SPTS

Original Article

Sagittal spine shape literacy in the general adult population, assessed by a novel, simple graphical tool

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Abstract. [Purpose] The sagittal shape of the spine is associated with back-pain, balance and quality of life. We developed, evaluated and report the responses of a graphical tool to assess sagittal spine shape knowledge (literacy). [Participants and Methods] Two hundred and fifty adults were randomly assigned, in a cross-sectional crossover study, to free-hand draw and select the "ideal" sagittal spine shape. We evaluated the inter and intra-rater reliability and agreement between tests and the sagittal and lordotic spine literacy between the drawing and selection test versions. [Results] Drawing test inter- and intra-rater agreement was 79% and 80% respectively. Drawing vs. selection agreement was 43%. More participants drew than selected the correct spine (30% vs. 21%) (p<0.001) and lumbar lordosis shape (56% vs. 42%) (p<0.001). Test order did not affect spine shape literacy scores. A significantly poorer literacy trend was observed with spine pain presence (p=0.02). [Conclusion] We developed a reliable method to evaluate spine shape literacy and established that only 21% and 42% of our sample demonstrated correct sagittal spine and lordotic spine shape literacy, respectively. The low literacy scores suggests that consideration of including spine shape literacy in health literacy and self-management programs may be warranted, especially in ageing populations.
Keywords: Health literacy, posture, back pain

INTRODUCTION

Spinal posture in the sagittal plane is associated with back pain[1)], increased falls[2)], reduced quality of life and future dependence in activities of daily living especially in older age[3)]. It typically consists of an anteriorly directed lumbar curve and posteriorly directed thoracic curve[4)] but the importance and necessity for patients to recognise the importance of this profile is currently unknown.

Deviation from the ideal direction and magnitude of sagittal spine curves is associated with increases in back pain and reduced quality of life[5–8)] especially in 30% of the population above the age of 60[9, 10)] who exhibit reduced lumbar lordosis associated with anterior sagittal balance[11)]. Furthermore, reduced lumbar lordosis is associated with increases in lower back pain and increased risk for disc disease[8, 12)].

Health Literacy is defined by the National Academies as "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions" [13)]. It is associated with better understanding, acceptance, adherence and outcomes to treatment interventions[14)]. Thus, considering the

prevalence of progressing anterior sagittal balance and spinal pain with ageing, a basic understanding of sagittal spine posture may be important.

Physical therapy management, for patients with or potential for sagittal malalignment aims to restore, maintain, or prevent further deterioration of the clinically modifiable factors associated with sagittal alignment[15]. This may include advice and functional exercises to maintain the direction, magnitude and mobility of these curves[16]. Adherence to these exercise programs may be enhanced with the inclusion of educational methods to increase health literacy of the sagittal spine profile[16, 17]. Therefore, recognising that health literacy programs have demonstrated increased engagement in health promoting activities and behaviours[17] it may be reasonable to suggest that increasing health literacy of the sagittal spine profile may have the potential to improve outcomes for older populations with back pain and sagittal malalignment.

In the absence of an established method to assess sagittal spine literacy (SSL) our aim was to: 1) develop and evaluate the reliability of a graphical method to assess SSL, 2) use the instrument to assess SSL and confidence of response in the general population and 3) investigate if SSL is associated with the presence of spinal pain and with age.

PARTICIPANTS AND METHODS

We conducted a randomised cross-sectional crossover study involving 250 adults, from the Sydney metropolitan area, aged 18 or older irrespective of presence of spine pain. Ethical approval was obtained from the local institution's committee (No. 2014/1019) and all participants provided informed consent. Recruitment entailed broad-based community advertising and targeted recruitment within tertiary colleges, community groups and corporate entities between June 2015 and November 2016. Given the community based recruitment strategy and graphical nature of the test there were no exclusion criteria.

Our first aim revolved around the development and psychometric properties of the survey instrument. The survey instrument was designed to graphically investigate whether respondents could demonstrate literacy of the "correct" sagittal spinal profile, consisting of an anteriorly directed lumbar lordosis and posteriorly directed thoracic kyphosis. The scoring scale was developed by classifying three curve shapes (lordosis, kyphosis and straight) within the lumbar and thoracic regions. The combination of the three options within each of the two spinal regions resulted in a nine-item ordinal rating scale. Scores were weighted towards the lumbar lordosis being more correct than the straight and kyphotic lumbar curves and the thoracic kyphosis being more correct than the straight and lordotic thoracic curves. The assessment tool score ranged from 0 (least correct: kyphotic lumbar and lordotic thoracic curve) to 8 (most correct: lordotic lumbar and kyphotic thoracic curve). A score of 4 was used to classify a straight lumbar and thoracic curve (Fig. 1).

We developed two versions of the assessment tool; a selection version and a free-hand drawing version. The selection version consisted of a graphical multiple-choice questionnaire with the nine stick figure shapes randomly (computer generated) presented on a page with an instruction to select the "correct" shape of the spine (Fig. 2a). The drawing version consisted of a facial featured circle to represent the head, and a series of lines representing the pelvis and lower limbs with an instruction to draw the "correct" shape of the spine (Fig. 2b).

The participants were randomised (computer generated) to either select or draw the correct shape of the spine first. Upon completion of the first test, the test was sealed in an envelope and they were given the second version to complete.

The drawing and selection test SSL results were scored according to the same scoring logic (Fig. 1). The SSL selection score (Fig. 2a) was simply identified from the pre-determined rating scale (Fig. 1). The SSL drawings were independently assessed by two trained physiotherapist raters (LC and SD). The physiotherapist raters had more than 28 years experience and participated in a one hour training and discussion session to agree on the classification of the drawn lumbar and thoracic shapes as either lordotic, kyphotic or straight. These shapes were then coded according to the SSL rating scale (Fig. 1) and
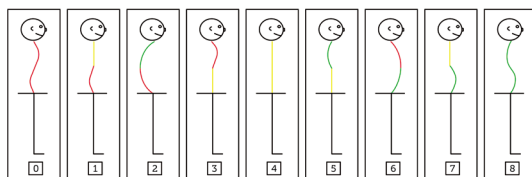

Fig. 1. Sagittal spine literacy rating scale depicting nine SSL shapes with rating score for each shape. (red curve is least correct, green curve is most correct, yellow curve is less correct).
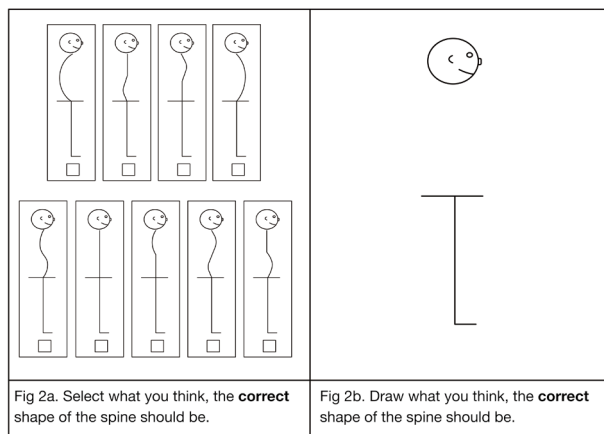

Fig 2a. Select what you think, the **correct** shape of the spine should be.

Fig 2b. Draw what you think, the **correct** shape of the spine should be.

Fig. 2. Spine shape selection test (2a) and spine shape drawing test (2b).

results recorded for inter-rater agreement analysis. Disagreement between the raters was resolved through consensus to establish a final drawing score which was utilised in the remainder of the statistical tests. A single intra-rater drawing score analysis (LC) was conducted on the complete sample six weeks after the initial rating.

The primary outcome measure was the SSL score which was recorded and scored from the selection and drawing tests, respectively. These scores were then used to determine the overall SSL of the sample population and the selection vs drawing agreement within and between participants. Participants who demonstrated correct SSL scored eight and correct lordotic lumbar spine literacy scored six, seven or eight on Fig. 1.

Additionally, participants were asked to rate their confidence in drawing or selecting the correct spine shape on a 10-point Likert rating scale, with one indicating lowest confidence and 10 indicating highest confidence. To determine whether drawing skills influenced drawing SSL, we asked respondents to indicate on a yes / no scale whether they had drawn and selected the same spinal shape and if not, whether they considered their results were impacted by their drawing skills.

For further secondary analysis, we asked participants to report whether they suffered from spinal pain. Those who reported spinal pain were asked to specify the location (neck, upper back, lower back) and severity on a 10-point scale for each location. Differences in SSL were compared between the spinal pain and pain-free groups.

A pilot-study of the drawing test conducted in a sample of health professionals and researchers (n=31), identified 67% of drawings demonstrating correct SSL. We assumed that 50% of the general population would draw a correct spine shape. Using a model for continuous data, we calculated a minimum sample size of 165 participants using a two tailed test with 80% power to detect a kappa of 0.60[18]. Allowing for errors in drawing and for secondary analysis, we recruited a sample size of 250.

To achieve our first aim, evaluating the psychometric properties of the survey instrument, we used weighted Kappa to assess inter-rater and intra- rater reliability and Kappa to evaluate the agreement between drawing and selection methods. Our second aim, to quantify and compare the SSL of the sample, involved using Fisher's exact test to compare the proportion of participants with correct SSL and correct lordotic lumbar spine selection within and between each testing method. We also assessed if the order of testing (selection vs drawing) made a difference to the SSL scores by, after testing for normality, comparing the scores of the two groups with Mann-Whitney U tests. Further to our second aim, sample characteristics and confidence of response were evaluated for normality and compared with paired and unpaired t-tests within and between the drawing first and select first subgroups.

For our third aim, we used the selection test scores in chi-squared linear trend tests to compare SSL between the spinal pain and the pain-free group. Additionally, we evaluated the correlation between SSL and age using Spearmans Rho coefficient. Significance was set at 0.05 and apart from the d'Agostino normality test conducted online at http://contchart.com the statistical analysis was conducted using SPSS version 24.0 (IBM Corp, Chicago, IL, USA).

RESULTS

We recruited 250 adult participants into our study. An error with the randomisation resulted in an unequal number of participants in each sub-group (119 participants drew first while 131 participants selected first). The raters were unable to score one, unclear drawing test, which was removed from the drawing analysis. Seven particpants reported working in allied health related fields (Appendix Table 1). The demographic characteristics and response data confirming no differences between the groups are detailed in Table 1.

The inter-rater agreement for the drawing test ranged from 79–93% (weighted kappa 0.74–0.86) and intra-rater agreement ranged from 80–94% (weighted kappa 0.76–0.88) (Table 2). The agreement between the drawing and the selection test ranged from 43% to 75% (Kappa 0.32–0.46) (Table 3).

Significantly more participants drew the correct spinal shape (30% vs. 21%) (p<0.001) and lordotic shape (56% vs. 42%) (p<0.001) than selected the correct shape. Test order, whether the participants drew or selected first, did not affect the drawing vs selection SSL scores (1.21 vs. 0.97, p=0.68). The respondents reported significantly greater confidence in selecting the correct spine shape compared with drawing the correct shape (6.41 vs. 5.76, p<0.001). This was observed in both the drawing first (6.04 vs. 5.58, p=0.002) and selecting first (6.24 vs. 5.92, p=0.007) groups. Although 71% of the respondents reported drawing and selecting similar shapes, only 38% of the respondents were rated as doing so. Difficulty with drawing was identified by 58% of the 71 respondents who reported differences with drawing and selection of spine shapes, however 14% of these were rated as drawing the same shape as selection. Participants reporting spinal pain exhibited lower SSL across the 9-item scale compared to participants reporting no spinal pain (p=0.02) but this difference was not observed with the lumbar lordosis literacy (p=0.16). Results of the Spearman correlation indicated that there was negligible association between SSL and age, (ρ=0.031, p=0.313).

DISCUSSION

Our study presents a novel rating method and two graphical test versions to assess SSL. We determined that the drawing test version has excellent inter and intra-rater reliability and established that only 21% to 30% of a sample from the general adult population were able to demonstrate correct SSL. We identified, through secondary outcome measures, that there may

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Table 1. Participant and group demographics

	Complete group (n=250)	Draw first (n=119)	Select first (n=131)	p-value
Age, years (SD)	40 ± 18	40 ± 18	40 ± 17	0.81
Female, n (%)	132 (53%)	67 (56%)	67 (51%)	0.61
Tertiary education	195 (78%)	93 (78%)	101 (77%)	0.88
Prevalence of overall spine pain	160 (64%)	75 (63%)	85 (65%)	0.79
Prevalence of neck pain	94 (38%)	42 (17%)	52 (21%)	0.51
Severity of neck pain	4.68 ± 2.04	4.64 ± 1.99	4.71 ± 2.09	0.11
Prevalence of upper back pain	65 (26%)	26 (10%)	39 (16%)	0.19
Severity of upper back pain	4.78 ± 2.08	4.73 ± 2.07	4.82 ± 2.11	0.11
Prevalence of lower back pain	135 (54%)	60 (24%)	75 (30%)	0.31
Severity of lower back pain	5.23 ± 2.16	5.33 ± 1.99	5.16 ± 2.30	0.11

Data reported as n (%). Pain severity reported as mean (SD) on 10 point Likert scale.

Table 2. Drawing test inter-rater & intra-rater agreement

		Rater 1 correct (%)	Rater 2 correct (%)	Proportional agreement	Kappa (95% CI)	p-value
Full spine	Inter-rater	29%	34%	79%	0.83 (0.79–0.88)	<0.001
	Intra rater	29%	26%	80%	0.84 (0.79–0.88)	<0.001
Lordotic spine	Inter-rater	36%	40%	93%	0.86 (0.79–0.92)	<0.001
	Intra-rater	36%	33%	94%	0.88 (0.81–0.94)	<0.001

Table 3. Agreement between drawing test and selection test for full spine and lordotic spine literacy

	Drawing test correct (%)	Selection test correct (%)	Proportional agreement (%)	Kappa (95%CI)	p-value
Full spine literacy	30%	21%	43%	0.32 (0.28–0.42)	<0.001
Lordosis literacy	37%	33%	75%	0.46 (0.34–0.56)	<0.001

be an association between better SSL and absence of spinal pain.

Our primary aim was to develop and evaluate a reliable measure of SSL. Previous studies examining the sagittal spine profile have not assessed SSL. They have assessed physiotherapists agreement on "best sitting posture"[19] as well as photographic postural response of children[20] and women[21] to the command "stand up straight". These studies examined outcomes based on the magnitude (degree) of the sagittal curves which are highly variable and not the more robust direction of the sagittal curves. Utilisation of pictures in health communication, when compared with text alone, has been shown to increase attention, comprehension to health information and adherence to health instruction, especially in the populations with low levels of health literacy[22]. Considering an absence of an acceptable gold standard to measure knowledge of the sagittal spine, we propose that the graphical tool presented in this paper may be useful to determine knowledge about the sagittal spine shape in future research studies.

Our secondary aim was to utilise the SSL test to quantify knowledge of sagittal spine shape in our sample population. Spinal deformity in the sagittal plane, especially reduced lumbar lordosis, is associated with increased lower back pain[8]. Additionally, adult spine deformity, affecting up to 30% of the ageing population[9] is associated with a reduced lumbar lordosis[11] and results in poorer quality of life outcomes than coronal plane deformity[23]. We established that 58% of our sample population was unable to demonstrate lumbar lordosis literacy. Considering that women and children have been observed to extend their thoracic spines to the verbal command "stand up straight"[20, 21] older adults may similarly and erroneously adopt this action instead of extending their lumbar spines. Therefore, since conservative treatment programs incorporating education and exercise are more beneficial than exercise alone[24] we suggest that SSL education focusing on the lumbar lordosis can be considered for inclusion into management strategies for the treatment and prevention of sagittal plane deformity and related back pain in ageing patients communities. However, we recognise that future research is needed to evaluate the psychometric properties of the tool, the responsiveness of the tool in ageing back pain and sagittal malalignment populations as well as the effectiveness of SSL education programs on clinical outcomes.

The surprising pilot study drawing test results (only 67% of health professionals drawing the correct sagittal spine shape)

raises interesting questions regarding the raw construct validity of the drawing test and its clinical application. Our findings reveal low agreement for SSL between the selection and drawing test (K=0.32), and that 17% of the participants reported difficulty with drawing the spinal curvature. Rather than discard the drawing test as an invalid tool, we caution that the drawing test be considered for clinical settings where time and individualised attention allow for in-depth levels of discussion between health professional and patient.

Although we identified that the presence of spinal pain was associated with a trend for reduced SSL, we cannot, through the cross-sectional nature of this study, establish causality. The evidence suggests that poorer health literacy is associated with poorer health outcomes[17] and this may be a relevant factor in back pain associated with adverse sagittal alignment. But this would need to be confirmed in further studies designed to investigate this relationship. We highlight that the novelty of our study was to establish a methodology to examine this link.

Our study results, in a sample from the general population with a mean age of 40, are not derived from the clinical or older population. However, the assessment methodology can be applied to these populations to explore further correlations with pain and responses to increasing sagittal profile literacy. Although the SSL tests did not assess cervical lordosis literacy, the scoring logic can be expanded to incorporate a cervical curve.

We developed and evaluated a graphical scoring system to assess SSL. Using two simple and reliable testing methods, we established that only 21–30% of our sample population demonstrated knowledge of the ideal spinal shape and that this may be associated with increased spinal-pain presence. This suggests that there may be potential to measure change following education as well as a potential health related benefit. The drawing and selection testing methods do not appear to be interchangeable and may be more appropriate for different clinical settings. However, given the prevalence of lower back pain and sagittal imbalance in the increasingly ageing population we hope that our study will encourage further research to establish whether SSL and education translates into increased health literacy and a clinically meaningful benefit.

Conference presentation

Sagittal spine shape literacy in the general adult population, assessed by a simple graphical tool. Cohen L, Simic M, Pappas E, K Refshauge, Dennis S. University of Sydney, Lidcombe, Australia. Australian Physiotherapy Association Conference, Sydney, Australia. October 19–21 2017.

Poster presentation: The development of a tool for assessment of sagittal spine shape literacy.

L Cohen, M Simic, S. Dennis, K Refshauge, E. Pappas. Faculty of Health Sciences, Discipline of Physiotherapy, The University of Sydney. 12th-annual-conference-of-the-Society-on-Scoliosis-Orthopaedic-and-Rehabilitation-Treatment, Lyon France. 04–06 May 2017

Conflict of interest

Author LC is a physiotherapist and has a financial interest in a physiotherapy practice in Sydney, Australia.

REFERENCES

1) Le Huec JC, Thompson W, Mohsinaly Y, et al.: Sagittal balance of the spine. Eur Spine J, 2019, 28: 1889–1905. [Medline] [CrossRef]

2) Fernandes VL, Ribeiro DM, Fernandes LC, et al.: Postural changes versus balance control and falls in community-living older adults: a systematic review. Fisioter Mov, 2018, 31.

3) Kamitani K, Michikawa T, Iwasawa S, et al.: Spinal posture in the sagittal plane is associated with future dependence in activities of daily living: a community-based cohort study of older adults in Japan. J Gerontol A Biol Sci Med Sci, 2013, 68: 869–875. [Medline] [CrossRef]

4) Claus AP, Hides JA, Moseley GL, et al.: Is 'ideal' sitting posture real? Measurement of spinal curves in four sitting postures. Man Ther, 2009, 14: 404–408. [Medline] [CrossRef]

5) Dickson RA, Lawton JO, Archer IA, et al.: The pathogenesis of idiopathic scoliosis. Biplanar spinal asymmetry. J Bone Joint Surg Br, 1984, 66: 8–15. [Medline] [CrossRef]

6) Sinaki M, Brey RH, Hughes CA, et al.: Balance disorder and increased risk of falls in osteoporosis and kyphosis: significance of kyphotic posture and muscle strength. Osteoporos Int, 2005, 16: 1004–1010. [Medline] [CrossRef]

7) Labelle H, Roussouly P, Berthonnaud E, et al.: Spondylolisthesis, pelvic incidence, and spinopelvic balance: a correlation study. Spine, 2004, 29: 2049–2054. [Medline] [CrossRef]

8) Chun SW, Lim CY, Kim K, et al.: The relationships between low back pain and lumbar lordosis: a systematic review and meta-analysis. Spine J, 2017, 17: 1180–1191. [Medline] [CrossRef]

9) Barreto MV, Pratali Rd R, Barsotti CE, et al.: Incidence of spinal deformity in adults and its distribution according SRS-Schwab classification. Coluna/Columna, 2015, 14: 93–96. [CrossRef]

10) Yoshida G, Kurosu K, Yamato Y, et al.: Novel measurement technique for the sagittal vertical axis and its clinical application in adult spinal deformity. Asian Spine J, 2017, 11: 190–197. [Medline] [CrossRef]

11) Le Huec JC, Charosky S, Barrey C, et al.: Sagittal imbalance cascade for simple degenerative spine and consequences: algorithm of decision for appropriate treatment. Eur Spine J, 2011, 20: 699–703. [Medline] [CrossRef]

12) Purcell L, Micheli L: Low back pain in young athletes. Sports Health, 2009, 1: 212–222. [Medline] [CrossRef]

13) Parker RM: Health literacy fact sheets. The National Academies Publication, 2012.

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14) Taggart J, Williams A, Dennis S, et al.: A systematic review of interventions in primary care to improve health literacy for chronic disease behavioral risk factors. BMC Fam Pract, 2012, 13: 49. [Medline] [CrossRef]

15) Yilgor C, Sogunmez N, Boissiere L, et al. European Spine Study Group (ESSG): Global Alignment and Proportion (GAP) score: development and validation of a new method of analyzing spinopelvic alignment to predict mechanical complications after aadult spinal deformity surgery. J Bone Joint Surg Am, 2017, 99: 1661–1672. [Medline] [CrossRef]

16) Legaye J: Follow-up of the sagittal spine by optical technique. Ann Phys Rehabil Med, 2012, 55: 76–92. [Medline] [CrossRef]

17) Edward J, Carreon LY, Williams MV, et al.: The importance and impact of patients' health literacy on low back pain management: a systematic review of literature. Spine J, 2018, 18: 370–376. [Medline]

18) Sim J, Wright CC: The kappa statistic in reliability studies: use, interpretation, and sample size requirements. Phys Ther, 2005, 85: 257–268. [Medline] [Cross-Ref]

19) O'Sullivan K, O'Sullivan P, O'Sullivan L, et al.: What do physiotherapists consider to be the best sitting spinal posture? Man Ther, 2012, 17: 432–437. [Medline] [CrossRef]

20) Czaprowski D, Pawłowska P, Stoliński L, et al.: Active self-correction of back posture in children instructed with 'straighten your back' command. Man Ther, 2014, 19: 392–398. [Medline] [CrossRef]

21) Barczyk-Pawelec K, Sipko T: Active self-correction of spinal posture in pain-free women in response to the command "straighten your back". Women Health, 2017, 57: 1098–1114. [Medline] [CrossRef]

22) Houts PS, Doak CC, Doak LG, et al.: The role of pictures in improving health communication: a review of research on attention, comprehension, recall, and adherence. Patient Educ Couns, 2006, 61: 173–190. [Medline] [CrossRef]

23) Lafage V, Schwab F, Patel A, et al.: Pelvic tilt and truncal inclination: two key radiographic parameters in the setting of adults with spinal deformity. Spine, 2009, 34: E599–E606. [Medline] [CrossRef]

24) Steffens D, Maher CG, Pereira LS, et al.: Prevention of low back pain: a systematic review and meta-analysis. JAMA Intern Med, 2016, 176: 199–208. [Medline] [CrossRef]

Appendix Table 1. SSL scores and confidence of correct response for seven allied health participants

	Occupation	SSL selection score	Reported confidence of correct response
1	Rehabilitation consultant	0	3
2	Occupational therapist	8	10
3	Pharmacist	6	9
4	Herbalist	1	6
5	Fitness trainer	7	8
6	Fitness trainer	6	8
7	Pilates instructor	8	10

SSL: sagittal spine literacy.