LOW BACK PAIN: BIOMECHANICS ANALYSIS AND PREVENTION

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Epidemiological studies have shown that lower back pain from golf represent 25% of all golf related injuries. A review of the literature shows that the etiology is pluri-factorial, with general and specific risk factors. For the average players and the elite players, the mechanical loadings on the lumbar spine must be analyzed during all the golf swing. The specific risk factors, as range of motion restriction, abnormal muscle recruitment, excessive X-factor, important right side bending with high velocity lumbar rotation (crunch factor) are essential elements to be considered in a prevention strategy. Golf can aggravate pre-existing low back pain, especially in a context of overuse, without correct warm-up and with important golf swing technical fault but golf could also be an efficient treatment when it is practiced in good conditions.

KEY WORDS: Biomechanics of golf, Back pain, X-factor, crunch factor.

AGEING OF THE POPULATION AND RELATED PROBLEMS: Ageing of the population is an important issue in western countries where the ratio between elderly and people in the working age is continuously growing. In France, according to INSEE (French National Institute of Statistics and Economic Studies), in 2060, one third of the population will be over 60 years old. With the increase of life expectancy, it raises the question of old people dependency, which obviously has an important human and economic cost. For example, in 2004, in France, expenses related to the loss of autonomy were about 4.7 billion euros, 75% being supported by the public finances. Thus, healthy and active aging is a real challenge to keep public expenses under control. Among degenerative diseases related to ageing, osteoarthritis and osteoporosis are frequent causes of disabilities in older adults. Common sites of related pain are hips and lumbar spine. The loss of spinal flexibility and low back musculature tone with increasing age are also key elements explaining the prevalence of lumbar problems in this population (Bressler et al., 1999). Due to the role of the lumbar spine and the hip joint in the mobility and in the support of body weight, pain can result in high reduction of the functional level in all gestures of the daily living. According to the evolution of the disease, the quality of life and the autonomy can be significantly limited by pain.
In the care of these chronic diseases, drugs are not the only way for recovering a correct functional level. In particular, the effective role of physical activity has been shown not only for rehabilitation, but also as a means of prevention. The healthy benefits of physical activity are well known and are provided through aerobic conditioning, stretching and strengthening. By a progressive approach, controlled exercises can give back strength and flexibility to the joints. At the same time, the game of golf has become more and more accessible and today 65 million people regularly play golf in the world (7 millions in Europe). In France, the number of licensees was 420 000 in 2012 (Golf is the 6th sport) and the average age of the players was 50 years. Players above 55 years represent 46% of the licensees. For senior adults, there are many benefits of playing golf. As an outdoor activity, golf allows to improve aerobic capacities and to reduce cardiovascular risk (Parkkari et al., 2000). The calories used by a 70 kg man, playing 18 holes with and golf trolley, on a semi-flat course are estimated to be on average 1400 (Zunzer et al., 2013). The motion of the spine and lower limbs due to swinging and twisting has a positive effect on musculature and joint flexibility as well as on joint proprioceptive acuity and dynamic standing balance control (Parkkari et al., 2000) (Tsang & Hui-Chan, 2004). Bone solicitations also provide bone density increase which decreases the risk of osteoporosis (Eser et al., 2008). Moreover, golf is a sport that can be

practiced regardless of the age and together with people of different generations. It therefore brings also mental benefits. Finally, when practiced as a moderate intensity activity, golf implies low injury risk (Thériault & Lachance, 1998). Provided that some specific rules are correctly followed, almost all elderlies can begin practicing golf whatever their age. Therefore, playing golf appears as an efficient way to keep active and healthy when getting older. In the same way, the golf activity has already been used as an integral part of rehabilitation program, in particular, following hip replacement (D'Amico et al., 2007). The French Federation of Golf, indeed, is already involved in actions to promote the golf practice among elderly people. However, until now, in the literature, most of the studies focused on performance (Silva et al., 2013) or injury prevention in elite players (Lindsay et al., 2000). So, further research is needed to evaluate the impact of golf motions on joint loading in a population of elderly people. This approach relies on biomechanical modeling of the human body and requires to identify and to quantify the specificities of the musculoskeletal system of these subjects. The ability to provide in field information to the player when performing the gesture would be also very useful to prevent injury risk and to allow for remote supervision.

INJURY MECHANISMS: In a context of overuse, without correct warm-up and with important golf swing technical fault, golf can aggravate pre-existing low back pain (McHardy et al. 2007; Gluck et al. 2008; Back et al., 2011; Menzer et al., 2015). Even if golf may look less demanding than other sports, it asks to generate very strong levels of forces and couples especially in the swing phase. Compression loads that are about one to four times a person's body weight in daily living activities are tus up to eight times a person's body weight in a golf swing (Hosea & Gatt, 1996). Golf swing is a complex 3D "in charge" motion combining flexion, lateral bending and torsion and this complexity in the swing kinematics and the associated internal loadings must be understood in order to prevent injury.
Everything starts from the address position that as an influence on the whole swing. "C" spine shape or "S" shape at address (presented in Figure 1) will not lead to the same loading during the swing as these shapes will put the whole spine and the pelvis in in a different loading pattern.

Figure 1: position at address

An exaggerated position will pre-stress the spine and specific anatomic structures: "S" shape will pre-stress the facet joints and "C" shape the intervertebral discs. We know that excessive axial rotation is a risk factor for low back pains (Marras et al., 1995) and that the facet joints limit the axial rotation (Haher et al.; 1993). For a long time, it was believe that the angle between the pelvis and the shoulder in the transverse plane known as X-factor (McLean, 1992; McLean, 1993) was correlated to performance and especially the clubhead velocity at impact (CV). However, the diffusion of portable motion analysis systems as K-vest® or AMM3D® that use inertial measurement units correlated to the use of ball flight radars such as Trackman® or FlightScope® allowing to take data during the game and specific studies in laboratories (Kwon et al., 2013) using optoelectronic systems have prove that whatever the computation methods (standard X-factor, swing plane-based X-factor or Cardan rotation-based method), there is no correlation between X-factor and CV (Figure 2).

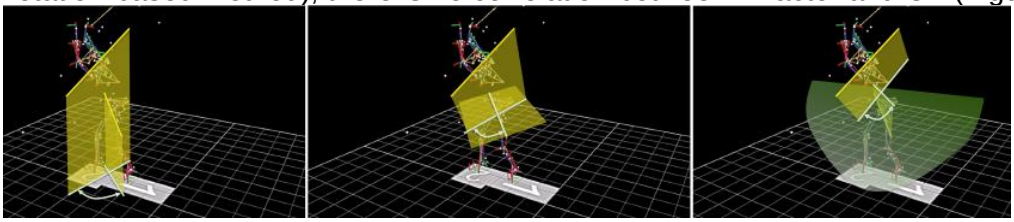
Figure 2: various X-factor computation methods

Performance and especially CV is correlated to X-factor stretched (Cheetham et al., 2001) to a dedicated kinematic sequence: pelvis/torso/arm/club (Cheetham et al., 2008; Tinmark et al., 2009; Tinmark et al., 2010) and to a swing with limited jerk (Choi et al., 2014). This better understanding of performance factors must help the coaches to define a better swing strategy that minimizes loading of sensible anatomic structures while improving performance.

However, there are still remaining several technical faults especially on average players that have been identified as injury risks:

- The pelvic tilt (PT). PT must be anterior at address, posterior at impact and anterior at finish as presented on Figure 3.
- The slide from left to right that generates lateral bending as presented on Figure 4 must be avoided.
- Other characteristic swing patterns (lumbar hyperextension, early extension, reverse spine factor) are deprecated as they generate more loading on the spine (Figure 5).
  Important crunch factor as presented in Figure 6 that is a characteristic of high-level professional players could be a significant risk factor as it is associated to right side bending (in right handed players) and high-speed lumbar rotation at impact and during follow through (Cole & Grimshaw, 2014).

Figure 3: pelvic tilt during the swing

Figure 4: left to right slide from the downswing position

Figure 5: lumbar hyperextension, early extension, reverse spine factor characteristics

Figure 6: crunch factor at impact (right) and during follow through (left)

CONCLUSION: Physiopathology of golf related back pain is pluri-factorial. Beside the general factors (aging, bad muscular control, overweight, etc.), there are specific golf factors that can be analyzed with biomechanics tools. Prevention for average player as for elite player needs technical corrections in order to eliminate technical faults. These corrections arise from biomechanics data and coaches must be trained in order to use them properly.

REFERENCES:

Back, J.D., Wyss, J.F., Lutz, G.E., (2011). Bertolotti Syndrome as a Potential Cause of Low Back Pain in Golfers. *PM and R*, 3 (8), p. 771-775.

Bressler, H. B., Keyes, W. J., Rochon, P. A. & Badley, E., (1999). The prevalence of low back pain in the elderly. A systematic review of the literature. *Spine (Phila Pa 1976),* Sep, 24(17), p. 1813-1819.

Cheetham, P., Martin, P., Mottram, R., St. Laurent, B.F., (2001). The importance of stretching the "X-Factor" in the downswing of golf: The "X-Factor Stretch". *Optimising Performance in Golf*, p. 192-199.

Cheetham, P., Rose, G., Hinrichs, R., Neal, R., R.E., M., Hurrion, P., Vint, P., (2008). Comparison of

kinematic sequence parameters between amateur and professional golfers. Science and golf V: *proceedings of the World Scientific Congress of golf*.

Choi, A., Joo, S., Oh, E., Mun, J., (2014). Kinematic evaluation of movement smoothness in golf: relationship between the normalized jerk cost of body joints and the clubhead. *Biomedical engineering online*, 13(1): 20.

Cole, M.H., Grimshaw, P.N., (2014). The crunch factor's role in golf-related low back pain. *Spine J.* 14(5): p. 799-807.

D'Amico, J., Betlach, M., Senkarij, R., Smith, R., Voight, M., (2007). Return to golf following felt total hip arthroplasty in a golfer who is right handed. *N Am J Sports Phys Ther,* 2, p. 251-261.

Eser, P., Cook, J., Black, J., Iles, R., Daly, R.M., Ptasznik, R., Bass, S.L., (2008). Interaction between playing golf and HRT on vertebral bone properties in post-menopausal women measured by QCT. *Osteoporos Int*, 19(3), p. 311-319.

Gluck, G.S., Bendo, J.A., Spivak J.M., (2008). The lumbar spine and low back pain in golf: a literature review of swing biomechanics and injury prevention. *Spine J.* 8(5): p. 778-788.

Haher, T.R., O'Brien, M., Kauffman, C., Liao, K.C., (1993). Biomechanics of the spine in sports. *Clin Sports Med*;12, p. 449-449.

McHardy, A.J., Pollard, H.P., Luo, K., (2007). Golf-related lower back injuries: an epidemiological survey. *Journal of Chiropractic Medicine*, 6 (1), p. 20-26.

Hosea, T.M., Gatt Jr., C.J., (1996). Back pain in golf. *Clinics in Sports Medicine*, 15 (1), p. 37-53.

Kwon, Y., Han, K., Como, C., Lee, S., Singhal, K., (2013). Validity of the X-factor computation methods and relationship between the X-factor parameters and clubhead velocity in skilled golfers. *Sports biomechanics / International Society of Biomechanics in Sports*, 12(3), p. 231–246.

McLean, J., (1992). Widen the gap. *Golf Magazine*, p. 49–53.

McLean, J., (1993). The X-factor swing and other secrets to power and distance. *Harper Collins*.

Lindsay, D.M., Horton, J.F. & Vandervoort, A.A., (2000). A review of injury characteristics, aging factors and prevention programmes for the older golfer. *Sports Med*, 30(2), p. 89-103.

Marras, W.S., Granata, K.P., (1995). A biomechanical assessment and model of axial twisting in the thoracolumbar spine. *Spine* 20, p.1440–1451.

Menzer, H., Gill, G.K., Paterson, A., (2015). Thoracic spine sports-related injuries. *Curr Sports Med Rep.* 14(1), p. 34-40.

Parkkari, J., Natri, A., Kannus, P., Mänttäri, A., Laukkanen, R., Haapasalo, H., Nenonen, A., Pasanen, M., Oja, P., Vuori, I., (2000). A controlled trial of the health benefits of regular walking on a golf course. *Am J Med,* 109(2), p. 102-108.

Silva, L., Marta, S., Vaz, J., Fernandes, O., Castro, M.A., Pezarat-Correia, P., (2013). Trunk muscle activation during golf swing: Baseline and threshold. *J Electromyogr Kinesiol,* 23(5), p. 1174-1182.

Thériault, G.,Lachance, P., (1998). Golf injuries. An overview. *Sports Med,* Jul, 26(1), p. 43-57.

Tinmark, F., Hellström, J., Halvorsen, K., Thorstensson A., (2009). Analysis of elite golfers' kinematic sequence in full-swing and partial swing shots. 27 *International Conference on Biomechanics in Sports*.

Tinmark, F., Hellström, J., Halvorsen, K., Thorstensson A., (2010). Elite golfers' kinematic sequence in full-swing and partial-swing shots. *Sports Biomechanics*, 9(4), p. 236–244.

Tsang, W.W.N., Hui-Chan, C.W.Y., (2004). Effects of exercise on joint sense and balance in elderly men: Tai Chi versus golf. *Med Sci Sports Exerc,* Apr, 36(4), p. 658-667.

Zunzer, S.C., von Duvillard, S.P., Tschakert, G., Mangus, B., Hofmann, P., (2013). Energy expenditure and sex differences of golf playing. *J Sports Sci,* 31(10), p. 1045-1053.

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