CLINICAL GUIDELINE FOR STANDING ADULTS FOLLOWING SPINAL CORD INJURY

2019

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United Kingdom and Ireland

Spinal Cord Injury Therapy Leads

MASCIP

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Development of Clinical Guideline for Standing Adults following Spinal Cord Injury

1. Introduction

The Guideline for Standing Adults following Spinal Cord Injury (GSASCI) was developed by the Spinal Cord Injury Centre Physiotherapy Lead Clinicians (SCIPL). Physiotherapists have a duty to base their practice on the best available evidence (Chartered Society of Physiotherapy [CSP] 2002). The guideline draws on available evidence and expert opinion with the purpose of providing a plain, practical and justified recommendation for standing following Spinal Cord Injury (SCI).

The GSASCI covers the practice of standing patients as part of rehabilitation and as part of a maintenance programme following discharge from the acute setting. This guideline addresses the clinical question:

► **What is the best practice in standing adults with spinal cord injury?**

2. Target Users

The information is aimed primarily at therapists but it is anticipated that it will also be used by patients, SCI clinicians, general practitioners, and those developing and financing care packages for SCI persons re-entering the community.

3. Aims

3.1 To facilitate best practice in physiotherapists' clinical reasoning when standing patients with SCI.

3.2 To standardise physiotherapists' management of standing adults following SCI.

3.3 To provide the best available information to enhance patient self-care.

4. Objectives

4.1 To identify and critically appraise the available evidence relating to standing in adults with SCI.

4.2 To make recommendations for practise of standing adults following SCI derived from available evidence and consensus expert opinion.

4.3 To provide guidance in the use of clinical judgement with regard to benefits and precautions of standing adults following SCI.

4.4 To highlight areas where further research is required.

5. Scope of the Guideline

This guideline is intended to apply to standing adults with SCI. It may be utilised to inform all stages of care from onset of the condition in the acute rehabilitation phase to long term community maintenance programmes following discharge.

It does not apply to children with SCI who derive additional benefits from standing and require different advice regarding standing prescription with respect to time and frequency.

6. Development Strategy

6. 1 The Guideline Development Group (GDG)

The guideline was developed by the Spinal Cord Injury Centre Physiotherapy Lead Clinicians for the UK and Ireland.

None had a conflict of interest.

6.2 Review

The guideline has undergone a quality assurance process, comprising of a national review involving peers and medical colleagues within the SCI centres.

Reviewers were briefed to critically comment on:

- ► The overall development strategy
- ► The validity of the recommendations
- ► The clinical relevance of the guideline
- ► The format, layout and presentation of the information.

Service user views were also obtained regarding the acceptability of the recommendation from their personal perspectives.

6.3 Funding

The GDG group members were released by their respective employers for their biennial meetings, in which time was set aside for the production and updating of the guideline. Funding was provided by the United Kingdom Spinal Cord Injury Research Network (UKSCIRN) to assist in the cost of the literature search.

In 2011 funding was provided by the Duke of Cornwall Spinal Treatment Centre to enable the guidelines to be updated.

This funding had no influence on the final recommendations.

No funding was sought for the 2019 update.

7. Searching for the Evidence

7.1 Literature Search Strategy for 2008 Guideline

The literature search strategy used the following computerised databases within their available dates:

- BNI (British Nursing Index) 1994 - October 2005,
- CINHAL (Cumulated Index to Nursing and Allied Health Literature) 1982 -September 2005,
- Embase, Rehab. And Physical Med. 1994 - September 2005,
- Medline 1951 - October 2005 (known also as PubMed),
- AMED (Allied and Complimentary Medicine) 1985 - October 2005,
- Cochrane part 4 2004,
- Pedro (Physiotherapy Evidence Database) 1929-2005

Web Resources including:

The meta Register of Controlled Trials (www.controlled-trials.com), www.nelh.nhs.uk, www.guideline.gov, www.nice.org.uk, www.lifecenter.ric.org, www.mscisdisseminationcenter.org, www.ncpad.org, www.nrr.nhs.uk/search.htm

An additional hand search was focused on:

- Index to Theses of Great Britain and Ireland
- Grey literature including conference notes and unpublished work (Booth 1998)
- Reference lists

Informal enquiry was also made through standing and wheelchair standing equipment manufacturer/suppliers Theo Davies and Sons and Gerald Simonds Healthcare Ltd.
Search terms used were (Spinal Cord Injuries OR Paraplegia OR Quadriplegia) AND (standing OR stand OR weight-bearing).

7.2 Literature Search Strategy for 2011 Guideline Update

The literature search strategy used all of the above computerised databases, searching between 1 Jan 2005 and 1 December 2011.
Additional hand search of reference lists was completed.
Search terms used were: Spinal cord injuries, quadriplegia, paralysis, standing, tilt table, standing frame and weight bearing.
The original literature search was conducted by a librarian, with short listing completed by clinical staff. Confidence in this process was achieved through cross referencing with other systematic reviews and hand searching of references.

7.3 Literature Search Strategy for 2019 Guideline Update

The literature search strategy used all of the above computerised databases, searching between 1 December 2011 and 31 May 2018.
Additional hand search of reference lists was completed.
Search terms used were: Spinal cord injuries, quadriplegia, paralysis, standing, tilt table, standing frame and weight bearing. Thesaurus and free text searching would have encompassed the terms tetraplegia and paraplegia and related words.
The original literature search was conducted by a librarian, with short listing completed by a clinical staff member. Confidence in this process was achieved through cross referencing with other systematic reviews and hand searching of references.

7.4 Inclusion Criteria

► The articles included had to be relevant to the purpose of the review, particularly relating to standing passively via orthoses, tilt-table, standing frame or standing wheelchair

► The studies had to be relevant to the question or transferable to the SCI group
► Papers relating to adults with SCI

7.5 Exclusion Criteria

► Papers relating to standing using Functional Electrical Stimulation (FES), robotic or exoskeleton assisted standing devices, specifically or solely, were excluded. Evidence for such treatments is available but at present these are not readily accessible to all SCI patients on a regular basis, therefore not included in this review. These areas could be expanded upon in future searches. (Papers that included data that relates to passive standing amongst FES have been reviewed).
► Papers describing animal research.

7.6 Results of the Search

For the 2008 guideline, 347 papers were identified from combining all the searches from above. Further careful screening of the abstracts using the inclusion/exclusion criteria reduced the amount to 24 papers of primary research, where the research is reported first hand, and 2 of secondary or integrative research which presented as review articles.
For the 2011 guideline review, 91 papers were identified from combining all searches. Further screening of abstracts, and full article where necessary, reduced the amount to 12 papers of primary research and 3 systematic reviews.
For the 2019 guideline review, 137 papers were identified from combining all searches. Further screening of abstracts, and full article where necessary, reduced the amount to 3 papers of primary research. Two literature reviews (Karimi 2011 and Dolbow *et al.* 2011) and 3 systematic reviews (Newman and Barker 2012, Paleg and Livingstone 2015, and Soleyman-Jahi *et al.* 2018) which include discussions on standing following spinal cord injury are included in the reference list.

7.7 Grading the Evidence

In order to weigh up the relative importance or weight of the evidence supplied within the literature, the School of Health and Related Research at Sheffield University (ScHARR 2005) hierarchy of evidence was used (see Appendix 1). This ranking passes from the highest level at systematic reviews and meta-analysis through to anecdotal evidence, and is noted in the data extraction framework (Appendix 3).

The recommendations have then been graded using the National Institute for Clinical Excellence format [NICE] (2001) (see Appendix 2).

7.8 Method of Formulating Recommendation

The evidence was considered, discussed and consensus between the GDG arrived at by an informal method of voting; making the best use of available information and collective wisdom. Content of 2011 updated guideline was agreed unanimously at the meeting of the GDG in April 2013. Content of the 2019 guideline was agreed at the meeting of the SCIPL GDG in October 2019.

8. Dissemination

The GDG recommends that copies of the guideline be distributed to:

- SCI centre lead physiotherapists
- The CSP website
- Multidisciplinary Association for Spinal Cord Injury Professionals (MASCIP)
- British Association Spinal Cord Injury Specialists (BASCIS)
- Association of the Chartered Physiotherapist in Neurology (ACPIN)
- Spinal Cord Injury Clinical Reference Group
- International Spinal Cord Injury Physiotherapy Network

9. Implementation

The GDG has presented a recommendation based on appraisal of the available evidence, to support consistent practice in standing adults following SCI. However, like all interpretations of evidence, it is necessarily subjective. It is not the intention to impose recommendations on colleagues or to compromise their individual autonomy as consumers of research. Nor is the guideline intended to present an alternative to individual assessment of persons with SCI, reflective practice or an obstacle to innovative practice.

10. Revision

The guideline was revised by the GDG in 2019. The guideline will be further revised should it be felt that substantial developments have occurred.

11. Outcome Measures

These are stated within the guideline.

12. Health Benefits, Side Effects and Risks

These are stated within the guideline.

13. Financial Implications

Consideration needs to be given to the cost implications when implementing this guideline. These include:

13.1 Human resource required to implement standing, both in acute/rehabilitation settings and in the community.

13.2 Equipment requirements, particularly post discharge from SCI centres if patients plan to continue standing as part of a home maintenance programme.

13.3 Equipment maintenance and servicing requirements in all settings.

13.4 Training staff with regard to use of equipment, including awareness of manual handling issues and any individual requirements of the patients using the equipment.

Clinical Guideline for Standing Adults following Spinal Cord Injury

Spinal Cord Injury (SCI) is a long term condition - it is therefore important that patients, professionals and caregivers recognise their key role in SCI management. 'Standing' is offered to the patient as one mode of facilitating SCI management following discharge and is introduced to them in their acute admission to hospital. It is commonly the responsibility of the physiotherapist to initiate a standing programme with the patient and advise them of the potential benefits of standing, the barriers to standing and the most appropriate equipment to facilitate the process. Equipment is necessary to compensate for the loss of muscle control experienced following SCI. Support from an external structure to splint the lower limbs and trunk is needed to enable patients to adopt the upright posture of standing against gravity. This support can be in the form of a standing frame or tilt-table which remains in one place or a wheelchair that can raise the patient into the vertical posture.

14. Benefits

14.1. Soft Tissue Effects

A reduction in muscle tone and an increase in range of movement or muscle length have been demonstrated (Adams and Hicks 2011, Ben *et al* 2005, Bohannon and Larkin 1985; Bohannon 1993; Deshpande *et al.* 2004; Dunn *et al*. 1998; Hendrie 2005; Kawashima *et al.* 2003; Odĕen and Knutsson, 1981; Shields and Dudley-Javorski 2005)

ScHARR ranking of evidence from 2-6

14.2 Bladder and Bowel Effects

Improved efficiency and regularity of the bowel function have been observed. Subjectively people reported standing improved bowel function (Kwok *et al.* 2015). Subjectively people reported benefits for their bladder (Dunn *et al.* 1998; Eng *et al.* 2001; Hoenig *et al*. 2001; Shields and Dudley-Javorski 2005; Walicka-Cuprys et al 2007; Walter *et al*.1999).

ScHARR ranking of evidence from 2-6

14.3 Quality of Life Effects

An improved sense of well-being and quality of life related to standing and a general sense of improved fitness and connection to the world have been reported (Dunn *et al*.1998; Eng *et al*. 2001; Faghri *et al*. 2001; Hawran *et al*. 1996; Hendrie 2005; Jacobs *et al*. 2003; Kunkel *et al*. 1993; Nordström *et al*. 2013; Nordström *et al*. 2014; Sergeeva *et al*. 1978; Walter *et al.* 1999). In addition, improvements in sleep and increased ability to take care of oneself have been reported (Walicka-Cuprys *et al.* 2007).

ScHARR ranking of evidence from 3-6

14.4 Bone Health Effects

A significant reduction in bone demineralisation was demonstrated when high frequency standing was started in the early stages of SCI and maintained (Alekna *et al.* 2008). Other studies demonstrated reduced bone demineralisation and/or calcium excretion with standing (Ben *et al.* 2005; De Bruin *et al.* 1999; Dionyssiotis *et al.* 2011; Gormaere *et al.* 1994; Kaplan *et al.* 1981).

ScHARR ranking of evidence from 2-6

14.5 Exercise Effects

Standing as a treatment adjunct:

Patients who present with incomplete spinal cord lesions show additional benefits of standing associated with development of postural control, strengthening of antigravity muscles, improved balance reactions, maintenance of functional ranges of movement and skill acquisition in components of gait.

Physiotherapists working with patients with complete spinal cord lesions use standing as an exercise to improve balance performance and strengthen trunk musculature as part of the rehabilitation programme.

ScHARR ranking of evidence 7

14.6 Other Effects

Improvements in cardiovascular function, respiratory function and skin condition have been reported (Cotie *et al.* 2011; Eng *et al.* 2001; Walicka-Cuprys *et al.* 2007).

ScHARR ranking of evidence 5

15. Precautions

There are areas of potential harm if a risk assessment is not performed and precautions are not taken:

15.1 Bone Demineralisation

Many studies highlighted the diminishing bone density following SCI (Alekna *et al.* 2008; Ben *et al.* 2005; Dauty *et al.* 2000; De Bruin *et al.*1999; Eser *et al.* 2003; Frey-Rindova 2000; Giangregorio 2002; Goemaere *et al.* 1994; Goktepe *et al.* 2008; Kaplan *et al.* 1981; Jones *et al.* 2002; Kunkel *et al.* 1993; Lazo *et al.* 2001; Vlychou *et al.* 2003; Wood *et al.* 2001) and suggest the risk of lower limb fracture is increased due to osteoporosis. The onset of bone demineralisation is immediate post injury but Alekna *et al.* (2008), Dauty et *al.* (2000) and De Bruin (1999) suggest that early weight–bearing can retard the process.

15.2 Cardiovascular Considerations

Orthostatic collapse and symptoms of low blood pressure including headaches, dizziness and fatigue can be related to standing. (Dunn *et al.*1998; Faghri *et al.* 2001; Liu 2008; Sergeeva *et al.* 1978; Walicka-Cuprys *et al.* 2007). In practice experience has demonstrated that patients can decrease these symptoms with repetition (Sergeeva *et al.* 1978) and initially by wearing an abdominal binder and support stockings (El Masry 1997), although some patients limit or avoid standing due to presyncope symptoms (Chelvarajah 2009). A single case study detailed symptoms of autonomic dysreflexia related to standing (Ogata *et al.* 2012).

15.3 Pain

Low back pain is reported in two studies (Kunkel *et al.* 1993; Eng *et al.* 2001). In practice, experience suggests this can be related to people standing with tight hip flexor muscles. Increased pain was also reported in a small percentage of patients in the study by Walicka-Cuprys *et al.* (2007).

15.4 Soft Tissues Considerations

Increased muscle spasm and spasticity have been reported (Walicka-Cuprys *et a*l. 2007 and Ogata *et al.* 2012). Autonomic dysreflexia symptoms were reported in the single case study by Ogata *et al.* 2010, relating the symptoms to muscle spasms associated with standing. Reduced skin integrity and the relationship to weight bearing surfaces during standing requires individual assessment.

<u>16. Risk Assessment</u>

- It is essential to risk assess each individual with respect to potential problems and particular areas of precaution in order to address standing in an appropriate manner with appropriate observations.
- Manual Handling of Loads risk assessment as part of standing process and equipment selection is essential.

<u>17. Recommendations</u>

17.1 Assessment

Standing following spinal cord injury has various potential benefits as previously discussed. These are broadly dependent on; patient presentation (including the risk of the development of complications), time since injury, and patient preferences. The benefits should be considered in balance with the potential risks to that individual and/or the staff supporting the standing practise. This assessment should include the ability to achieve normal body alignment in standing and identification of suitable equipment required to achieve this. It should also include the risk that the patient will be non-compliant with a standing programme.

Recommendation:

All patients with SCI should be individually assessed for the potential benefits of standing.

Grading of recommendation (NICE 2001) C

17.2 Goal Setting and Outcome Measurement

Outcomes in the literature include measurement of bone mineral density (BMD), joint range of movement, spasticity, quality of life (QOL), bowel frequency and duration of bowel regime, complications, cardiovascular parameters, respiratory function and skin condition. This list should be used as a guide and does not exclude other relevant outcome measures identified as being appropriate for individuals.

Recommendation:

Specific goals should be identified for the individual based on the initial assessment and on-going evaluation. Suitable outcome measures should be used.

Grading of recommendation (NICE 2001) C

17.3 Commencement

Successful outcomes for reducing bone demineralisation are related to early commencement of standing following initial SCI (Alekna *et al.* 2008; *Ben et al.* 2005; De Bruin *et al.* 1999 and Dauty *et al.* 2000). Standing may be considered as part of a prophylactic management programme in order to prevent the development of secondary complications such as contractures.

Recommendation:

Individuals should be assessed for standing as soon as physiologically stable and it is practically possible following SCI.

Grading of recommendation (NICE 2001) A

17.4 Frequency

Range within the literature varies between once to seven times a week (Adams and Hicks 2011; Alekna *et al.* 2008; Ben *et al.* 2005; Bohannon 1993; Dauty *et al.* 2000; De Bruin *et al.* 1999; Dunn *et al.* 1998; Eng *et al.*2001; Eser *et al* 2003; Goemaere 1994; Hendrie 2005; Hoenig *et al*. 2001; Kaplan *et al.* 1981; Kunkel *et al.* 1993; Shields and Dudley-Javorski 2005; Walter *et al.* 1999).

Studies related to positive outcomes in BMD, soft tissue length, spasticity and bowel frequency used high frequency standing of 3 or more times a week (Adams and Hicks 2011; Alekna *et al.* 2008; Ben *et al.* 2005; Bohannon 1993, De Bruin *et al.* 1999; Frey-Rindova 2000, Goemaere *et al.* 1994; Hoenig *et al.* 2001; Kaplan *et al.* 1981)

Recommendation:

Standing should take place three or more times a week.

Grading of recommendation (NICE 2001) A

17.5 Duration

Range within the literature varies between ten to sixty minutes, with the majority of studies intervening with 30-60 minute standing times (Adams and Hicks 2011; Alekna *et al.* 2008; Ben *et al.* 2005; Bohannon and Larkin 1985; Bohannon 1993; Dauty *et al.* 2000; De Bruin 1999; Dunn *et al.* 1998; Eng *et al.* 2001; Faghri *et al.* 2001; Frey-Rindova 2000; Goemaere 1994; Hendrie 2005; Hoeing *et al.* 2001; Jacob *et al.* 2003; Kaplan *et al.* 1981; Kunkel *et al.* 1993; Odéen and Knutsson 1981; Ragnarson *et al.* 1981; Sergeeva *et al.* 1978; Shields and Dudley-Javorski 2005; Walter *et al.* 1999).

Recommendation:

Standing should take place for thirty to sixty minutes each time.

Grading of recommendation (NICE 2001) A

18. Further Research

There is limited high quality evidence available to draw firm conclusions about the benefits of standing for individuals with SCI. In most studies small sample sizes and poor or variable methodology exist such that it is difficult to compare results. There are contradictory outcomes between studies, however, on closer scrutiny the studies are not comparable due to the

sample population characteristics or methodology. The spinal cord injured population is small, and as a result it is difficult to conduct large scale robust research.
Future studies should include both short and long term follow up, should consider the timing of the intervention post SCI (particularly in relation to the process of bone demineralisation), the clinical relevance of outcome measurements (e.g. sites of BMD measurement in relation to fracture risk), and identify adequate sample sizes. Furthermore, long term studies are likely to be necessary to demonstrate small changes over time, which are potentially significant for the SCI population. This group of individuals experience insidious changes associated with living with a long term condition.

19. Conclusion

The GDG met the aims and objectives and agreed on the recommendations in this clinical guideline, based on available evidence and expert consensus opinion.
Experts in the field recognise the importance of standing for some adults following spinal cord injury.
The responsibility of the clinician is to identify the patients who will benefit from the introduction and maintenance of standing.
Demonstration of benefits enables all parties involved with short and long term treatment planning, the patient included, to make informed decisions about providing opportunities for, and participation in, standing following spinal cord injury.

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Appendix 1

The ScHARR Hierarchy

Rank:	Methodology
1	Systematic reviews and meta-analyses
2	Randomised controlled trials
3	Cohort studies
4	Case-control studies
5	Cross sectional surveys
6	Case reports
7	Expert opinion
8	Anecdotal

Adapted from the School of Health and Related Research, Sheffield University (2005)

Appendix 2

Grading of Recommendations (after NICE 2001)

Grade	Evidence
A	At least one randomised control trial as part of a body of literature of overall good quality and consistency addressing the specific recommendation.
B	Well conducted clinical studies but no randomised clinical trials on the topic of the recommendation.
C	Expert committee reports or opinions and/or clinical experience of respected authorities. This grading indicates that directly applicable studies of quality are absent.

Appendix 3

Data Extraction Framework

Author	Aim	Sample and population size	Method	Results and Discussion	SCHARR Level of evidence	Rigour
Adams and Hicks (2011)	To compare the effects of Body Weight Support Treadmill Training (BWSTT) and Tilt Table Standing (TTS) on spasticity, motor neurone excitability and related constructs.	7 male and female subjects with chronic SCI > 1 year post injury. Para and tetra American Spinal Injury Association Impairment Scale (ASIA) A-C. "Stable" spasticity, consistent medication and physical routine, wheelchair dependent.	Pilot study. Random cross over design. Subjects served as own controls. Subjects performed 12 sessions of BWSTT over 4 weeks and 12 sessions of TTS (**20-30 minutes 3 x week**), with 4 week detraining period between two conditions. Tests related to spasticity, clinically and self-reports.	No change in self-reports of spasticity. After 12 sessions TTS showed reduction in extensor spasms (Effect size = 0.95). Unable to detect change in soleus motor neurone excitability.	2	Small patient group. Attempts to control for other factors known to affect spasticity.
Alekna *et al.* (2008)	To assess bone loss in persons with SCI and its dependence on weight-bearing activity (passive standing) during the first 2 years post injury.	54 patients with traumatic SCI, ASIA A and B, male and female.	Longitudinal, 2 groups – one not standing and one standing for minimum of **1 hour not less than 5 days per week.** Subjects matched for age, gender, height and weight. BMD measured at 6-16 weeks, 1 year and 2 years post injury. Standing intervention started as early as possible - within 4 months post injury.	After 2 years patients in standing group had statistically significantly higher BMD in the legs and pelvis. >1.0g/cm2.	3	Participants self-reported their standing practise. Participants not randomised. Intervention started as early as possible post SCI. Measurements over significant period of 2 years.

Author	Aim	Sample and population size	Method	Results and Discussion	SCHARR Level of evidence	Rigour
Ben *et al.* (2005)	Determine the effect of large stretch torques applied regularly over a 12 week period, on ankle range of movement and bone mineral density.	20 subjects who had sustained spinal cord injury within the last 12 months, 8 paraplegics, 12 tetraplegics, with lower limb motor score less than 2/5.	RCT-assessor blinded, within subject design, using leg contralateral to intervention as control. Right or left legs randomly assigned to control group. Initial measurement of ankle range using standardised torque and BMD using DEXA. Subjects stood for **30 minutes 3 x week** for 12 weeks on tilt table except one who used standing frame. Experimental foot stood on wedge inclined to 15 degrees, with nothing placed under control foot. Ankle mobility tested within 1 day of completion of standing period, BMD tested within 2 days of completion of standing period.	There was an overall mean beneficial effect of 4 degrees on ankle mobility with regular standing. The control leg lost mean of 6.6% BMD, the experimental leg lost a mean of 6% BMD. It is unclear whether such a small treatment effect is clinically worthwhile.	2	Sample size calculation performed and appropriate sample selection. Some variation in standing method between subjects. Not documented within article that device used to measure ankle range had been validated, although device was referenced. Repeatability – unclear as to what “pre-stretch” consisted of prior to ankle range assessment, however both groups underwent same procedure.

Author	Aim	Sample and population size	Method	Results and Discussion	SCHARR Level of evidence	Rigour
Bohannon and Larkin (1985)	To review the use of a wedge to produce passive dorsiflexion on tilt table standing.	20 consecutive patients with neurological conditions and limited ankle dorsiflexion contributing to difficulty standing and walking. 1 transverse myelitis, 1 Guillain-Barrie Syndrome, 3 brain injuries, 1 hypoxia, 14 Cerebrovascular Accidents. (USA)	Each patient's treatment was tailored to the individual. Only procedure to increase range in Gastrocnemius was standing on the tilt table with a wedge of 70º under feet for **30 minutes.** Total number of treatments and number per week were determined by need and appointment times, ranged from **2.3 to 6.4 /week**.	Treatment numbers ranged from 5 to 22. All patients demonstrated an increase in ankle dorsiflexion, range from 3 – 17º.	3	No spinal cord injury patient in study but it is feasible that the central nervous system lesions would have problems comparable to incomplete spinal cord injury. Poor information available re the additional interventions. No control available or structure to the treatment. Measured by a consistent person No statistical analysis
Bohannon (1993)	To determine the effect of tilt table standing on spasticity and spasm.	Single case study. 28 year old man with T12 paraplegia of 3 years. (USA)	Stood on tilt table, **for 30 minutes**, up to 80˚, **5 non-consecutive days over 2 week period.** Spasticity measured by observation of lower limb behaviour during transfer, resistance to passive movement and the Pendulum Test (timed reflex response of knee extensors when foot dropped – performed on a Cybex dynamometer).	Resistance to passive movement reduced from 3 to 2 Modified Ashworth Scale and Pendulum Test 10 to 6 seconds post stand. Carry over extended until the next day. Demonstrated that tilt table standing can have a favourable effect on involuntary muscle activity.	6	These changes were only demonstrated on one patient. The methodology is unclear, with approximations of timing this would make it difficult to reproduce the study. No significance calculated.
Chelvarajah (2009)	Quantify proportion of SCI patients who are limited or fear using standing apparatus because of orthostatic hypotension (OH)	293 SCI patients responded to article on SIA website and magazine.	Single page questionnaire.	152 respondents use or had used standing apparatus, 141 had not. Of the former, 59 reported OH symptoms had limited standing apparatus use (20% total). 16 of the non-users didn't stand for fear of symptoms (5.5%). Concluded that symptoms or fear of symptoms of OH limited standing apparatus use.	5	Questionnaire validated with appropriate statistics and displayed reliability. Construct validity shown. Limitations highlighted; self-selected, non-random subjects and possible bias in selection relating to suggested OH symptoms.

Author	Aim	Sample and population size	Method	Results and Discussion	SCHARR Level of evidence	Rigour
Cotie *et al*. (2011)	Determine effects of short term and long term body-weight supported treadmill (BWST) and tilt-table standing (TTS) training on skin temperature and resting blood flow in chronic SCI	7 subjects >1 year post SCI, wheelchair dependent, para and tetraplegic, ASIA A-C.	Random cross over design. Subjects served as own controls. Subjects performed 12 sessions of BWSTT over 4 weeks and 12 sessions of TTS (**20-30 minutes 3 x week**), with 4 week detraining period between two conditions. Measurements of skin temp and lower limb blood flow taken before and after first and last sessions.	Results showed resting skin temp decreased with BWST training in 4 sites compared to pre training and only 1 site in TTS training.	2	Unclear method. Small sample size. Study limited in that site of measurements of skin temp unrelated to key pressure areas. Clinical significance is therefore limited. Pressure sore development was not an outcome measure.
Dauty *et al*. (2000)	First aim to evaluate precisely the sub and supralesional bone mineral density (BMD) in SCI patients injured more than I year and secondly to correlate sublesional demineralisation to daily standing and the use of long leg braces.	Population Caucasian, male aged between 18 and 60 years, I year post injury. Sample 31 SCI patients and 31 age matched controls from hospital worker population with sedentary lifestyles. 8 patients already had a fragility fracture. France.	BMD measured by Dual-photon absorptiometry (DPX). Blood and urine samples taken for analysis. Correlation between bone mineral content (BMC) and functional parameters established by simple linear regression. 45-60 minutes/day	Bone demineralisation in sublesional area is 41% of controls. Femoral neck 30% and trochanter 39%. None in supralesional area. Paraplegics have a 6% increase BMC in the humerus. Demonstrated no significant correlation between use of long leg callipers (6 patients) and passive verticalization patients. The BMC of the trochanteric area was significantly related to the duration of the initial bed rest period (p=0.009)	4	The method was clear and should be reproducible. Keeping the population male removes complication from hormonal osteoporotic issues. This however means that it does not represent the full SCI population. There appears to be a high number of fractures within the group already existing.

Author	Aim	Sample and population size	Method	Results and Discussion	SCHARR Level of evidence	Rigour
De Bruin *et al*. (1999)	To evaluate the effectiveness of an early loading intervention program in paraplegia on attenuating BMD loss and simultaneously measuring bone material composition and strength of bone (tibia).	19 SCI subjects chosen over 18 month period, all male. Last 6 were only followed up for 5 weeks. All receive 2g Cortisol as routine. Because of the heterogeneity of the population involved part of the data analysis performed by controlled, single -case, experimental, multiple baseline design study.	If selected for standing/walking program subjects started training as soon as possible after injury and performed 1/2 hour walking (average 40% weight bearing) and 1/2 hour standing 5 days /week for 6 months. Subjects performing standing only started as soon as possible 1 hour /day for 5 days /week. Random selection to each group. Bone density and bending stiffness of tibia measured.	In patients with early mobilisation the trabecular bone demonstrated none or moderate loss and was not dependent on the type of exercise performed. Trabecular bone revealed a significant difference between immobilised subjects and subjects performing early exercise programs. Early intervention exercise training reduced the rate of bone loss compared to immobilised patients, no differences between the mobile and the static.	3	Changes in the bone rigidity - it is unclear whether they are related to bone content or geometric properties. All male subjects reduce risk of complication of hormonal osteoporotic issues but does represent full SCI population. Randomisation for selection not described, an area for potential bias. Convenience sample Follow up poor
Deshpande *et al*. (2004)	To establish the reliability of the soleus H-reflex elicited in the seated position, before and after a standard standing protocol.	10 healthy subjects with no orthopaedic or neuromuscular problems. USA.	H-reflex recruitment curves were obtained for each subject in the sitting posture before and after 3 bouts of standing passively (knees 30º flexion) against a strap then straightening up actively into full extension.	H- reflex measurements are highly reproducible following such a standing protocol. This minimally influences the H-reflex and can be concluded that there is influence on the motor neurone pool.	6	A clear effort at validating a commonly used tool. Achieved their aim. Sample size is not representative of population.
Dionyssiotis *et al.* (2011)	To evaluate the influence of positive and negative factors on bone loss in men with SCI.	61 males, 31 paraplegics ASIA A >1.5 years post SCI with control group of 30 volunteers. Matched for age weight and height.	All subjects examined by peripheral quantitative computed tomography in distal epiphyses and mid shaft of tibia. Results compared with anthropometric data and clinical information. Positive factors included spasticity and use of standing frames and callipers, and negative factors included neurological injury and duration of paralysis.	Paraplegics who used regular standing frames or long brace orthoses for standing /therapeutic walking had statistically significant higher trabecular BMD ($p=0.03$), and cortical thickness.	4	No detail available regarding parameters of standing/orthoses use.

Author	Aim	Sample and population size	Method	Results and Discussion	SCHARR Level of evidence	Rigour
Dunn *et al*. (1998)	To investigate the use of standing devices by SCI subjects.	Individuals were chosen who had returned their warranty card to 2 manufacturers. 32% response rate (99/310) USA.	Questionnaire sent with covering letter. 42 questions relating to demography, amount and effects of standing, 2 open-ended with regard to additional benefits and problems encountered. Questionnaire not available to view.	40% had between 1-5 years' experience with the device, 84% were currently using the device, 41% 1-6 x/week, 2/3 stood between 30-60 minutes each time, 21% able to empty bladder more completely + reduction in bladder infections, 23% favourable responses also relating to bowel regularity, leg spasticity(43%), significant correlation to time spent standing (p=0.005), and reduction in bed sores. Less than 10% reported side effects such as nausea and head aches 79% highly recommended standing devices to others with SCI. Numerous positive statements.	5	The 2 types of equipment are different -one being a static, passive standing frame, the other a wheelchair that can also stand the occupant- there is no separation of results to establish if either are preferred. The respondents are potentially biased because these were motivated to use a standing device in the first place, probably self-purchased - the authors acknowledge this. The non-responders could include users who have had problems.

Author	Aim	Sample and population size	Method	Results and Discussion	SCHARR Level of evidence	Rigour
Eng *et al.* (2001)	To 1) document the extent to which prolonged standing is undertaken, 2) compare characteristics of people who engage in prolonged standing with those who do not, 3) summarise methods, frequency and duration, 4) summarise perceived benefits and negative effects of prolonged standing.	Population members of the British Columbia Paraplegic Association, all with SCI (463). 152 respondents 26 of which had only minimal effects were fully ambulatory, leaving 126 who had the potential to benefit from prolonged standing.. British Columbia, Canada.	Cross-sectional Survey, subjects with high lesions (i.e. C1-C2)were excluded because of respiratory problems would limit standing time. Fill-in-the-blank and closed ended questions were used. Definitions were provided to establish common understanding and to enable grouping of the respondents. Questionnaire not available to view.	38/126 (30%) reported they engaged in prolonged standing as a method to improve or maintain their health (**40 minutes, 4x/week)**. Significantly more with paraplegia stood than tetraplegia and engaged in physical activity regularly. 17 use combination of walker/callipers, 20 use a standing frame. 52% report positive effect on bladder and bowel, 44% report improved digestion, 74% report improved circulation and 425 reduced swelling in legs. Those who did not stand 29 (1/3) said it was too expensive, 23 (1/4) were unaware of devices to help standing or there were time constraints.	5	The results might be biased because distributed through an organisation that by being a member of would demonstrate an interest in their condition. Also the sharing of positive responses is more likely to be done than those of negative experiences. Author acknowledges this. Study highlights and discusses samples size as a limitation. Reports perceived effects. Piloted.
Eser *et al.* (2003)	To investigate the effect of functional electrical stimulation (FES) on bone loss after SCI .	38 para and tetraplegics, male and female.	Longitudinal study. Controls matched for sex age and level of injury. Two groups; experimental group 30 minutes of FES cycling 3 times a week, **control passive standing 30 minutes 3 times a week.** Intervention with FES started once patients up for “some portion of day” (between 4 weeks to 3 months). First BMD at 4.5 weeks post injury (mean), second BMD at 26-28 weeks post injury.	Both groups showed reduction of BMD of 0-10% within first 3-10 months post injury. No statistical difference between groups.	3	Lack of detail in methodology, particularly control group, including when standing commenced. No detail regarding compliance in control group. Patients self-allocated to intervention or control group potentially introducing bias.

Author	Aim	Sample and population size	Method	Results and Discussion	SCHARR Level of evidence	Rigour
Faghri *et al.* (2001)	To evaluate the effects of FES of lower limbs during 30 minutes of standing on central and peripheral hemodynamic response in persons with SCI.	A convenience sample of 34 from 2 regional acute rehabilitation hospital out patient departments. 14 subjects with SCI (7 tetraplegic, 7 paraplegic) completed the study. USA	Used a repeated-measure design study. Subjects were used as their own control and underwent 2 testing protocols of FES augmented standing and non-FES (passive) standing for 30 minutes. Measurements taken were: central hemodynamic responses of stroke volume, cardiac output, heart rate, arterial blood pressure, total peripheral resistance (TPR), and rate pressure product (RPP). All measures were performed during supine and sitting positions before and after standing and during 30 minutes of upright standing.	Paraplegics showed a significant increase (by 18.2%, p=. 015) in heart rate after 30 minutes of FES standing compared to tetraplegics . During 30 minutes of passive standing it increased by 6% (p=.041). TPR in tetraplegics significantly (p=.003) increased by 54% compared with paraplegics during passive standing and significantly lower systolic blood pressure (p=.013) and arterial pressure (p=.048) than paraplegics during passive standing. These differences were not detected during active standing. Demonstrating proof of the expected circulatory hypokinesis and orthostatic hypotension that exists when standing passively. Experienced more by the tetraplegic group than the paraplegic group.	4	The methodology, inclusion /exclusion criteria were very clearly described. The measurements and equipment used also received detailed description. Statistically the differences were significant but these were only a small subject group. Strengthened results in this instance by being own controls. The different types of standing were at least 24 hours apart so although both methods were tried on each subject there should have been no carry over between to interfere with the results

Author	Aim	Sample and population size	Method	Results and Discussion	SCHARR Level of evidence	Rigour
Frey-Rindova (2000)	To evaluate the trabecular and cortical BMD development for upper and lower extremities in subjects with paraplegia and tetraplegia and to obtain more detailed information about the factors influencing this development over time after SCI.	29 subjects with SCI (27 male and 2 female). Switzerland.	Over a period of 2½ years the consecutive patients admitted and enrolled on study. Only accepted after full medical screen. Bone measurements taken by a low dose peripheral quantitative computed tomography. Separately assessing trabecular and cortical bone density. Patients allocated as neurology allowed walking or standing program. Patients unable to reach **3x/week for 30 minutes** were placed in an inactive group for the study.	All subjects the tibia bone showed a pronounced loss of trabecular bone compared to cortical bone. Trabecular bone loss 5% at 6 months and 15% 12 months post SCI. Cortical bone losses of 2% and 7% at the same times. No significant differences between paraplegia and tetraplegia. Degree of spasticity and the chosen intensity of physical activity of this study did not influence this loss significantly. In the 2 subjects who were exceptionally active over the course of their rehabilitation the bone loss depleted more slowly than expected with regard to other subjects. This is descriptive and is not statistically significant, possibly clinically significant.	3	Possible selection bias present. Only 8 of the 29 subjects performed the standing program - small numbers. In 2½ years there were no fractures noted. The study performed its intentions and would be repeatable.
Giangregorio (2002)	A comparison of models of disuse Osteoporosis.		Review of current literature with a focus on recent accounts of disuse osteoporosis.	The author concluded that post SCI bone loss and the biomechanical changes are comparable to those seen in bed rest and space flight. In such cases mobilising allows restoration of lost bone but not to normal or at the same rate as the diminishing.	6	The author highlights that differences in study design and lack of information limits the comparisons. There is no account of how the literature was chosen.

Author	Aim	Sample and population size	Method	Results and Discussion	SCHARR Level of evidence	Rigour
Goemaere *et al.* (1994)	To establish whether early and regular passive mechanical loading has any long-term effect on bone mineral density.	53 paraplegic patients (42 male, 11 female - not post-menopausal or under 20 years of age) with complete traumatic SCI and 53 matched control population selected from staff. All patients were injured for at least one year. Standing performed by long leg braces, 20, Standing frame, 9, Standing wheel chair, 9.Did not persist with standing, 15. Belgium.	A cross sectional study. BMD of lumbar spine and hip (neck, trochanter and total hip) measured by dual photon X-ray absorptiometry(DXA). Patients divided into 3 groups based on frequency of standing: **daily for at least an hour**, infrequently (3 times a week) and no standing. Ashworth scale for spasticity and functional independence measured.	Body weight was significantly higher in those not performing standing. BMD significantly reduced in comparison to control group (total hip by 33%, femoral shaft 25%). No significant differences between those standing daily, or 3x/ week so put those results together. Standing group showed a partially preventative effect of standing on bone loss at the femoral shaft not the hip. Those using long leg callipers had significantly higher BMD in the hip region than passive standing.	4	A single snap shot of a population compared to control group and against the non-standers useful but small numbers. Convenience sample. Discussed the fallouts from the study. Grouping after the event results could introduce a bias
Goktepe *et al.* (2008)	To compare the bone density loss in patients with chronic SCI who perform therapeutic standing with that of their non-standing counterparts, and to investigate the association between bone density and the average daily standing time.	92 subjects aged 18-46 years, ASIA A and B at least 1 year post SCI (who applied to the rehab centre) were enrolled but then 21 incomplete (ASIA C,D,E) excluded to prevent confusion relating to muscle strength. Remainder assigned to groups: A: 1 hour or more daily stand (20) B: less than 1 hour daily stand (11) C: control - non standing (40)	Cross sectional study. Bone Mineral Density measured at trochanters, Ward's triangles, femoral necks and L2-L4 spine. t scores (measure of BMD) calculated.	No statistically significant difference found among t scores of lumbar and proximal femoral regions between the groups. BMD loss in proximal femoral region in all groups. Lumbar measurements appeared near normal possibly due to weight bearing during sitting or wheelchair activities.	5	Recruits were from those who applied to the rehabilitation centre with potential to introduce bias. BMD measuring technician blinded to group allocation. Limitations stated-self reported standing times, retrospective design. No explanation of t score given.

Author	Aim	Sample and population size	Method	Results and Discussion	SCHARR Level of evidence	Rigour
Hawran *et al.* (1996)	To establish the use of long leg callipers by paraplegic patients.	45 paraplegic patients discharged with long leg callipers between 1973-82 from the Rehabilitation Hospital, Hornbæk, Denmark. 40 survivors were interviewed. 30 (7 female) complete paraplegia + 10 (2 female) incomplete paraplegia.	A review of the medical records established the patients to be interviewed either by phone or on attendance for reassessment. Each interview was carried out according to a fixed questionnaire.	Only 3 patients were still using their callipers at follow up, 6 never used them after discharge, 8 (20%) used them up to 1 year post discharge. Those still using were not in daily use (1x/week, 1x/fortnight, 1x every 2 months to do stairs). Reasons for not using them: difficult to don/doff, physically demanding, functionally limiting because hands are occupied. 10 patients who had been supplied with standing frames were still using these on a regular basis, remaining subjects were interested in having one.	5	Covered all the reasons for discontinued use, balanced with social/employment circumstances that might have an influence on time. All the subjects are from 1 rehabilitation unit, initial selection process might not have been robust initially. There is no description of the environs for the subjects, Denmark might not be "calliper friendly".
Hendrie (2005)	To review the outcomes of one patient using an Oswestry Standing Frame for 18 months.	Single case study of 44-year-old female subject with multiple sclerosis (MS).	Outcome measures taken before commencing standing regime of **30 minutes, 3x/week**, after 6 months and after 18 months of standing. With progressive exercises prescribed as balance and control improved.	Amended Motor Club Assessment Scale improved 9 to 22 out of possible 48. Multiple Sclerosis Impact Score reduced from 104 to 58 out of possible 148 (measures impact of MS on life, the lower the score the less the perceived impact of disease on aspects of everyday life). Sitting balance objectively improved from static only to dynamic with function (e.g. emptying dishwasher). Subject reported that standing made her feel "a normal person again", which she wanted to repeat and gave her a feeling of empowerment.	6	Possibly the information is transferable to SCI because the subject was using a wheelchair for 95% of her mobility, and was described as having a spastic paraparesis. No upper limb weakness described. Description of the specific exercises were not included and it is possible that the subject would have improved if these had been prescribed in a sitting posture, although perhaps not as significantly without the stability of the trunk being so fully challenged. This is only one subject and there is no control.

Author	Aim	Sample and population size	Method	Results and Discussion	SCHARR Level of evidence	Rigour
Hoenig *et al.* (2001)	To determine whether or not the use of a standing table significantly improved bowel function in a paraplegic patient with chronic constipation.	Single case study, 62 year old male paraplegic injured for 36 years. Multiple problems, but working 3-5 times a week.	Controlled bowel treatment regime. Dose of standing determined by willingness, was **1 hour/day, 5 days/week,** for 28 days. Outcomes were measured in frequency of bowel movements, duration of bowel care and symptoms of constipation.	Frequency of bowel movements nearly doubled (10-18), Time spent on bowel care reduced from 21-13 minutes. Significance $p<0.05$. The patient then reduced the amount of times (5-3), 2 days later he required an enema for constipation.	6	A single case study performed with a subject who had multiple medical problems, but a significant change brought about.
Jacobs *et al*. (2003)	To compare the acute physiologic responses to Functional Electrical Stimulation (FES) Assisted Standing (AS) and to frame supported passive standing (PS).	Volunteer participation of 15 (13 male, 2 female) complete paraplegic SCI individuals. All had been through 6 months of FES walking program. USA	Each completed 3 exercise tests. First a peak Arm Cranking Exercise (ACE), 2 standing tests within one week AS and PS. Each stand maintained for **30 minutes.** Physiologic responses were recorded through each test.	$P<0.05$. Heart rate significantly lower in PS than AS. VO^2 responses were significantly greater to AS to PS and ACE. The responses to AS fall into guidelines for developing and maintaining cardio-respiratory fitness. Included in review due to the documented effects of passive standing	6	Individuals already trained would not find PS standing stressful. Convenience sample.
Jones *et al*. (2002)	To compare BMD of the total body, upper limbs, lower limbs, hip and spine regions in very active SCI adult males and a carefully matched control group	20 subjects invited to participate (65% tetraplegic). 17 of which displayed the level of activity required (60+ minutes /week on top of rehabilitation). New Zealand.	Cross sectional study. DXA scanning to determine bone mass. Questionnaires to establish levels of activity.	Lumbar spine and arm BMD and BMC did not differ between SCI and Able-bodied control. BMD in hip regions were significantly lower in SCI group than control group.	4	A carefully matched study. Report contains many statistically worked comparisons and correlation to World Health Organisation (WHO) definitions. Convenience sample.

Author	Aim	Sample and population size	Method	Results and Discussion	SCHARR Level of evidence	Rigour
Kaplan *et al.* (1981)	To determine the effect of weight bearing across long bones on calcium metabolism in tetraplegics	8 men and women aged 19-56 years, incomplete C5-C7.	6 subjects studied within 6/12 of SCI (early group), 5 subjects studied 12-18/12 of SCI (late group). Tilt table session of **at least 20 minutes, at least 1xday** with angle of 45 degrees or more. Measured urinary and faecal calcium and calcium balance before and after standing.	Significant improvement in calcium balance, and reduction in excretion of urinary calcium for both groups ($p<0.01$).	6	Small subject group. Do not know clinical significance of the decrease in urinary calcium – no target for reduction of calcium loss documented.
Kawashima *et al.* (2003)	To clarify whether the Soleus H-reflex in patients with motor complete SCI is reduced when they stand passively.	6 SCI (T5-12 level) patients and 6 neurologically normal controls. Japan.	Performed in sitting and passive standing. Surface EMG signal of soleus muscle recorded.	The H-reflex response was lower in the standing position compared to the sitting in both the normal and the SCI groups. Suggesting that even in SCI the standing posture can generate inhibitory neural inputs to the soleus spinal motor neurone pool. ($p<0.05$)	4	Convenience sample. Small numbers used. No mention of spasticity levels of subjects involved and if that would have affected results. Importantly joint ranges in standing were observed.

Author	Aim	Sample and population size	Method	Results and Discussion	SCHARR Level of evidence	Rigour
Kunkel *et al.* (1993)	To test the hypothesis that "standing" in a frame daily for 6 months would significantly 1) decrease spasticity in the legs, 2) enhance range of motion of hips knees and ankles, 3) enhance bone density of lumbar spine and femoral neck, 4) reduce fracture risk in the legs and feet, 5) have no untoward side effects.	6 wheelchair bound adult males (4 SCI, 2 MS), who were enrolled in the Rehabilitation medicine Clinic, and volunteered to be part of study. Paraparesis existent for more than 2 years. USA.	Subjects consented to stand in a frame for **45 minutes 2x/day,** daily for 5 months, following a period of introduction to standing for 1 month. The criteria for each element of the hypothesis were measured. A questionnaire asked to score feelings regarding the effects of standing on relaxation, sleep appetite, and wellness.	No fractures sustained during standing. No changes to levels of contracture, spasticity, osteoporosis noted. No increase of serum alkaline phosphatase. 4/6 elected to continue after study completed, reporting feeling healthier even though standing only had marginal effects on sleep and relaxation. They would recommend standing to other paralysed persons. 2 discontinued because of difficulty obtaining assistance to stand.	3	This study rightly highlights that it does not address the effectiveness of standing early in rehabilitation before contractures develop, or used in conjunction with other specific stretches and modes of treatment to increase range of movement. The photographed position of the subject standing did not display full extension at the hip that would also reduce the effect on tone. Convenient sample.
Kwok *et al.* (2015)	To determine effects of a 6 week standing programme on bowel function in people with spinal cord injury.	Sample of convenience from Australia (19) and UK (1). 20 wheelchair dependent, community dwelling people with SCI above T8 AIS A or B, more than a year post injury, with stable bowel regime.	Single-blind randomised crossover trial: 16 week trial: 6 week stand phase, 6 week no stand phase separated by 4 week washout period. Stand for 30 mins, 5 times a week for 6 weeks. Outcome measures include time to first stool and time to complete bowel care.	3 participants withdrew. Median age 46 years and years since injury 6. Regular standing appeared to have no effect on bowel time to first stool. Study unable to demonstrate therapeutic effects on bowel for standing. 8 participants perceived standing improved bowel function.	2	Had a control group. Discusses dropouts, treatment effects and limitations. Discusses how standing effects varies between people with SCI. Small sample size. Bowel function difficult to quantify. Some self-reporting could contribute bias. Effects of standing on bowel function may differ with different levels of SCI and different ages or time since injury.

Author	Aim	Sample and population size	Method	Results and Discussion	SCHARR Level of evidence	Rigour
Liu (2008)	Provide criteria for the biofeedback design of tilt table training systems aimed at overcoming posture hypotension in SCI patients	38 tetraplegic patients (ASIA A,B or C), injured within the previous 4 months, with recent history of presyncope symptoms	BP, HR, LF/HF (low frequency/high frequency ratio of the heart rate), SpO2 and presyncope symptoms recorded at 2 minute intervals for 6 minutes at 0, 30,45,60 and 75 degrees on a tilt table. Subjects were considered trained when they had recovered from any symptoms and had experienced all angles.	From abstract, it was reported that SpO2 and LF/HF differed significantly with the level of presyncope symptoms. It was discussed that tilt angle and ASIA grade can affect BP, SpO2 and HR during head up tilt.	3	No details on recruitment of subjects. No details on subject's history of presyncope symptoms. In depth detail regarding the hardware design given (from an engineering and computing journal). Unclear method. Results difficult to follow. Graphs difficult to interpret.
Nordström *et al.* (2013)	Illuminate the meaning of standing in standing devices for the persons that use them.	15 adult participants using standing devices. (Not just SCI).	Qualitative interviews	Main theme: the upright body position provides an opportunity for connection to the outside world. 4 further themes emerged: the upright body position alters the person's sense of self, augments the person's availability to the world, strengthens social interplay, and changes a person's motivation and expectations over time.	5	People selected from a register of users of standing frames, therefore may be bias. Participants not just SCI.
Nordström *et al.* (2014)	To investigate the psychosocial impact of standing devices as experienced by users.	284 participants (ranging from 2 to 86 years) in Sweden with a disability, using a standing device. (Not just SCI).	Questionnaire (including Psychosocial Impact of Assistive Devices Scale).	Psychosocial impact of standing devices generally perceived as positive.	5	Participants were users of standing frames already so may introduce bias. Participants not just SCI. Limitations to study discussed.

Author	Aim	Sample and population size	Method	Results and Discussion	SCHARR Level of evidence	Rigour
Odēen and Knutsson (1981)	To evaluate the effects of muscle stretch and weight load in patients with spastic paraplegia.	Nine patients (8 men, 1 woman) with paraplegia of greater than 3 years. Sweden.	Spastic resistance to ankle joint movement was measured in each, angular displacement recorded, in some EMG were taken. Before and after measurements were taken 8 times during a 4 day period. 3 methods a) weight bearing through dorsiflexed feet, b) weight bearing through plantar flexed feet, c) stretch imposed to calf in supine for **30 minutes**.	The 3 methods resulted in a reduction of tone; 15 32% (significance p<0.001) 16 26% 17 17% Comments made that a follow up study shows that patients without physiotherapy can maintain range of movement and spasticity in lower limbs, in the community. Written in another paper that would need translation.	6	The study draws attention to its own limitations in the accuracy of being able to confine resistance to spasticity, EMG studies were not available for all. It is a shame that there is only one sentence devoted to the follow up study. Convenient sample.
Ogata *et al*. (2012)	No specific aim given.	Case study report on case of unusual response to standing. One male C7 ASIA A.	BP and heart rate monitored at 1 minute intervals, during different activities (sitting, standing and passive walking-like exercise (PWE) using Easy stand Glider). EMG recorded activity in rectus femoris, biceps femoris medial gastrocnemius and tibialis anterior. VO2 measured using a respiratory gas analyser.	All BP parameters increased during passive standing, with decreased heart rate. After onset of PWE, BP parameters decreased with an increase in heart rate. Discussed similarities between observations and autonomic dysreflexia (AD), and linked this with the increase EMG activity. The EMG activity during standing represents muscle spasm. Suggests that passive standing can induce exaggerated hypertension associated with muscle spasm.	6	This case study documents the potential risk of inducing autonomic dysreflexia in the process of standing, secondary to muscle spasm. As a case study cannot be generalised to SCI population, however raises awareness of potential risks of AD.

Author	Aim	Sample and population size	Method	Results and Discussion	SCHARR Level of evidence	Rigour
Ragnarsson *et al*. (1981)	To study SCI subjects with different level lesions and compare their renal circulation while supine and during head up tilt with normal controls.	17 SCI (8 paraplegic, 9 tetraplegic) and 8 healthy controls. USA.	Glomerular filtration rate (GFR) and renal plasma flow (RPF) and Mean arterial pressure (MAP) recorded in subjects when supine and with head-up tilt following a stabilisation period of 30 minutes.	Paraplegic responses were not significantly different to the control. In the tetraplegia subjects GFR and RPF were significantly lower than controls in the supine position, and with head-up tilt the MAP and RPF decreased significantly, but not the fall in GFR ($p<0.05$). In all groups the GFR during head up tilt was similar. Conclusion that in spite of loss of supraspinal sympathetic control tetraplegic subjects apparently equally constrict their afferent and efferent renal arterioles during orthostatic stress and thus prevent excessive fall of GFR.	4	This is a complex study, with much care placed on eliminating external factors affecting the renal output e.g. Diet. The levels and length of time post injury are clearly stated but there is no mention of how the subjects were chosen and from what size population. Convenience sample.
Sergeeva *et al*. (1978)	To study haemodynamics at rest and during orthostatic tests on patients with tetraplegia.	36 patients, length of injury from 1 month to 8 years, aged 18 - 36 years. 12 healthy subjects for control. USSR	Blood pressure (BP), stroke volume (SV), cardiac output (CO), volume blood flow (VBF), were measured and the total peripheral resistance (TPR) calculated. These measurements were taken at horizontal, 75° tilt, and return to horizontal. Recordings were taken after **10 minutes** in each position.	Patients could be divided into 2 groups by their response to the test. Group 1 - 24 patients, SCI level C5-7, 1-2 minutes of vertical position SV fell 46%, BP by 36%, TPR by 29% (in the normal this would rise because of compensatory vasoconstriction) leading to orthostatic collapse. Group 2 - showed different changes and did not collapse. Patients who had undergone a period of rehabilitation were able to move from group 1 to Group 2.	4	A convenient sample group, the population is not stated. No statistical analysis available. Rehabilitation not described fully.

Author	Aim	Sample and population size	Method	Results and Discussion	SCHARR Level of evidence	Rigour
Shields and Dudley-Javoroski (2005)	To describe a method of quantifying a dose of standing outside the laboratory, to describe the standing patterns of 1 subject and their satisfaction with the standing protocol.	Single case study of T10 paraplegic. USA.	Subject's standing wheelchair fitted with a custom made micro-controller -based logger. Logger recorded date, duration, angle of standing and start/stop times. Recommended program - to stand for at least 20 minutes during 5 days of any calendar week. No other constraints. Period of 2 years. 3 monthly questionnaire re use of system for standing, sitting, mobility, positive or negative health changes attributable to standing and recommendation of standing to others.	Mean angle /bout of standing 60° above horizontal. Average bout time (mean) 12.3 minutes. Although he exceeded the monthly recommended standing duration he typically stood fewer than the suggested 5 days of each calendar week. Subject often stated that he believed the standing to have a beneficial effect on his leg spasticity and that on the days he did not stand his spasms were more frequent and bothersome. On 2 occasions he could not use the chair due to repairs, he noticed detrimental changes to his spasticity and on his bowel program.	6	These results can only be argued to be effective for this subject without monitoring others. No comparisons can be made except for within the period of time the subject was unable to stand due to broken equipment when it could be argued that he was his own control
Vlychou *et al*. (2003)	a) To compare BMD of paraplegic patients and able-bodied controls. b) To correlate BMD with neurological level, physiotherapy and standing. To discuss the use of DXA in the clinical practice of paraplegic patients.	57 patients (33 men, 24 women) with paraplegia as a result of SCI, from 6 months to 27 years. Data compared to 36 able-bodied age-matched controls. Inclusion criteria and detailed breakdown of data re patients supplied. Greece.	BMD was measured in specific area of forearm and hip. Due to reported significant differences between USA and Greek BMD values data was used from a pool 380 Greeks to assist with the calculation of the number of standard deviations in relation to BMD, age and sex.	Significant demineralisation of paraplegics compared to controls ($p<0.05$). This was not influenced by neurological status, sex, length of time post injury, or whether the patient had performed or not performed in a rehabilitation program, including therapeutic standing.	4	A clear and transparent study with regard to selection and information about patients. Includes a discussion of BMD relating to physiotherapy and therapeutic standing, but these are not defined. Convenience sample.

Author	Aim	Sample and population size	Method	Results and Discussion	SCHARR Level of evidence	Rigour
Walicka-Cupryś et al. (2007)	Present significant effects of prolonged standing in patients with SCI of cervical spine.	52 SCI patients (27 cervical spine injuries and 25 with thoracic injuries) hospitalised in Rzeszów, Poland, who stood regularly.	Questionnaire	Positive effects reported: improvement in well-being and ability to take care of oneself. Also reported statistically significant improvement of functioning of digestive system, and reported improvement in functioning of circulatory and respiratory systems, skin condition and sleep. Negative effects of standing also reported (smaller percentage): increase in pain, increased tiredness and spasticity, disorders of the circulatory system.	5	Translated article (Polish Journal of Physiotherapy). Uses t-student test to discuss statistical significance however, data is not parametric. Unclear what data is used for the statistical analysis. Unclear time since injury. Limited details re the questionnaire. Limited details re scales for measuring function.
Walter *et al.* (1999)	To evaluate the amount of home standing and several SCI outcome variables.	This is a re-analysis of the findings of the paper by Dunn et al. (1998).	Previous paper used descriptive findings. This re-analysis of the survey data includes patient perceived outcomes by frequency, duration of standing and time after injury. Descriptive terms placed into ordinal scales.	33% of respondents stood at least once/day, 41% at least once/week. 1/99 respondents reported a broken bone in relation to standing. Quality of Life outcome measure was significant ($p<0.05$), and secondary complication (spasticity, sores) improvement rates were related to time post injury and length of time standing (30 minutes + on a daily basis).	5	Concerns (author acknowledges) relating to the possibility that it is the people with a positive attitude to standing that return the survey. There was a low response rate of 32% but there is no clarification that the patients received it. But it is good that the survey did prompt the respondent to note negative effects.
Wood *et al.* (2001)	To assess the extent of bone loss in subjects with SCI in and correlation to age, time post injury and level of lesion.	22 male Caucasian subjects, traumatic SCI (T3 to T12), being screened in relation to a research programme investigating the restoration of standing via FES - they had been preparing for this by standing. UK.	BMD of femoral neck and lumbar spine measured using DXA.	57.1% had BMD above the normal mean in the lumbar spine (5 subject had to be excluded due to internal fixation in spine). BMD at the femoral neck suggested that 81.8% were at risk of fracture but only 22.7% were at high risk. There was no correlation found between BMD in lumbar spine or femoral neck and age, level of lesion and time post-injury.	3	Convenience sample. Clear about exclusions from the study.

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