Original Research

Riding position and lumbar spine angle in recreational cyclists: A pilot study

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ABSTRACT

Int J Exerc Sci 3(4) : 174-181, 2010. This pilot study investigated the reliability of an inclinometer to assess lumbar spine angle in three different cycling positions, and explored the relationship between lumbar spine angle and riding position, anthropometry, bike measures and low back pain (LBP). Cyclists were recruited from two cycle clubs. Anthropometric variables and bike set-up were measured before participants' bikes were secured in a wind trainer. Cyclists then adopted three positions for riding, upright on the handlebars, on the brake levers and on the drops, according to a random allocation. The angle of the lumbar spine was measured; using an inclinometer, at zero minutes and after cyclists had completed 10 minutes of cycling. Intra-measurer reliability for inclinometer use to measure lumbar spine angle in each position was excellent (ICC=0.97). The angle of the lumbar spine changed significantly over 10 minutes in the brake position ($p=0.004$). Lumbar spine angle at 10 minutes was significantly different between the brake and drop positions ($p=0.018$, $p<0.05$), and between upright and drop positions ($p=0.012$, $p<0.05$). Lumbar spine angle was not related to anthropometric measures. The change in lumbar spine angle varied from one degree of extension to 12 degrees of flexion, with increased flexion occurring in 95% of trials. An inclinometer has excellent intra-measurer reliability to measure lumbar spine angle in cycling positions. Future research with a sample of 72 or more participants is required to determine if there is a significant relationship between LBP and lumbar spine angle in different cycling positions.

KEY WORDS: cycling; low back pain; physical activity; measurement.

INTRODUCTION

Cyclists may ride with either a "round-back" or "flat-back" posture as a result of the degree of pelvic and spinal flexion required to reach the handlebars (1). Anecdotally, the best all-round riding position is with the hands on the brake levers. This position allows quick, easy access to the brakes and good steering (1). Riding with the hands on top of the handlebars in a more upright position is considered to be of greater comfort to the cyclist however; this position is less aerodynamic creating greater wind resistance (2). The drop position, with the hands placed on the lowest part of the handlebars, is the most aerodynamic with the average sized male cyclist reducing wind resistance by 30% when altering riding position from on top of the handlebars to the drops (2). Hence cyclists have valid reasons to adopt each of these cycling positions. It has been suggested that handlebars in an extremely low position result in an increased lumbar lordosis (3)

and that any alteration in saddle to stem height or top tube length (see Figure 1) may alter the angle of the lumbar spine (2). Cycling lliterature suggests that the handlebars should be at or lower than the seat height on a dropped handlebar bike, depending on individual characteristics of the cyclist such as their height and flexibility (4). However the effect on lumbar spine posture of adopting each of these common riding positions has not been investigated. Further as the prevalence of low back pain (LBP) in recreational cyclists has been reported to be as high as 50% (5) information regarding lumbar spine posture and riding position is required to guide cyclists' choice of riding position.

Published studies which have investigated lumbar posture and low back pain (LBP) in cyclists have reported two scenarios in relation to symptom production. Burnett et al. (6) recruited 18 subjects to participate in a pilot study examining whether differences in spinal kinematics exist in cyclists with chronic LBP (n=9) and without chronic LBP (n=9). Spinal kinematics were calculated using an electromagnetic tracking system with subjects riding in one of two different riding positions being on the drops or on the aero bars (similar to the brake position with arms stretched further forward). They identified non-significant trends towards increased flexion and axial rotation of the lower lumbar spine in those cyclists with non-specific chronic LBP and a trend towards increased upper lumbar spine axial rotation and flexion in those with no back pain (6).

In contrast, an uncontrolled case series by Salai et al. (5) captured pelvic tilt in cyclists (n=40) using fluoroscopic images of the lateral view of the lumbo-pelvic area. An inclination towards hyperextension at the lumbo-pelvic junction was found in those who reported LBP. Anterior saddle inclination of 10-15° was found to decrease hyperextension. When the saddle was tilted anteriorly by 10-15° from horizontal for six months, 72% of participants reported they no longer experienced LBP and 20% reported a major reduction in the frequency of LBP (5). The conflicting findings of these studies which may be due to small sample sizes and differing methodologies support the need for further investigation. Further, both studies used methods only available to elite cyclists at specialised training facilities and an alternate measurement method is required for use in the recreational cycling context.

An inclinometer is commonly used in clinical practice to assess lumbar spine angle (7). Two valid methods for measuring lumbar spine angle with an inclinometer were identified in the literature and considered for the method of this study (7). One method calculated lumbar spine flexion from isolated lumbar flexion (8) using two inclinometers. The other method calculated lumbar spine angle from total lumbo-pelvic range using one inclinometer (9). For simplicity and time efficiency the second method as described by Refshauge and Gass (9) was adopted in this study.
The aims of this pilot study were to determine:

- Intra-measurer reliability of inclinometer use to measure lumbar spine angle in three common cycling positions - upright, on-the-brakes and on-the-drops
- Differences in lumbar spine angle when each cycling position is adopted and after 10-min of stationary, wind resistance cycling

- If lumbar spine angle was related to bike or anthropometric measures
- If the position in which cyclists reported LBP was related to the angle of the lumbar spine.

METHODS

Ethics and recruitment

Ethics approval for this study was granted by the Human Research Ethics Committee of James Cook University, Townsville. An information letter and online survey was distributed to members of the Townsville and Rockhampton Cycle Clubs via the cycle club's website and monthly newsletter. Cyclists aged 18 years and over were invited to complete the survey and return it via email to the researcher. A reminder e-mail was sent one month after initial survey distribution.

In the survey cyclists reported the absence or presence of non-traumatic LBP experienced while cycling or directly after cycling, and the usual cycling position in which back pain was experienced. Cyclists indicated in the survey if they were willing to participate in the measurement study which this paper reports. Those participants who reported LBP from trauma in the previous two years and known lumbar spine pathology were excluded from the study.

Measurement

Measurements were conducted in a laboratory at the James Cook University, Townsville and at the Rockhampton Cycling Club. Prior to measurement participants were questioned to ensure that cyclists were feeling well and were free from other injury. All measurement tools were calibrated against a known length, angle or mass preceding measurements. Repeated measures were undertaken to establish intra-measurer reliability for rider and bike measurements, and lumbar spine angle.

Anthropometry

Height and weight were measured with participants in cycling attire without shoes and socks. Height was measured to the nearest mm using either a flexible measuring tape against a vertical surface and a set-square to allow an accurate horizontal reading or a portable stadiometer (10). Body mass was measured to the nearest 100 g with portable electronic bathroom scales (10).

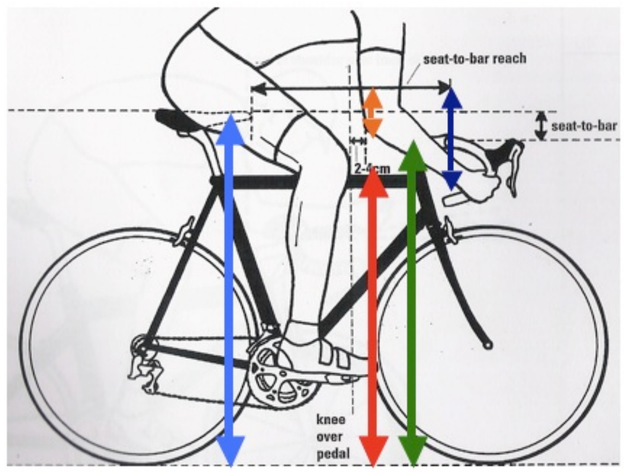

Figure 1: Bike measures calculated. Picture reproduced with permission from Zinn [13]. Light blue line represents the "saddle to the floor (true seat)" measure, green line represents "stem to the floor (true handlebar)" measure, red line represents the "drops to floor" measure, orange line represents the "stem to stem" measure, and the dark blue line represents the "saddle to drops" measure.

Bike measures

The participants' bike was secured in a resistance trainer and measured to determine the distance from the resting position of the hands to the saddle in each cycling position. Measurements included the distance from:

- The most anterior and superior part of the saddle to the floor,
- Top of the handlebars to the floor

- Top of the brake levers to the floor and
- Top of the drops to the floor.

From these measurements the vertical distance from the saddle to the top of the handlebars, brake levers and drops was calculated (see Figure 1).

Lumbar spine angle

The angle of the subjects' lumbar spine was recorded at zero time and after subjects rode their own road bike on an indoor wind resistance trainer for 10-min. This allowed for visco-elastic creep and soft tissue deformation (11). Subjects were instructed to ride at their normal cycling pace in each cycling position: with their hands fixed on top of the handlebars, on the brake levers and on the drops. The order of position was randomised for each participant by selecting a number (from one to three) from an envelope with each number representing a handlebar position.

In order to standardize the cyclists' position during angle measurement, the cyclists' hands were maintained on the handlebars in the riding position with both feet affixed to the cycle. The subject was asked to move their right leg until it was perpendicular to the floor and their right foot was parallel to the floor. Horizontal marks were then made on the subjects' skin with a white board marker in the midline of the second sacral vertebrae (S2) and midline of the twelfth thoracic and first lumbar vertebrae (T12-L1). The inclinometer was zeroed against a vertical surface and recordings made at S2 and T12-L1 (9). This process was repeated and measurements recorded after 10 minutes of cycling in all three riding positions for each subject. Subjects were requested to stand and walk for three minutes between adopting each test cycling position.

Data Management

Body mass index (BMI) was calculated using the formula weight in kilograms / height in metres squared (10). A three group classification of BMI was adopted where a BMI of 20 to 24.9 was considered normal, 25 to 27.5 was considered moderately overweight and greater than 27.5 was considered obese (12).

Lumbar flexion was calculated by subtracting the measure at S2 from the T12-L1 measure at both zero and ten minutes. The change in lumbar spine angle was calculated by deducting the lumbar spine angle at zero minutes from the lumbar spine angle at 10-min.

Statistical Analysis

Analysis was undertaken using Statistical Package for Social Sciences (SPSS) Version 16.0. The level of significance was set at $p<0.05$. Intraclass correlation coefficients (ICC) were calculated for bike and rider measurements to calculate intra-measurer reliability. Unpaired t-tests were performed to examine any differences in demographic data of the LBP and no low back pain (NLBP) groups. ANOVA test was performed to compare lumbar spine angles across all positions.

RESULTS

Reliability

Intra-measurer reliability in measuring lumbar spine angle with an inclinometer at T12-L1 and S2 were excellent, having an ICC of 0.97. High reliability was found for measuring height (ICC=0.99) and weight (ICC=1.00) of the cyclist. Results showed high reliability for all bike measures: seat to floor (ICC=0.98), handlebars to floor (ICC=0.98) and drops to floor (ICC=0.97).

Table 1: Spinal angle recorded at zero and 10 minutes, and change in angle over 10 minutes when riding in three riding positions.

	Upright			Brakes			Drops		
NLBP	Zero (0) time	Ten (10) minutes	Difference	Zero (0) time	Ten (10) minutes	Difference	Zero (0) time	Ten (10) minutes	Difference
1	27	28	1	27	28	1	29	31	2
2	16	25	9	14	24	10	20	26	6
3	-5	-3	2	-3	2	5	-1	1	2
4	19	24	5	20	23	3	25	26	1
NLBP Median (SD)	17.5 (± 13.6)	24.5 (± 14.4)	3.5 (± 3.6)	17 (± 12.8)	23.5 (± 11.7)	4.0 (± 3.9)	22.5 (± 13.4)	26.0 (± 13.5)	2.0 (± 2.2)
LBP									
5	10	18	8	15	27	12	**22**	**27**	**5**
6	**29**	**29**	**0**	28	29	1	29	28	-1
7	23	25	2	**20**	**27**	**7**	26	30	4
8	32	32	0	**33**	**36**	**3**	34	37	3
9	**2**	**8**	**6**	2	4	2	5	5	0
10	33	33	0	**35**	**34**	**-1**	34	37	3
11	**32**	**32**	**0**	32	38	6	40	44	4
12	24	27	3	25	27	2	**25**	**27**	**2**
13	34	36	2	38	38	0	**37**	**38**	**1**
LBP Median (SD)	29.0 (± 11.3)	29 (± 8.8)	2.0 (± 2.9)	28.0 (± 11.4)	29.0 (± 10.4)	2.0 (± 4.1)	29.0 (± 10.5)	30.0 (± 11.2)	3.0 (± 2.0)
Whole group: Median (SD)	24.0 (± 12.4)	27.0 (± 10.9)	2.0 (± 3.1)	25.0 (± 12.5)	27.0 (± 11.3)	3.0 (± 3.9)	25.0 (± 11.8)	28.0 (± 12.2)	2.0 (± 2.0)

- Extension of the lumbar spine
SD = standard deviation
Bold print = riding position in which the cyclist reported low back pain

Participant Demographics

A total of 13 participants (one female and 12 males) aged between 19 and 53 years participated in this study.

Anthropometry and LBP

No statistically significant relationship was found between reports of LBP and age, height, body mass or BMI.

Lumbar spine angle – between positions

The angle of the lumbar spine recorded at zero and 10 minutes when riding in an upright position, on the brakes and on the drops is shown in Table 1. The riding positions in which the cyclists reported LBP are in bold print. Descriptively, there was no clear trend identifying if increased lumbar flexion or extension was a contributing factor to LBP. Small sample size precludes further statistical analysis comparing LBP and NLBP groups.

The angle of the lumbar spine at zero time, at 10-min and the change in lumbar spine angle over 10-min duration was evaluated with no significant difference across all riding positions (p>0.05).

When comparing pairs of riding positions the angle of the lumbar spine at 10-min was significantly different when comparing the brake and drop positions (p=0.018) and when comparing the upright and drop positions (p=0.012). The comparison of lumbar spine angles between pairs of riding positions at zero time and considering the change in angle over 10-min were not significantly different.

Lumbar spine angle – within position change

Analysis revealed a significant change in spinal angle over 10-min when adopting the brake position (p=0.004, r=0.571). No other significant relationship was identified between bike measures, specifically saddle to stem and saddle to drops measures, and spinal angle at any time or over time in any positions.

Anthropometry, bike measures and lumbar spine angle

Analysis revealed a statistically significant relationship between height and saddle to drop measures (p=0.019, r=0.637). No other significant relationship was identified between any anthropometric measure and bike measures. No significant relationship was identified between anthropometric variables and spinal angle at either time or over 10-min in any position.

Sample size calculation

The results of this pilot study allowed sample size calculation for a subsequent study. An estimated sample size of 72 cyclists is required to detect differences in lumbar spine angle after cycling for 10-min in different cycling positions. This was calculated using a standardized difference of 0.76, alpha of 0.05 and a power of 0.9.

DISCUSSION

Use of an inclinometer is a reliable method for measuring lumbar spine angle in three different cycling positions. It is a low technology, transportable, inexpensive, readily available and usable method for establishing lumbar spine angle in recreational cyclists.

This study identified significantly greater lumbar spine flexion when riding in the drop position compared to the brake position and significantly more flexion in the drop position compared to the upright position. Lumbar spine angle change varied from one degree extension to 12° flexion over 10-min of cycling. These results are in contrast to a previous pilot study, where lumbar spine angle was measured at the beginning and every 5-min throughout the duration of a ride until the onset of LBP (6) and found a maximal change of 1.1° during the ride. The authors concluded that the stability of spinal kinematics in the sagittal plane across the duration of the ride

indicated that spinal creep did not occur in the cycling position (6). Lumbar spine range of movement was not reported in the paper and hence the reader is unable to determine if a mid range position was adopted. Future studies should include examination of full lumbar spine range preferably whilst seated on the bike prior to commencement of cycling.

There is little scientific or biomechanical literature available regarding spinal posture in cyclists however considerable anecdotal information is available from cyclists, cycling clubs and bike shops. This pilot study found that in 95% of trials lumbar spine flexion increased when participants cycled for 10-min. It is interesting that flexion increased given that the effect of gravity would make an increase in extension of the spine more probable. It is possible that adoption of greater flexion is a mechanism to decrease end range position of the lumbar facet joints and joint compression in an extended position. Although this pilot study provides evidence that riding position alters lumbar spine angle, the relationship between lumbar spine angle and LBP in recreational cyclists requires investigation. With a sample size of 13 (LBP=9, NLBP=4), this sample was too small to make any comprehensive comments on lumbar spine angle, handlebar position and LBP.

Bike set-up including the height of the handlebars and saddle, saddle to stem measurements (2,6), length of the stem (2,3), and gearing (3) have been suggested to influence the amount of force being loaded on the spine whilst cycling and by implication the angle of the spine. This pilot study found a relationship between the height of the cyclist and bike measurements, specifically saddle to stem and saddle to drop measures. This was an expected finding as the participants' in this study cycle regularly and have appropriately adjusted and fitted bicycles.

This pilot study did not take into consideration other measurements of the cycle including stem length (length of the stem attached to the handlebars) and top tube length (length of the top bar of the bike), which the general cycling literature suggests, is critical in bike set-up (3). If the stem or top tube is too long, the cyclist may adopt an extended lumbar posture possibly altering lumbar spine angle (3). Alternatively, if these distances are too short, the cyclist may adopt a more flexed position (3).

In this study participants were instructed to pedal at their normal cycling pace. This allowed different cadences and gear ratios between cyclists hence the cycling intensity between participants may have varied. Further studies should standardize cadence with use of a mechanical device to calculate the speed of the cyclist in reps per minute. Gear ratios will therefore be varied as each individual aims to achieve the desired cadence. The gear ratio may then be recorded and provide data for further analysis.

Having participants stop cycling and align their lower leg to the vertical before placing the inclinometer on the spine may have altered lumbar spine position. Cycling is a functional task, recording spinal kinematics of the spine whilst the participant continues cycling provides more accurate measures of spinal activity. Comparative studies using electronic motion assessment and inclinometers are required to determine if

the inclinometer represents a valid measure. As the lumbar spine angles are small, technical error of measurement should be assessed prior to further studies.

Given the opportunity, there is scope to replicate this study with a larger sample. Future studies should include additional anthropometric measures including lumbar spine, hip and knee range of motion and muscle length assessment. Additionally, research regarding the relationship between height and stem and top tube length may provide further information on bike set-up and lumbar spine angle.

In summary, the angle of the lumbar spine was significantly different when cyclists adopted three common riding positions. The use of an inclinometer is a reliable method to measure lumbar spine angle. Given the small variation in lumbar spine angle validation is also required. A large well-powered study using the method of this pilot study is indicated to explore the relationship between lumbar spine angle and low back pain in recreational cyclists.

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