

Research article

## Lumbar Corsets Can Decrease Lumbar Motion in Golf Swing

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### Abstract

Swinging a golf club includes the rotation and extension of the lumbar spine. Golf-related low back pain has been associated with degeneration of the lumbar facet and intervertebral discs, and with spondylolysis. Reflective markers were placed directly onto the skin of 11 young male amateur golfers without a previous history of back pain. Using a VICON system (Oxford Metrics, U.K.), full golf swings were monitored without a corset (WOC), with a soft corset (SC), and with a hard corset (HC), with each subject taking 3 swings. Changes in the angle between the pelvis and the thorax (maximum range of motion and angular velocity) in 3 dimensions (lumbar rotation, flexion-extension, and lateral tilt) were analyzed, as was rotation of the hip joint. Peak changes in lumbar extension and rotation occurred just after impact with the ball. The extension angle of the lumbar spine at finish was significantly lower under SC (38°) or HC (28°) than under WOC (44°) conditions ( $p < 0.05$ ). The maximum angular velocity after impact was significantly smaller under HC (94°/sec) than under SC (177°/sec) and WOC (191°/sec) conditions, as were the lumbar rotation angles at top and finish. In contrast, right hip rotation angles at top showed a compensatory increase under HC conditions. Wearing a lumbar corset while swinging a golf club can effectively decrease lumbar extension and rotation angles from impact until the end of the swing. These effects were significantly enhanced while wearing an HC.

**Key words:** Golf, back pain, motion analysis, orthosis, corset.

### Introduction

Low back pain (LBP) frequently occurs in both professional and amateur golfers (Batt, 1992; McCarroll, 1996). During a golf swing, the lumbar spine is exposed to compression, lateral tilt, extension, and torsional forces (Marras and Granata, 1995). LBP in golfers is mainly caused by the torsional motion of the lumbar spine at the top of the swing and by overextension through the down-swing and follow-through (McHardy and Pollard, 2005; Vad et al., 2004). Stress on the lumbar spine is dependent on swinging technique (Adlington, 1996; McHardy and Pollard, 2005). Due to their poorer swing mechanics, amateur golfers are more likely than professional golfers to experience overextension and torque of the lumbar spine (Hosea and Gatt, 1996).

During a modern golf swing, the shoulder turns completely while the pelvis remains still relatively stationary, facing the ball, resulting in a large torsional

torque on the lumbar spine. In addition, the swing is terminated in a body position generally known as the “reverse C”, which can put extension force on the lumbar spine (Adlington, 1996; Hosea and Gatt, 1996; McHardy and Pollard, 2005). Although the goal of a modern golf swing is to convey the ball as accurately as possible for a long distance, the swing can simultaneously result in both rotational and extension forces on the lumbar spine, leading to symptomatic degeneration of the spine. Compared with asymptomatic amateur golfers, those with LBP have a reduced range of hip rotation during a golf swing, (Murray et al., 2009) suggesting that greater lumbar rotation during a golf swing may cause golf-related LBP. Furthermore, during a golf swing, golfers with LBP show a more asymmetric rotational motion than asymptomatic golfers (Van et al., 2008).

Lumbar orthosis has been used to treat back pain in athletes (Lee and Chen, 2000; Miyamoto et al., 1999; Walsh and Schwartz, 1990; Vogt et al., 2000; Prateepavanich et al., 2001). Although lumbar orthosis has shown biomechanical effects on trunk performance, including stiffening of the torso (Cholewicki et al., 2010; Miyamoto et al., 1999; 2008), its effects on a golf swing have not yet been described. We therefore evaluated the effects of wearing lumbar corsets on the 3-dimensional motion of the trunk in amateur golfers.

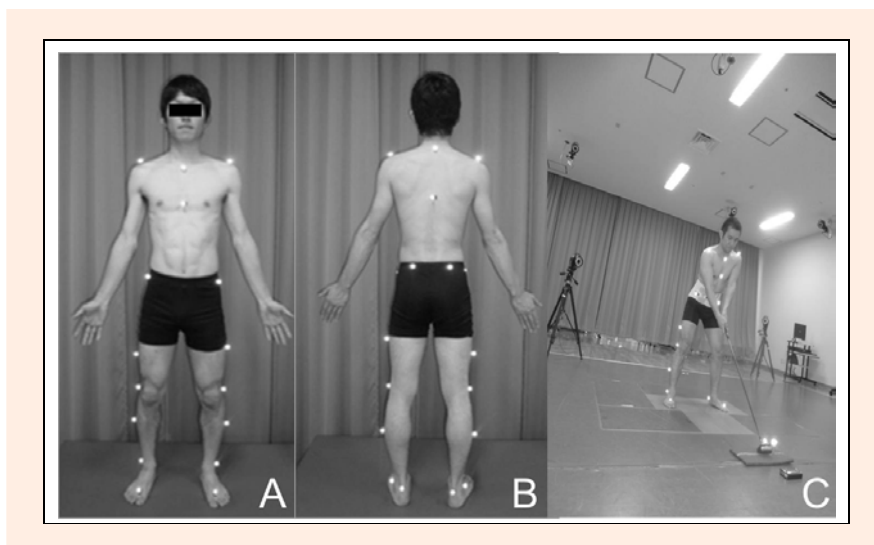
### Methods

#### Subjects

Eleven amateur male golfers, of mean age 26.4 years (range 22-36 years), mean height 1.73 m (range 1.58-1.81 m) and mean weight 66.8 kg (range 47-84 kg) volunteered for this study. All subjects were in good health and none had a history of low back problems or spinal surgery. Their average golf score over the last 5 rounds of golf (18 holes each) was 80.2.

#### Preparation for 3-dimensional analyses of golf swing

Twenty-two reflective markers were attached to the right and left heels, the right and left ankles (lateral malleolus), the right and left toes (dorsal surface over the second metatarsal head), the right and left knees (lateral condyle of femoral bone), the right and left anterior and posterior superior iliac spine, the right and left thighs (between the knee and the anterior superior iliac spines), the right and left tibiae (between the knee and ankle markers), the C7



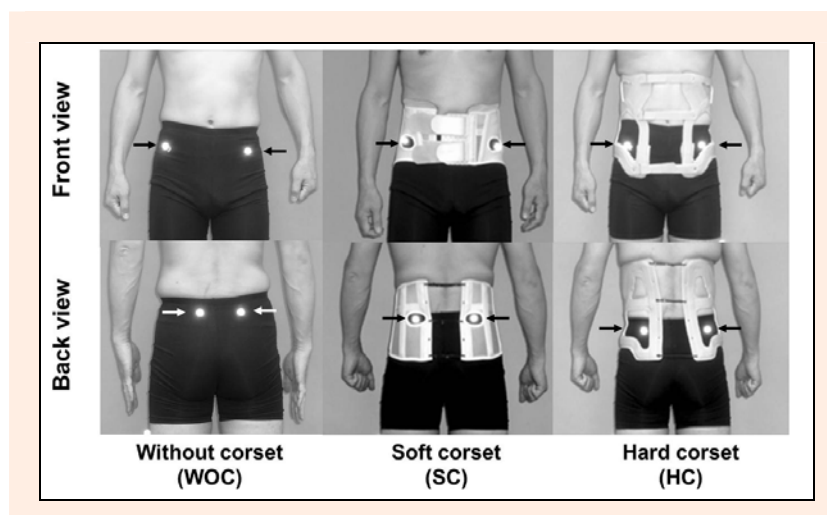
**Figure 1A, B, C.** Subjects with reflective markers on the skin.

and Th10 spinous processes, the xiphoid process of the sternum (STRN), the jugular notch where the clavicle meets the sternum, and the right and left acromioclavicular joints of each subject (Figure 1-A, B). All subjects took three full swings under three conditions (Figure 1-C): without corset (WOC), wearing a soft corset (SC), and wearing a hard corset (HC) (Figure 2). The SCs and HCs were cinched between the lower border of the ribs and just above the greater trochanter. Four holes were made in each corset to place reflective markers directly onto the pelvis landmarks. Actually, 3 sizes of corsets in each type were prepared for this study. Also, the size of the holes was large enough with a diameter of 35 mm. Therefore locate the marker consistently at the same anatomical landmarks. We also ensured that these markers were not removed when corsets were removed or attached, resulting in more accurate measurements of the motions of the pelvis (Figure 2, arrows).

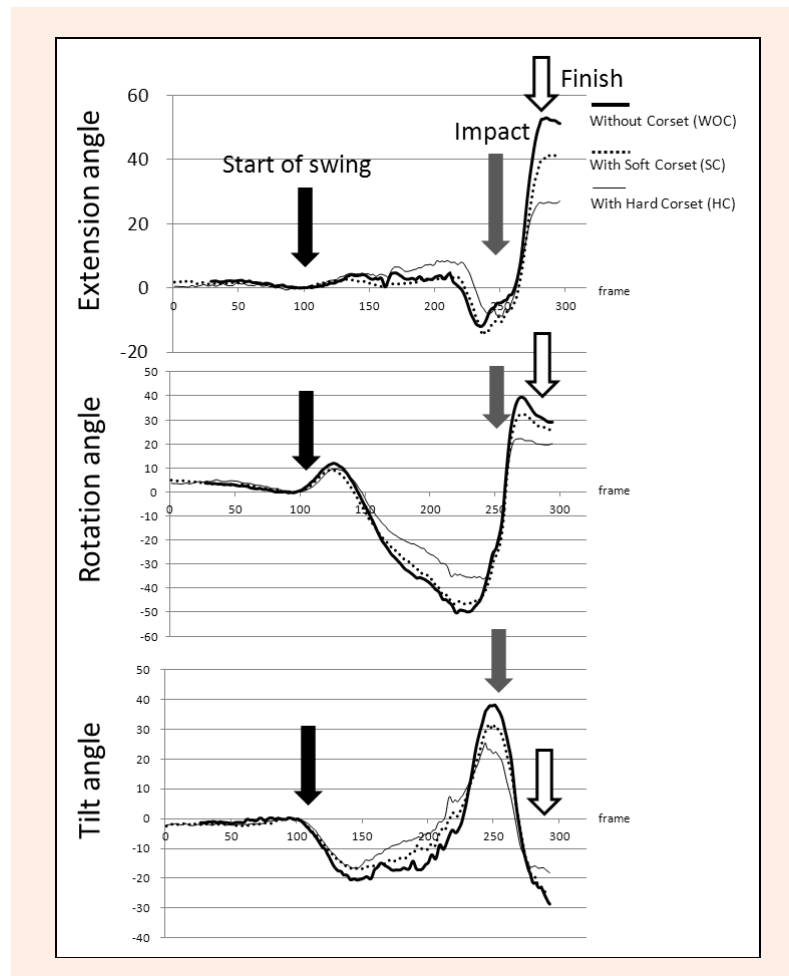
### Three-dimensional analyses of golf swings

Using a VICON system (Oxford Metrics, Oxford, UK), 3-

dimensional kinematic data of the skin markers during golf swings were recorded at a frequency of 120 Hz using 11 cameras. Each subject took three full swings with maximal effort under each of the 3 conditions (WOC, SC, and HC). Three dimensional marker trajectories of all swings were synchronized at impact. Dynamic changes of the thoraco-lumbar spine were calculated as the angle and angular velocity between the thorax and pelvis. Rotation angles of both hip joints were measured, and the intersegmental motion between the thorax and pelvis in extension, rotation, and lateral tilt was calculated using Euler angles. Using the VICON system, the positions of the body surface markers were digitized. Four points, on the right and left anterior-superior iliac spine (ASIS) and posterior-superior iliac spine (PSIS), were used to define the pelvic frame, with the medial-lateral axis being the line connecting the right and left ASISs, and the superior-inferior axis being that normal to the surface defined by the 2 ASISs and the midpoint of the PSISs. The frame of the thorax was defined by 3 points, the jugular notch, xiphoid and C7. On the frame of the thorax, the superior-



**Figure 2.** Front and back views of a subject without a corset (WOC, left), wearing a soft corset (SC, middle) and wearing a hard corset (HC, right). The holes in both corsets enabled markers to be placed on the skin (arrows).



**Figure 3.** Examples of three-dimensional kinematic data of the skin markers during golf swing.

inferior axis was defined by the line connecting the jugular notch and the xiphoid, and the medial-lateral axis was the normal vector to the surface defined by the jugular notch, the xiphoid, and C7. Movements of thorax segment were expressed in extension, left rotation, and lateral tilt with respect to the pelvis segment, by calculating Euler angles between these two segments. The rotational matrix of the thorax with respect to the pelvis (RTP) was expressed:

$$\text{RTP} = \text{R}(\gamma) \text{R}(\beta) \text{R}(\alpha)$$

where  $\alpha$ ,  $\beta$ , and  $\gamma$  represent the angles of extension, left rotation, and right tilt, respectively.

### Study parameters

**Lumbar extension, rotation, and tilt angle:** Under all 3 conditions (WOC, SC, and HC), the lumbar extension, rotation and tilt angles were measured at the top of the backswing when the club head had stopped, at impact when the club contacted the ball and at the end of the swing when the shoulder turn stopped (Figure 3, 4).

**Lumbar range of motion in the sagittal, axial, and coronal planes from the top position to the finish:** Ranges of motion were calculated in the sagittal (flex-extension), axial (rotation) and coronal (tilt) planes. The ranges were between the top position and impact and between impact

and finish (Table 1).

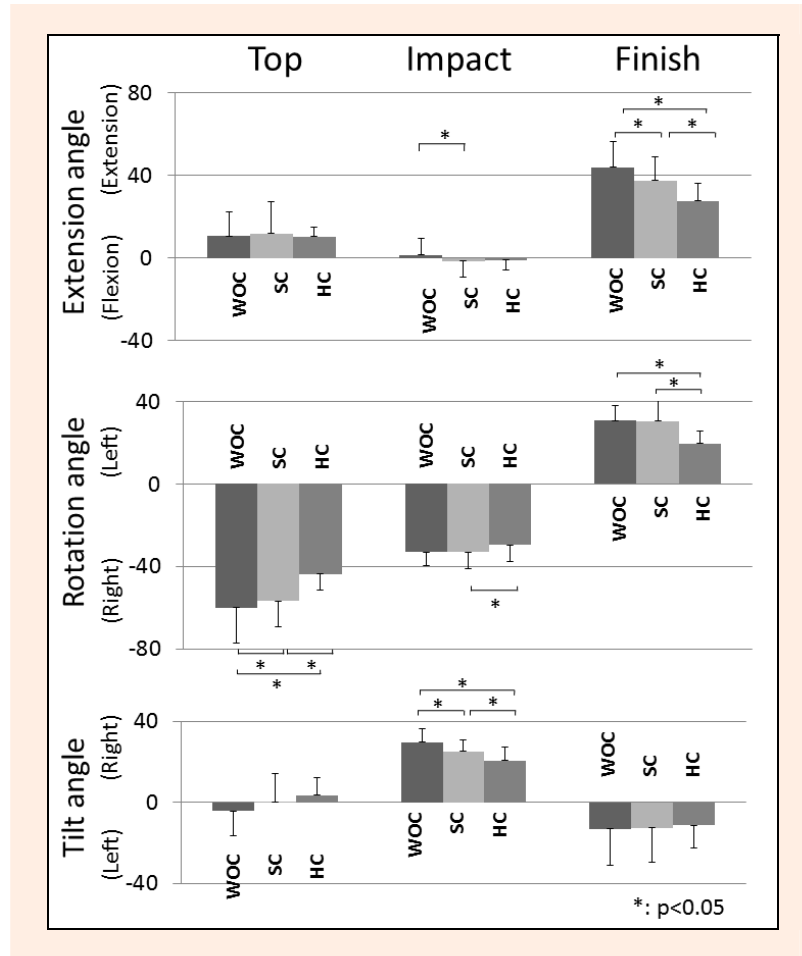
**Maximum angular velocity in extension, rotation, and tilt of the lumbar spine just after impact:** Angular velocity of the lumbar spine in extension, rotation, and tilt was continuously monitored throughout the swing, as well as just after impact (Figure 5).

**Hip rotation angle:** Using Plug in Gait software (Vicon, Oxford Metrics, Oxford, UK) (Hwang and Kim, 2009; Thummerer et al., 2012), hip rotation was measured along the long axis of the thigh segment and was calculated between the sagittal axes of the thigh and pelvis projected onto the plane perpendicular to the long axis of the thigh. A positive hip rotation corresponded to an internally rotated thigh, and a negative hip rotation to an externally rotated thigh (Figure 6).

### Statistical analysis

Consistently, all of the 3 swing trials were averaged for analysis in each subject. Each parameter measured under the 3 conditions was compared using the Friedman test, followed by Wilcoxon's signed rank test. The statistical significance was consistently defined as p value of less than 0.05 throughout the study.

### Ethical problems



**Figure 4.** Lumbar extension, rotation, and tilt angles in various conditions.

This study design was approved by the ethics committee of our institution, and all participants provided written informed consent.

**Results**

*Overview of the 3-dimensional motion of the lumbar spine during golf swings (Figure 3):* Figure 3 shows typical lumbar extension, rotation, and tilt angles during golf swings under the 3 corset conditions by a 26-year old male subject. At the end of the swing, the extension and rotation angles were smaller with corset (HC and SC) than without (WOC) corsets.

**Three-dimensional motion of the lumbar spine:**

**1. Lumbar Extension**

*1-A. Lumbar extension angle:* Compared with the WOC

condition, the lumbar extension angle at finish were significantly decreased with corsets, by 15% in the SC and by 37% in the HC conditions ( $p < 0.05$  each) (Figure 4, top panel). SC and HC condition decreased lumbar extension angle only at finish.

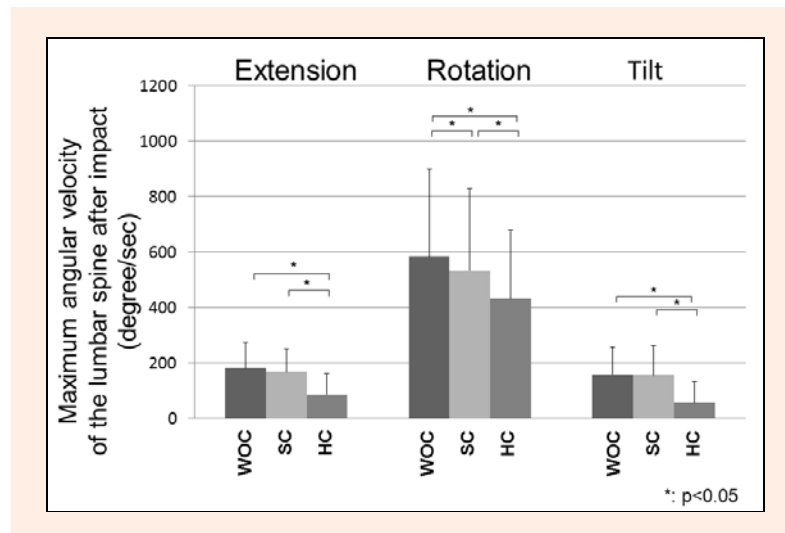
*1-B. Lumbar range of motion in the sagittal plane:* Between the top of the swing and impact, and between impact and finish, the lumbar range of motion in the sagittal plane was significantly decreased in the HC relative to the WOC and the SC condition, by 6% and 32%, respectively ( $p < 0.05$  each). In contrast, between the top and impact, the range of motion in the sagittal plane was significantly greater in the SC than in the WOC condition (Table 1, top panel). HC condition decreased lumbar range of motion in sagittal plane.

*1-C. Lumbar extension velocity just after impact:* Relative to the WOC condition, lumbar extension velocity was

**Table 1.** Lumbar range of motion in sagittal, axial, coronal, planes from top position to finish in 3 different conditions. Data are means ( $\pm$ SD).

		WOC (1)	SC (2)	HC (3)
Sagittal	top-impact	11.9 (11.6) <sup>2,3</sup>	14.7 (15.4) <sup>1,3</sup>	11.2 (5.1) <sup>1,2</sup>
	impact-finish	42.5 (15.1) <sup>3</sup>	39.0 (13.9) <sup>3</sup>	28.7 (9.5) <sup>1,2</sup>
Axial	top-impact	26.9 (17.5) <sup>3</sup>	23.7 (15.2) <sup>3</sup>	14.2 (6.9) <sup>1,2</sup>
	impact-finish	63.8 (9.5) <sup>3</sup>	63.6 (11.4) <sup>3</sup>	49.4 (10.3) <sup>1,2</sup>
Coronal	top-impact	33.9 (11.0) <sup>3</sup>	25.7 (11.2) <sup>3</sup>	18.5 (9.9) <sup>1,2</sup>
	impact-finish	42.7 (23.4) <sup>2,3</sup>	38.5 (20.4) <sup>1</sup>	32.0 (15.2) <sup>1</sup>

Superscripts indicate significant differences between the groups ( $p < 0.05$ ).



**Figure 5.** Maximum angular velocity of the lumbar spine in extension, rotation, and tilt after impact in various conditions.

decreased 52% in the HC condition ( $p < 0.05$ ), but was not significantly decreased in the SC condition (Figure 5, left panel). HC condition decreased lumbar extension velocity just after impact.

## 2. Lumbar Rotation

**2-A. Lumbar rotation angle:** Lumbar rotation angles at both the top and the end of the swing were significantly decreased in the HC relative to the WOC condition, by 27% and 36%, respectively ( $p < 0.05$  each). In the SC condition, a significant decrease was observed only at the top of swing (6%,  $p < 0.05$ ) (Figure 4, middle panel). HC condition decreased lumbar rotation angle at both top and finish.

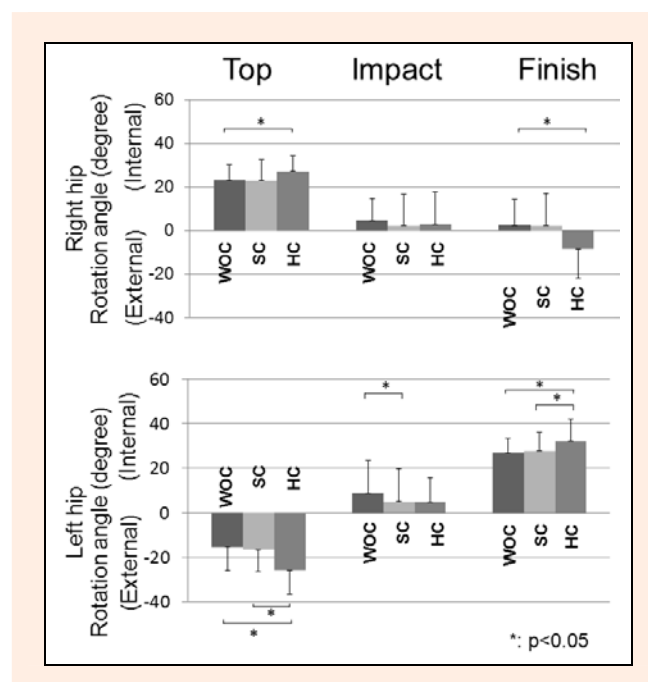
**2-B. Lumbar range of motion in the axial plane:** In the HC condition, the lumbar ranges of motion in the axial plane were significantly decreased, both from the top of the swing to impact and from impact to finish, compared

with the WOC condition (Table 1, middle panel). In contrast, no significance differences were observed between the SC and WOC conditions. HC condition decreased lumbar range of motion in axial plane.

**2-C. Lumbar rotation velocity just after impact:** Lumbar rotation velocity was significantly lower in the SC and HC conditions than in the WOC condition ( $p < 0.05$  each) (Figure 5, middle panel). SC and HC condition decreased lumbar rotation velocity just after impact.

## 3. Lumbar Tilt

**3-A. Lumbar tilt angle:** Wearing corsets altered the lumbar tilt angle at the impact of the swing, being 15% lower in the SC and 30% lower in HC conditions ( $p < 0.05$  each) than in WOC conditions (Figure 4, bottom panel). SC and HC condition decreased lumbar tilt angle only at impact.



**Figure 6.** Rotation angle of the right and left hip at the top, impact, and at finish of the swing in various conditions.



**3-B. Lumbar range of motion in the coronal plane:** The lumbar range of motion in the coronal plane was significantly lower under HC than under WOC conditions, both from the top of the swing to impact and from impact to finish (Table 1, bottom panel). Under SC conditions, however, the lumbar range of motion in the coronal plane was significantly lower than under WOC conditions only from the top of the swing to impact. HC condition decreased lumbar range of motion in coronal plane.

**3-C. Lumbar tilt velocity just after impact:** Lumbar tilt velocity was 64% lower under HC than under WOC conditions ( $p < 0.05$ ) (Figure 5, right panel). HC condition decreased lumbar tilt velocity just after impact.

#### 4. Hip rotation angle

The rotation angle of the right hip at the top of the swing was 16% higher ( $p < 0.05$ ) and the rotation angle of the left hip at the end of the swing was 19% higher ( $p < 0.05$ ) under HC than under WOC conditions (Figure 6). Neither of these angles differed significantly, however, when SC was compared with WOC conditions. Under HC condition, both right and left hip rotation increased significantly.

### Discussion

#### New findings in this study

Our analysis in 11 amateur golfers showed, for the first time, that wearing lumbar corsets during a golf swing can effectively decrease lumbar extension and rotation angles and angular velocity, thus presumably relieving stress at the lumbar spinal structures. This effect was significant in hard, but not in soft, type corsets. Moreover, we found that wearing lumbar corsets increased the rotational motion of the hip joint while reducing the rotation of the lumbar spine.

#### Decrease in lumbar extension and rotation angle at the finish of a golf swing

Trunk hyperextension at the finish of a golf swing has been considered a risk factor for LBP (Geisler, 2001). Importantly, as long as the end of the swing is initiated and regulated by the moment of the swinging club, this posture is passively determined by the speed, weight, and velocity of the club and the stiffness of the trunk. We found showed that lumbar hyperextension and rotation during this phase are decreased by wearing both type of corsets, with HCs having significant effects. These differences were likely due to an increase in trunk stiffness provided by the corsets (Cholewicki et al., 2010).

#### Wearing corsets restrict lumbar range of motion during golf swings

A case study of a golfer with LBP showed that decreasing the amount of spinal motion in the axial, sagittal, and coronal planes during golf swings can reduce compressive and torsional loads on the lumbar spine, thus reducing LBP. (Grimshaw and Burden, 2000) We, however, separated these swings into 2 phases; from the top of the swing to impact, and from impact to finish. Wearing an HC significantly decreased lumbar ranges of motion

(ROMs) in extension, rotation, and tilt during both phases, whereas wearing an SC significantly reduced only extension ROM from top to impact and tilt ROM from impact to finish. An HC was therefore effective in restricting lumbar motion in the axial, coronal, and sagittal planes, whereas an SC was effective only in the sagittal plane.

#### Wearing corsets restrict lumbar angular velocity during golf swings

Rapid spinal rotation velocity during a golf swing has been reported to result in a considerable spinal load, resulting in the development of low back injuries (Hosea et al., 1994). We found that wearing an HC decreased the maximum angular velocity of the lumbar spine in extension, rotation and tilt, which may reduce golf-related LBP.

#### Effects of wearing corsets on hip rotation

Hip rotation plays an important role in rotation related sports (Vad et al., 2004). Recently, Gulgin, et al. (2010) suggested an importance of hip rotation ROM or asymmetry during golf swing as a possible indicator for injury risk. During a golf swing, the golf club propels the ball through maneuvers of the upper extremities, including the hands and arms, maneuvers initiated by the rotation of the shoulder girdle. The position of the shoulder girdle is mainly regulated by the sum of the rotations of the trunk and hip joint. The latter two rotations compensate for each other, with each showing a different magnitude of involvement. Reducing excessive motion by the lumbar spine and increasing the compensatory rotational motion of the hip joint during a golf swing can reduce the incidence of low back-injuries (Murray et al., 2009). Wearing a lumbar corset can therefore prevent golf-related back problems. Indeed, wearing an HC significantly increased the side hip rotation angles at both the top and end of a swing, suggesting that wearing an HC results in the greatest restriction of lumbar motion. Importantly, this effect was not observed when wearing an SC. The differences between HCs and SCs on the restriction of hip rotation are compatible with the restrictions of lumbar rotation at the end of the swing.

#### Different effects of the 2 types of orthosis

We assessed 2 types of corsets, SCs and HCs. Our motion analyses suggest that wearing an HC may result in a greater reduction in lumbar spinal range of motion in 3 planes during golf swings. This result was compatible with a study on lumbar orthosis in healing symptomatic lumbar spondylolysis (Sairyo et al., 2012). However, SCs also significantly decreased lumbar ranges of motion when compared with the WOC condition. Golfers would prefer not to wear HCs while playing, presumably because of their bulkiness. Future studies should include the development of lumbar orthosis for golfers that can manipulate the range of motion of the lumbar spine in any plane, in accordance with each type of lumbar pathological condition.

#### Limitations of the study

This study had several limitations. First, 3-dimensional motion analyses were performed using skin markers, which may introduce a bias. Second, healthy young male amateur golfers participated in this study. To better understand 3-dimensional motions in golfers with low back disorders, motion analyses should be performed in golfers with LBP. Third, wearing lumbar corsets may have affected swing performance including head speed, accuracy of control, and carrying distance. Fourth, in this study, the immobilizing effect of the corset on lumbar spine and subsequent effects on thoracic spine, pelvis, and hip joints were analyzed. However, problems in the subsequent effects on the other parts of the body have not been discussed. Future study needs to focus on the negative effects of wearing lumbar corsets during golf swing.

## Conclusion

Our findings may be important for both clinicians and golfers. First, wearing a corset can restrict the hyperextension of the lumbar spine, which may be a pain generating maneuver associated with spondylolysis or facet syndrome. Second, wearing an HC can reduce the magnitude of lumbar rotation and increase hip rotation, changes that may benefit patients with conditions of lumbar disc degeneration. Third, wearing corsets may prevent the development of LBP in golfers. Fourth, providing golfers with this type of kinesiological information may increase their awareness of the effect of lumbar orthosis on their swing.

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## Key points

- Rotational and extension forces on the lumbar spine may cause golf-related low back pain
- Wearing lumbar corsets during a golf swing can effectively decrease lumbar extension and rotation angles and angular velocity.
- Wearing lumbar corsets increased the rotational motion of the hip joint while reducing the rotation of the lumbar spine.

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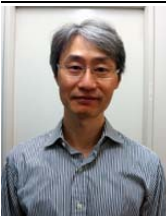
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