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Original article

Physiotherapist perceptions of optimal sitting and standing posture

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ABSTRACT

Background: Assessment of, and advice about, spinal posture is common when people with spinal pain present to physiotherapists. Most descriptions regarding optimal spinal posture have been qualitative in nature.
Objectives: To determine the beliefs of physiotherapists regarding optimal sitting and standing posture.
Design: Online survey.
Method: 544 Greek physiotherapists selected an optimal sitting (choice of seven) and standing (choice of five) posture, while providing justification for their choice.
Results: Education regarding optimal sitting and standing posture was considered "considerably" or "very" important by 93.9% of participants. Three different sitting postures, and two different standing postures, were selected as the optimal posture by 97.5% and 98.2% of physiotherapists respectively. While this reflects a lack of complete consensus on optimal posture, the most commonly selected postures were all some variation of upright lordotic sitting, in contrast slouched spinal curves (sitting) or forward head posture (sitting and standing) almost never being selected as optimal. Interestingly, participants used similar arguments (e.g. natural curves, muscle activation) to justify their selection regardless of the spinal configuration of each selected posture.
Conclusions: These results reinforce previous data suggesting that upright lordotic sitting postures are considered optimal, despite a lack of strong evidence that any specific posture is linked to better health outcomes. While postural re-education may play a role in the management of spinal pain for some patients, awareness of such widespread and stereotypical beliefs regarding optimal posture may be useful in clinical assessment and management.

Introduction

The concepts of "postural health" and "optimal posture" (OP) have been discussed in the healthcare professionals' community for decades (Kendall, 1952; Staffel, 1884) and broadly accepted beliefs regarding "good" and "bad" postures exist (Kim et al., 2015; Moustafa and Diab, 2015; O'Sullivan et al., 2013a; O'Sullivan et al., 2012). In 1947, the Posture Committee of the American Academy of Orthopaedic Surgeons (AAOS, 1947) defined healthy posture as *"…the state of muscular and skeletal balance which protects the supporting structures of the body against injury or progressive deformity …"* and poor posture as *"…a faulty relationship of the various parts of the body which produces increased strain on the supporting structures …"*. These stereotypes, such as "protection", "injury", "deformity", and "faulty" were carried over the years and resulted in qualitative descriptions of the optimal standing (StP) and sitting posture (SP) with the potential to affect the perception of healthcare providers on posture.

The optimal StP has been described to involve a mid-range position of the pelvis, slight lumbar lordosis, slight thoracic kyphosis, and with the head in a well-balanced position (Kendall, 1952; Woodhull et al., 1985). However, several spinal curve combinations meet this qualitative description. Consequently, there is debate regarding alignment relative to the standing lateral view (Harrison et al., 1999) on whether the: i) centre of gravity should be anterior to the talus (Woodhull et al.,

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1985), or ii) ear, shoulder, hip, knee and talus should be perfectly aligned (Kuchera, 1995), or iii) posterior parts of the head, back and gluteal muscles should be vertically aligned (Kapandji, 1974). Regarding the optimal SP there is also a lack of consensus, particularly in the lumbar region. Optimal spinal curves in sitting have variously been described as: i) a lordotic spinal curve similar to standing (Castanharo et al., 2014; Lee, 2007; Pope et al., 2002), ii) lumbar lordosis without detail regarding the curvature configuration of the thoracic and cervical spine (Sahrmann, 2002), iii) lordosis in both thoracic and lumbar regions (Sprague, 2001), iv) lumbar lordosis and slight thoracic kyphosis (McKenzie and May, 2003), and v) flat lower thoracic and lumbar regions (Magee, 2006). Interestingly, justification of each OP is based on similar arguments regarding the interplay of biomechanical and/or physiological domains, such as intradiscal pressure, viscoelastic creep, loading on zygapophysial joints, tissue stress, and muscle activation (Harrison et al., 1999; Pope et al., 2002; Pynt et al., 2001, 2008).

Clinically, 'corrective' postural interventions and advice are commonly used by physiotherapists in managing spinal pain based on the presumption that postural variations from the ideal posture are causative of LBP (Poitras et al., 2005). While evidence suggests that a large percentage of individuals are susceptible to spinal symptoms development during standing (Andersen et al., 2007; Gallagher and Callaghan, 2015; Nelson-Wong and Callaghan, 2010; Tissot et al., 2009), and various postural interventions have shown some potential to reduce the incidence of LBP (Pillastrini et al., 2010), reduce low back discomfort (O'Sullivan et al., 2013b), and reduce disability and pain (Sheeran et al., 2013), there is limited evidence that any specific spinal posture is causative of LBP (Laird et al., 2014). For example, while specific StPs adopted for a prolonged time involving increased lumbar lordosis or increased thoracic extension have been implicated in the development of spinal symptoms (Gallagher et al., 2014; Sorensen et al., 2015), longitudinal studies have failed to demonstrate a strong relationship between these postures and LBP (Smith et al., 2017).

While the specifics of the OP remain broadly debated, community perceptions seem to be consistent despite a lack of solid evidence (O'Sullivan et al., 2013a). Lordotic lumbar SPs were favoured among members of the community and there were no differences in perceptions between people with and without LBP (O'Sullivan et al., 2013a). One study (O'Sullivan et al., 2012) evaluated physiotherapists' beliefs regarding SPs, but not StPs, showing these beliefs were largely in line with the previously reported perceptions of community members, and justified by describing such postures as natural, relaxed and efficient. Qualitative comments indicated that SPs which matched the natural shape of the spine, and appeared comfortable and/or relaxed without excessive muscle tone were often deemed advantageous (O'Sullivan et al., 2012). However, no previous study has examined the perceptions of physiotherapists about StPs. This is notable considering the evidence that the beliefs of healthcare professionals strongly influence their LBP management approach (Darlow et al., 2012). Before concluding if and how spinal posture should be modified in people with spinal pain, it is important to understand perceptions regarding the OP and the importance attached to OP by physiotherapists. Based on existing evidence, it was hypothesised that physiotherapists would select mainly upright postures as optimal, and that these would be justified based on assumptions that these postures were safe and natural.

Drawing on a cohort based in Greece, this study aimed to investigate: i) the perceptions of physiotherapists on the optimal StP and SP and ii) how these physiotherapists describe and quantify the characteristics they associate with OPs.

Methods

Study design

A cross-sectional design was used via an online survey in Greece. The survey was designed to explore the perceptions of physiotherapists on the optimal StP and SP that they would use for postural education. Ethical approval was granted by institutional ethics committee (4-2/13-2-2013). Participants were advised that completion of the survey was accepted as informed consent.

The survey was promoted on social media, physiotherapy groups, and through the Panhellenic Physical Therapy Association's (PPTA) member networks from 2014.

Reporting of the study followed the STROBE statement (STrengthening the Reporting of OBservational studies in epidemiology) for cross-sectional studies (von Elm et al., 2008).

Survey design and piloting

An original web-based survey was designed as there is no existing reliable and valid tool assessing this construct. The survey used consisted of three sections: a) a closed question regarding the perceived importance of postural education in clinical practice (4-point Likert scale; 1 = not important at all; 4 = very important); b) a choice between seven SPs and five StPs from photographs to select one of each as "optimal" for postural education; c) free text boxes for choice justification and finally d) demographic information including sex, age, level of educational qualifications, years of experience, clinical area of expertise, postgraduate diplomas and certifications, work location, and employment status. This demographic information was obtained to explore whether any variation seen in the selection of OP could be explained by these variables.

Twenty physiotherapists (10 male and 10 female; age range 21–50 years) piloted the survey for feasibility, readability and face validity. Piloting identified a few required formatting changes and adjustments to enhance readability and went live in June 2014.

Procedures and generating images of sample SPs and StPs

A digital camera (Sony Cyber-shot) positioned 3 m from the model and a 10 camera T-40 Vicon system (Oxford, UK) were used for image generation and kinematic data collection.

A 37 year-old female with no history of spinal pain and adequate flexibility to assume a variety of StP and SPs acted as a model.

Reflective markers were applied to the pelvis over the anterior and posterior superior iliac spines, to the spine over the C7, T5, T10, L3 and S2 spinous processes, and to the sternal notch and xiphoid process. Finally, markers were adhered to the head over the lateral margins of the orbit and over the external occipital protuberance by using an elastic band and on the main protuberance of the forehead between the eyebrows. These markers enabled calculation of eight sagittal angles between markers and upper body segments (Fig. 1) (Korakakis et al., 2014, 2017).

For the SPs image generation she sat unsupported on a stool that was adjusted to the height of the popliteal crease, hips and knees were positioned at 90° of flexion, ankles at plantargrade. A range of postures described in the literature and usually observed in clinical practice including variations of cervical, thoracic, and lumbar curvature were chosen. In terms of SP the model assumed postures between slouched posture (posterior pelvic tilt, kyphotic lumbar and thoracic spine, and protruded head) and hyper-lordotic upright (anterior pelvic tilt, lordotic lumbar and extended thoracic regions, and retracted head) and combinations of these. For StPs, an upright posture with the ear lobe, tip of the shoulder, and centre of the hip and knee vertically aligned just anterior to ankle joint was used, along with variations such as sway back standing and rounded shoulders, and flat back and forward head postures.

Prior to photograph generation, the model was assisted in moving through her available spinal, pelvic and head range of motion as a warm-up and to ensure the fixation of the reflective markers. An image of the postures was presented to the model and a demonstration of each posture and verbal description was given by an experienced

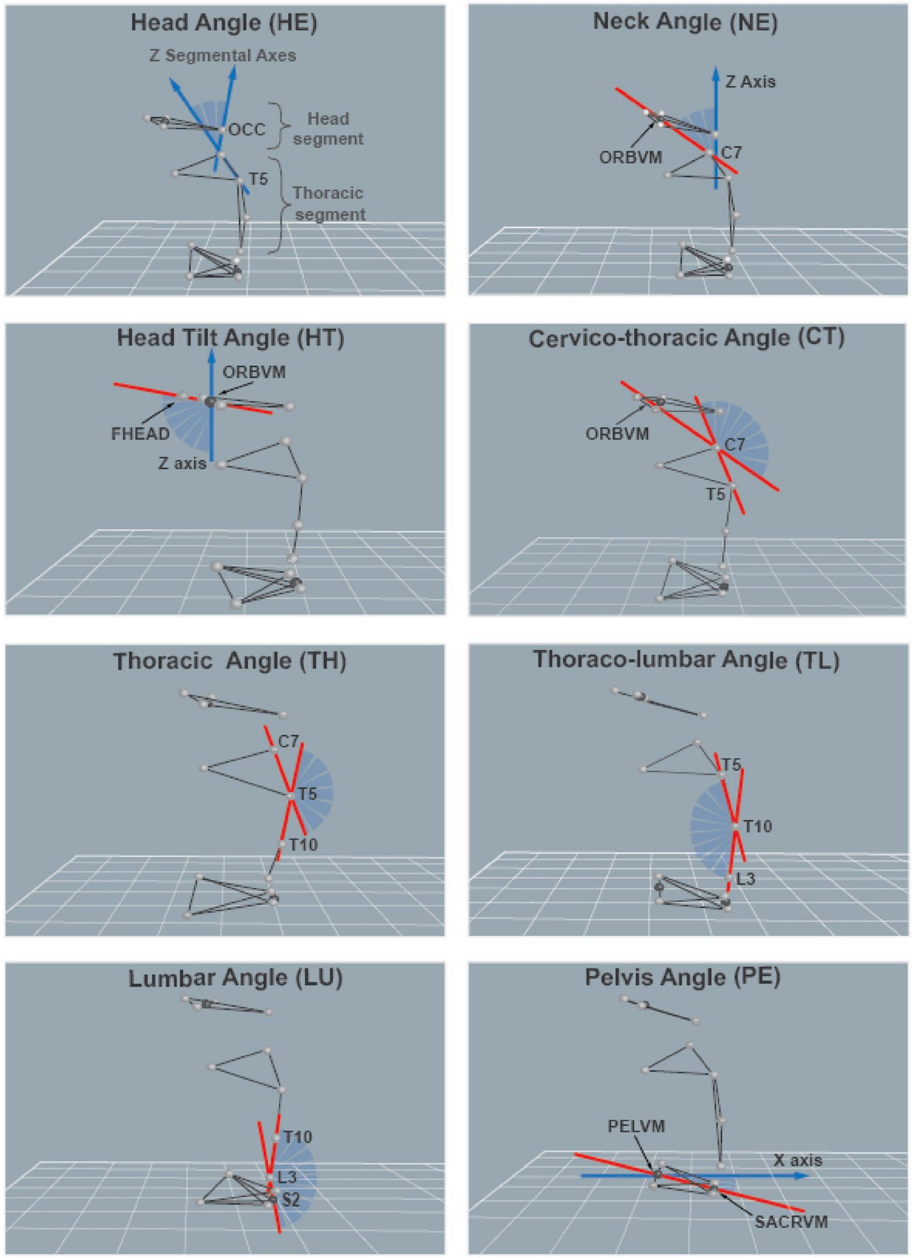

Fig. 1. The eight sagittal angles calculated in the study to describe spinal configuration of each seated and standing posture.

physiotherapist. During the positioning manual facilitation and verbal feedback were provided. The model was assisted to attain and requested to maintain each posture for 15 s while the 3D capture was recorded and the photographs were taken. To minimise bias, the testers were careful not to infer that any one StP or SP was considered to constitute the OP.

The postures were randomly numbered (Figs. 2 and 3) and the angular data associated are displayed in Table 1.

Participants

No sample size calculations were undertaken. To be eligible, respondents had to confirm that they were physiotherapists, and specify if they were undergraduates or graduates.

Data analysis

Data was analysed using SPSS 21.0 and Microsoft Excel. All responses received were included in the analysis regardless of missing data; therefore results are reported accordingly.

Categorical data were expressed as counts and percentages. Means and standard deviations were used for continuous data. The Kolmogorov-Smirnov test was used for normality testing and Mann-Whitney *U*-tests were employed to evaluate differences in continuous variables. The chi-square goodness-of-fit test was used to test the distribution of SPs and StPs selected among physiotherapists. To test the hypothesis that the relative proportions of selected postures (SPs or StPs) were independent of work environment, academic qualifications, location within the country, years of experience, specialisation, and area of expertise, Fisher's exact test of independence was used. Additional post hoc tests were used due to violations of chi-square test's assumptions (cells with expected values less than 1 and more than 20% of expected counts less than 5) (Boslaugh and Watters, 2008).

The qualitative comments justifying the selection of postures were categorised into common themes using a semantic approach. The themes were identified within the explicit meanings of the data and

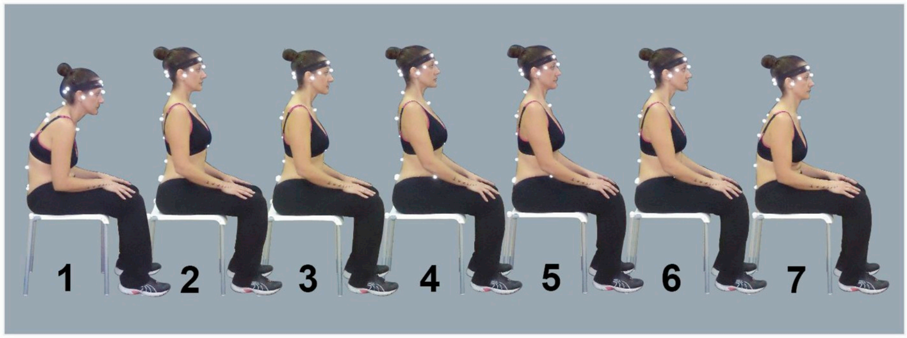

Fig. 2. The seven seated postures used as options in the study. Numbers correspond to descriptions in main text.

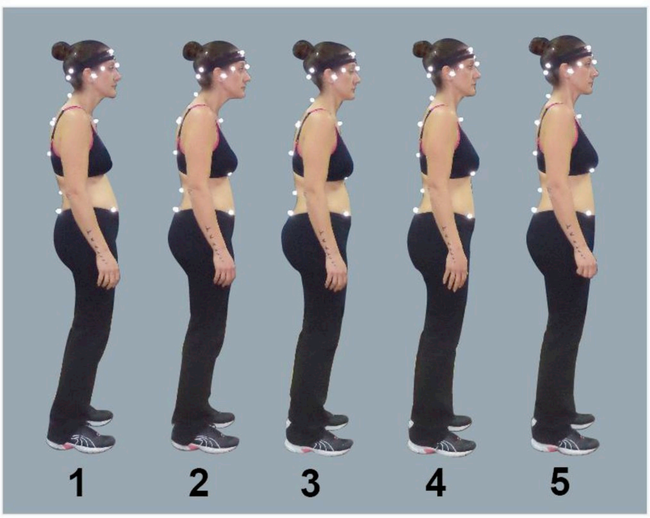

Fig. 3. The five standing postures used as options in the study. Numbers correspond to descriptions in main text.

strictly based on what participants wrote in their responses (Braun and Clarke, 2006).

The level of significance was set at $p < 0.05$ and Bonferroni corrections were applied where applicable.

Results

Participants and demographics

544 physiotherapists participated in the survey, representing an approximate response rate of 7% of the countrywide registered practitioners in PPTA. All areas of Greece were represented within the data (Fig. 4). The demographic characteristics of the participants are presented in Table 2 (Appendix 1). Males and females were equally represented (50.4% and 49.6%, respectively) and females (age 31.2 ± 9.2 years) were older than males (age 27.5 ± 8.0 years) ($U = 26828.0$, $p < 0.0001$). The highest degree obtained among physiotherapists was most commonly a BSc (54.3%). Most had 0–3 years of experience (55.4%). Musculoskeletal physiotherapy was the representative area of expertise (79.9%), while 30.2% worked primarily in private clinical practice.

Importance of postural education

93.9% of physiotherapists rated the education of optimal StP and SP as "considerably" and "very" important (28.7% and 65.2%, respectively) in clinical practice. Only 5% of the respondents stated that postural education is not important at all.

The optimal SP and StP

Three SP were most commonly selected as optimal from 95.7% of the participants: posture 2 ($n = 225$, 41.4%), posture 5 ($n = 150$, 27.6%), and posture 4 ($n = 145$, 26.7%); while two StP were selected from 98.2% of the participants: posture 4 ($n = 225$, 41.3%) and posture

Table 1
Sagittal spinal angles for each selected photograph for sitting and standing postures.

	Posture	HE	NE	HT	CT	TH	TL	LU	PE
SITTING	1	47.6	63.6	96.6	162.8	163.7	155.8	179.7	−11.1
	2	27.3	46.8	107.6	147.7	165.3	172.8	150.7	−4.5
	3	35.3	54.9	106.6	148.8	158.1	176.6	158.4	−2.9
	4	28.8	41.6	114.3	147.6	165.8	179.2	157.0	−4.8
	5	32.6	44.0	109.8	153.3	167.5	176.1	172.3	−11.4
	6	39.2	52.0	111.1	151.2	163.5	173.8	173.6	−12.4
	7	48.3	41.2	115.9	165.7	173.8	164.4	169.8	−18.1
STANDING	**Posture**	**HE**	**NE**	**HT**	**CT**	**TH**	**TL**	**LU**	**PE**
	1	53.7	46.7	113.5	165.1	157.4	155.0	157.3	−6.6
	2	47.3	52.3	115.7	156.2	156.5	160.5	149.1	−0.3
	3	35.6	46.3	111.0	154.6	161.4	168.7	149.7	4.5
	4	32.7	47.6	109.2	152.4	164.1	167.4	153.4	1.4
	5	38.4	48.1	107.3	159.6	165.6	159.4	160.3	−2.2

Note: all values are presented in degrees; negative values in pelvis angle represent more posterior pelvic tilt.
Abbreviations. HE, head angle; NE, neck angle; HT, (head tilt angle), CT, cervico-thoracic angle; TH, thoracic angle; TL, thoraco-lumbar angle; LU, lumbar angle; PE, pelvis angle.

Fig. 4. The percentage of respondents per corresponding Greek region (n = 468).

5 (n = 309, 56.9%).

Two of the SPs (2 and 4) involved a moderately lordotic lumbar spine, while posture 5 involved a less lordotic lumbar spine SP. In posture 2 the lumbar spine was positioned in lordosis, the thoracic spine was in slight kyphosis, while the head and shoulders were aligned over the pelvis with the chin over the chest, moderately retracted, while posture 4 involved less lordosis in the lumbar spine and more extension in TL spine.

SP 2 was significantly more popular than all the other postures; $x^2(6, N = 544) = 673.492$, $p < 0.001$, $V = 1.1$. No significant difference in popularity was found between posture 4 and 5; $x^2(1, N = 295) = 0.085$, $p = 0.771$. All three of these postures (2, 4 and 5) were significantly more popular than the rest (1, 3, 6, and 7) of the SP choices (all $p < 0.05$).

The two most commonly selected StPs (4 and 5) were relatively similar; both were upright involving less thoracic flexion and had the head aligned over the trunk compared to the other choices. Posture 4 involved slightly more lumbar lordosis and anterior pelvic tilt than StP 5. StP 5 was significantly more popular than all the other postures and posture 4; $x^2(4, N = 544) = 798.575$, $p < 0.001$, $V = 1.2$ and $x^2(1, N = 533) = 13.555$, $p < 0.001$, $V = 0.16$ respectively.

Factors associated with choice of optimal SP or StP

Female sex was initially found to influence SP (p = 0.03) but not StP (p = 0.310) selection, however that was not confirmed following Bonferroni correction ($p < 0.0036$).

No significant interaction was found following Bonferroni corrections between SP or StP selection and work environment (p = 0.798, p = 0.185 respectively), academic qualifications (p = 0.071, p = 0.179, respectively), location within the country (p = 0.022, p = 0.184, respectively), years of experience (p = 0.371, p = 0.377, respectively), specialisation (p = 0.249, p = 0.276, respectively), and area of expertise (p = 0.187, p = 0.271 respectively).

Postures selected and qualitative comments

Participants used similar justifications for their selection regardless of the spinal configuration of each posture. Five major themes identified relating to SP were: i) natural spinal curvatures, ii) muscle recruitment and energy expenditure, iii) optimal pelvis position, iv) neutral spine, and v) stereotypes for “ideal” posture. 39.2% of the responses were categorised on theme (v) with respondents using general biomechanical considerations based on beliefs of “ideal” posture and/or load distribution. The majority of surveyed physiotherapists (37.9%) argued that the selected posture “matches the natural spinal S-shape” (theme i). Respectively, 10.5% justified their selection based on neutral spinal alignment that does not approach end-range (theme iv), 7.2% discussed the activation of key postural muscles and the sustainability of posture (muscle energy expenditure) (theme ii), and 5.2% based their selection on how the pelvis position influenced the seated spine (theme iii).

For StPs we identified the same major themes as for SPs and an additional theme related to the line of gravity (theme vi). The biggest percentage (31.2%) of surveyed physiotherapists based their response on stereotypes (theme v) regarding “ideal” posture and ergonomic and biomechanical considerations, while 27.4% argued that their selection “matches the natural S-shape of the spine” (theme i). 16.9% based their choice on the line of gravity, centre of mass and base of support (theme vi), 10.7% based on neutral spinal alignment (theme iv), 9.0% based

Table 2
Demographic and descriptive characteristics of the respondents (n = 544).

%			(n)
Age[a]	Male	27.5	± 8.0
	Female	31.2	± 9.2
	Total	29.3	± 8.8
Sex	Male	50.4	(274)
	Female	49.6	(270)
	Total	100	(544)
Qualifications	Undergraduate	33.7	(183)
	BSc	54.3	(295)
	MSc	10.3	(56)
	PhD	1.7	(9)
Years of experience	0–3	55.4	(301)
	3–6	10.5	(57)
	6–10	7.9	(43)
	> 10	25.0	(136)
Area of expertise	Musculoskeletal	79.9	(434)
	Neurological	43.1	(234)
	Cardiopulmonary	15.8	(86)
	Sports injuries	45.9	(249)
Diplomas/Certificates	Manual therapy	14.7	(80)
	McKenzie	11.0	(60)
	Mulligan	9.6	(52)
	PNF	10.3	(56)
	Other	21.4	(116)
Work status	Self-employed	30.2	(164)
	Hospital	12.0	(65)
	Employee	14.5	(79)
	Home visits	16.9	(92)
	Unemployed	23.6	(128)

Note: Respondents could select multiple areas of expertise and diplomas or certificates and data is presented accordingly in the table. All responses received were included in the analysis regardless of missing data; therefore results are reported accordingly.
Abbreviations: PNF, proprioceptive neuromuscular facilitation.
[a] Indicates that values are presented as mean ± SD.

their selection on the optimal pelvis position, and 4.8% discussed the activation of key postural muscles and the sustainability of posture with regard to muscular energy expenditure (theme ii).

Discussion

The vast majority of physiotherapists surveyed (93.5%) believe that training a specific spinal posture is important in clinical practice, in agreement with the beliefs of physiotherapists and community members (O'Sullivan et al., 2013a; O'Sullivan et al., 2012). It was found that physiotherapists mostly believed that upright lordotic spinal postures in both sitting and standing are optimal are in line with previous data suggesting that upright sitting postures are considered optimal, despite a lack of strong evidence that any specific posture is causative of spinal pain. While postural re-education may play a role in the management of spinal pain for some patients, the widespread and stereotypical beliefs regarding upright lordotic spinal posture being “optimal” posture may be based more on dominant clinical opinions than contemporary evidence.

Selection of SPs

SPs involving an increased lordotic lumbar curvature were selected by 70.5% of the physiotherapists based on visual observation, including the most lordotic posture (SP 2) in contrast to less lordotic curvatures (postures 5,6 and 7) that were selected by 28.9%. SPs involving relative lumbar kyphosis were selected by only 0.8% of respondents. In addition, SPs associated with forward head posture (1, 3 and 6) were picked only by 4.1% of physiotherapists. Overall, there appears to be a strong tendency among physiotherapists to believe that optimal SP incorporates an upright lordotic spinal alignment, with a lordotic lumbar spine, a relatively relaxed thoracic spine, and with the head retracted rather than protruded. This belief is likely to influence their clinical practice.

The selected lordotic SPs (2 and 4) are likely to be associated with higher levels of trunk muscle activation compared to SP 5 (Claus et al., 2009; O'Sullivan et al., 2006; O'Sullivan et al., 2002). Similarly, these SPs have been associated with neck pain (Richards et al., 2016) and LBP (Dankaerts et al., 2006), and have been shown to increase cervical muscle activity (Basler et al., 1997; Caneiro et al., 2010; Fountain et al., 1966). The ability to sustain lordotic SPs for a long period of time has also been questioned, because the demands may exceed the endurance capacity of the spinal muscles (Claus et al., 2009), and may be associated with greater fatigue, pain, and discomfort in both cervical and lumbar regions (Genaidy and Karwowski, 1993; Vergara and Page, 2002). However, lordotic SPs comprised the vast majority (91.8%) of the OPs selected in a previous study (O'Sullivan et al., 2012), consistent with our study. Despite a lack of evidence for clear superiority of lordotic sitting compared to other SPs, the former is consistent with published literature on the proposed benefits of lordotic sitting and was reflected in the responses of the physiotherapists (Pope et al., 2002; Pynt et al., 2001).

It has been proposed that adopting “neutral” lumbar postures (usually defined as being mid-range, and/or involving mild lordosis) to avoid potentially painful end-range positions may be beneficial by reducing passive tissue strain, (Scannell and McGill, 2003) facilitation of key postural spinal muscles (Claus et al., 2009; Falla et al., 2007; O'Sullivan et al., 2006), altering spinal symptoms (Sheeran et al., 2013), and possibly decreasing the incidence of LBP (Pillastrini et al., 2010). However, neutral posture is dependent on the available seated range of motion (O'Sullivan et al., 2010) and influenced by factors such as age (Kuo et al., 2009). Furthermore, there is no clear consensus among physiotherapists on whether a neutral posture is in fact straight or curved (O'Sullivan et al., 2012). This was evident also in the present study by the justification of the physiotherapists for their selection. A plausible explanation could be confusion between neutral StP and neutral SP, as SP has been shown to incorporate more flexion than standing (Scannell and McGill, 2003).

It is noteworthy that only 4% of SPs selected by physiotherapists involved a flexed lumbar spine or protruded head, consistent with the hypothesis that spinal flexion is considered a synonym of “poor” posture. This likely reflects long-standing beliefs that a flexed SP is associated with increased intradiscal pressure (Nachemson, 1976, 1981), increased intervertebral disc creep (Adams et al., 1996), decreased disc nutrition (McMillan et al., 1996), elevated disc degeneration (Videman et al., 1990), and increased proprioceptive deficit (Dolan and Green, 2006; Korakakis et al., 2017). Similarly, forward head posture has been associated with increased load moments, and higher cervical extensor muscle activity (Edmondston et al., 2011; Szeto et al., 2005), which has been proposed to contribute to neck pain in individuals adopting these postures (Straker et al., 2009; Yip et al., 2008). To our knowledge there is no strong scientific evidence to support that flexed postures directly cause LBP or neck pain (Roffey et al., 2010; Wai et al., 2010). The data from this study, along with a previous survey (O'Sullivan et al., 2012), suggests that these stereotypes regarding “good” and “bad” SPs are widespread among the physiotherapy community.

Selection of StPs

Two relatively similar upright StPs (postures 4 and 5) that did not incorporate thoracic flexion or forward head posture were selected as optimal by 98.2% of the physiotherapists. The selection was again based on perceived biomechanical ideals, such as alignment with the line of gravity (Kapandji, 1974; Kuchera, 1995), or “optimal” sagittal balance (Roussouly et al., 2005). In a prospective radiographic study (Roussouly et al., 2005) aiming to document normal variations in the sagittal alignment of the standing spine, spinal curves could be grouped into four broad categories of lordosis: Type 1) lordosis only at the lower lumbar segments and significant kyphosis at the TL junction and thorax; Type 2) hypolordotic lumbar and hypokyphotic thoracic region; Type 3) the inflection point is at the thoracolumbar junction and lumbar region is lordotic; and Type 4) segmental hyperextension with both lumbar and TL regions in lordosis. While the original authors described the Type 4 lordosis as reflecting a "well balanced" spine, it is debatable whether any specific spinal configuration is an optimal StP, given the variety of thoracic and lumbar curve combinations meeting the qualitatively described criteria in the literature (Booth et al., 1999; Kuntz Iv et al., 2007). While there is evidence that changing position in standing might increase comfort (Gallagher and Callaghan, 2015; Gallagher et al., 2011, 2016; Gregory and Callaghan, 2008), to our knowledge there is limited evidence from prospective studies linking any specific StP with development of spinal symptoms (Andersen et al., 2007; Nelson-Wong and Callaghan, 2014; Smith et al., 2017). Furthermore, the wide variation in postural alignment among healthy individuals suggests that to be without spinal symptoms does not always require a "well balanced" sagittal alignment (D'Amico et al., 2017; Roussouly et al., 2005). This is further supported by systematic review findings of no significant differences in lumbar lordosis or pelvic tilt in standing between people with or without LBP (Laird et al., 2014). Therefore, the concept that any SP is optimal and is protective against spinal pain requires better evidence to be accepted.

Clinical inferences and significance

The primary rationale for posture selection among physiotherapists was mostly related to beliefs associated with biomechanical domains and stereotypes for OP, such as better load distribution, a lordotic lumbar curvature, the natural shape of the spine, and what appeared most relaxed. We suggest that these beliefs are likely to influence their clinical practice and advice on postural re-education.

Interestingly, while there was variation in exactly how upright the various OPs selected were, OP almost never involved lumbar flexion or forward head posture. While we know that healthy individuals often habitually adopt flexed SPs (Edmondston et al., 2007; Korakakis et al., 2014, 2017), the belief that upright lordotic sitting is best appears to be common among both clinicians and members of the community (O'Sullivan et al., 2013a). Therefore, it is important for clinicians to understand that patients may hold strong posture beliefs that influence their behaviors, whether these are evidence-based or not (O'Sullivan et al., 2018). In contrast, there may be no one optimal posture, but rather any position - lordotic or kyphotic - maintained for a period of time without interruption may lead to discomfort and pain (Sorensen et al., 2015; Womersley and May, 2006).

Limitations and future research

We acknowledge that postures were considered only during static sitting and standing, restricted to a sagittal-plane view, while several alternative spinal configurations could be used as options. Furthermore, different postures could likely have been selected for a male or an elderly individual. The variation in posture selection in the present study must be interpreted with caution considering the small angular difference between some postures, and the potential for subcutaneous tissue and variation in marker surface application to contribute to an unknown measurement error. Future studies incorporating multiple choices not only for optimal posture, but also for what is considered the most suboptimal posture, could be helpful. Another future research direction could be for clinical trials evaluating whether technology such as wearable devices to provide postural feedback can influence LBP development or persistence in people with or without pain.

Conflicts of interest and source of funding

None declared.

Ethics approval

The study was approved by the University of Thessaly Research Ethics Committee.

Appendix 1

Table
Percentage of participants who selected each sitting and standing posture as the optimal posture based on their working environment.

Postures		Private practice (n = 164)	Hospital (n = 65)	Staff private practice (n = 79)	Home care (n = 92)	Unemployed (n = 128)	Overall (n = 528)
Sitting	1	0	1.5	1.3	0	0.8	0.6
	2	44.5	36.9	48.1	40.2	34.4	40.9
	3	2.5	4.7	1.3	2.2	2.3	2.5
	4	26.8	26.1	20.2	30.4	28.9	26.9
	5	25.0	30.8	27.8	27.2	30.5	27.8
	6	1.2	0	1.3	0	2.3	1.1
	7	0	0	0	0	0.8	0.2
Standing	1	1.8	1.5	0	0	0.8	0.9
	2	0	0	2.5	1.1	0	0.6
	3	0	0	0	2.2	0	0.4
	4	35.4	44.6	43.1	44.5	43.7	41.3
	5	62.8	53.9	54.4	52.2	55.5	56.8

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