsay et al. 2014**).

More generally, it has been shown that these pains or injuries appear during or following the swing, in particular due to poor warm-up – or even lack thereof – or following excessively intensive training sessions. To sum up, golf seems like a good candidate to be a lifelong sport; however, currently, we suffer from a lack of understanding of the associated biomechanics to know to what extent its practice will be beneficial or, on the contrary, will induce pain or injury.

Thus, the problem currently investigated by many researchers around the world is to increase the understanding of the biomechanics of the swing to allow the practice of golf while minimizing the risk of injury.

However, what does this mean concretely? Where are we currently in terms of research in the field? What can be measured in the laboratory? Can we have the same information directly in the field?



Image showing the percentage of the most common injuries in Golf

Hand/Wrist

Wrist pain does not usually occur due to the repetitive nature of the golf swing but more often it is injured acutely during the swing. This can happen when you accidentally hit the ground too hard during your swing or hit a tree root that you didn't



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know was there. The impact of the club on your hand and wrist can cause anything from a sprain or even a fracture of a hand or wrist bone. Always make sure you move your ball away from any hazards and into a safe spot free of sprinklers, tree roots and rocks. Rest, ice and possibly splinting can help this type of injury. If the injury persists it is important to seek help from an orthopedic hand/upper extremity specialist.

Elbow

A very common golfing injury in the elbow is called medial epicondylitis, or **‘golfer’s elbow.’** This occurs due to the repetitive use of the flexor tendons in your forearm during each swing. This causes a tendinitis on the inside aspect of your elbow. This can be extremely painful and if it occurs, you should refrain from golfing until the pain is gone. Rest, ice and anti-inflammatory medications should be utilized and if the injury does not improve, evaluation by an orthopedic specialist should be considered. They might supply you with a brace or send you for physical therapy. Occasionally, steroid injections are performed to help with the pain. Rarely surgical intervention is necessary. You can try to prevent this type of injury by slowing down your swing, loosening your grip on the club and loosening your elbows during your swing.

Shoulder

Shoulder pain is common in golfers due to the large range of motion required for a golf swing and the repetitive jolt on the shoulders when divots are made. Rotator cuff tendinitis or ‘impingement syndrome’ are common and occasionally a rotator cuff tear can occur. An acute rotator cuff tear is rare while golfing, but a degenerative tear can occur due to the repetitive nature of the golf swing. To prevent shoulder injuries during golf you can maintain your shoulder flexibility and range of motion as well as upper extremity strength. Slowing down your swing and possibly decreasing your back swing range of motion or flattening your back swing can also help decrease shoulder pain. If these suggestions do not help, rest is the next step as well as following up with an orthopedic specialist. Physical therapy and



injections are possibilities to help with shoulder pain. Surgery is also an option if all conservative measures do not alleviate the pain.

Although it may seem like your upper body does most of the work in golf, your back and lower extremities take a lot of the stress also.

Back pain

Back pain is the most common golf injury and sidelines a lot of golfers, both professional and casual golfers. The posture of a golfer and high-velocity of his/her swing along with the twisting motion performed puts a lot of stress on the lower back. Back injuries can range from muscle strain to muscle spasms to things like disk herniation causing leg numbness/pain/tingling. Proper swing mechanics is extremely important to prevent back pain. It is vital to try and keep your back flexible and loose. Warming up prior to playing is very important. Lessons on swing mechanics might be in your best interest if you experience back pain while golfing. Also make sure you use your legs when you lift your golf bag and bend at the knees (not back) when you pick up your ball. As with most injuries, rest and anti-inflammatory medications can help with your back pain. If rest and medications do not work, you should come see one of our spine specialists to take a closer look at you. They may prescribe you stronger anti-inflammatory medications, steroids or physical therapy.

Knee pain

Although the knees do not take much stress during the golf swing, any underlying disease can be aggravated during a round of golf. Occasionally an acute injury to the knee can occur from your spike getting stuck in the ground and quick rotation of your swing. This motion can cause a meniscal tear. Knee arthritis can flare during golf, especially if you walk the course. In order to prevent knee pain, you can try



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switching to golf shoes without spikes to decrease the torque on your knees during your swing. You should also consider using a golf cart if you have underlying knee pain. Again, as previously stated slowing down your swing can decrease the stress on your knees, as well as most joints. If you have underlying knee pain, pre-treating with anti-inflammatories prior to playing golf can help reduce the pain. If this is an acute knee injury that does not improve with rest, ice and medication, seeking advice from an orthopedic specialist would be the next step. They may offer stronger anti-inflammatory medication, bracing and/or steroid injections.

If you experience any of the above injuries, or any other injury while golfing, call our office at 412-782-3990 and schedule an appointment with one of our orthopedic specialists. We would be happy to help you get back to the game you love. **(Bethany wink, 2017)**

Performance in golf

Before improving the performance, it is necessary to define it. By definition, a more successful golf player is a player who manages to complete his course in fewer strokes than his competitors. For this, the player must analyze the field, the weather conditions, choose the right club according to the distance to be covered, achieve a controlled swing to achieve the longest distance or the desired distance. **(Bouchareb, 2013.p60)**

Under these conditions, how to compare the real performance between two players, that due to the environment of that due to the player (his own technique)? Thus, laboratory measurements make it possible to control the situation with which the player is confronted and therefore to study only the technique of the latter.

For example, a laboratory study will not confront the player with external weather conditions: there will be wind only if the experimenter wants it and potentially it will be controlled, as in the case of wind tunnel studies. (to our knowledge never done so far for golf).



In this way, it is possible to isolate the technical component of the performance, that is to say the one solely related to the gesture. Thus, it is common in the laboratory to estimate performance solely by club head speed, which can be measured by radars such as the Trackman. However, it is rare to consider the carry (distance traveled by the ball) or the side (deviation of the ball from the target orientation, once stopped) because these two elements are estimated using the measurement of the flight of the ball at impact.

Indeed, it is common for swings to be executed inside a building, so the ball must be stopped in mid-flight (often with the help of a net). Thus, the carry and the side are simulated - and not measured - from a very limited number of measurements during the first meters of flight and therefore potentially marred by errors.

In addition, the trajectory of the ball is influenced by the biomechanical technique of the golfer but also by the quality of the material, the position of the ball on the face of the club at impact, its inclination, etc.

From a biomechanical point of view, a perfect swing executed a few millimeters off the ball could generate the same club speed but the ball would not have an ideal trajectory.

By taking performance as club head speed, we choose to focus on the biomechanical technique of the golfer: the organization and evolution of his body in space during the swing. The golfer will then be able to work on his positioning in relation to the ball. But performance is not the only element studied in the laboratory, the interest is also to study the risk of injury.

Pain

The study of the risk of injury or the appearance of pain is necessarily complicated: for this, the volunteer would have to be injured when the measurement is taken.

However, no experimenter wants to hurt the volunteers who engage in a research protocol. Everything is done so that this is not the case. The study of lesion mechanisms is therefore done indirectly by posing the hypothesis, for example, that if the forces (forces, mechanical torques, energy, power) are weaker, then the

structures such as bones, ligaments, tendons are less solicited and less likely to cause pain or injury. **(Ribaud et al. 2013).**

The results of this research must be transferred to practitioners, by coaches or the French Golf Federation, for example. However, the transfer to coaches is sometimes tricky for at least two reasons. The first is, for some, a poor understanding of the physical or mechanical phenomena that are at stake in order to fully understand movement.

A complete analysis requires an understanding of the forces (forces and mechanical moments), of the kinematics (the movement of the different areas of the body, grouped into segments such as the arm, the trunk, the pelvis), but also of the dynamics which allow link efforts to kinematics (the curious may recall Newton's theorems), or even energy (kinetic energy, mechanical work and power).

All these elements must be put into perspective with the characteristics of the golfer: his physiology for example, but also his physical form on the day, etc. The work of the biomechanic (expert in the application of mechanical theories to the human body to understand its functioning) is complementary to that of the coach (who now also has the task of translating what the biomechanic wants to say to the golfer).

The second reason concerns the material because that available on the market is of variable quality, at several levels. The first level is what the hardware actually measures. Most Market Force Platforms (like Smart2Move) measure the vertical force between each foot and the ground. We can then deduce the center of pressure of each foot, the global center of pressure, the left/right distribution of the vertical force.

However, the forces applied by the golfer on the ground are three-dimensional. However, this system does not make it possible to measure the components of these forces in the plane of the contact surface (medio-lateral component and antero-posterior component). However, the effort in the plane is necessary because it is he who allows the propulsion of the movement thanks to the adhesion.

Anyone who does not understand where we are coming from can try to make a swing on an ice rink: once you try to start a backswing, your feet risk slipping, because the grip on the ground is not adequate, and therefore the swing cannot be performed properly. Measuring only the vertical force implies that the role of ground/foot adhesion is not important.

However, it is to improve this grip that some use specific crampons on the course. However, it is only very recently that players in the golf market have positioned themselves to offer means of measuring horizontal forces: to our knowledge, only the Swing Catalyst system claims to be able to do so.

In addition to the measurement, it is important to interpret the data. For example, we can measure the position of the trunk and the pelvis in space, but it is more common to give indicators, such as the X-factor which represents the dissociation between the pelvis and the shoulders. Originally introduced by McLean in 1992, it works on the principle that the trunk acts as a torsion spring during the swing, stretching during the backswing and relaxing during the downswing. **(Swanson et al. 2009).**

Therefore, the more the spring is stretched, the greater the potential energy available to the downswing will be. However, scientific articles on this subject show that it is not so simple: some have shown that this factor is weakly related to performance (Chu et al. 2010, Joyce et al. 2016, Cheetham et al 2001), and other than it was not (Ferdinands et al. 2013, Kwon et al. 2013). In general, the calculation of this factor does not currently have a fixed methodology.

There are mainly two ways to calculate the X-factor: the shoulder/pelvis one where we look globally at where the shoulders are located in relation to the pelvis (spine and shoulders). And the thorax/pelvis where we mainly look at the rotation of the spine.

To measure the X-factor, some golf coaches use the K-Vest. This is a set of sensors that are used over clothing. Since the K-Vest sensors are on the pelvis, trunk and hand, it is only possible to measure the trunk/pelvis X-factor. In addition, the sensors being placed over clothing, there can be a slippage potentially source of



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measurement errors, and leading to a problem of repeatability from one measurement session to another.

Researches and golf development

The tools used in research are developed to allow the most precise measurement possible (while controlling the uncertainties and biases inherent in the measurements). These tools are not necessarily the same as those used directly in the field because the constraints of use are different. In the laboratory, we can use heavy and complex equipment that does not have to be moved.

For example, the force platforms make it possible to measure in 3 dimensions the forces (vertical and horizontal) but also the movements (rotational forces, or effect of a force at a distance by its lever arm) (**Bouchareb, 2013.p95**)

This at measurement frequencies of the order of 1000 Hz, i.e. 1000 measurements taken per second. These systems have been calibrated regularly and are never moved as this could recalibrate them and thus distort the measurement.

But this is not enough because it is also necessary to know how the body moves in space. For this, in research, it is common to use an optoelectronic motion capture system. It is a system composed of infrared light emitters/receivers but also of reflective balls (or markers).

Thus, the light is emitted by the transmitter, then reflected by the marker and captured by the receiver. In practice, these are cameras with a red or infrared light filter. From the moment two cameras see this ball, it is possible to know its position in 3D space.

This requires that the cameras know where they are in relation to each other, which is achieved through a system calibration step. In this way, the measurement accuracy is less than one millimeter. These balls are positioned directly on the body in characteristic anatomical areas.

Very often, they are glued directly to the skin because the relative movement of the garment in relation to the skin causes additional relative movements between the ball and the bones, thus decreasing the accuracy of the results.

A third tool commonly used in sports biomechanics is the measurement of electromyographic (EMG) activity through the electrical activities of muscles. These are electrodes that measure the differences in electrical potential (voltage) of a muscle when it is stressed.

This allows you to know which muscle is activated, when, and at what intensity. However, this methodology is long to set up, requires experts to position the electrodes, check the signals but also process them.

Additionally, the swing motion is a full body motion. It would therefore be necessary to be able to put electrodes for each muscle, which is experimentally very complicated, if not impossible. In particular because the electrodes for the deep muscles are needles to be inserted into the muscle.

These are only rarely used in the study of sports movements because of their complexity of use but also because of the discomfort caused during movement. Also, for electrodes placed on the surface of the skin (surface electrodes), fat mass prevents accurate measurement because it increases impedance – the resistance to electrical current – which can be problematic for the abdominal belt for example. . So, it is clear that there is very specific equipment in research allowing precise measurement. However, this is not everything: it is also necessary to extract useful information from this measurement. This is done with the choice of models that include many parameters, particularly related to the morphology of the golfer (articular center, length of segments, etc.).

The scientific community relies on several approaches to determine them: extrapolation of measurements made on cadavers, or the use of medical imaging systems to precisely adapt the model to the person. This is done, for example, at the Georges-Charpak Institute of Human Biomechanics, where certain research protocols use the EOS system.

This allows two simultaneous X-rays to be taken, front and side, then to reconstruct the golfer's skeleton in 3D (see next image). But also to locate the markers on these x-rays. Thus, we have the relative position of the bones in relation to the balls. In this way, the measurement made by the optoelectronic system becomes, after data processing, a measurement of the position of the skeleton in space during the swing. From these measurements, it is possible to study many geometric parameters such as the X-factor, but also those related to ground forces. It is also possible to assess the relative contributions of the different joints in the movement (joint dynamics). However, if the baseline measurement is not accurate and the s treatment models are coarse, the result will necessarily have to be taken with hindsight. On the other hand, a precise measurement added to a model faithful to reality makes it possible to obtain rich information.



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In addition to the measure, there is the question of the objective: towards what do we want to direct the golfer? One would be tempted to suggest that amateur players get as close as possible to the movements of professional players.

Nevertheless, how to be sure that the player has the physical capacity? Can we reasonably say to an amateur player in his fifties, who does one practice session and one round per week that his swing should be as close as possible to that of a young professional player of 25 who trains 40 hours a week? Professional players allow us to understand the key elements of performance and it is the understanding of the mechanical phenomena put in place allows us to identify the course to follow to perform.

Conclusion

Golf is a very popular sport loved by many. Although golf is a non-contact sport, as you can see from above, it can still result in many different injuries. As stated many times, it is extremely important to execute proper swing mechanics and warm up prior to golfing. Even if you are going to the driving range, make sure you stretch and hit a few shots with your wedges prior to fully swinging or using your driver, to sum up, the universal perfect swing does not exist, but there is an optimal swing for each practitioner. Thus, measurement seems to be increasingly crucial in the quest for performance. But it will only make sense if the analysis carried out is personalized and adapted.

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