

Analysis of Lumbar Spine Load during Golf Swing in Pro. Golfer

Low back pain is a common phenomenon among the golfers. In an attempt to understand low back pain, the kinematic changes and golf swing motion analysis has been performed to focus on lumbar spine in pro. golfers. According to the swing pattern, significant variations of the lumbar joint forces and loads has related with muscles activities so the motion analysis of lumbar spine were discussed. The purpose of this study was to analyze motion of lumbar spine and it was to compare joint force during golf swing in pro. golfers. The swing motion of the subjects was tracked using a 3D motion analysis system by Motion Analysis Ltd. and SIMM software. The angle changes of lumbar spine rapidly in vx direction during the top back swing and the finish and in vy direction during the follow through and in vz direction during the down swing and the impact(Subject A). The angle changes of lumbar spine rapidly in vx direction during the top back swing and in vy direction during the down swing, the impact and the follow through and in vz direction during the down swing(Subject B). In conclusion, subject A and B both show sudden angle changes between 1st–3rd lumbar spine and 4th–5th lumbar spine during the stage from address to top back swing which caused by over upper body twisting.

Key words: *Golf Swing; Lumbar Spine Load; Motion Analysis; SIMM Software*

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INTRODUCTION

Golf population has increased dramatically as a sports in Korea and golf-related injuries are also increased as well. Because of biomechanical characteristics, the golf swing generates a lot of forces to lumbar spine such as compression force, shear force, rotational moment(1). The most common golf injuries are reported in the low back pain which represent 22–24% of all in professionals(2). To diagnose anatomical problems of lumbar spine, the image techniques are used as an effective analysis for low back pain such as X-ray, CT scan and MRI. However, the utility of these methods were reported only 12–15% low back pain patients who have got a clear anatomical causes since causal complexity of low back pain(3). For that reason, it is difficult to distinguish degree of the low back pain and measure the functional lumbar motion by

existing image techniques.

Recently, the kinematic methods were introduced and evaluated quantitatively the range of motion of lumbar movement, the muscle strength and muscle endurance as a high reliability techniques(4, 5, 6). Mayer et al. reported that it is important recovery sign to the chronic low back pain patients when the pelvic movement return in normal range of motion during rehabilitation(7). It is different from individuals, usually a pro. golfers can be taken out power about 4 horse power at down swing when a muscle of 30 pounds contraction and it takes out this power in the lumbar spine with maximum force at least(8). At the time of golf swing of pro. golfers, shear force and compression reaction force are added to spine and an average maximum shear reaction force is appeared 596N and 329N respectively between amateur and pro. golfers(9). The pro. golfers practice more than several hundred times a day through a powerful

swing so it causes unequal state. Asymmetry of golf swing may be potentially harmful to lumbar spine therefore low back pain is the endemic problems to pro. golfers. The pain of right side is worsened by follow-through and it appears that asymmetry lumbar degenerative changes in comparison with the group which does not play golf.

These days, many kinematic researches of golf swing are reported and analyzed. There are used the measurement which is the electromyogram and camera for methodology. Cole and Grimshaw reported that the results of erector spinae with the electromyogram measurement between the golfer who is having low back pain or not(10). Horanm et al. reported that the tilt angle and velocity of thorax and pelvis at down swing between men and women using motion analysis(11). Tsai et al. used a camera in research report, it was photographed analysis after adhesion of a marker that the angle of trunk measured during golf swing(12). Especially, Marras et al. measure the kinematic variables, such as speed and acceleration of lumbar movement, in order to clarify significance of a statistical difference between normal and low back pain patients. Because lumbar movement of low back pain patients is done by lumbar spine and pelvis therefore it is emphasized that the necessity of motion analysis of this two joints simultaneously(13).

However, there are not direct measurements and interpretation about reaction force of lumbar spine during golf swing at all. Therefore, the purpose of this study was that measure the joint force(JF) of lumbar spine from first to fifth each and find out the maximal reaction force of each swing phase in pro. golfers.

MATERIALS AND METHODS

Subjects

Two male pro. golfers, who are the right-handed, participated in the study. The detail for subjects were described in table 1. All subjects gave the questionnaire about low back pain before an experiment and they were not injuries and musculoskeletal diseases for orthopaedics. In addition, for the purpose of this study, swing phases was divided into six phases (adress-top back swing-down swing-impact-follow through-finish) and progressed by interpretation.

Table 1. Characteristics of the golfers

	Subject A	Subject B
Age(yrs)	35	39
Height(m)	1.80	1.78
Weight(kg)	80	68
Career(yrs)	15	20

Protocol

We used 3-dimensional motion analyzer(Eagle 4, Motion Analysis Ltd., USA), which was consisted of two ground reaction force plate(Piezoelectric force plate, 600mm×900mm, Kistler Ltd., Swiss), eight infrared camera, 10mm reflection marker, CCD camera, VCR, data processing manipulation PC, as a measurement tools for golf swing analysis. Subjects were wearing their golf shoes and shorts which did not give golf swing hindrance. Before carrying out golf swing analysis, we did calibration to minimize the error that could occur with a camera. Then Helen Hayes Marker Set(14) was being used by an existing thesis mainly, the kinematic analysis of golf swing was carried out after adhesion of the 10mm diameter reflection marker, which can be recognize by an infrared camera, in anatomical position of human body.

Subjects were measured once static and stretching posture for a build application before an experiment and were practiced. Golf swing was drove on two ground reaction force plate(GRFP) spread at a bottom each and the right and left ground force of human body were calculated and ten times of golf swing were measured by enforcement repeatedly. Anthropometric characteristics were measured before an experimental and the height, weight, foot length, foot width and the longest foot length measured in the wide place horizontally.

Static posture test was carried out to confirm each articular position and then dynamic posture test was carried out after removed the medial makers of the right and left inside thigh arthrosis tubercle and the right and left ankle and elbow. Characteristic of each subject was described with 3 dimensions of motion capture pictures by SIMM software and each subject was measured the joint force of lumbar spine at the time of golf swing phases.

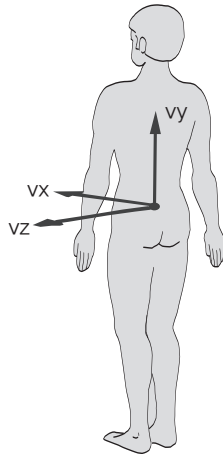


Fig. 1. Definition of plane-projection

RESULTS AND DISCUSSION

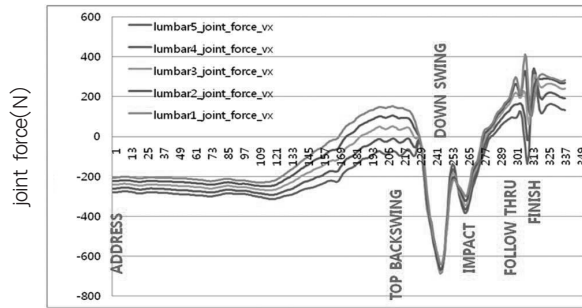
The motion of lumbar spine during golf swing was

analyzed with a 3 dimension of motion analysis systems. After that, SIMM software was used for interpretation of the joint force each lumbar spine at the time of golf swing phases. Definition of spine segment was done in figure 1 for purpose of this study. When it was recorded in Body plane, frontal plane was set in a vx direction, transverse plane was set in a vy direction and sagittal plane was set in a vz direction. The results appeared as follows.

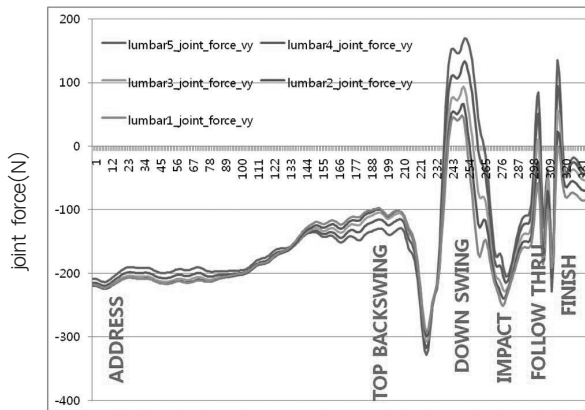
Table 2 appeared that the time and joint force of 1st–5th lumbar spine(subject A) at golf swing phase and figure 2 showed that the direction and joint force of 1st–5th lumbar spine in vx, vy, vz during golf swing(subject A). When measured the joint force of vx direction is appeared that a positive shows anterior direction of joint force and a negative shows posterior direction of joint force. When measured the joint force of vy direction is appeared that a positive shows cranial direction of joint force and a negative shows ground direction of joint force. When measured the joint force of vz direction is appeared that a positive shows left direction of joint force and a negative shows right direction of joint force.

Table 2. The time and joint force of lumbar spine during golf swing(subject A)

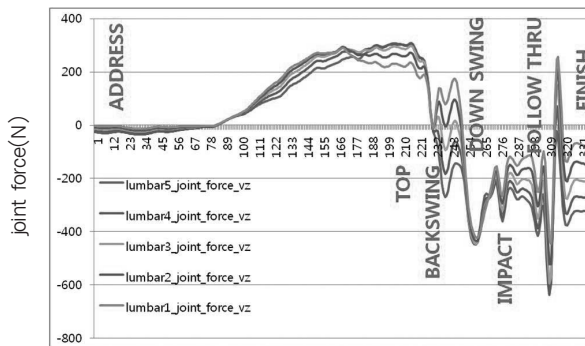
	Address	Top back swing	Down swing	Impact	Follow through	Finish
Time(s)	.792	1.725	2.025	2.075	2.15	2.592
vx – lumbar joint force(N)						
lumbar5	-289,109	-80,785	-627,555	-475,412	-256,532	-90,641
lumbar4	-270,946	-16,726	-642,469	-492,411	-255,582	-16,804
lumbar3	-253,523	45,45	-641,744	-502,585	-252,664	59,314
lumbar2	-236,941	101,609	-626,477	-505,209	-248,009	131,613
lumbar1	-221,83	148,723	-598,535	-500,293	-242,909	196,012
vy – lumbar joint force(N)						
lumbar5	-195,469	-129,51	152,47	151,014	116,19	-228,567
lumbar4	-200,339	-115,017	110,668	115,869	63,674	-204,808
lumbar3	-202,825	-105,403	74,629	81,953	-5,862	-190,863
lumbar2	-203,791	-101,785	51,763	59,612	-54,584	-187,446
lumbar1	-202,452	-101,544	40,535	45,67	-100,253	-190,409
vz – lumbar joint force(N)						
lumbar5	32,075	301,446	-165,34	-160,863	-447,084	-444,851
lumbar4	31,486	303,754	-82,085	-115,871	-447,374	-449,703
lumbar3	33,408	291,079	-.878	-70,888	-442,541	-436,813
lumbar2	33,479	264,029	82,222	-19,224	-430,398	-405,764
lumbar1	33,817	225,211	162,136	33,98	-413,067	-358,834



(1) Joint force of vx direction



(2) Joint force of vy direction



(3) Joint force of vz direction

Fig. 2. The direction and joint force of lumbar spine in vx, vy, vz during golf swing(subject A)

Pro. golfer kinematic profiles for joint force of lumbar spine at the golf swing phase, the angle changes of 1st–3rd lumbar spine(L1–L3) and 4th–5th lumbar spine(L4–L5) rapidly in vx direction during the top back swing and the finish. At the top back swing, the joint force of vx direction is appeared that a positive shows anterior direction of joint force about 148.723 N, 101.609N, 45.45N on L1–L3 respectively and a negative shows posterior direction of joint force

about -16.726N, -80.785N on L4–L5 respectively. At the finish, the joint force of vx direction is appeared that a positive shows anterior direction of joint force about 196.012N, 131.613N, 59.314N on L1–L3 respectively and a negative shows posterior direction of joint force about -16.804N, -90.641N on L4–L5 respectively.

The angle changes of L1–L3 and L4–L5 rapidly in vy direction during the follow through. At the follow through, the joint force of vy direction is appeared that a negative shows ground direction of joint force about -100.253N, -54.584N, -5.862N on L1–L3 respectively and a positive shows cranial direction of joint force about 63.674N, 116.19N on L4–L5 respectively.

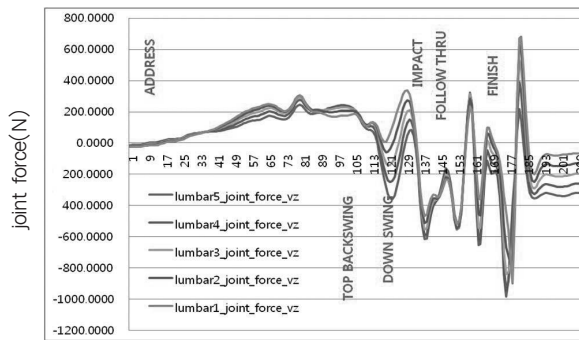
The angle changes of L1–L2 and L3–L5 rapidly in vz direction during the down swing and the angle changes of L1 and L2–L5 rapidly in vz direction during the impact. At the down swing, the joint force of vz direction is appeared that a positive shows left direction of joint force about 162.136N, 82.222N on L1–L2 respectively and a negative shows right direction of joint force about -.878N, -82.085N, -165.34N on L3–L5 respectively.

In each graph shows that a direction of force and size according to each swing phases and it was understood that the direction of force changed with a turn of trunk at the time of golf swing(Fig. 2). As a result of time comparing to position, the change of angle are different with a most of position sections, especially it shows that the angle changes of L1–L3 and L4–L5 rapidly during top back swing(TBS). It may estimate that a lot of upper body parts are turned in a change from an address to top back swing. In addition, when it moves from top back swing to down swing, the angle of L1–L3 and L4–L5 changed reversely. It may estimate that the upper body parts are maintained continually to top back swing but the phenomenon of turning pelvis sway to the down swing.

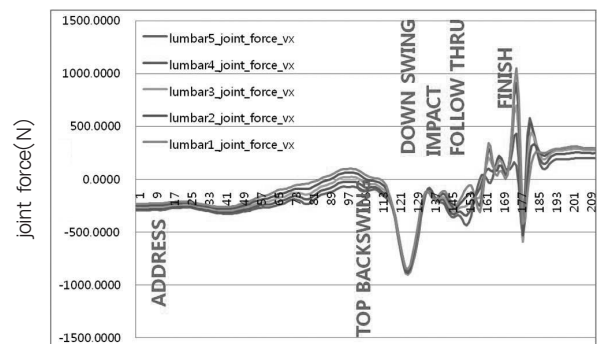
Table 3 appeared that the time and joint force of 1st–5th lumbar spine(subject B) at golf swing phase and figure 3, 4 showed that the direction and joint force of 1st–5th lumbar spine in vx, vy, vz during golf swing(subject B). When measured the joint force of vx direction is appeared that a positive shows anterior direction of joint force and a negative shows posterior direction of joint force. When measured the joint force of vy direction is appeared that a positive shows cranial direction of joint force and a negative shows ground direction of joint force. When measured the joint force of vz direction is appeared that a positive shows left direction of joint force and a negative shows right direction of joint force.

Table 3. The time and joint force of lumbar spine during golf swing(subject B)

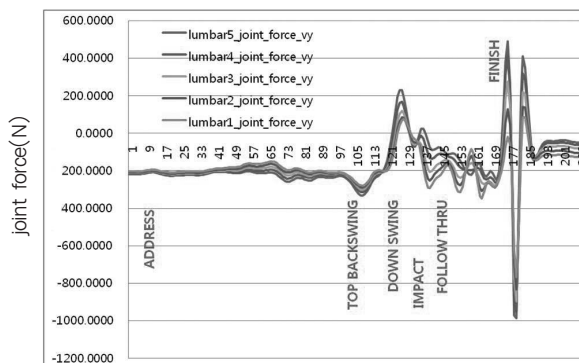
	Address	Top back swing	Down swing	Impact	Follow through	Finish
Time(s)	.158	.833	1.025	1.083	1.133	1.617
vx – lumbar joint force(N)						
lumbar5	-270.255	-72.072	-781.400	-500.931	-110.72	188.935
lumbar4	-255.358	-24.095	-819.017	-482.129	-130.898	239.769
lumbar3	-241.222	21.877	-831.673	-454.780	-148.223	273.1
lumbar2	-227.659	62.945	-821.606	-420.766	-162.318	288.389
lumbar1	-215.021	97.208	-791.924	-381.247	-174.327	287.106
vy – lumbar joint force(N)						
lumbar5	-227.661	-237.675	123.087	-16.805	24.2	-40.431
lumbar4	-225.005	-228.213	59.911	-29.210	-31.392	-53.907
lumbar3	-220.915	-223.589	.654	-24.776	-101.037	-70.874
lumbar2	-216.350	-220.276	-38.219	-16.529	-146.234	-95.163
lumbar1	-210.685	-218.551	-61.609	1.674	-185.721	-117.537
vz – lumbar joint force(N)						
lumbar5	25.144	240.325	-335.959	81.307	-529.093	-319.444
lumbar4	19.351	240.692	-216.831	149.129	-509.133	-262.555
lumbar3	17.886	228.218	-94.353	212.255	-479.091	-200.044
lumbar2	13.566	206.299	28.539	266.950	-444.896	-134.202
lumbar1	9.989	174.969	148.086	314.048	-406.062	-70.226



(1) Joint force of vx direction



(3) Joint force of vz direction



(2) Joint force of vy direction

Fig. 3. The direction and joint force of lumbar spine in vx, vy, vz during golf swing(subject B)

The angle changes of L1-L3 and L4-L5 rapidly in vx direction during the top back swing. At the top back swing, the joint force of vx direction is appeared that a positive shows anterior direction of joint force about 97.208N, 62.945N, 21.877N on L1-L3 respectively and a negative shows posterior direction of joint force about -24.095N, -72.072N on L4-L5 respectively.

The angle changes of L1-L2 and L3-L5 rapidly in vy direction during the down swing, the impact and the follow through. At the down swing, the joint force of vy direction is appeared that a negative shows ground direction of joint force about -61.609 N, -38.219N, on L1-L2 respectively and a positive shows cranial direction of joint force about .654N, 59.911N, 123.087 N on L3-L5 respectively. At the impact, the joint force of vy direction is appeared that a positive shows cranial direction of joint force about 1.674N on L1 and a negative shows ground direction about -16.529N, -24.776N, -29.210N, -16.805N on L2-L5 respectively. At the follow through, the joint force of vy direction is appeared that a negative shows ground direction of joint force about -185.721N, -146.234N, -101.037N, -31.392N on L1-L4 respectively and a positive shows cranial direction of joint force about 24.2N on L5.

The angle changes of L1-L2 and L3-L5 rapidly in vz direction during the down swing. At the down swing, the joint force of vz direction is appeared that a positive shows left direction of joint force about 148.086N, 28.539N on L1-L2 respectively and a negative shows right direction of joint force about -94.353N, -216.831N, -335.959N on L3-L5 respectively.

In each graph shows that a direction of force and size according to each swing phases and it was understood that the direction of force changed with a turn of trunk at the time of golf swing(Fig. 3). As a result of time comparing to position, the change of angle are different with a most of position sections, especially it shows that the angle changes of 1st-3rd lumbar spine and 4th-5th lumbar spine rapidly during top back swing same as subject A. It may estimate that a lot of upper body parts are turned in a change from an address to top back swing. In addition, when it moves from top back swing to down swing, the angle of L1-L3 and L4-L5 lumbar spine changed reversely. It may estimate that the upper body parts are maintained continually to top back swing but the phenomenon of turning pelvis in pursuance of down swing.

The maximal force occurred in down swing and before impact that seems with preparation of maximal power stage to hit a ball. Because of upper body parts are excessive turned in a change from an address to top back swing(TBS), it is appeared that the angle changes of L1-L3 and L4-L5 rapidly both A and B subject. when it moves from top back swing to down swing, the angle of L1-L3 spines changed reversely and the maximal shear force occurred. Therefore, it seems to give a massive force to lumbar

spine during top back swing in A and B subject.

CONCLUSION

The cause of golfer's frequent low back pain is various but generally it caused by spines over extension during swing. Calliet reported 80-90 percent of low back pain occurs between L1 to S1 especially L3 to S1(L4).

Through this study, several reaction force on lumbar spine and angle of lumbar spine during swing motion were measured and also data was made. According to the results, both subject A and B show sudden angle changes between 1st-3rd lumbar spine and 4th-5th lumbar spine during the stage from address to top back swing which caused by over upper body twisting. During the stage from top back swing to down swing, the angle was reversed and influenced remarkably by shear force. The shear force was extremely strong and dramatic angle change occurs in lumbar spine 1st-3rd and lumbar spine 4th-5th from following though to finish. These results show that pro. golfer who plays over 10 years may occurs lumbar spine 1st-3rd injury frequently. Further research with more subjects would be studied kinematic analysis of lumbar spine for the prevention of low back pain in pro. golfers as a piloted in this study.

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