Eur Spine J (2015) 24:513–520
DOI 10.1007/s00586-014-3626-y

ORIGINAL ARTICLE

Documenting female spine motion during coitus with a commentary on the implications for the low back pain patient

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Received: 28 February 2014 / Revised: 14 October 2014 / Accepted: 15 October 2014 / Published online: 24 October 2014

Abstract

Purpose To describe female lumbar spine motion and posture characteristics during coitus and compare these characteristics across five common coital positions. Exacerbation of low back pain during coital movements and positions is a prevalent issue reported by female low back pain (LBP) patients. To address this problem, the first study to examine lumbar spine biomechanics during coitus was conducted.

Methods Ten healthy males and females performed coitus in the following pre-selected positions and variations: QUADRUPED (fQUAD1 and fQUAD2 where the female is supporting her upper body with her elbows and hands, respectively), MISSIONARY (fMISS1 and fMISS2 where the female is minimally and more flexed at the hips and knees, respectively), and SIDELYING. An electromagnetic motion capture system was used to measure three-dimensional lumbar spine angles that were normalized to maximum active range of motion—a transmitter and receiver were affixed to the skin overlying the lateral aspect of the pelvis and the spinous process of the twelfth thoracic vertebra, respectively. To determine if each coital position had distinct spine kinematic profiles (i.e., amplitude probability distribution function and total range of lumbar spine motion), separate univariate general linear models followed by Tukey's honestly significant difference post hoc analysis were used. The presentation of coital positions was randomized.

Results Female lumbar spine movement varied depending on the coital position; both variations of QUADRUPED, fQUAD1 and fQUAD2, were found to use a significantly greater range of spine motion than fMISS2 ($p = 0.017$ and $p = 0.042$, respectively). With the exception of both variations of MISSIONARY, fMISS1 and fMISS2, the majority of the range of motion used was in extension. These findings are most pertinent to patients with LBP that is exacerbated by motions or postures. Based on the spine kinematic profiles of each position, the least-to-most recommended positions for a female flexion-intolerant patient are: fMISS2, fMISS1, fQUAD1, fSIDE, and fQUAD2. These recommendations would be contraindicated for the extension-intolerant patient.

Conclusions The findings provided here may guide the clinician's specific recommendations, including alternative coital positions and/or movement patterns or suggesting a lumbar support, depending on the female LBP patient's specific motion and posture intolerances.

Keywords Lumbar spine · Biomechanics · Coitus · Low back pain · Sexual intercourse

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Introduction

The creation and maintenance of a sexual relationship with a partner is considered an integral factor in the World Health Organization's (WHO) international standard to describe and measure health and disability [1] and sexual activity is a known indicator of quality of life (QoL) [2]. The potential effect of low back pain (LBP) on sexual activity has been recognized and incorporated into one of the most commonly recommended condition-specific outcome measures for spinal disorders: the Oswestry disability index (ODI) [3]. The influence that sexual activity has on QoL, health, and disability has important implications for women who experience LBP; between 48 [4] and 73 [5] percent of women with LBP have reported a marked reduction in the frequency of their sexual activity.

Findings from qualitative studies examining the sexual activity of women with LBP indicate that the central cause for this significant reduction in frequency is an increase in back pain during coitus. Structured interviews of patients with chronic LBP revealed that 44 % of women reported physical discomfort during coitus and 52 % reported that LBP restricted their sexual enjoyment [4]. A questionnaire-based study investigating the adverse effects of chronic LBP on sexual activity found that 58 % of women experienced marked discomfort as well as an exacerbation of their LBP during coitus [6]. Furthermore, the most frequently reported difficulties experienced during coitus by female patients were finding a position of comfort and difficulty with pelvic movements [6]. Patients also disclosed which coital positions they found to exacerbate their LBP the most: prone followed by supine and side-lying [6]. These patient reports not only expose the primary reason for reduced coital frequency as mechanical, but also suggest the importance of an examination of these mechanical factors to develop a biomechanical rationale for the exacerbation of LBP during coitus and subsequently, recommendations for patients.

Current recommendations for patients with LBP are based on clinical experience [7] and popular media resources [8, 9] instead of empirical data because, to our knowledge, a biomechanical investigation of coitus has not been conducted. Furthermore, many health care practitioners are not inclined to discuss the sexual needs of their clients [10], despite the fact that their patients consider their sexuality to be an important domain that is never discussed in relation to their condition [6]. Many sexologists agree that concerns with regard to sexual activity should be addressed by the health care practitioner and advice on coital movement and position adjustments would lead to improvements in sexual activity [4–6].

The main objective of this study was to describe female lumbar spine motion and posture characteristics during coitus and compare these characteristics across five common coital positions. This aim was motivated by compelling patient reports from qualitative studies, the paucity of information in the literature with regard to mechanical factors of coitus that may exacerbate LBP, and the apparent need for recommendations for health care practitioners. Lumbar spine motion was expected to occur primarily in the sagittal plane and distinct spine kinematic profiles for each coital position were also anticipated.

Methods

All subject recruitment and data collection procedures were performed in accordance with the university's Office of Research Ethics guidelines.

Participants

Ten healthy males and ten healthy females (29.8 ± 8.0 years, 164.9 ± 3.0 cm, 64.2 ± 7.2 kg)—with 4.7 ± 3.9 years of sexual experience with each other—were recruited for analysis in this study. Participants were considered for inclusion in this study if they did not have a history of spinal, abdominal, or hip surgery, a pre-existing disabling back or hip condition, current and relevant musculoskeletal concerns, any sexual dysfunction that would prevent them from engaging in coitus for the duration of the data collection, and/or registered-student status at the university.

Coital positions

Participants performed each of the five pre-selected positions, presented in random order, for 20 s. Participants were encouraged to move as naturally as possible, given the laboratory setting, as they engaged in coitus. The five chosen coital positions were based on qualitative research that identified common coital positions for patients with LBP [4, 6, 11], as well as frequently recommended positions for patients with LBP [12], and a biomechanical rationale.

QUADRUPED

Two variations of QUADRUPED were included in this study. In the first variation, fQUAD1, the female is supporting her upper body with her elbows in the quadruped position and the male is kneeling behind her. In the second variation, fQUAD2, the female is supporting her upper body with her hands in the quadruped position and the male is kneeling behind her.

MISSIONARY

Two variations of MISSIONARY were included in this study. In the first variation, fMISS1, the female is minimally flexed at the hips and knees in the supine position and the male is in the prone position on top of her while supporting his upper body with his hands. In the second variation, fMISS2, the female is flexed at the hips and knees in the supine position and the male is in the prone position on top of her while supporting his upper body with his elbows. In both variations, the female's feet remain in contact with the mattress.

SIDELYING

The female is lying on her left side and the male is lying on his left side behind her (fSIDE). Both the male and female have their hips and knees flexed.

Maximum active range of motion (aROM)

To measure the maximum range of lumbar spine flexion, extension, left and right lateral flexion, and left and right axial rotation possible through active movement (without any assistance), each participant was asked to assume an upright standing posture (i.e., neutral) before bending forward, extending back, side-bending (to the left and right), and twisting (to the left and right) at the waist as far as they could. The spine position measured in the upright standing posture was considered to be zero lumbar spine angular displacement in all coital positions. This trial was performed after completion of all coitus trials.

Data collection

To quantitatively measure the three-dimensional (3D) lumbar spine kinematics, torso and pelvis motion were considered necessary to monitor. Tracking the relative orientation of the pelvis and the torso (at the level of the twelfth thoracic vertebra) served as a surrogate for direct measurement of segmental lumbar spine kinematics for this study. An electromagnetic motion capture system (3SPACE Isotrak®, Polhemus, VT, USA) was used to track torso and pelvis motion. This is a camera-less 3D human motion measurement system that uses a transmitter, which generates a varying electromagnetic field, and a receiver, which senses the electromagnetic field; the position and orientation of the receiver relative to the transmitter is recorded. The transmitter and the receiver were firmly affixed to the skin overlying the lateral aspect (right side) of the pelvis and the spinous process of the twelfth thoracic vertebra, respectively, with adhesive tape and fabric hook-and-loop fasteners. During pilot testing, the research team confirmed the absence of any substantial artifact (e.g., due to soft tissue movement or contact between the receiver and the mattress) using this technique of securing the instrumentation to each participant as well as the specific placement of the transmitter and receiver; the electromagnetic motion capture system was calibrated in the participant's neutral standing posture and no marked difference was seen between the spine angles measured during this calibration trial and the same neutral standing posture after pilot testing was completed. During signal processing, the research team visually inspected all kinematic signals to ensure that instrumentation contact with the mattress, and the other participant, did not introduce noise into the signal—no additional noise due to instrumentation collision was detected. 3D lumbar spine kinematic signals were continuously collected for the duration of each trial and were sampled at a rate of 30 Hz.

Data processing

A custom computer program in MATLAB software (Version r2009B, The MathWorks Inc., Natick, MA, USA) was used to normalize the kinematic data and calculate the outcome measures. Recorded 3D lumbar spine flexion, extension, left and right lateral flexion, and left and right axial rotation angles were normalized to their respective maximum amplitudes achieved during the maximum aROM trial.

An amplitude probability distribution function (APDF) was then calculated for each position; the amplitude probability at a certain spine angle value is the probability that the spine angle is less than or equal to that value during a coitus trial [13]. Spine angles recorded during each coitus trial were found to be cyclic in nature, but the difference between consecutive local maxima and minima was highly variable (see Fig. 1 for an example of variable spine motion during a given position); thus, the APDF provided valuable insight into the distribution of the varying spine angles achieved during a coitus trial (i.e., maximum, minimum, and median spine angles are values found at amplitude probabilities of 1.0, 0.0, and 0.5, respectively).

On an APDF curve for any given coital position, total range of lumbar spine motion used in the sagittal plane is a 200-point scale, where flexion is between 0 and −100 % and extension is between 0 and +100 %. To calculate the outcome measure, total range of lumbar spine motion used in the sagittal plane (expressed as a percentage of maximum lumbar spine active range of flexion–extension motion), the maximum spine angle value recorded is subtracted from the minimum, divided by 200, and multiplied by 100.

Data analysis

In this study, the independent variable was coital position and the dependent variables were the 3D lumbar spine angular displacements at amplitude probabilities of 0.0, 0.5 and 1.0 as well as the range of spine motion in one plane.

IBM® SPSS® statistics software (Version 19, IBM Corporation, Somers, NY, USA) was used for all statistical analysis. Separate univariate general linear models (GLM) (factor: coital position = five levels, $\alpha = 0.05$) were used

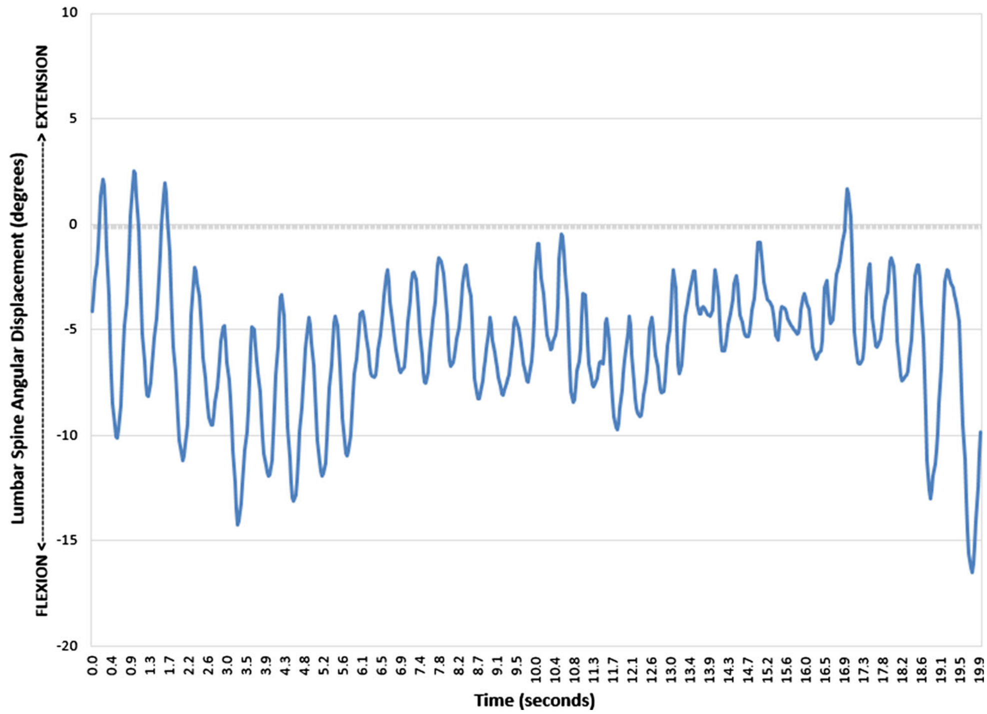

Fig. 1 Sample data from one subject for fSIDE, which demonstrates the variability in spine motion during a trial. Table 2 reports both the absolute maxima and minima scores for each trial, which occur at approximately 1.0 and 19.8 s in this trial, respectively, as well as an average of the local maximas and minimas found throughout a 20 s trial

at all three of these amplitude probabilities as well as on the range of spine motion in one plane variable to assess whether each coital position had distinct spine kinematic profiles. This was followed by Tukey's honestly significant difference (HSD) post hoc analysis to assess any main effects of coital position on spine kinematics.

Results

Only findings pertaining to the sagittal plane of motion are discussed below, since visual inspection of the kinematic data for all coital positions revealed that the majority of the kinematic signal was in the sagittal plane (i.e., flexion/extension).

Range of spine motion used for each coital position—expressed as a percentage of maximum lumbar spine aROM in the sagittal plane of motion (i.e., a combination of maximum flexion and extension aROM)—differed across coital positions. The average range of lumbar spine sagittal plane motion used was highest in fQUAD1 (35.50 ± 3.50 % sagittal aROM), followed by fQUAD2 (33.50 ± 3.50 % sagittal aROM), fSIDE (26.20 ± 3.50 % sagittal aROM), and fMISS1 (22.40 ± 4.80 % sagittal aROM). During fMISS2, the lowest range of spine motion was used (18.30 ± 3.80 % sagittal aROM), which was found to be of significantly less range [$F(4.31) = 3.828$, $p = 0.012$] than fQUAD1 ($p = 0.017$) and fQUAD2 ($p = 0.042$).

The mean values for each coital position at several amplitude probabilities, including 0.0 (the 'lowest' spine angle value achieved), 0.5 (the median spine angle value achieved), and 1.0 (the 'highest' spine angle value achieved) are shown in Table 1 and Fig. 2. The raw scores are also provided in Table 2 for the interested reader; the absolute maximum and minimum of each trial as well as an average of all local maxima and minima values are included due to the variability of spine motion during a trial (Fig. 1). Amplitude probability distribution function values were compared at probabilities of 0.0, 0.5, and 1.0. Significant differences were found at probabilities of 0.0 [$F(4.31) = 12.602$, $p < 0.001$], 0.5 [$F(4.31) = 19.805$, $p < 0.001$], and 1.0 [$F(4.31) = 22.261$, $p < 0.001$] (Fig. 3). At all three amplitude probabilities, fMISS2 was significantly lower than fQUAD1 ($p = 0.006$, $p < 0.001$, and $p < 0.001$, respectively), fQUAD2 ($p < 0.001$, $p < 0.001$, and $p < 0.001$, respectively), and fSIDE ($p < 0.001$, $p < 0.001$, and $p < 0.001$, respectively). fMISS1 was also significantly lower than fQUAD1 ($p = 0.039$ and $p = 0.006$, respectively), fQUAD2 ($p < 0.001$ and $p < 0.001$, respectively) and fSIDE ($p = 0.004$ and $p = 0.008$, respectively) at amplitude probabilities of 0.5 and 1.0, but only significantly lower than fQUAD2 ($p = 0.001$) and fSIDE ($p = 0.012$) at an amplitude probability of 0.0. The first variation of QUADRUPED, fQUAD1, was significantly lower than the second variation, fQUAD2, at an amplitude probability of 0.5 ($p = 0.031$).

Table 1 Lumbar spine angular displacement (% aROM) by coital position for specific amplitude probabilities

Amplitude probability	fQUAD1	fQUAD2	fMISS1	fMISS2	fSIDE
0.0	−22.0 ± 34.5	9.0 ± 41.6	−49.8 ± 19.9	−65.6 ± 17.8	−4.4 ± 34.8
0.1	−4.0 ± 40.8	30.0 ± 46.3	−40.2 ± 15.4	−58.3 ± 17.4	12.3 ± 34.4
0.5	14.4 ± 40.8	52.4 ± 44.5	−28.2 ± 13.0	−50.7 ± 16.1	26.7 ± 36.0
0.9	35.3 ± 44.0	67.5 ± 45.7	−15.6 ± 15.9	−38.8 ± 13.7	38.5 ± 37.4
1.0	49.0 ± 42.0	76.0 ± 44.7	−2.5 ± 25.5	−28.9 ± 14.5	48.0 ± 34.5

Negative values represent lumbar spine flexion and positive values represent lumbar spine extension. For a graphical representation of the numerical data presented here, see Fig. 2

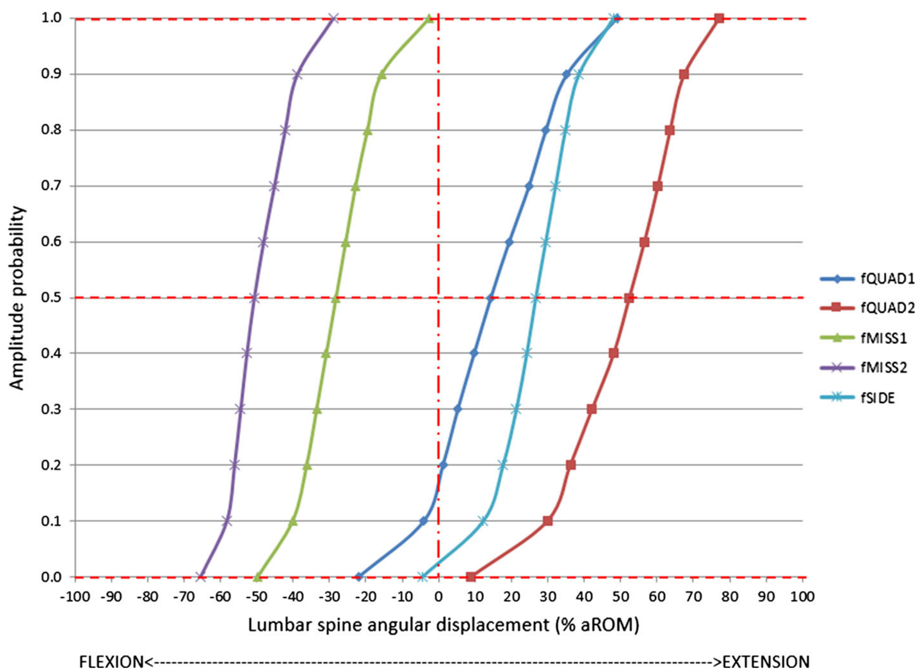

Fig. 2 Amplitude probability distribution of average lumbar spine angular displacement (% aROM) across all coital positions. The *dashed horizontal lines* indicate the amplitude probabilities at which statistical tests were performed (i.e., 0.0, 0.5, and 1.0). The *dashed vertical line* indicates zero lumbar spine angular displacement (i.e., a neutral spine position in upright standing)—to the left of this line is lumbar spine flexion and to the right of this line is lumbar spine extension. The angular displacement values at any amplitude probability can be interpreted as the probability that angular displacement was equal to or lower than that value during that coital position. Using fQUAD2 as an example, 50 % of the time during fQUAD2, spine motion was equal to or less than approximately 52 % of lumbar spine flexion aROM

Table 2 Lumbar spine angular displacement (degrees) by coital position for specific variables

Variable	fQUAD1	fQUAD2	fMISS1	fMISS2	fSIDE
Absolute maxima	7.0 ± 11.2	13.9 ± 12.0	−4.3 ± 6.1	−13.9 ± 6.9	8.6 ± 7.2
Absolute minima	−9.2 ± 10.7	−1.4 ± 11.0	−16.8 ± 6.8	−25.3 ± 8.0	−3.8 ± 9.0
Average	−0.6 ± 11.3	7.5 ± 11.5	−10.7 ± 4.8	−20.5 ± 7.4	3.6 ± 7.6
Average of local maximas	5.5 ± 8.4	12.9 ± 8.3	−7.5 ± 5.6	−17.1 ± 7.6	6.5 ± 7.3
Average of local minimas	−2.3 ± 10.9	7.5 ± 10.1	−14.0 ± 5.2	−23.3 ± 7.7	1.5 ± 8.0

Negative values represent lumbar spine flexion and positive values represent lumbar spine extension

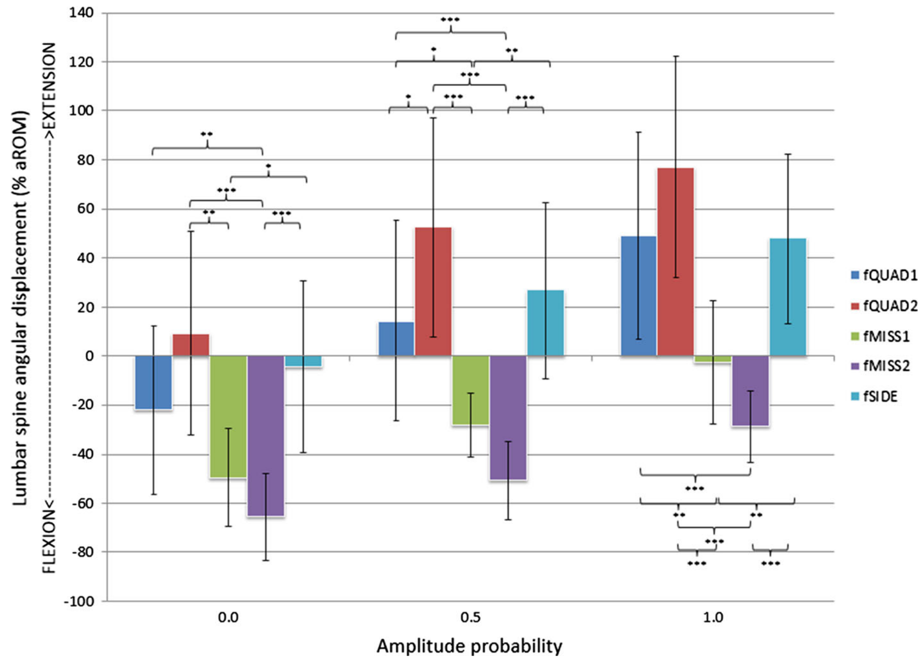

Fig. 3 Histogram showing the means and standard deviations of average lumbar spine angular displacement (% aROM) at amplitude probabilities of 0.0, 0.5, and 1.0 across all coital positions. Statistical significance is represented by the following: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Discussion

Until now, a description of spine kinematics during coitus did not exist in scientific literature. The completion of this study demonstrates the feasibility of future coitus biomechanics research as well as the recruitment of couples to voluntarily partake in such an intimate aspect of their romantic relationship in a scientific setting. The principal objective of this study was not only to describe female spine motion and posture characteristics during coitus, but also to compare these characteristics across five common coital positions. Regardless of the coital position, female coital movement was cyclic and predominantly in the sagittal (i.e., flexion/extension) plane of motion. Therefore, the following discussion is most pertinent to patients with LBP that is exacerbated by motions (i.e., motion-intolerant) or postures (i.e., flexion- and/or extension-intolerant). If the pain-provoking biomechanical variable (i.e., a motion and/or a posture) is avoided, then a coital position is considered to be ‘spine-sparing’.

Initial recommendations on coital positions and movement can be developed for patients with these various motion and posture intolerances based on the findings of this study (see Figs. 4, 5 for a summary). For the flexion-intolerant patient, both variations of MISSIONARY, fMISS1 and fMISS2, are least recommended because flexion–extension motion of the spine occurred completely within flexion aROM. Whereas spine motion remained within extension aROM during fQUAD2 and fSIDE—these positions are considered the most spine-sparing of the coital positions studied for the flexion-intolerant patient. These recommendations would be contraindicated for the extension-intolerant patient.

Since all coital positions included in this study were male-centric, it was expected that the female spine kinematic profile would remain relatively stable. Although less spine motion was used in fMISS2 in comparison to both variations of QUADRUPED, thus making fMISS2 the most recommended position for the motion-intolerant patient and both variations of QUADRUPED the least recommended (Fig. 5), the spine kinematic profile across positions was cyclic, and not stable. Therefore, not one coital position included in this study is considered spine-sparing for the motion-intolerant patient; however, coaching patients to limit spine motion using a hip- [14] and/or knee-hinging technique has been shown to immediately reduce pain in LBP patients with specific load, posture, and motion intolerances [15]. Using this intervention on motion-intolerant patients during coitus may aide the patient in developing hip- and/or knee-dominant coital movement and reduce spine motion. This technique may also be beneficial for the flexion- and extension-intolerant patient, but the effectiveness of this movement pattern intervention during coitus for any motion or posture intolerant patients will require further investigation.

Notable differences in the spine kinematic profile were not only found across positions, but also within variations of a position. For example, the spine kinematic profile was significantly altered when the female changed her upper body support from her hands (fQUAD2) to her elbows (fQUAD1) while in the quadruped position—fQUAD2 was found to be more spine-conserving for the flexion-intolerant

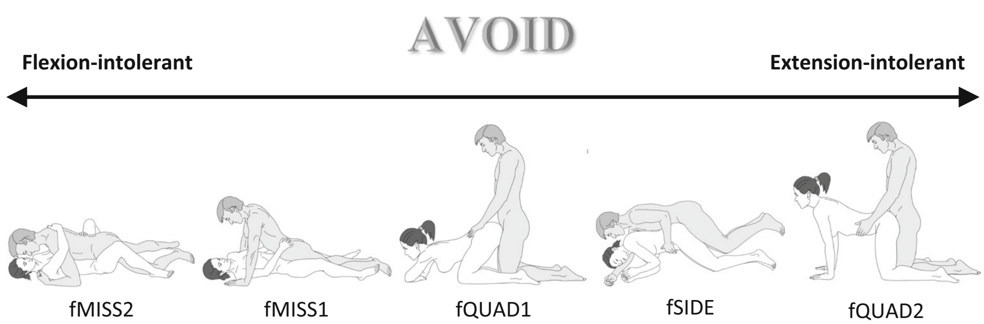

Fig. 4 Initial recommendations of coital positions *to avoid* for female patients whose LBP is exacerbated by specific movements and/or postures (i.e., flexion- and extension-intolerance). Positions indicated as 'to avoid' are those that present the greatest risk of exposure to the pain-provoking biomechanical variable, and thus exacerbation of LBP. *Note* these recommendations are limited to specific motion intolerances and male-centric positions, and did not consider kinetics or include pained individuals

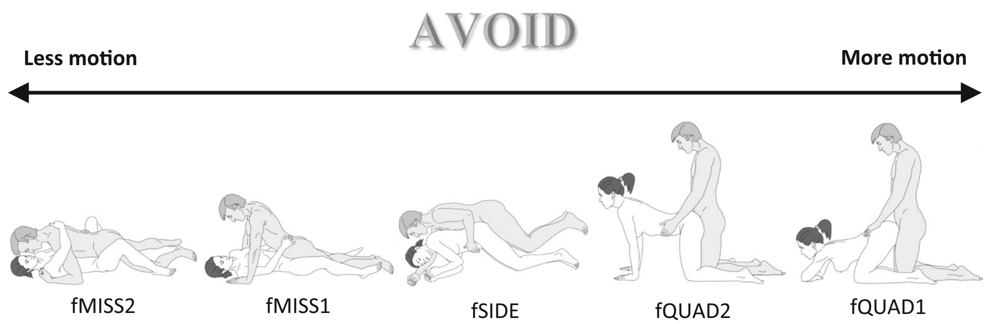

Fig. 5 Initial recommendations of coital positions *to avoid* for female patients whose LBP is exacerbated by lumbar spine motion

patient. Furthermore, as the female's hips and knees changed from a less flexed (fMISS1) to a more flexed (fMISS2) position during different variations of MISSIONARY, lumbar spine flexion increased. Based on this trend, if the female were to flex her hips even more and remove foot contact with the mattress, it is assumed that even more spine flexion would be exhibited. A pneumatic lumbar support has been shown to reduce lumbar spine flexion in a seated posture [16] and may have the same effect on spine flexion during MISSIONARY. Thus, seemingly subtle changes in posture should not be underestimated with regard to the effect it may have on spine kinematic profiles and should be considered when making recommendations.

The most commonly-circulated recommendation in scientific literature [12, 17] for all patients with LBP is to adopt the side-lying position (i.e., fSIDE) when engaging in coitus. However, our findings not only suggest a biomechanical explanation for patient reports on mechanical factors exacerbating LBP during coitus [4, 6], but also that one position is likely not suitable for all patients with LBP—the intervention must be tailored to the individual, or in this case, the couple.

Limitations

This analysis and the initial recommendations that resulted were limited to females, specific motion and posture intolerances and male-centric coital positions (due to instrumentation constraints). Expanding this biomechanical analysis of coitus to include female-centric positions, other motion and posture intolerances, and load intolerances will further develop recommendations.

The electromagnetic motion capture system used to record spine motion has known methodological considerations, including the restriction of metallic objects in the electromagnetic field due to a possible effect on the accuracy of the system [18]. Despite the use of a coil-spring mattress in this study, pilot testing did not reveal an issue with the accuracy of the 3SPACE Isotrak device. This is assumed to be due to the present metal being outside of the sensitive zone between the transmitter and the sensor. Furthermore, use of the electromagnetic motion capture system to measure the relative motion of the pelvis and the torso (at the level of the twelfth thoracic vertebra) served as a surrogate for direct measurement of segmental lumbar spine kinematics for this study. This technique for measuring the curvature of the lumbar spine has been developed and used in our laboratory for over three decades and validated by other authors. For example, Adams et al. [19] found that measuring the curvature of the lumbar spine using two inclinometers attached to the skin overlying the spinous processes of L1 and S1 was strongly correlated ($r = 0.91$) with flexion angles measured from radiographs.

Finally, only participants who did not have a pre-existing disabling back or hip condition were included in this study, but the recommendations developed are intended for LBP patients with specific motion and posture intolerances. This patient population may have different movement patterns during coitus and will be included in further coitus biomechanics investigations.

Conclusions

This biomechanical analysis of female lumbar spine kinematics during coitus provides empirical data that will strengthen coital motion and posture adjustment recommendations. Clinicians may consider advising alternative coital positions and/or movement patterns or suggesting a lumbar support, depending on the patient's specific motion and posture intolerances. These findings may also facilitate dialog between clinicians and their patients with regard to this important issue.

As a new area of biomechanics research, there are many future directions that coitus biomechanics researchers can explore. Describing spine motion and posture characteristics during female-centric coital positions and within a pained population (i.e., LBP) will expand and improve recommendations as would an intervention study investigating the effectiveness of coital movement (e.g., hip- and/or knee-hinging) and posture (e.g., lumbar support) adjustments.

Acknowledgments The authors acknowledge the Natural Sciences and Engineering Research Council of Canada (NSERC) for their ongoing laboratory funding, and Dr. Edward Cambridge from the Department of Kinesiology, Faculty of Applied Health Sciences, University of Waterloo for his invaluable assistance.

Conflict of interest The authors do not have any conflicts of interest to report.

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