

Coulter, E. H., McLean, A. N., Hasler, J. P., Allan, D. B., McFadyen, A., and Paul, L. (2016) The effectiveness and satisfaction of web-based physiotherapy in people with spinal cord injury: a pilot randomised controlled trial. *Spinal Cord*, (doi:[10.1038/sc.2016.125](https://doi.org/10.1038/sc.2016.125))

This is the author's final accepted version.

There may be differences between this version and the published version. You are advised to consult the publisher's version if you wish to cite from it.

<http://eprints.gla.ac.uk/121187/>

Deposited on: 27 July 2016

**Title: The effectiveness and satisfaction of web-based physiotherapy in people with spinal cord injury: a pilot randomised controlled trial**

Elaine H Coulter PhD<sup>1</sup>, Alan N McLean MBChB FRCP<sup>2</sup>, Jon P Hasler MPhil<sup>2</sup>, David B Allan MBChB FRCS<sup>2</sup>, Angus McFadyen PhD<sup>3</sup>, Lorna Paul PhD<sup>1</sup>

<sup>1</sup>School of Medicine, University of Glasgow, Scotland, UK; <sup>2</sup> Queen Elizabeth National Spinal Injury Unit, NHS Greater Glasgow and Clyde, Scotland, UK; <sup>3</sup>AKM-STATS, Statistical Consultant, Glasgow, Scotland, UK.

**Running title:** WEB-based Physio for SCI

**Corresponding author:**

Elaine Coulter

School of Medicine

University of Glasgow

59 Oakfield Avenue

Glasgow

G12 8LL

UK

Email: [Elaine.Coulter@glasgow.ac.uk](mailto:Elaine.Coulter@glasgow.ac.uk)

Tel: (+44) 141 330 3249

**Support:** This study was funded by the Queen Elizabeth National Spinal Injuries Unit, Glasgow.

**Conflict of interests:**

The authors declare no conflicts of interest.

1 **Title: The effectiveness and satisfaction of web-based physiotherapy in people**  
2 **with spinal cord injury: a pilot randomised controlled trial**

3 **Abstract**

4 **Study Design:** Pilot randomised controlled trial

5 **Objectives:** The aims of this study were to evaluate the effectiveness and  
6 participant satisfaction of web-based physiotherapy for people with Spinal Cord  
7 Injury (SCI).

8 **Setting:** Community patients of a national spinal injury unit in a university teaching  
9 hospital, Scotland, UK

10 **Methods:** Twenty-four participants were recruited and randomised to receive eight  
11 weeks of web-based physiotherapy (intervention), twice per week, or usual care  
12 (control). Individual exercise programmes were prescribed based upon participant's  
13 abilities. The intervention was delivered via a website ([www.webbasedphysio.com](http://www.webbasedphysio.com))  
14 and monitored and progressed remotely by the physiotherapist.

15 **Results:** Participants logged on to the website an average of  $1.4 \pm 0.8$  times per  
16 week. Between-group differences, although not significant were more pronounced  
17 for the 6 minute walk test. Participants were positive about using web-based  
18 physiotherapy and stated they would be happy to use it again and would recommend  
19 it to others. Overall it was rated as either good or excellent.

20 **Conclusions:** Web-based physiotherapy was feasible and acceptable for people  
21 with SCI. Participants achieved good compliance with the intervention, rated the  
22 programme highly and beneficial for health and well-being at various states post

23 injury. The results of this study warrant further work with a more homogenous  
24 sample.

25

26 **Sponsorship:** This study was funded by the Queen Elizabeth National Spinal  
27 Injuries Unit, Glasgow.

28 **Keywords:** Spinal Cord Injury; Telerehabilitation; Exercise; Physical Therapy  
29 Modalities

30

31

32

33

34

35

36

37

38

39

40

41

## 42    **Introduction**

43    Cardiovascular disease (CVD) is one of the leading causes of premature death in  
44    people with SCI (1,2). Physical activity and exercise can potentially reduce the risk of  
45    developing CVD in people with SCI (3–5), and can help maintain or improve muscle  
46    strength, flexibility and reduce pain (6). This results in improved health, well-being  
47    and quality of life (7). A systematic review reported that exercise is effective in  
48    improving physical capacity and muscle strength, with no evidence to suggest it is  
49    harmful for people after SCI (8). Some people with SCI however find it difficult to  
50    exercise due to lack of motivation or individually tailored exercise programme  
51    coupled with issues over costs and transport (9,10).

52

53    Home-based exercise programmes are effective in improving exercise endurance  
54    and physical activity in people with SCI (11,12). Telerehabilitation, defined as ‘the  
55    use of information and communication technology to deliver rehabilitation services  
56    over a distance’ (13) may be a feasible option to enable people to exercise at home  
57    as an adjunct, or alternative to, traditional physiotherapy. Previous studies have  
58    shown that telerehabilitation is generally well received, yet few studies have been  
59    conducted investigating the effectiveness of telerehabilitation for administering home  
60    exercise for people with SCI (14). Kowalczewski et al. (15) investigated a 6 week  
61    telerehabilitation programme to improve hand function in 13 people with tetraplegia  
62    in which participants were provided with a laptop, webcam and internet connection.  
63    This study found significant improvements in hand function and high participant  
64    satisfaction (15). More recently, a 12 week exercise programme using face-to-face  
65    physiotherapy and a handout, followed by video-conferencing sessions was  
66    investigated in 16 people with SCI complaining of sub-acromial impingement (16).

67 Half of participants achieved a compliance rate of  $\geq 50\%$  and results included a  
68 reduction in pain and improved muscle strength and function (16). The potential use  
69 of virtual games (Nintendo Wii) was investigated in a single exercise session in 10  
70 people with SCI (17). This study found virtual games, particularly boxing, may  
71 provide a form of aerobic exercise. There have been no studies that have  
72 investigated physiotherapy exercise delivered via the internet for people with SCI.  
73 Our group recently developed web-based physiotherapy  
74 ([www.webbasedphysio.com](http://www.webbasedphysio.com)), and explored its use in 30 people with Multiple  
75 Sclerosis (18). This study found the intervention was feasible and acceptable with  
76 some trends towards improvement in physical ability with participants logging in an  
77 average of 1.3 times/week. The aim of the present study was to evaluate the  
78 effectiveness of web-based physiotherapy for people with SCI and the participant  
79 satisfaction with the intervention.

80

## 81 **Methods**

82 Ethical approval was obtained from the West of Scotland Research Ethics Service  
83 (ref: 14/WS/1054). Twenty-four participants were recruited between October 2014  
84 and June 2015 from SCI outpatient clinics at the Queen Elizabeth National Spinal  
85 Injuries Unit (QENSIU), Glasgow, Scotland. The sample size was pragmatically  
86 based on an estimated recruitment rate of 2-3 participants per month. Participants  
87 were included if they were spinal cord injured; over 18 years old; mobilising  
88 independently using a manual wheelchair or walking with/without aids; had access to  
89 a laptop, personal computer or tablet device and the internet; living within  
90 central/west of Scotland; and able to read and understand English. Participants were  
91 excluded if they were already regularly exercising twice per week; pregnant or had

92 significant co-morbidity which would prevent exercise participation. Participants were  
93 randomised to either the intervention or control group on a 2:1 ratio following  
94 baseline assessment. A random number sequence was generated in Microsoft  
95 Excel by an independent researcher and the numbers corresponding to intervention  
96 and control inserted into opaque sealed envelopes. There is no published protocol  
97 and registry for this pilot study.

98

#### 99 *Intervention*

100 The website, [www.webbasedphysio.com](http://www.webbasedphysio.com), was used to deliver individualised exercise  
101 programmes (15). The website consists of exercise, exercise diary, advice and  
102 education sections. Each exercise page has a video, a written explanation of the  
103 exercise and an audio description. The website was adapted with health  
104 professionals at the QENSIU and people with SCI. Exercises suitable for people with  
105 SCI were filmed, using individuals with SCI and uploaded on to the exercise  
106 catalogue on the website and an advice section was developed, with the content  
107 based on the patient education provided at the QENSIU (example log in:  
108 [sciphysiopatient@gmail.com](mailto:sciphysiopatient@gmail.com), password: *password*). For those in the intervention  
109 group individualised exercise programmes were prescribed by a physiotherapist and  
110 consisted of aerobic, strengthening, stretching and balance exercises as appropriate  
111 based upon participant's abilities. Participants were provided with an individual log-in  
112 to access their online exercise programme and were advised to undertake the  
113 programme, lasting approximately 30 minutes, a minimum of twice per week for a  
114 period of eight weeks and to complete their online exercise diary. Diaries were  
115 reviewed remotely by the physiotherapist who contacted participants by email or

phone every two weeks. Progress was discussed and updates to exercise programmes were made, as appropriate, by adding/removing exercises, or changing the difficulty or number of repetitions/sets.

Participants in the control group received usual care, consisting of self-management of their condition. If participants were currently exercising (eg. home-based exercise, gym or exercise class), they were asked to continue and to keep an exercise diary noting any exercise or activities in which they participated. Participants in the control group were offered access to the web-based intervention at the end of the study.

#### *Outcome measures*

Demographic information including age, sex, time since SCI, level and completeness of injury and Spinal Cord Independence Measure III (SCIM III) were recorded. Outcome measures were recorded at baseline and at the end of the intervention period (8 weeks) by an unblinded physiotherapist at the QENSIU. The primary outcomes were the 6 Minute Push Test (6MPT) (19) or 6 Minute Walk Test (6MWT), depending on participants' primary means of mobility. A standardised script instructed participants to propel their wheelchair or walk as far as possible within six minutes over a 20m straight corridor, and advised that they could slow down or stop at any point during the test. The distance travelled during 6 minutes was recorded. Both the 6MPT and 6MWT are valid and reliable for people with SCI (19,20). A range of secondary outcome measures were utilised. Change in Heart Rate (HR) (work HR- resting HR) (Polar FT2 Heart Rate Monitor) and the Rate of Perceived Exertion



using the Borg scale (21) were recorded after the 6MPT/6MWT. Muscle strength (shoulder abductors, elbow flexors/extensors, wrist extensors, hip flexors, knee extensors, ankle dorsiflexors/plantarflexors) was measured using a 'make test' (22) with a hand-held dynamometer (Manual Muscle Tester, Model 01163, Lafayette, IN, USA). This test was completed whilst sitting, repeated three times, and the mean score was recorded. Finally, participants completed the Hospital Anxiety and Depression Scale (HADS) (23) and World Health Organisation Quality of Life Bref Scale (WHOQoL) (24). Both questionnaires are valid and reliable for use in the SCI population (25,26). Compliance to exercise was based on the number of days per week participants completed their exercise diary. Participants in the intervention group completed an online exercise diary while those in the control group completed a paper exercise diary. After 8 weeks, participants allocated to web-based physiotherapy (intervention) completed a website evaluation questionnaire (27) and were invited to take part in a telephone interview to explore their satisfaction with the intervention.

#### *Data analysis*

Demographic variables and outcome measures were summarised by group for each assessment with intervention effects estimated with mean and standard deviation reported. All analysis was performed using IBM SPSS v22. Repeated measure ANOVA models with Greenhouse-Geisser correction factors were used in order to assess any time, group or interaction effects. Telephone interviews were recorded, transcribed and verified. Emerging themes and sub-themes were identified and agreed between two independent researchers.

163

## 164 **Results**

### 165 *Participants*

166 Twenty-four people were recruited, 16 were allocated to the intervention group and 8  
167 to the control group (Figure 1). All participants provided written informed consent.  
168 Participants in both groups had a wide range of injury levels (C3/4-L3) and varied in  
169 their use of mobility aids (Table 1). The control group scored higher in the SCIM III  
170 than the intervention group, indicating that they were more physically able to manage  
171 self-care tasks and required less assistance with mobility than participants in the  
172 intervention group (Table 1). One participant, allocated to the intervention group, was  
173 unable to complete the 6MPT due to an issue with their wheelchair and one  
174 participant, allocated to control group, was unable to complete the HR measurement  
175 and muscle strength assessment due to a skin allergy. Three participants withdrew  
176 from the study (Intervention n=1, control n=2) (Figure 1). No adverse events were  
177 reported.

178 **Figure 1 near here**

179 **Table 1 near here**

180

### 181 *Quantitative results*

182 There were improvements in the 6MPT and the 6MWT in the intervention group. In  
183 particular, the mean distance walked during the 6MWT increased by 58m in the  
184 intervention group, exceeding the minimal detectable change (45.8m) (20). These  
185 results demonstrated small within-group effect sizes which were not statistically

significant. Between-group differences whilst non-significant were more pronounced for the 6MWT (Table 2). For the HADS, repeated measures ANOVA results indicated an overall time effect for the depression subscale ( $p=0.038$ ) and group effects for the anxiety subscale ( $p=0.025$ ) and depression subscale ( $p=0.005$ ). In addition there was a group effect for the WHO-QOL BREF scale ( $p=0.043$ ). No interaction effects were found. From the evaluation questionnaire participants in the intervention group stated that they had no or minimal issues with using a computer and the website, they would like to receive web-based physio again in the future, would recommend it to others and rated web-based physio as either good or excellent (Table 3).

**Table 2 near here**

**Table 3 near here**

### *Compliance*

Participants in the intervention group logged on to the website ([www.webbasedphysio.com](http://www.webbasedphysio.com)) an average of  $1.4 \pm 0.8$  times per week over the 8 week period. Weekly log-ins ranged from 0 to 4 times per week. Four participants achieved a compliance rate of over 100% (exercising more than twice/week). Five participants achieved a compliance rate of 50-100% (exercising 1-2 times/week). Compliance did not decrease over the 8 week intervention period, with participants logging on to the website with an average of  $1.6 \pm 1.5$  and  $1.6 \pm 1.8$  times during week 1 and week 8 respectively. Participants in the control group exercised an average of  $0.8 \pm 1.3$  times per week. Two participants in the control group self-reported they began exercising

208 during the study period; at a gym (n=1) and using a home exercise programme  
209 (n=1).

210

### 211 *Telephone interviews*

212 Five themes and ten sub-themes emerged from the telephone interviews (Table 4).  
213 Participants reported using a combination of different devices to access web-based  
214 physio; personal computers (n=2), laptops (n=5), tablet devices (n=7) and smart  
215 phones (n=3). All participants reported the website was 'easy to use'. A small  
216 number of participants reported minor 'issues encountered' (Table 4). Regarding the  
217 exercise programme, participants found the programme was good and that they  
218 could fit it around their work or other commitments. Participants consistently reported  
219 completing their programme twice or more times per week (n=8) or once per week  
220 (n=1). Three participants reported that feeling unwell impeded their ability to exercise  
221 in the later stages of the programme while one participant complied initially however  
222 latterly stopped their programme due to health issues. All participants stated that it  
223 was good to have a structured, varied and progressive exercise programme targeted  
224 to their needs. Participants reported the videos were useful to remind them of the  
225 correct technique and speed of the exercise. Participants noticed some physical and  
226 psychological benefits from exercising with improvements in pain (n=3), strength  
227 (n=2), mobility (n=3), flexibility (n=1), mood/energy (n=2), balance (n=1), confidence  
228 (n=1) and health (n=1). Three participants did not notice a benefit but two of those  
229 noted that this may have been due to lack of compliance with the programme (Table  
230 4). Regarding 'web-based physio as a mode of delivery', participants 'enjoyed'  
231 following the programme, they discovered that they could do more than they

previously thought, with some adding that they needed something constructive to do after discharge from the rehabilitation unit. The majority of participants liked the bi-weekly telephone and email 'contact with physio', during which they could discuss their programme and problem solve any issues and therefore felt that this wasn't a generic website and it motivated them to continue. All participants were happy to exercise at home, particularly if they could not exercise outdoors due to the weather or could not attend a gym. Some participants drew comparisons with other home exercise programmes they followed in the past, stating that web-based physio was superior to printed exercise sheets and mobile phone applications due to the benefits of watching the exercise videos and the awareness that the physiotherapist could remotely monitor and progress exercises. Finally, all participants reported they planned to continue using their web-based physiotherapy exercise programme and three participants planned to integrate other exercises into their programme or start attending a gym class (Table 4).

**Table 4 near here**

## **Discussion**

The results demonstrate that web-based physiotherapy is a feasible method of delivering exercise and is acceptable to people with SCI. There were no statistically significant differences found in the primary outcomes, the 6MPT and 6MWT. Despite this, the mean difference of the 6MWT exceeded the minimal detectable change indicating a real clinical difference. The lack of statistically significant results and small effect sizes were likely due to the small and heterogeneous sample. Data from the 6MPT and 6MWT were used to calculate the sample size required for a fully

powered randomised controlled trial. In order to detect a change of 60m in either the 6MPT ( $\pm 56$ m) or the 6MWT ( $\pm 74$ m) and to achieve a power of at least 90%, at the 5% level of significance, at a recruitment ratio of 1:1, group sizes would require at least 19 and 34 respectively.

The evaluation questionnaire and qualitative interviews indicate that the website was easy to use, highly rated by participants, was enjoyable to follow and beneficial in terms of health and well-being for both para and tetraplegic participants. Nine of 15 participants who received the web-based intervention complied with the programme, completing at least one session per week. Compliance to the intervention was similar to compliance rates in other telerehabilitation interventions, for instance Van Straaten et al (13) found 8 of 16 participants achieved a compliance rate of  $\geq 50\%$ . Similarly, compliance in the present study is comparable to the compliance rate in our previous work with people with Multiple Sclerosis (15) and compliance to exercise in the general population which is generally between 30 and 57% (28). A reduction in log-in rates over time was not observed in the present study unlike previous studies (15, 22), this may be due to the relatively short intervention period.

The present study adds to the current evidence that supports the use of telerehabilitation for people with SCI and other neurological conditions (15–17). The results of this study also corroborate with our previous work investigating web-based physio and supports further development of this work (15). Web-based physiotherapy exercise programmes can be individually prescribed, monitored remotely and adjusted. It is therefore fundamentally different to other home exercise

programmes. Establishing healthy behaviours and engaging in PA after a SCI is important. Noreau et al (30) stated that those who are encouraged to have an active lifestyle early after their SCI are more likely to continue to do so in the long-term. In this study, all participants reported an intention to continue using web-based physiotherapy, with three participants planning to include other means to exercise into their routine.

This study has a number of limitations. As a pilot study the number of participants was small, and a short intervention period which may have been too short to result in significant changes. In addition, two participants in the control group regularly exercised during the intervention period. This may have affected the results of the control group. The samples were also very heterogeneous, therefore the quantitative results should be interpreted with caution. Finally, outcome measures were only conducted before and after the 8 week intervention period therefore the long-term effect of the intervention and compliance is unknown.

## **Conclusion**

The results of this pilot study, particularly from the evaluation questionnaire and qualitative interviews, demonstrate that web-based physiotherapy is a feasible method of delivering exercise and is acceptable to people with SCI. Participants rated the programme highly, described it as easy to use, enjoyable to follow and beneficial in terms of health and well-being for people at various stages post injury, particularly continued rehabilitation post discharge and for long-term health

303 maintenance. The results of this study warrant further work with a more homogenous  
304 sample.

305  
306 **Acknowledgements**

307 This study was funded by the Queen Elizabeth National Spinal Injuries Unit,  
308 Glasgow. The authors would like to thank Mr David Collins and the individuals with  
309 SCI for filming the exercises. We would also like to thank Sister Karen McKarron,  
310 Nurse Laura McLean and Dr Mariel Purcell for their assistance in recruitment.  
311 Finally, we would like to thank the study participants for taking part in the study.

312  
313 **Conflict of interests**

314 The website, [www.webbasedphysio.com](http://www.webbasedphysio.com), was developed by two of the authors (EC,  
315 LP) at the University of Glasgow. However as this is not a commercial entity there  
316 are no conflicts of interest. All remaining authors declare no conflicts of interest.



## References

1. Groah SL, Weitzenkamp D, Sett P, Soni B, Savic G. The relationship between neurological level of injury and symptomatic cardiovascular disease risk in the aging spinal injured. *Spinal Cord*. 2001;39:310–7.
2. Whiteneck GG, Charlifue SW, Frankel HL, Fraser MH, Gardner B, Gerhart KA, et al. Mortality, morbidity, and psycho-social outcomes of persons spinal cord injured more than 20 years ago. *Paraplegia*. 1992;30:617–30.
3. Bauman WA, Alexander LR, Zhong Y-G, Spungen AM. Stimulating Leg Ergometry Training Improves Body Composition and HDL-Cholesterol Values. *J Am Parapleg Soc*. 1994;17:201.
4. Hetz SP, Latimer AE, Buchholz AC, Martin Ginis KA. Increased participation in activities of daily living is associated with lower cholesterol levels in people with spinal cord injury. *Arch Phys Med Rehabil*. 2009; 90(10):1755–9.
5. Nooijen CFJ, de Groot S, Postma K, Bergen MP, Stam HJ, Bussmann JBJ, et al. A more active lifestyle in persons with a recent spinal cord injury benefits physical fitness and health. *Spinal Cord*. 2012; 50(4):320–3.
6. Santiago M, Coyle C. Leisure-time physical activity and secondary conditions in women with physical disabilities. *Disabil Rehabil*. 2004; 26(8):485–94.
7. Hicks AL, Martin Ginis KA, Ditor DS, Latimer AE, Craven C, Bugaresti J, et al. Long-term exercise training in persons with spinal cord injury: effects on strength, arm ergometry performance and psychological well-being. *Spinal Cord*. 2003; 41(1):34–43.
8. Hicks AL, Martin Ginis KA, Pelletier CA, Ditor DS, Foulon B, Wolfe DL. The effects of exercise training on physical capacity, strength, body composition and functional performance among adults with spinal cord injury: a systematic review. *Spinal Cord*. 2011; 49(11):1103–27.
9. Scelza WM, Kalpakjian CZ, Zemper ED, Tate DG. Perceived barriers to exercise in people with spinal cord injury. *Am J Phys Med Rehabil*. 2005; 84(8):576–83.
10. Rimmer JH, Rubin SS, Braddock D. Barriers to exercise in African American women with physical disabilities. *Arch Phys Med Rehabil*. 2000; 81(2):182–8.
11. Keyser RE, Rasch EK, Finley M, Rodgers MM. Improved upper-body endurance following a 12-week home exercise program for manual wheelchair users. *J Rehabil Res Dev*. 2003;40(6):501–10.
12. Latimer AE, Ginis KAM, Arbour KP. The efficacy of an implementation intention intervention for promoting physical activity among individuals with

- spinal cord injury: A randomized controlled trial. *Rehabil Psychol*. 2006; 51(4):273–80.
13. Kairy D, Lehoux P, Vincent C, Visintin M. A systematic review of clinical outcomes, clinical process, healthcare utilization and costs associated with telerehabilitation. *Disabil Rehabil*. 2009; 31(6):427–47.
  14. Kim J, Lim S, Yun J, Kim D-H. Telerehabilitation needs: a bidirectional survey of health professionals and individuals with spinal cord injury in South Korea. *Telemed J E Health*. 2012; 18(9):713–7.
  15. Kowalczewski J, Chong SL, Galea M, Prochazka A. In-home tele-rehabilitation improves tetraplegic hand function. *Neurorehabil Neural Repair*. 2011; 25(5):412–22.
  16. Van Staaten M, Cloud B, Morrow M, Ludewig P, Zhao K. Effectiveness of home exercise on pain function and strength of manual wheelchair users with sci: a high dose shoulder program with telerehabilitation. *Arch Phys Med Rehabil*. 2014;95(10):1810–7.
  17. Gaffurini P, Bissolotti L, Calza S, Calabretto C, Orizio C, Gobbo M. Energy Metabolism during activity-promoting video games practice in subjects with spinal cord injury: evidences for health promotion. *Eur J Phys Rehabil Med*. 2013;49(1):23–9.
  18. Paul L, Coulter EH, Miller L, McFadyen A, Dorfman J, Mattison PGG. Web-based physiotherapy for people moderately affected with Multiple Sclerosis; quantitative and qualitative data from a randomized, controlled pilot study. *Clin Rehabil*. 2014; 28(9):924–35.
  19. Cowan RE, Callahan MK, Nash MS. The Six Minute Push Test Is Reliable and Predicts Low Fitness in Spinal Cord Injury. *Med Sci Sports Exerc* [Internet]. 2012 May 22; 44(10):1993–2000.
  20. Lam T, Noonan VK, Eng JJ. A systematic review of functional ambulation outcome measures in spinal cord injury. *Spinal Cord*. 2008; 46(4):246–54.
  21. Borg GA. Psychophysical bases of perceived exertion. *Medicine and science in sports and exercise*. 1982. p. 377–81.
  22. Bohannon RW. Make tests and break tests of elbow flexor muscle strength. *Phys Ther*. 1988;68(2):193–4.
  23. Zigmond AS, Snaith RP. The hospital anxiety and depression scale. *Acta Psychiatr Scand*. 1983; 67(6):361–70.
  24. Skevington SM, Lotfy M, O'Connell KA. The World Health Organization's WHOQOL-BREF quality of life assessment: psychometric properties and results of the international field trial. A report from the WHOQOL group. *Qual Life Res*. 2004; 13(2):299–310.

25. Müller R, Cieza A, Geyh S. Rasch analysis of the Hospital Anxiety and Depression Scale in spinal cord injury. *Rehabil Psychol*. 2012; 57(3):214–23.
26. Jang Y, Hsieh C-L, Wang Y-H, Wu Y-H. A validity study of the WHOQOL-BREF assessment in persons with traumatic spinal cord injury. *Arch Phys Med Rehabil*. 2004; 85(11):1890–5.
27. Finkelstein J, Lapshin O, Castro H, Cha E, Provance PG. Home-based physical telerehabilitation in patients with multiple sclerosis: A pilot study. 2008;45(9):1361–73.
28. Sluijs EM, Knibbe JJ. Patient Compliance with Exercise : Different Theoretical Approaches to Short-Term and Long-Term Compliance. *Patient Educ Couns*. 1991;17(3):191–204.
29. Dlugonski D, Motl RW, Mohr DC, Sandroff BM. Internet-delivered behavioral intervention to increase physical activity in persons with multiple sclerosis: Sustainability and secondary outcomes. *Psychol Health Med*. 2012; 17(6):636–51.
30. Noreau L, Shephard RJ, Simard C, Paré G, Pomerleau P. Relationship of impairment and functional ability to habitual activity and fitness following spinal cord injury. *Int J Rehabil Res*. 1993; 16(4):265–75.

## **Titles and legends to figures**

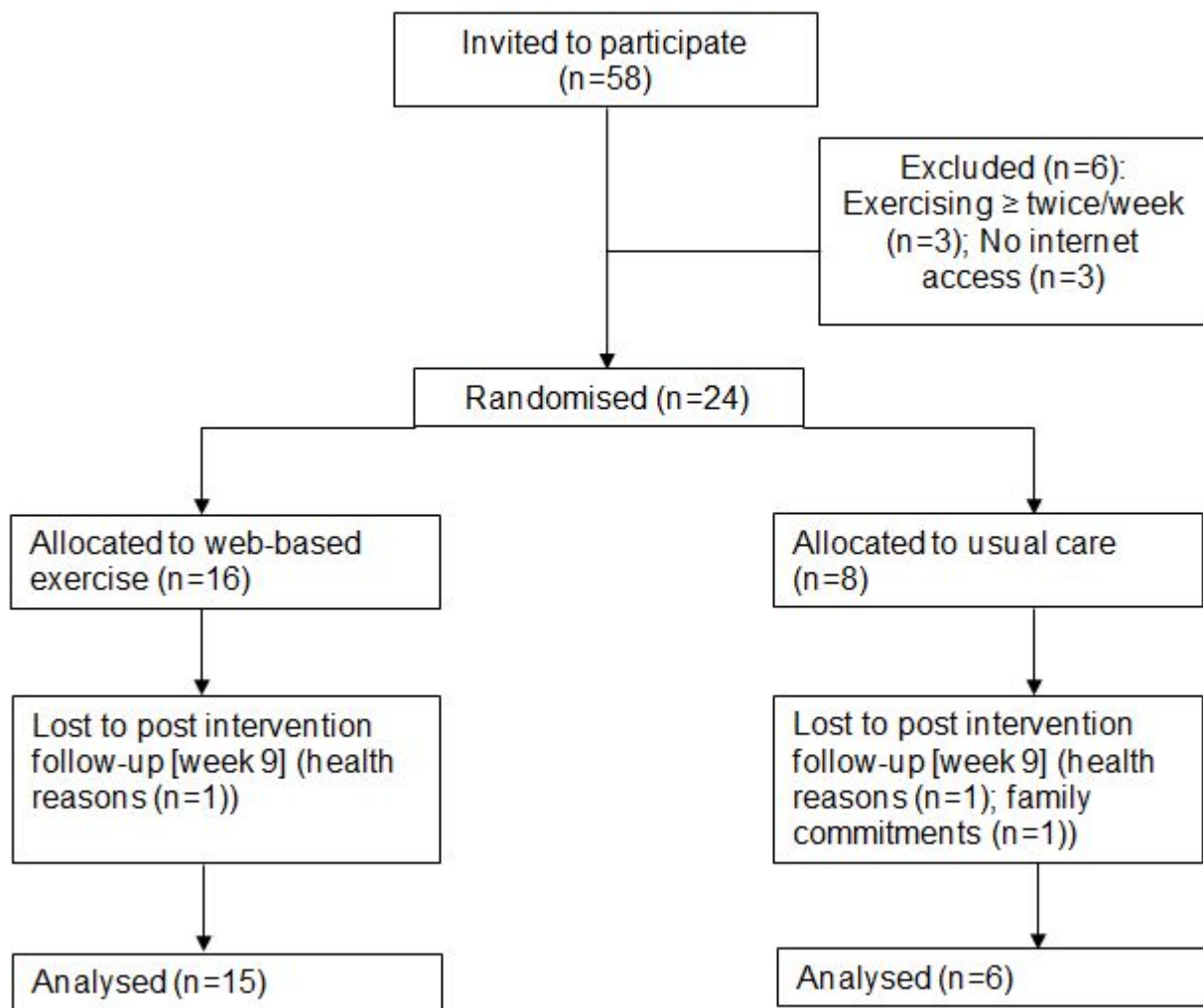
**Figure 1.** Consort diagram for participants randomised to the web-based intervention and usual care.

**Table 1.** Characteristics of participants allocated to the intervention (web-based physio) and control (usual care) groups.

**Table 2.** Mean [standard deviation] at baseline and after 8 weeks for participants allocated to the intervention (web-based physio) and control (usual care) groups.

**Table 3.** Evaluation questionnaire results from participants who received web-based physio. Based on the evaluation questionnaire used by Finklestein et al (n=15).

**Table 4.** Qualitative results from the telephone interviews with participants receiving web-based physio intervention (n=13).



**Table 1.** Characteristics of participants allocated to the intervention (web-based physio) and control (usual care) groups.

	Intervention Group (n=15)	Control Group (n=8)
Gender		
<i>Male</i>	9 (56%)	5 (63%)
<i>Female</i>	7 (44%)	3 (38%)
Age (years)	51.5 [13.0]	48.1 [10.6]
Time since injury (years)	13 [11.6]	15.7 [9.7]
SCI level		
<i>C<sub>1-4</sub></i>	1 (6%)	1 (13%)
<i>C<sub>5-8</sub></i>	4 (25%)	5 (63%)
<i>T<sub>1</sub>-S<sub>5</sub></i>	11 (69%)	2 (25%)
<i>Complete</i>	7 (44%)	5 (63%)
<i>Incomplete</i>	9 (56%)	3 (38%)
Mobility		
<i>Manual wheelchair</i>	10 (63%)	3 (38%)
<i>Wheeled walker</i>	2 (13%)	0
<i>2 sticks/crutches</i>	3 (19%)	2 (25%)
<i>1 stick/crutch</i>	0	1 (13%)
<i>No aid</i>	1 (6%)	2 (25%)
SCIM III (max 100)	63.8 [13.1]	72.5 [19.0]

Mean [standard deviation]. Abbreviations: M, Male; F, Female; SCI, Spinal Cord Injury, C, Cervical, T, Thoracic, S, Sacral, SCIM III, Spinal Cord Independence Measure III.

**Table 2.** Mean [standard deviation] at baseline and after 8 weeks for participants allocated to the intervention (web-based physio) and control (usual care) groups.

Variable	Baseline Mean [SD]	Post Mean [SD]	Mean Difference [SD]	Within Group Effect size	Between Group Mean [SD]	Between Group p-value	Between Group 95% CI
6MPT (m)							
Intervention (n=7)	547.8 [31.9]	562.1 [39.9]	14.4 [26.2]	0.40	3.5 [24.8]	0.892	-53.8, 60.7
Control (n=3)	359.4 [369.3]	370.3 [354.0]	10.9 [55.8]	0.03			
6MWT (m)							
Intervention (n=7)	239.8 [124.1]	297.7 [164.3]	57.8 [74.1]	0.40	63.5 [28.2]	0.064	-5.1, 132.1
Control (n=3)	232.0 [166.9]	226.3 [162.0]	-5.7 [5.3]	-0.03			
HADS_A (max 21)							
Intervention (n=15)	4.5 [2.7]	5.0 [3.1]	0.5 [2.4]	0.16	-0.4 [1.1]	0.735	-2.6, 1.9
Control (n=6)	7.7 [3.2]	8.5 [3.6]	0.8 [1.5]	0.24			
HADS_D (max 21)							
Intervention (n=15)	3.7 [2.8]	4.4 [3.0]	0.7 [1.6]	0.23	-0.3 [0.8]	0.660	-1.9, 1.2
Control (n=6)	7.3 [1.4]	8.3 [1.7]	1.0 [1.3]	0.61			
WHO-QOL BREF (max 400)							
Intervention (n=15)	249.1 [48.9]	249.1 [39.6]	0.0 [30.5]	0.00	18.8 [13.6]	0.183	-9.7, 47.3
Control (n=6)	216.5 [38.8]	197.7 [34.2]	-18.8 [20.4]	-0.51			

Abbreviations: SD, Standard Deviation, 6MPT, 6 Minute Push Test, 6MWT, 6 Minute Walk Test, HADS\_A, Hospital Anxiety and Depression Scale Anxiety subscale, HADS\_D, Hospital Anxiety and Depression Scale Depression subscale, WHO-QOL BREF, World Health Organization Quality of Life Bref Scale.

**Table 3.** Evaluation questionnaire results from participants who received web-based physio. Based on the evaluation questionnaire used by Finklestein et al (n=15).

Question	Response (%)
<b>1. How complicated was it to use the computer?</b>	
Very complicated	0
Moderately complicated	0
Slightly complicated	13
Not complicated at all	87
<b>2. Did you have any difficulty in moving from one screen to another?</b>	
Not at all	87
Very rarely	13
Frequently	0
All the time	0
<b>3. How difficult was it to use the keyboard/mouse?</b>	
Very difficult	0
Moderately difficult	0
Slightly difficult	13
Not difficult at all	87
<b>4. Did you have any difficulties in reading text from the computer screen?</b>	
Not at all	93
Very rarely	7
Frequently	0
All the time	0
<b>5. Was the size of the text presented on the screen sufficient?</b>	
Fully sufficient	93
Sufficient almost all the time	7
Sufficient some of the time	0
Not sufficient at all	0
<b>6. Did you like the colours used on the computer screen?</b>	
Certainly yes	47
To a large extent	47
To some extent	7
No	0
<b>7. Did you like the audiovisual content provided by the computer?</b>	
Certainly yes	80
To a large extent	20
To some extent	0
No	0
<b>8. Did you get all the necessary information about using the website and computer during the initial visit?</b>	
All information	100
Partial information	0
Very limited information	0
<b>9. Did you come across any unknown words which were not explained?</b>	
Very significant	0
Considerable	0
A few	0
None	100
<b>10. How difficult were the sentences used on the website?</b>	



Very difficult	0
Moderately difficult	0
Slightly difficult	0
Not difficult at all	100
<b>11. How much new information did you get using the website?</b>	
Very significant amount	20
Considerable	60
Little	13
Very little	7
<b>12. Did you get any feedback from the computer/ website about your training progress?</b>	
All the time	7
Occasionally	40
Very rarely	13
Never	40
<b>13. How frequently did you find the information/instructions on the website confusing?</b>	
Very frequently	0
Occasionally	0
Very rarely	27
Never	87
<b>14. How frequently did you find the contents (information/ instructions) difficult to understand?</b>	
Very frequently	0
Occasionally	0
Very rarely	13
Never	87
<b>15. Did you have to wait for new information to come up on the screen?</b>	
All the time	0
Occasionally	0
Very rarely	7
Never	93
<b>16. Would you like to use this program in the future?</b>	
Certainly yes	87
To a large extent	13
To some extent	0
No	0
<b>17. Would you advise other patients to use this program?</b>	
Certainly yes	87
To a large extent	13
To some extent	0
No	0
<b>18. Overall how would you grade this program?</b>	
Needs serious improvement	0
Needs some improvement	0
Good	40
Excellent	60

**Table 4.** Qualitative results from the telephone interviews with participants receiving web-based physio intervention (n=13).

Themes	Subthemes	Indicative quotes
Website use	Ease of use	'You would really have to be struggling not to be able to comprehend the processes, it's very simple, it's very well laid out so it's an easy programme to follow' <i>SC11 [T4/5 Complete]</i>
	Issues encountered	'[my wife] did all the clicking, I couldn't because of my hands' <i>SC19 [C4 Incomplete]</i> 'if the exercise took longer than 2 minutes the screen would black out, it's not a big issue, you just tap it and it comes back on. If you don't do it within the time then you need to put in your security [pin] again' <i>SC17 [L1 Incomplete]</i> 'The only thing I would have occasionally was when I viewed the video it crashed my computer' <i>SC12 [T8/9 Complete]</i>
Exercise programme	Participation	'Depending on what shifts I was on, I was trying to do it twice a week' <i>SC10 [T6 Incomplete]</i> 'The first couple of weeks it was maybe twice. Then there were quite a few weeks at the end when I didn't do anything....I didn't participate as much as I thought I would have' <i>SC14 [T6/7 Complete]</i>
	Benefits of the video	'One thing that I would say that was good is that you actually have a video of the chap or of the lady actually doing the exercise. The fact that you could watch someone do the exercise before doing it yourself was very helpful' <i>SC17 [C5 Incomplete]</i> 'It reminded me just to keep the speed down, and go the pace that they are going rather than the pace that I think I should be going, you know, to remind myself that it wasn't a race!' <i>SC123 [T7/8 Complete]</i>
	Progression	'I reported back that if something was too easy it would be adjusted for me. It was motivational. Things that were difficult would become easier and I would report back that they were becoming easier and then you would upscale what I had to do or the weights I had to use. It helps'. <i>SC17 [C5 Incomplete]</i>
Physical and psychological change		'I noticed after about 5 weeks that my shoulder pain had almost disappeared and my balance was better and I was stronger too....I feel a lot stronger and fitter, my breathing is a lot better too' <i>SC11</i> 'I'm walking a bit better, I can walk further' <i>SC115 [L1 Incomplete]</i> 'I think might have seen a benefit in my fitness but I really didn't give it my all if I'm being 100% honest' <i>SC14 [T6/7 Complete]</i>
Mode of delivery	Enjoyed	'I really enjoyed it' <i>SC17 [C5 Incomplete]</i> It's been a really positive experience, I think I have benefitted from it and it made me do or discover that I could do more things' <i>SC17 [C5 Incomplete]</i>
	Contact with physio	'It was good to get contact and to know that there was an interest being taken in how it was going and that was helpful. One thing that was good about the chats was you sort out which bits of the programme worked best for you, move them around a bit, or just discuss' <i>SC11 [T4/5 Complete]</i> 'It's not just a generic site, there is someone alive at the other end, reading your notes and saying 'what about this and what about that?', that again is another motivator' <i>SC17 [C5 Incomplete]</i>
	Keeping an	I suppose it was good to see what problems you had and then either adjusted it slightly so I didn't have as

exercise diary	<p>many. It was more for me, it was a memory jog, cause you sometimes forget, so it was good to go back and think' <i>SCI8 [T6/7 Incomplete]</i></p> <p>'I left comments for her [my physio] as well, either that was easy or that was hard, to give her [the physio] a prompt to know, you know should I increase the number of reps' <i>SCI11 [C6/7 Incomplete]</i></p> <p>'I ticked the box.... just a couple of messages for [my physio], like the time I didn't do it [due to feeling unwell] that I would catch up. I didn't leave any comments that it was easy because, well, it wasn't. I just mainly ticked the box.' <i>SCI7 [C5 Incomplete]</i></p>
Exercising at home	<p>'It's good it's available then when you want it. I think those that say you should go to a gym its more for a social aspect, depending on the person's life. I can't really fit it all in to the day. To do it in the house is better for me. If I was to go to a gym I don't think I would have [done it]' <i>SCI7 [C5 Incomplete]</i></p> <p>'Doing this indoors and on your own is really quite useful because you can't always do things with other people. There aren't many 'like souls' about, there aren't many paraplegics of your level and can participate with you, unless you are into wheelchair basketball, which I'm not, you're left to just get on with it and wheel yourself around. So from that perspective doing it at home is really good' <i>SCI1 [T4/5 Complete]</i></p> <p>'It's definitely better than getting a sheet of exercise and told to go home. You know yourself, you put the sheet down and you go to look at it the day before you are due to go back to see the physio and you haven't done any of your exercises...with this, you've got half an hour, you go online and you go through them. I found that better' <i>SCI7 [C5 Incomplete]</i></p>
Suggested changes	<p>'Obviously there was the telephone calls and emails [from the physio].....I don't know, whether there could be a box with your comments and then a box with your response, I don't know, a bit like internet banking I guess to say you have a messages box with feedback' <i>SCI23 [T7/8 Complete]</i></p>
Future plans	<p>'Yes, I did say I would like to keep going. I might not do it twice a week. But, some of the exercises I can do while I'm making the dinner' <i>SCI7 [C5 Incomplete]</i></p> <p>'For the next 2 months I'm going to keep using it then I'm going to ask my physio for a gym referral' <i>SCI8 [T6/7 Incomplete]</i></p>