The effectiveness of seated combined extension-compression and transverse load traction in increasing cervical lordosis- challenging the underlying framework

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Introduction: The goal of this study was to assess the effectiveness of seated combined extension-compression and transverse load (ECTL) traction as a new method for increasing a reduced lordosis of less than 30 degrees in a Malaysian population between the ages of 18 and 60 years. Possible changes in disc height were measured in accordance with the underlying theoretical framework, that suggests the anterior cervical structures would elongate due to creep over the fulcrum of the traction device.

Method: This was a single centre, randomised, blinded controlled clinical trial with parallel groups, used to test the superiority of the seated combined ECTL traction together with physiotherapy exercises when compared with the same physiotherapy exercises used as a control. Fifty randomly allocated subjects who completed the forty treatments over the fourteen weeks were analysed using non-parametric tests for changes in outcomes.

Results: There were no significant changes in outcomes for disc height changes seen in this study. The findings of a greater overall increase in posterior disc height changes compared with anterior disc height changes were in contrast with the proposed underlying theoretical framework for this type of ECTL traction. The greater height changes occurring in the control group were also unexpected.

Conclusion: The findings in this study of the contrasting changes in disc height of greater posterior than anterior height changes, question the underlying theoretical framework as postulated for this type of traction.

IeJSME 2016 10(3): 24-33

Keywords: extension compression and transverse load traction, cervical lordosis, disc height

Introduction

There is recent increase in focus on research on spinal curves and postures, and how this relates to degenerative changes as well as clinical outcomes. Numerous studies over the last few years have shown this to be a common problem, with a correlation between abnormal spinal curves and an increase in degeneration,[1-9] as well as a possible link to pain and function.[10-15]

Abnormal spinal postures alter biomechanics. Asymmetrical loading of tissues and increased stresses and strains on the tissues, ultimately result in dysfunctions and pathologies.[16-19] These can lead to an increase in degeneration as well as clinical outcomes such as pain.[12] Due to this, new methods for improving a decreased cervical lordosis are being sought.

This study aims to investigate the effectiveness of seated combined extension-compression and transverse load (ECTL) traction as a new method for increasing a reduced cervical lordosis, by comparing this form of structural rehabilitation to the more conventional functional physiotherapy exercises used in a Malaysian setting for rehabilitation of abnormal spinal postures, as well as assess height changes seen in the cervical discs as a result of the traction intervention used.

It is postulated that the treatment group is more likely to have greater improvement in their reduced cervical lordosis, as well as a greater increase in anterior disc height after receiving ECTL traction combined with the physiotherapy exercises, than the control group undergoing the same exercises alone.

The theory of how this type of traction can improve a reduced cervical lordosis is based on creep.[20] This together with the three-point bending mechanism of the traction device should create tension in the anterior cervical structures[10], the anterior longitudinal ligament, anterior disc and anterior neck muscles. This should result in permanent elongation of these structures, and by stretching the anterior anatomy, over a fulcrum, thereby allowing improvement of a reduced cervical lordosis.[10,11] It was also expected that there would be changes in the height of intervertebral discs on MRI, as has been shown in other traction studies.[15, 21-24]

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The underlying postulated theoretical framework for this type of traction suggests more of an increase in the anterior disc height when compared with the posterior disc height, as a result of the fulcrum. [10,11]

In a study by Harrison *et al* (2003) a similar traction device showed a significant improvement in cervical lordosis in a Caucasian sample after 38 visits conducted over a 14-week period.[10] Changes in disc height on MRI were however not measured as one of the outcomes in the study by these same authors.

This study aims to further validate the results shown by Harrison et al (2003)[10] in a Malaysian setting, by utilising a similar number of visits over the same time-frame. It may also highlight any differences seen between the two different populations, and includes the additional outcome of disc height changes on MRI to evaluate the changes as proposed by the underlying theoretical framework for this type of traction intervention.

Methods

This was a single centre, randomised, blinded controlled clinical trial conducted at TAGS Specialists Center, a specialist hospital in spine and joint care, situated in Cheras, between February 2014 and April 2015.

Subjects were recruited by means of self-selection and referral by means of advertisement in the centre. Eligible participants were those between the ages of 18 and 60 with a cervical lordosis of less than 30 degrees as measured by using the Cobb (C2-C7) measurement and who gave consent to participate. Sixty-one volunteer subjects with anterior head carriage and neck pain underwent an initial assessment of their cervical lordosis by means of a lateral neck radiograph. As the traction is performed in a hyper-extended and compressed position, exclusion criteria included the following: (1) subjects with radicular signs and symptoms; (2) severe central cervical stenosis; (3) compression fractures at any cervical level; (4) any prior cervical spine surgery; (5) those with hypertension or with visual disturbances, such as episodic loss of vision, blackouts, localised patch blurring of vision, ocular muscle weakness and/or ptosis; (6) rheumatoid arthritis; (7) acute whiplash; (8) those subjects unable to undergo X-ray or MRI; (9) pregnancy. Ethical approval was obtained from a Medical Research Ethics Committee (UPM/TNCPI/RMC/JKEUPM/1.1.18.1/ F1) in accordance with ICH-GCP guidelines, prior to conducting this study.

The initial sample size recruited was that of 61 participants based on the determination of a sample size of N = 58. One (1) participant was withdrawn after entry due to not being able to complete the initial MRI. Nine (9) were lost to follow-up due to not being able to comply with treatment frequency, one (1) withdraw due to not being able to tolerate the physiotherapy exercises. One (1) participant's data was excluded after treatment completion due to being the only Caucasian to remain in the study. This was in order to analyse the results on an Asian population.

Parallel groups were used to test the superiority of the ECTL traction combined with physiotherapy exercises, compared with a control of the same physiotherapy exercises. Each participant was randomly assigned into either the treatment or control group by means of randomisation by a computerised random number generator. Figure 1 shows a flow diagram of the participants through the phases of the randomised trial of treatment and control groups.

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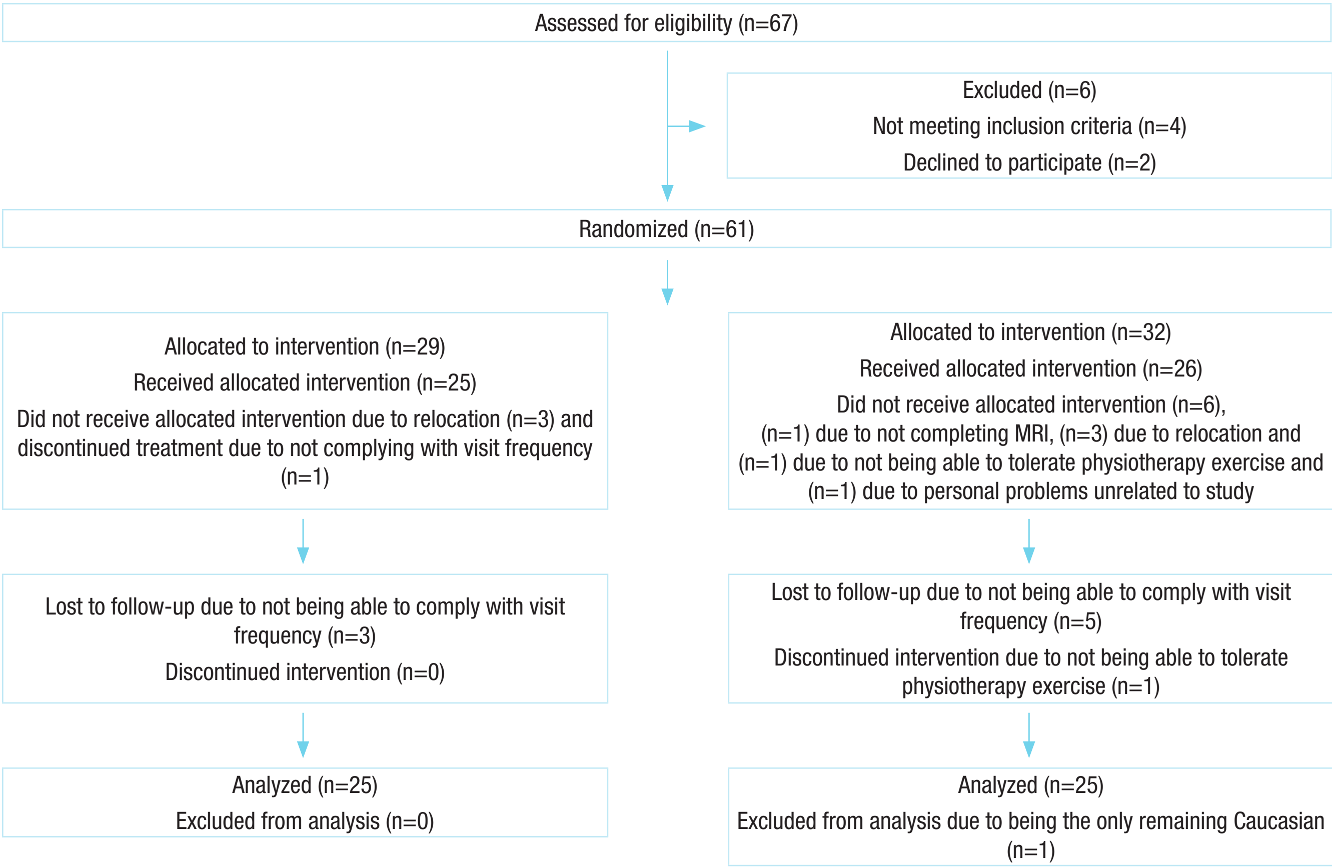
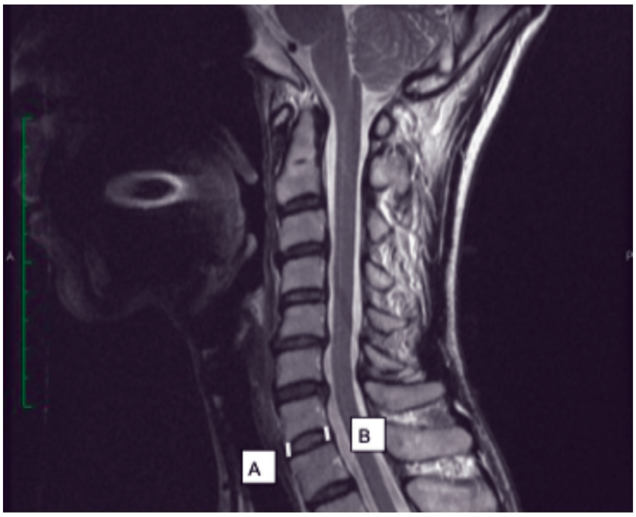


Figure 1: Flow diagram of the progress through the phases of the randomised trial of the treatment and control groups.

Participants in this study were required to attend forty treatments at the centre over the study period of fourteen weeks, which is in keeping with the number of visits in a similar previous study conducted in a Caucasian sample.[10] Participants were required to have a pre- and post- study cervical x-ray and MRI after completing the 40 visits.

All cervical curvature radiographs were taken in the left lateral view with the head and neck in the neutral position, this neutral positioning has been shown by several studies[8, 24, 25] to be both reliable and reproducible. Cervical MRI was used to determine for any potential changes in disc height and was conducted using a Siemens 0.35 Tesla Open MRI, and PACS software "Syngo" from Siemens, with the patient in supine position. Cervical MRI settings were as follows: FOV read-260mm, FOV phase-100.0%, phase resolution-80% with scan region position: Head. Each cervical MRI contained four series, two t2 and two t1-weighted images, using 5 series (T2 sag, T1 sag, CISS3D tra, T2 tra and T1 tra. All radiological measures were performed digitally on the same DICOM- Centricity* software, USA, version 3.0. by a blinded, independent musculoskeletal specialist radiologist.

The primary outcomes measured included; changes in cervical lordosis, as measured by Cobb method at levels C1-C7, C2-C7 and C3-C7, Gore method,[19] depth in curve and atlas plane angle seen on radiograph. Baseline degenerative findings were determined, using both X-ray and MRI evaluations, and disc height was measured off MRI. The height of each of the individual cervical discs was measured using standard ruler measurement in millimetres. The mean of the anterior and posterior disc heights (Dabbs method) was measured off the mid-sagittal slice of the MRI, as seen in Figure 2. The anterior and posterior disc heights were defined as the smallest thickness cranial-caudal both anterior and posterior.



Disc Height on MRI measured in millimetres using standard ruler measurement. This is measured on the **midsagittal slice** using Dabbs method, which is the **mean of the anterior and posterior disc heights**. The anterior and posterior disc heights are defined as the smallest thickness cranio-caudal both anterior and posterior. The discs to be measured include all of the cervical discs: C2/3, C3/4, C4/5, C5/6 and C6/7.

Measurement = (A+B)/2

Figure 2: MRI Measurement for Disc Height

Statistical analysis

The final sample size of 50 participants (N= 50) was analysed using the Statistical Analysis System (SAS) software, developed by SAS Institution Inc. N. Carolina, version 9.4. Descriptive and frequency tables were produced for the sample. Non-parametric analysis including Mann-Whitney U Test and Wilcoxon Rank-Sum Test were used to compare medians between the two groups, for any difference in the primary outcome measure of cervical lordosis (measured in degrees) as well as any other differences seen in the remaining radiographic and MRI measurements such as angles, depth, disc height and grades of degeneration.

Results

The results of this paper focussed on the changes in disc height in keeping with the underlying theoretical framework. Other measures such as changes in lordosis and degenerative findings are discussed in other papers.

Table 1 shows all demographic information of the participants while Table 2 shows the baseline median anterior and posterior disc heights between the two groups, which varied from 3.50 mm to 4.00 mm. There were no significant differences seen between the treatment and control groups for anterior, posterior or mean disc heights at baseline.

Table 1: Demographics of Subjects by Group

Characteristics	Intervention (N=25)	Control (N=25)	P-value
Age in Year (Years)			
Median (±SD)	34.6 (±10.4)	32.0 (±10.2)	0.3699
Height (cm)			
Median (±SD)	164.0 (±9.1)	163.4 (±7.3)	0.7642
Weight (kg)			
Median (±SD)	63.7 (±16.8)	65.6 (±19.0)	0.6862
BMI (kg/m^2)			
Median (±SD)	23.4 (±4.8)	24.5 (±7.2)	0.5014
Gender, n (%)			
Male	9 (36.0)	5 (20.0)	
Female	16 (64.0)	20 (80.0)	0.2077
Ethnicity, n (%)			
Malay/Bumiputra	7 (28.0)	3 (12.0)	
Chinese	14 (56.0)	19 (76.0)	
Indian	4 (16.0)	2 (8.0)	0.2618
Smoke Status, n (%)			
Smoker	4 (16.0)	2 (8.0)	
Non-Smoker	21 (84.0)	23 (92.0)	0.6671
Unknown/Missing	0 (0)		
Occupation, n (%)			
Office Worker	22 (88.0)	19 (76.0)	
Non Office Worker	3 (12.0)	6 (24.0)	0.2695
Exercises, n (%)			
Yes	23 (92.0)	24 (96.0)	NA
No	1 (2.0)	0 (0.0)	
Unknown	1 (2.0)	1 (4.0)	

Table 2: Baseline Median Anterior and Posterior Disc Heights between Groups

	TREATMENT (N=25)	CONTROL (N=25)	
Anterior Disc Height, in mm	median (95%CI)	median (95%CI)	P-value
C2C3	3.50 (3.20, 3.80)	3.60 (3.20, 4.00)	0.8307
C3C4	3.80 (3.30, 4.00)	4.00 (3.20, 4.10)	0.7484
C4C5	3.60 (3.30, 4.20)	3.80 (3.20, 4.20)	0.7703
C5C6	3.60 (3.00, 4.10)	3.80 (3.20, 4.10)	0.3706
C6C7	3.50 (3.10, 4.00)	3.90 (3.50, 4.40)	0.0722
Posterior Disc Height, in mm	median (95%CI)	median (95%CI)	P-value
C2C3	3.60 (3.30, 4.30)	3.90 (3.50, 4.00)	0.8688
C3C4	3.90 (3.30, 4.20)	4.00 (3.50, 4.10)	0.7558
C4C5	3.50 (3.30, 4.20)	4.00 (3.10, 4.20)	0.8917
C5C6	3.70 (3.10, 4.20)	3.60 (3.10, 4.10)	0.9612
C6C7	3.40 (3.20, 4.10)	3.70 (3.50, 4.10)	0.3557

These baseline heights are in keeping with the normal heights, as taken from lateral cervical spine x-rays of 135 healthy subjects[30] which ranged from 0.33 mm to 0.39 mm.

Table 3 summarises the descriptive results of the pre and post median anterior and posterior disc heights of the two groups. There were no significant changes seen in any of the height changes in either group.

Table 3: Median Pre and Post Anterior and Posterior Disc Height by Group

	TREATMENT			CONTROL		
	Pre	Post		Pre	Post	
Anterior Disc Height (mm)	median (95%CI)	median (95%CI)	P-value	median (95%CI)	median (95%CI)	P-value
C2C3	3.50 (3.20, 3.80)	3.50 (3.30, 4.00)	0.4658	3.60 (3.20, 4.00)	3.80 (3.40, 4.10)	0.5212
C3C4	3.80 (3.30, 4.00)	3.90 (3.30, 4.20)	0.478	4.00 (3.20, 4.10)	4.00 (3.30, 4.20)	0.4248
C4C5	3.60 (3.30, 4.20)	3.80 (3.40, 4.20)	0.5212	3.80 (3.20, 4.20)	4.00 (3.40, 4.20)	0.5019
C5C6	3.60 (3.00, 4.10)	3.50 (3.30, 4.10)	0.5469	3.80 (3.20, 4.10)	3.70 (3.30, 4.20)	0.5658
C6C7	3.50 (3.10, 4.00)	3.70 (3.30, 4.20)	0.3709	3.90 (3.50, 4.40)	4.00 (3.50, 4.40)	0.9149
Posterior Disc Height (mm)	median (95%CI)	median (95%CI)	P-value	median (95%CI)	median (95%CI)	P-value
C2C3	3.60 (3.30, 4.30)	4.20 (3.30, 4.50)	0.3502	3.90 (3.50, 4.00)	3.90 (3.60, 4.10)	0.8534
C3C4	3.90 (3.30, 4.20)	4.00 (3.30, 4.50)	0.4778	4.00 (3.50, 4.10)	4.00 (3.70, 4.30)	0.4250
C4C5	3.50 (3.30, 4.20)	3.80 (3.10, 4.40)	0.6761	4.00 (3.10, 4.20)	4.00 (3.40, 4.30)	0.4956
C5C6	3.70 (3.10, 4.20)	3.70 (3.10, 4.20)	0.6975	3.60 (3.10, 4.10)	3.90 (3.30, 4.20)	0.3260
C6C7	3.40 (3.20, 4.10)	3.40 (3.20, 4.30)	0.7118	3.70 (3.50, 4.10)	3.90 (3.50, 4.40)	0.2552

Two levels in the treatment group (C2C3, C4C5) showed more of a posterior disc height increase than the expected anterior increase, with C2C3 level showing the greatest change of all the cervical levels of an increase in posterior disc height from 3.60 mm to 4.20 mm, and the anterior height remaining constant. For the C4C5 level, both anterior and posterior changes were similar, with the posterior showing only a slightly greater change by 0.10 mm. In the control group, the opposite was seen, at these same levels, with the anterior heights increasing by 0.20 mm and the posterior heights remaining constant at 3.90 mm and 4.00 respectively.

Only one level (C6C7) in the treatment group showed an anterior height increase of 0.20 mm from 3.50 mm to 3.70mm, which was more than the posterior height which remained the same at 3.40 mm. The same was not seen for the control group, which showed a greater posterior height increase from 3.70 mm to 3.90 mm and an anterior increase from 3.90 mm to 4.00 mm.

The C3C4 level in the middle of the cervical curve remained relatively constant, with the treatment group only increasing by 0.1 mm both anteriorly from 3.80 mm to 3.90 mm and posteriorly from 3.90 mm to 4.00 mm. This same level in the control group remained at 4.00 mm both anteriorly and posteriorly.

Level C5C6 was the only level to show a decrease in the anterior disc height of 0.1 mm in both the treatment and control groups. For the posterior disc height, this remained unchanged at 3.70 mm in the treatment group and increased from 3.60 mm to 3.90 mm in the control group.

For the control group, the posterior disc height showed no change for three out of five cervical levels (C2C3, C3C4 and C4C5). The treatment group showed an increase in combined (all levels added together) median disc height of 0.40 mm from a combined pre-median anterior disc height of 18.00 mm to 18.40 mm post-median. The same increase was seen in the control group for the combined median anterior disc height which increased from a pre-median of 19.10 mm to a post-median combined anterior height of 19.50 mm.

The treatment group showed a larger increase in combined (all levels added together) median posterior disc height of 1.00 mm from a combined pre-median posterior disc height of 18.10 mm to 19.10 mm post-median. The increase seen in the control group for the combined median posterior disc height was from a pre-median of 19.20 mm to a post-median combined anterior height of 19.70 mm. A combined increase of median posterior disc height of 0.50 mm.

For the changes seen in posterior disc height, the treatment group showed the larger increase in height likely due to the traction, but this was in posterior disc height, rather than in the expected change in anterior disc height.

These means when combined for each of the groups showed an overall increase in mean disc height of 0.20 mm for the treatment group and 0.55 mm for the control group respectively. However, none of the changes seen were significant.

Discussion

Both the treatment and the control groups showing the same overall increase in median anterior disc height was not expected, as it was hypothesised that the treatment group would show the greater increase due to the traction intervention.

In relation to the theoretical framework of this type of extension traction, it was expected that the anterior disc height would increase more in relation to the posterior disc height.

Despite no significant changes in median anterior disc heights seen in either group, there were height changes seen, in keeping with other traction studies. A study[31] found an increase in spinal height with the use of aquatic vertical spinal traction in 60 subjects with low back pain. In subjects with disc herniation’s that were treated with spinal decompression therapy, there was an increase in lumbar disc height.[32] The use of cervical traction demonstrated an increase in intervertebral disc spaces during traction.[26] An increase in foraminal area and height was seen with an increase in weight applied during traction.[33] An increase in intervertebral disc space was also found using computerised tomography.[34]

In this study, median posterior disc heights showed a non-significant increase or remained constant. In contrast with anterior disc height, none of the levels showed a decrease in posterior disc height.

Despite the assumption of anterior disc height increasing more than posterior, especially in the treatment group, the reverse was seen.

Level C6C7 in the treatment group was the only level where the anterior disc height showed more increase in height than the posterior disc height. Level C3C4 showed equivalent change and all other levels showed posterior greater than anterior change.

Levels C2C3 and C4C5 showed a greater increase in anterior disc height than posterior disc height, but for levels C5C6 and C6C7, the posterior height change was greater. Level C3C4 showed no change in both anterior and posterior disc heights.

With the traction intervention postulated to increase anterior disc height more than posterior disc height, the findings of more of the levels in the control group showing an increase in anterior height over posterior height does not support the theory that this type of traction intervention stretches the anterior structures. In fact, the findings in this study support the reverse.

One of the limitations of this study was that of sample size. Due to a larger sample variation than anticipated, the calculated sample size may not have been adequate. However, the original sample calculations are based on previous similar studies[10,11] that did show significant changes in the outcome of cervical lordosis. As the outcome of changes in disc height were not the primary outcome under consideration, the sample size may not have been large enough to detect small changes in disc height as a secondary outcome measure.

An additional limitation was that all MRI's were not able to be performed at the same exact time of day for all involved participants due to availability. This may have resulted in some of the differences seen in height changes, as disc heights may vary with diurnal changes.[35] However, to minimise this effect, each participant was booked for their follow-up MRI within a maximum of a two-hour window period of the time of their baseline scan was conducted. This ensured that individual participants would not show changes in disc height as a result of diurnal changes.

It is not known why the findings in this study are contradictory to those as suggested by the underlying theoretical framework. However, it is hypothesised that the difference seen may be due to anatomical and structural variation, whereby the posterior spinal elements allow for more movement as a result of the nature and position of the facet joints posteriorly in comparison with the anterior structures being more stable, as they consist of ligaments and the annulus fibrosis of the discs. The facet joints located posteriorly could have allowed for increased movement and ultimately more creep in the posterior structures. These findings are supported by those of an *in vivo* study showing a significant increase in intervertebral foramen area with cervical traction of up to 10kg of weight.[33]

The differences seen may also have been due to the fact that this study was conducted in an Asian population. There are a number of recent studies that document the difference between Asian and Caucasian spinal structures, including bone density,[35] vertebral body size with spinal canal diameter[37] and spinal curves.[37-38]

The Chinese bone structure has been shown to have a greater rate of bone loss in comparison to Caucasians[35] as well as a difference in anatomical structure.[36] A study conducted in Singaporean cadavers, showed a significantly smaller spinal canal diameter when compared with matched Caucasian measurements. Other vertebral structures including the vertebral body, spinous process and transverse process were also found to be smaller than in Caucasians.[36]

The differences are not only seen in the spinal structure, but also in the sagittal spinal curves. A comparison between asymptomatic Asian and Caucasian lumbar lordosis showed the Asians to have a much smaller lumbar lordosis curve by comparison.[37] Chinese show a significant difference in pelvic incidence and sacral angles when compared with Caucasian measurements, and much less sagittal curve.[38]

As this study was conducted in an Asian population with the majority of participants (66%) Chinese, the anatomical and alignment differences seen between Asian and Caucasian spines may account for the difference seen in response to the underlying theoretical framework of this study. It should therefore be considered if the differences seen in relation to the theoretical framework of this study are due to the framework itself, or if the differences seen are due to the structural differences of the populations upon which this type of traction mechanism was utilised.

Acknowledgement

This study was funded by Tonik Asia Group Sdn Bhd (Kuala Lumpur, Malaysia).

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