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Effect of obesity and low back pain on spinali mobility: a cross sectional study

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1 Introduction

Obesity is nowadays a pandemic condition. Obese subjects are commonly characterized by musculoskeletal disorders and particularly by non-specific low back pain. However, the relationship between obesity and LBP remains to date unsupported by an objective measurement of the mechanical behaviour of the spine and its morphology in obese subjects. Such analysis may provide a deeper understanding of the relationships between function and the onset of clinical symptoms.

To objectively assess the posture and function of the spine during standing, flexion and lateral bending in obese subjects with and without non-specific low back pain (LBP) and to investigate the role of obesity in LBP.

2 Materials and methods

Thirty seven volunteer subjects were recruited. Three groups of adult female patients admitted in our Department of Orthopaedic Rehabilitation were recruited: 13 obese patients with no LBP (Group O) (age: 38.3 ± 8.9 years, BMI: 39.2 ± 3.6 kg/m^2), 13 obese patients with non-specific chronic LBP (Group LBP) (age: 49.1 ± 8.6 years, BMI: 41.9 ± 5.6 kg/m^2), and 11 healthy women with no history of musculoskeletal complaints as the control group (Group C) (age: 31.9 ± 8.6 years, body mass index BMI: 20.1 ± 1.2 kg/m^2). We considered three groups of female subjects in order to take into account the same mass distribution typical of women and because the prevalence of LBP is greater in women than in men. At the time of the study, LBP patients were not under any treatment. The study has been approved by the local Ethical Committee and all the participants gave written informed consent.

Experimental setup

The study was conducted at the Laboratory of Gait and Posture Analysis of our Institute. Data were acquired with a 6-camera optoelectronic motion analysis system (Vicon 460, Vicon Motion Systems, Oxford, UK) operating at a sampling rate of 100 Hz. The reflective markers were spherical with diameter of 14 mm.

The location of the markers, the movements, and the angles definitions have been previously described. In brief, five markers were placed along the spine (Figure 1): two on the thoracic (T1 and T6), two on the lumbar vertebrae (L1 and L3), and one on the sacrum (S1). Four markers on the pelvis: right anterior superior iliac spines (LASI/RASI) and left and right posterior superior iliac spines (LPSI/RPSI). Two markers were then applied on the acromion of the left (LSHO) and right shoulders (RSHO).

As for the movements analyzed, two different tasks were considered: forward flexion and lateral bending both sides. Subjects were instructed to perform the test comfortably at their own preferred speed with feet apart at shoulder width. Each movement was repeated three times in order to evaluate the inter-subject variability.

Modelling and data processing

Three-dimensional data from the optoelectronic system were processed using the multi-purpose biomechanical software SMART Analyzer (BTS, Milan, Italy). As for forward flexion, we defined the angles shown in Figure 2 to characterize trunk mobility in the sagittal plane. Specifically we considered: forward trunk inclination (αFTI), pelvic tilt (α1), angle related to lordosis (αL) lumbar movement (α2), angle related to kyphosis (αK), and dorsal movement (α3).

The above mentioned angles were evaluated at the initial standing position (START) and at maximum forward flexion (MAX). The range of motion (ROM) between START and MAX was also computed. As for lateral bending, similar angles were considered (Figure. 3): lateral trunk inclination (βLTI), pelvic obliquity (β1), lumbar curve (βDC), lumbar movement (β2), dorsal curve (βPC), dorsal movement (β3), and shoulders (β4).

Again the ROM for each angle was evaluated, by computing the difference between maximum left- and right-bending. We also computed the symmetry index of lateral trunk inclination (βLTI), representing the difference between the maximum left- and right-bend, and the centre of rotation (CoR), a semi-quantitative index used to locate the centre of rotation based on the trajectories of the markers in the frontal plane during the lateral bending. In particular, we identified the CoR by defining different zones delimited by the markers (Figure 4).

Figure 1. Marker setup. Markers were placed on superior posterior iliac spines (LPSI, RPSI), on superior anterior iliac

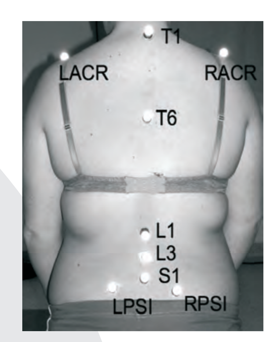


Figure 2. Representation of markers and angles in sagittal plane during forward flexion. On the left (Figure 1A) are shown: frontal trunk inclination (aFTI), pelvic obliquity (a1), angle

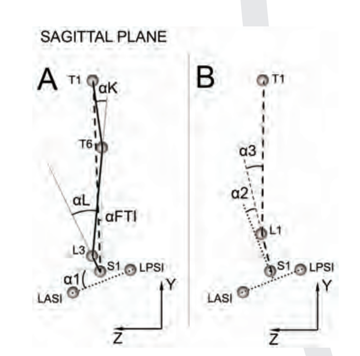


Figure 3. Representation of markers and angles in frontal plane during lateral bending. On the left (Figure 2A) are shown: lateral trunk inclination (βLTI), pelvic obliquity (β1), proximal curvature (PC), distal curvature (βDC). On the right (Figure

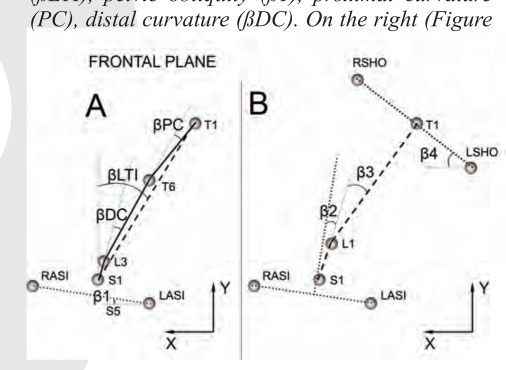
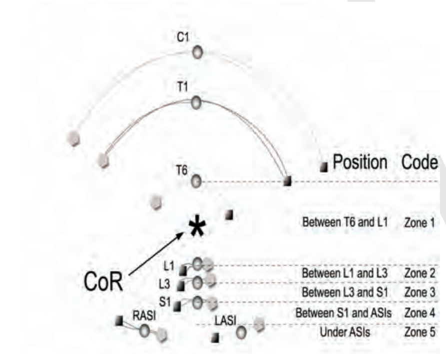


Figure 4. Lateral bending movement in frontal plane, with representation of markers (sphere: standing position, square: left bending, pentagon: right bending), and the localization of the center of rotation (CoR).



3 Results

We considered the mean values of the forward flexion and lateral bending repetitions correctly performed by each subject. Parameters acquired from markers which were not visible during the tests were excluded from further analysis.

Forward Flexion

The ROM of spine flexion was reduced in O and LBP patients as compared to C (αFTI, ROM). This reduction was mainly influenced by the different standing posture (αFTI, START).

O and LBP patients presented an increased pelvic tilt angle (α1, START) but only LBP patients had a statistically significant reduction in ROM as compared to C.

The angle related to lordosis (αL) was significantly increased in LBP patients in the START position as compared to the C and O. No statistical differences in ROM (αL) were evident.

Lumbar movement (α2) in LBP was significantly reduced only in MAX.

The angle related to kyphosis (αK) was similar in the three groups in the START position, but the ROM was significantly reduced in O and LBP (αK, ROM).

The dorsal movement (α3) was significantly reduced in O and LBP as compared to C, not only in MAX but also in ROM.

Lateral bending

LBP patients showed a significant reduction in lateral bending as compared to O and C (αLTI, ROM) No differences in pelvic obliquity were observed among groups.

Furthermore, LBP patients showed a significantly reduced ROM of the lumbar curve (αDC, ROM) but no differences among groups were observed in lumbar movement (α2).

The dorsal curve (αPC, ROM) was statistically different among the three groups, with the LBP patients resulting as the most limited. LBP patients also showed a significant reduction in dorsal movement (α3, ROM) as compared to O and C.

A significant reduction in shoulder movement (α4, ROM) was observed.

The qualitative analysis of lateral bending by locating the CoR showed different trajectories among groups: subjects in C showed an "hourglass" shape (Figure 5A), while O and LBP showed a "cone" shape (Figure 5B and Figure 5C). CoR was located between L1 and L3 in C subjects (CoR Zone: 2) and between S1 and anterior superior iliac spine (ASIS) in O and LBP (CoR Zone: 5)

Table 1. Main results about the forward flexion movement.

		C	O	LBP patients
		Mean (SD)	Mean (SD)	Mean (SD)
Sagittal Plane				
Forward trunk inclination (αFTI) [deg]	START (*,**)	1.2 (2.7)	5.0 (2.5)	4.0 (3.5)
	MAX (**)	119.4 (9.2)	112.1 (7.5)	103.9 (14.8)
	ROM (*,**)	118.2 (9.3)	107.1 (7.5)	99.8 (14.6)
Pelvic tilt (α1) [deg]	START (*,**)	11.2 (2.4)	20.9 (7.8)	23.9 (8.6)
	MAX	72.7 (6.5)	75.2 (13.7)	77.1 (12.4)
	ROM (**)	61.4 (6.2)	54.3 (10.4)	53.2 (9.5)
Angle related to lordosis (αL) [deg]	START (**,***)	30.2 (5.2)	32.7 (8.6)	41.0 (12.9)
	MAX (*,**,***)	-21.3 (2.6)	-14.6 (5.1)	-5.5 (8.5)
	ROM	51.5 (5.0)	47.3 (5.9)	46.5 (15.9)
Lumbar movement (α2) [deg]	START (**)	-1.7 (5.1)	-7.8 (13.5)	-15.3 (14.2)
	MAX (**,***)	22.8 (5.2)	19.2 (11.0)	10.9 (11.3)
	ROM	24.5 (5.6)	27.0 (12.2)	26.1 (12.2)
Angle related to kyphosis (αK) [deg]	START	23.7 (6.4)	25.5 (4.1)	24.9 (5.9)
	MAX (*)	34.6 (8.2)	27.2 (5.5)	29.0 (7.4)
	ROM (*,**)	10.9 (7.2)	1.8 (5.4)	4.1 (6.4)
Dorsal movement (α3) [deg]	START	-10.2 (6.7)	-9.0 (14.6)	-4.9 (9.6)
	MAX (*,**)	33.9 (5.2)	25.5 (6.6)	23.4 (9.2)
	ROM (*,**)	44.1 (8.5)	34.5 (10.0)	28.2 (9.6)

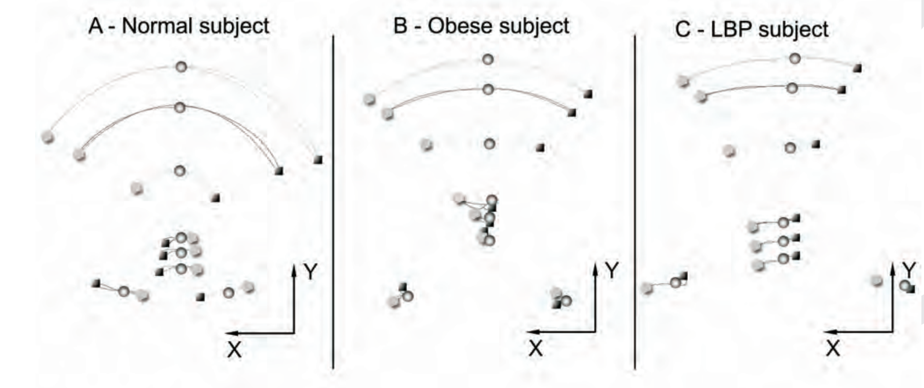
Trunk, pelvis, lumbar, dorsal, and cervical positive values were used in case of forward flexion of the considered segment, negative values otherwise. Negative values of the angle related to lordosis were used to highlight a kyphosis curve of the lordosis segment.
** differences between NG and OG (P<0.05)*
*** differences between NG and LBP patients (P<0.05)*
**** differences between OG and LBP patients (P<0.05).*

Table 2. Main results about the lateral bending movement.

		C	O	LBP patients
Frontal Plane		Mean (SD)	Mean (SD)	Mean (SD)
Lateral trunk inclination (βLTI) [deg]	START	-0.2 (1.0)	0.7 (1.5)	0.5 (1.7)
	ROM (**,***)	77.8 (13.7)	80.7 (8.0)	60.7 (21.3)
Pelvic obliquity (β1) [deg]	START	-0.5 (1.7)	0.0 (1.6)	-0.2 (2.6)
	ROM	12.1 (2.6)	15.2 (4.8)	11.7 (5.6)
Lumbar curve (βDC) [deg]	START	1.9 (4.6)	2.1 (3.1)	1.5 (5.5)
	ROM (**,***)	46.0 (7.0)	43.9 (11.3)	29.4 (11.8)
Lumbar movement (β2) [deg]	START	-1.9 (1.7)	-0.9 (3.0)	-1.1 (4.2)
	ROM	20.1 (8.2)	26.6 (9.3)	21.3 (16.8)
Dorsal curve (βPC) [deg]	START	2.2 (2.3)	0.4 (3.1)	0.1 (3.2)
	ROM (*,**,***)	42.2 (9.0)	31.3 (9.0)	23.0 (8.9)
Dorsal movement (β3) [deg]	START	2.7 (2.4)	2.8 (2.6)	1.4 (5.3)
	ROM (**,***)	59.2 (9.7)	50.5 (11.8)	35.5 (12.9)
Shoulder movement (β4) [deg]	START	1.1 (2.0)	0.5 (2.6)	1.3 (2.0)
	ROM (**,***)	105.7 (12.6)	102.3 (13.8)	79.3 (22.6)
Symmetry [deg]		-1.4 (2.5)	0.6 (5.2)	2.5 (6.8)
COR weight	(*,**)	Zone 2	Zone 5	Zone 5

Positive values were used in case of right bending of the segment.
** differences between NG and OG (P<0.05)*
*** differences between NG and LBP patients (P<0.05)*
**** differences between OG and LBP patients (P<0.05).*

Figure 5. Lateral bending movement represented in frontal plane (C1, T1, T6, L1, L3, S1, LASI and RASI trajectories) for the different groups. On the left (Figure 4A) the "hourglass" shape of a normal subject, in the center (Figure 4B) the "cone" shape of a representative obese subject and on the right the "wider cone" shape of a nLBP subject.



4 Conclusion

Our data show that obesity induces static and dynamic adaptations in the kinetics of the spine: under static conditions, obesity *per se* seems to generate an increased pelvic tilt; under dynamic conditions, to impair the mobility of the dorsal spine. Obesity with LBP is associated with higher spinal impairment than obesity without LBP and the presence of LBP is associated with an increased lumbar lordosis. Bending is performed in a qualitatively different mode when LBP is present and appears the most meaningful clinical test for detecting lower spinal impairments and monitor functional consequences of obesity.

Other spin-offs of our study are that rehabilitative interventions in obese patients should include strengthening of the lumbar and abdominal muscles as well as mobility exercises for the dorsal spine and pelvis.

The clinical usefulness of an optoelectronic approach is already widely acknowledged by the standardisation of gait analysis in the rehabilitation of several neurological and orthopaedic conditions, but only two studies so far has used kinematics analysis of the spine in healthy subjects. Our study suggests that kinematics of the spine can represent a non-invasive clinically useful technique for functional investigation in various spinal conditions and evaluation of effectiveness in rehabilitation.

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