

# The importance of stretching the “X-Factor” in the downswing of golf: The “X-Factor Stretch”

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## **Abstract**

The “X-Factor” is a popular term for the relative rotation of shoulders with respect to hips during the golf swing. A relatively large X-Factor at top of backswing is thought to facilitate high club head speed at impact. Little consideration, however, has been given to how the X-Factor changes early in the downswing. We tested the hypotheses that highly skilled golfers have a higher X-Factor at the top of the backswing and a greater increase in the X-Factor early in the downswing (“X-Factor Stretch”) than less skilled golfers. Multiple swings of 10 highly skilled (handicap 0 or better plus one long drive champion) and 9 less-skilled (handicap  $\geq 15$ ) golfers were captured with a SkillTec 3D-Golf™ swing analysis system (Skill Technologies Inc., Phoenix AZ). The X-Factor was measured at the top of backswing and at its maximum in the downswing. A contrast of the X-Factor means at the top of backswing showed no significant difference between the highly skilled and less skilled golfers, ( $t=1.017$ ,  $p=0.326$ ). Further, the effects of skill level (highly skilled and less skilled) and swing position (top and maximum) on the X-Factor were assessed using a two-factor ANOVA. The X-Factor averaged for both the top and maximum was 11% higher in highly skilled golfers than the less-skilled players, but this difference was not statistically significant (group main effect  $F_{1,17}=1.93$ ,  $p=.18$ ). The X-Factor Stretch occurred during the early stages of the downswing for both highly skilled and less skilled golfers (swing position main effect  $F_{1,17}=131.57$ ,  $p<.001$ ), but was significantly greater for the highly skilled players (19%) than the less skilled golfers (13%; group x swing position interaction  $F_{1,17}=6.90$ ,  $p=.02$ ). This suggests X-Factor Stretch early in the downswing is more important to an effective swing than simply the X-Factor at the top of backswing.

## ***Introduction***

The term X-Factor was coined by John Andrisani of Golf Magazine and was introduced by Jim McLean in a 1992 Golf Magazine article titled "Widen the Gap", (McLean, 1992). It was used to describe the relative rotation of shoulders with respect to hips during the golf swing, specifically at the top of backswing. His article was based on the research done by Mike McTeigue of Sport Sense Inc. (Mountain View, CA) using a measurement device called the Swing Motion Trainer. After analyzing tour professionals they found the bigger the rotational difference between the hips and the shoulders, the longer the drives. In his 1993 article titled "X-Factor 2: Closing the Gap", (McLean, 1993), McLean concluded that it was not only important to have a large X-Factor at the top of backswing but it was also important to close it very rapidly during the downswing.

McTeigue et al. (1994) studied 51 PGA tour professionals and 46 senior PGA tour professionals and concluded that the long hitters "generated more of the turn" from the X-Factor than the rest of the group. So it was concluded that a large X-Factor at the top of backswing was key in generating a large club head velocity at impact, provided of course that the rest of the swing mechanics are intact. In the same study McTeigue, et al. also concluded that the majority of tour players begin the downswing with the hips leading the shoulders. He concluded, "Approximately 70 percent of Tour players rotate their hips first in the downswing". He did not however go on to quantify how much the hips lead the shoulders at the beginning of the downswing, and how the X-Factor changes early in the downswing.

The initiation of an athletic motion by the rotation of the body's larger proximal segments (hips and shoulders) followed progressively by the more distal segments (arms) has been reported in several sports. It has been recognized in baseball (Hay, 1993), tennis (Marshall and Elliott, 2000) and soccer (Robertson and Mosher, 1985; Putnam, 1993). This has been termed proximal-to-distal sequencing (Bunn, 1972; Kreighbaum and Barthels, 1985; Robertson and Mosher, 1985; Putnam, 1993; Marshall and Elliott, 2000) and the "kinetic link principle" (Kreighbaum and Barthels, 1985). In the golf swing, the hips leading the downswing is just the beginning phase of this sequence.

Parks and Price (1999), from research conducted by GolfTEC Inc. (Denver, CO) on both PGA and Nike tour professionals, using the SkillTec 3D-Golf™ system, recommended that, "In order to develop the most efficient X-Factor, you need to limit the rotation of your hips and maximize the rotation of your shoulders". They were referring to the X-Factor at the top of the backswing but did not progress to discuss what happens to the X-Factor early in the downswing. Recently however, several golf instructors have recommended that the rotational separation between hips and shoulders should increase on the downswing (McLean, 1996, Leadbetter, 2000, Hogan, 2000), but this increase has not been quantified.

The purpose of this study was to quantify the X-Factor's increase on the downswing. Specifically we tested the hypotheses that highly skilled golfers have a higher X-Factor at top of the backswing, (as found by McTeigue et al.), and also have a greater increase in X-Factor early in the downswing than less skilled golfers. We term this increase the "X-Factor Stretch" and consider it to be at least as important as the X-Factor itself.

### **Methods**

Multiple swings of 10 highly skilled golfers and 9 less skilled golfers were captured using the SkillTec 3D-Golf™ system, (Figure 1). The less skilled players all had a handicap of 15 or higher. The highly skilled players included 8 playing professionals with handicaps of zero or better, one long drive champion and one highly ranked collegiate player.



Figure 1. PGA professional golfer Brandel Chamblee being analyzed by the SkillTec 3D-Golf™ system.

The SkillTec 3D-Golf™ system is comprised of the Fastrak (Polhemus Inc., Colchester, VT), electromagnetic tracking system, and the Skill Technologies' motion capture and analysis software. Electromagnetic tracking systems have been found to be accurate for quantification of human motion in many different applications, (An et al., 1988; Johnson and Anderson, 1990; Mannon et al., 1997; Bull et al., 1998). The tracking system works on an electromagnetic sensing principle, (Raab et al., 1979).

There is a two-inch cubic transmitter that has three perpendicular coils. Each coil transmits an electromagnetic signal. This transmitter is used as the global reference frame. Each half-inch cubic sensor also has three coils, and each coil receives the corresponding signal from the transmitter and computes position (x, y, z) and orientation (bend, tilt, twist) of each sensor in real-time. Each sensor is used as a local reference frame for the segment to which it is attached. The golfer's body is transparent to the electromagnetic field and so there are never any missing data samples. From these sensor measurements a virtual-reality, three-dimensional model of the golfer is displayed and the dynamics of the golf swing are calculated, including segment and joint positions, angles, speeds and accelerations.

For this study a sensor harness was used to place sensors on the posterior aspect of the golfer's pelvis, back at T3, forehead and back of left hand (Figure 1). All the golfers were right handed and all swings were with a 5 iron. An initial neutral standing position of the golfer was taken before any swings were captured. The golf swing was sampled at a rate of 30Hz. This sample rate is adequate since only the sensors on the pelvis and back, in the vicinity of the top of backswing, were used in the calculations. A fourth order Butterworth digital filter with a cut-off frequency of 12Hz was used to smooth the position and orientation data. X-Factor was computed as the difference between the rotational position of the pelvis and T3 sensors at all points during the swing.

X-Factor values at top of backswing and the X-Factor maximum in the downswing were extracted and averaged over each golfer's swings. To test the hypothesis that highly skilled golfers have a higher X-Factor at top of the backswing than less skilled golfers, we performed a contrast of the means of each group at this position. To examine the X-Factor trends more broadly and to test the hypothesis that the highly skilled golfers have a greater increase in X-Factor early in the downswing than less-skilled golfers, we conducted a two-factor ANOVA. This allowed us to compare the effects of skill level (highly skilled and less skilled) and swing position (top and max) on the X-Factor.

## Results

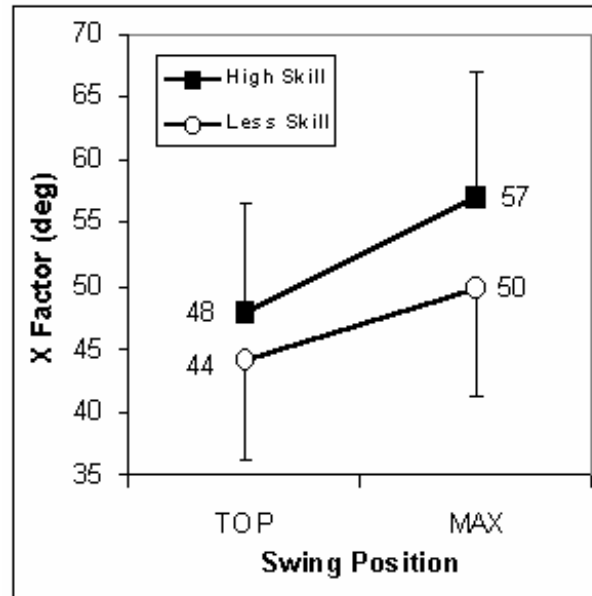


Figure 2. X-Factor means as a function of swing position for highly skilled and less skilled golfers. The means can be seen to be larger for the highly skilled golfers in both positions, but more so at max.

X-Factor trends are shown in Figure 2. On average the highly skilled golfers showed a 19% increase in the X-Factor due to the stretch at the beginning of the downswing and the less skilled only a 13% increase. This difference between groups is supported by a significant interaction of skill level and swing position found using a two-factor ANOVA. This showed that the X-Factor Stretch was significantly greater for the highly skilled golfers than the less skilled golfers, ( $F_{1,17}=6.90$  and  $p=.02$ ). This supported our hypothesis that highly skilled golfers have a greater increase in the X-Factor early in the downswing (“X-Factor Stretch”) than less-skilled golfers. Further, the results of a direct contrast of the X-Factor means at the top of backswing showed them not to be significantly different ( $t=1.017$ ,  $p=0.326$ ) between groups. This disagrees with our hypothesis that highly skilled golfers have a higher X-Factor at the top of the backswing. These two results suggest that X-Factor Stretch is more important to an effective swing than simply X-Factor at top of backswing.

The two-factor ANOVA also revealed other relationships. When the X-Factor means were collapsed across swing position, (averaged for both top and max for all highly skilled and then again for all less

skilled), the resulting mean in the highly skilled golfers was 11% higher than the mean of less skilled golfers but this difference was not statistically significant, ( $F_{1,17}=1.93$  and  $p=0.18$ ). Finally, when the X-Factor means were collapsed across skill level, (averaged for both highly skilled and less skilled for top of backswing and then again for maximum), the resulting mean at maximum was 16% higher than the mean at top of backswing. This difference was statistically significant, ( $F_{1,17}=131.57$  and  $p<.001$ ). This shows that both highly skilled and less skilled golfers exhibited an X-Factor Stretch. So even the less skilled golfers did in fact increase their X-Factor somewhat at the beginning of the downswing.

### Discussion

In order to illuminate the differences in the “X-Factor Stretch”, we will extract two extreme example swings from each skill level, and discuss them.

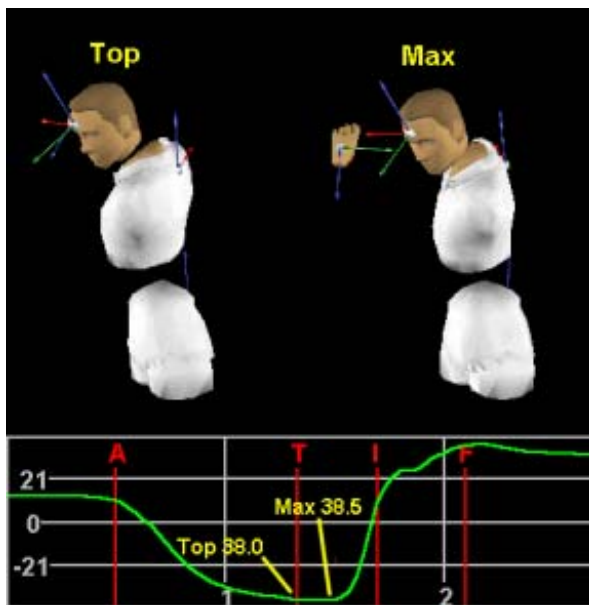


Figure 3. The less skilled golfer

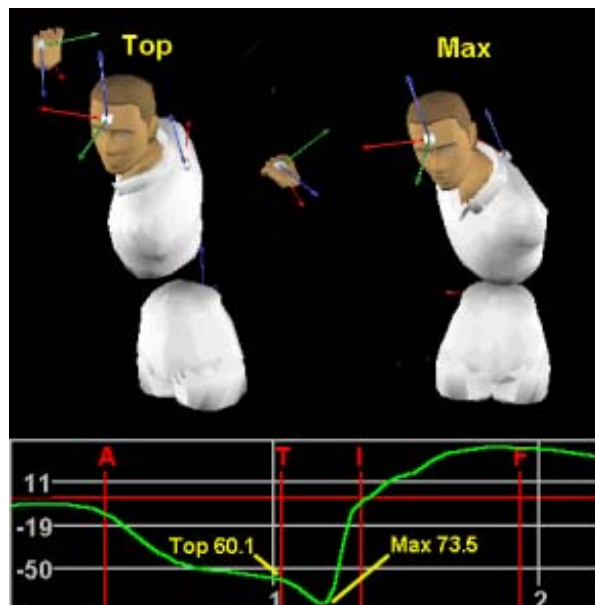


Figure 4. The highly skilled golfer

Figures 3 and 4 show graphs of the X-Factor throughout the swing for the less skilled golfer and the highly skilled golfer and the models at two points, top of backswing and maximum X-Factor. The red vertical lines mark address, top of backswing, impact and finish. The X-axis is time and the Y-axis is X-Factor in degrees. The negative direction represents a closed X-Factor, that is, the shoulders are, rotated more away from the target than the hips. Two models are shown in each figure, at the positions of top of backswing and maximum X-Factor. The corresponding X-Factor values are labeled in the graphs.

Figure 3, shows the two positions of a less skilled player. At top he has an X-Factor of 88.0 degrees. On his downswing he only stretches this to a max of 38.5 degrees, giving an X-Factor Stretch of only 49.5

degrees. In other words his hips and shoulders rotated down virtually together early in the downswing. This is shown by the flat spot on the curve between top and max.

Figure 4, shows the two positions of a highly skilled player. At top he has an X-Factor of 60.1 degrees. On the downswing he stretches his X-Factor to 73.5 degrees, an X-Factor Stretch of 13.4 degrees. In the early stage of his downswing his hips have rotated significantly faster than his shoulders causing a stretch in the torso of 13.4 degrees. This is shown by the rapid change in the graph between top and max.

For most highly skilled golfers just prior to the transition from the backswing to the downswing, the pelvis slows down and changes direction to rotate forward while the upper body continues to rotate backwards, (Figure 5). This head start of the pelvis moving towards the ball causes an increase in the stretch of the large and powerful rotating muscles of the trunk. Early on in the downswing, the pelvis has a higher rotational velocity than the upper body and so will "outrun" the upper body toward the ball. Because of this initially higher velocity of the pelvis, the X-Factor increases, and in some highly skilled golfers it grew by as much as 15 degrees.



Figure 5. For an instant at the beginning of the downswing the pelvis rotates forwards into the downswing while the upper body continues to rotate backwards.



Research has shown (Goewitzke and Milner, 1988; Nordin and Frankel, 1989), that extra stretch on muscle, and active resistance to this stretch, can increase the force of contraction of muscle. Several mechanisms are responsible for this. A rapid rotation of the pelvis early in the downswing may trigger sensitive stretch receptors (called muscle spindles) in the muscles to quickly shorten the muscle. Therefore, as the hips initially rotate forward toward the ball, the maximally stretched rotational muscles of the trunk respond by a faster and more forceful contraction. A second mechanism relates to stored elastic energy in the muscles. The opposing directions of the shoulders and hips at the top of the backswing will stretch the torso muscle facilitating storage and finally release of elastic energy. The end result is that the X-Factor Stretch increases the force production on the downswing, facilitating greater club head speed at impact.

### ***Summary***

After contrasting the X-Factor at the top of the backswing and at its maximum early in the downswing for highly skilled and less skilled golfers, we found that the X-Factor at the top of the backswing was not significantly larger for the highly skilled players than less skilled players. We also found that both highly skilled and less skilled golfers did significantly increase their X-Factor early in the downswing. They did not immediately begin to rapidly close the X-Factor. Finally, we found that this stretch of the X-Factor early in the downswing was significantly greater for the highly skilled golfers than less skilled golfers. This suggests that X-Factor Stretch is more important to an effective swing than simply X-Factor at top of backswing and that the X-Factor should actually increase early in the downswing before it rapidly decreases to impact. This research also indicates that the aim of the backswing is not just to put the golfer in the correct position for the downswing, but also to dynamically tension the torso muscles correctly to allow them to contract maximally during the downswing, hence generating optimum power.

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