Individuals with chronic low back pain have a lower level, and an altered pattern, of physical activity compared with matched controls: an observational study

Cormac G Ryan, P Margaret Grant, Philippa M Dall, Heather Gray, Mary Newton and Malcolm H Granat

Glasgow Caledonian University, UK

Question: Is there a difference in the level and pattern of free-living physical activity between individuals with chronic low back pain and matched controls? **Design**: Observational, cross-sectional study. **Participants**: Fifteen individuals with chronic low back pain and fifteen healthy controls matched for age, gender, and occupation. **Outcome measures**: Participants wore an activity monitor for seven days. Level of physical activity was measured as time standing and walking, and number of steps averaged over a 24-hour day (midnight to midnight), day time (9.00 am – 4.00 pm), and evening time (6.00 pm – 10.00 pm), and work days versus non-work days. Pattern of physical activity was measured as number of steps and cadence during short (< 20 continuous steps), moderate (20–100 continuous steps), long (> 100–499 continuous steps), and extra long walks (≥ 500 continuous steps). **Results**: Over an average 24-hour day, the chronic low back pain group spent 0.7 fewer hours (95% CI 0.3 to 1.1) walking, and took 3480 fewer steps (95% CI 1754 to 5207) than the healthy controls. They took 793 fewer steps/day (95% CI –4 to 1591) during moderate walks, and 1214 fewer steps/day (95% CI 425 to 2003) during long walks, and 11 fewer steps/min (95% CI 4 to 17) during extra long walks than the healthy controls. **Conclusion**: Individuals with chronic low back pain have a lower level, and an altered pattern, of physical activity compared with matched controls. **[Ryan CG, Grant PM, Dall PM, Gray H, Newton M, Granat MH (2009) Individuals with chronic low back pain have a lower level, and an altered pattern, of physical activity compared with matched controls: an observational study. *Australian Journal of Physiotherapy* 55: 53–58]**

Key words: Low back pain, Physical activity, Measurement, Matched pair analysis

Introduction

According to the fear-avoidance model of musculoskeletal pain, a person with chronic pain may avoid activities which they perceive could lead to further pain or reinjury (Leeuw et al 2007, Lethem et al 1983, Philips 1987). This, in turn, may lead to disuse, which has been described as performing at a reduced level of physical activity in everyday life (Verbunt et al 2003). Such disuse contributes to the pain experience, maintaining and/or exacerbating the condition (Verbunt et al 2003). It may be inferred from this model that individuals with chronic low back pain are less physically active than their healthy counterparts.

However, only a small number of studies have compared the level of physical activity in people with chronic low back pain with that of healthy controls using objective methods such as activity monitoring, and the findings are conflicting. Verbunt et al (2001) reported no difference in energy expenditure between people with chronic low back pain (n = 13) and matched controls (n = 13). In contrast, Spenkelink et al (2002) reported that people with chronic low back pain (n = 38) spent more time lying down during both the day and the evening, less time standing in the evening, and generally walked with a slower cadence than matched controls (n = 10). Van den Berg-Emons et al (2007) reported that people with chronic pain (n = 18), six of whom had back pain, spent less time sitting, more time lying down, and moved with a lower 'intensity' than matched controls (n = 18). All of these studies controlled for age and gender; however none adequately controlled for occupation, even though occupation has been shown to affect physical activity (Philippaerts and Lefevre 1998, Sallis et al 1985). Previous studies comparing the physical activity of individuals with chronic low back pain to matched controls concentrated more on level of physical activity than pattern of activity (Verbunt et al 2001), which may have left important differences undetected. Therefore the research question for this study was:

> Is there a difference in the level and pattern of physical activity between individuals with chronic low back pain and matched healthy controls?

Method

Design

In this cross sectional study, the physical activity of individuals with chronic low back pain and a group of matched healthy controls was compared. People with chronic low back pain were recruited from physiotherapy outpatient departments in Glasgow, Scotland, prior to receiving any intervention. They were then matched with healthy controls. Physical activity was measured using an activity monitor which was worn 24 hours/day for seven days. It was removed only during water-based activities. Participants were encouraged to carry out their daily activities as normal.

Table 1. Characteristics of each group of participants and difference between groups reported either as mean difference (95% CI) or odds ratio (95% CI).

Characteristic	Groups		Difference between groups
	Chronic low back pain (n = 15)	Healthy controls (n = 15)	Chronic low back pain minus healthy controls
Gender, n females (%)	12 (80)	12 (80)	OR 1.00 (0.17 to 5.98)
Employed, n (%)	11 (73)	11 (73)	OR 1.00 (0.20 to 5.04)
Age *(yr)*, mean (SD)	39 (11)	40 (11)	MD –1 (–3 to 1)
Height *(m)*, mean (SD)	1.69 (0.11)	1.66 (0.07)	MD 0.03 (–0.3 to 0.08)
Weight *(kg)*, mean (SD)	73.6 (9.6)	67.4 (14.4)	MD 6.2 (–1.1 to 13.5)
BMI *(kg/m^2)*, mean (SD)	25.7 (2.3)	24.2 (3.3)	MD 1.5 (–0.8 to 3.7)
Duration of pain *(yr)*, mean (SD)	8.2 (8.3)	n/a	n/a
Pain intensity *(0 to 100)*, mean (SD)	31 (18)	n/a	n/a
RMDQ *(0 to 24),* med (IQR)	8 (6)	n/a	n/a

RMDQ = Roland Morris Disability Questionnaire, n/a = non applicable

Table 2. Matching of participants for occupation and physical demand.

Occupation		Physical demand	
Chronic low back pain	Healthy controls	Chronic low back pain	Healthy controls
Secretary	Secretary	S	S
Day nurse	Physiotherapist	M	M
Housewife	Housewife	L	L
NHS Interpreter (PT 20hrs)	Clerical Assistant (PT 18hrs)	S	S
Beautician	Hairdresser	L	L
Employee trainer*	Administration assistant	S	S
Student	Student	n/a	n/a
Stock broker	Architect	S	L
Student	Student	n/a	n/a
Building labourer	Agricultural labourer	H	H
Housewife	Housewife	L	L
Housewife	Housewife	L	L
Housewife	Housewife	L	L
Teacher	Lecturer	L	L
Student	Student	n/a	n/a

PT = part time. S = sedentary, L = light, M = medium, H = heavy, V = very heavy work. * 'Employee trainer' was not an option in the Dictionary of Occupational Titles (DOT) thus based on the demands of the job described by the participant (mostly administrative and office related), the job was categorised by the researcher as sedentary. While pair eight differed by one category on the DOT, the description of the jobs provided by the participants provided a reasonable rationale to compare the participants. n/a = non applicable: There was no DOT category for the occupation of student.

Participants

The inclusion criteria for individuals with chronic low back pain were: age 18–65 years and non-specific low back pain for greater than three months duration. They were excluded if they had non-back related musculoskeletal problems which could affect physical activity or a history of spinal surgery. A group of healthy participants, with no history of back pain in the past six months (Spenkelink et al 2002), were recruited as controls. The healthy participants were individually matched to the chronic low back pain participants for gender, age (± 5years), and occupation. Occupational status was matched using the physical demands category of the Dictionary of Occupation Titles (National Academy of Sciences 2003). This is a system which categorises occupation types based upon different rationales such as the physical demands of the job. Demographic characteristics (gender, age, employment status, height, weight, and body mass index) were collected for all participants. The participants with chronic low back pain reported the duration of their symptoms and completed the Roland Morris Disability Questionnaire, a validated measure of activity limitations (Roland and Fairbank 2000, Roland and Morris 1983), and a pain diary (Frost et al 1995, Jensen and McFarland 1993).

Measurement of physical activity

Physical activity was measured using the activPAL™ monitor[a]. The activPAL™ is a small (53 x 35 x 7 mm), lightweight (20 g), single unit, accelerometer-based monitor which attaches to the front of the thigh using a double sided adhesive[b]. The monitor produces a signal related to the inclination and movement of the thigh which is interpreted by algorithms using the proprietary software. The monitor records, on a second-by-second basis, the postures of sitting/lying, standing and walking, and also records the number of steps and cadence (steps/minute). The activPAL™ has been shown to be valid for measuring physical activity in healthy adults (Godfrey et al 2007, Grant et al 2006, Ryan et al

Table 3: Mean (SD) level of physical activity over an average 24-hour day for each group and mean (95% CI) difference between groups.

Physical activity	Groups		Difference between groups
	Chronic low back pain (n = 15)	Healthy controls (n = 15)	Chronic low back pain minus healthy controls
Standing *(hr/day)*	3.6 (1.2)	3.9 (0.7)	–0.3 (–0.9 to 0.4)
Walking *(hr/day)*	2.2 (0.6)	2.9 (0.6)	–0.7 (–1.1 to –0.3)
Steps *(steps/day)*	8334 (2448)	11 818 (2160)	–3480 (–5207 to –1754)

Table 4. Mean (SD) level of physical activity for day-time versus evening-time on a work day and a non-work day for each group and mean (95% CI) difference within groups.

Physical activity	Groups				Difference within groups	
	Day time		Evening time		Evening time minus day time	
	Chronic low back pain (n = 15)	Healthy controls (n = 15)	Chronic low back pain (n = 15)	Healthy controls (n = 15)	Chronic low back pain (n = 15)	Healthy controls (n = 15)
Work day						
Walking *(min/hr)*	9 (3)	11 (4)	8 (3)	11 (3)	–2 (–3 to 0)	–0 (–4 to 3)
Steps *(steps/hr)*	613 (203)	800 (295)	477 (266)	845 (354)	–137 (–285 to 12)	45 (–264 to 354)
Non–work day						
Walking *(min/hr)*	10 (4)	13 (5)	6 (3)	8 (3)	–4 (–6 to –2)	–5 (–8 to –3)
Steps *(steps/hr)*	590 (327)	891 (400)	328 (158)	408 (195)	–262 (–452 to –73)	–483 (–648 to –319)

2006) and individuals with chronic low back pain (Ryan et al 2008).

Level of physical activity was measured as time in standing and walking, and number of steps. These were calculated for the following time periods: 24-hour day (midnight to midnight), day time (9.00 am – 4.00 pm), and evening time (6.00 pm – 10.00 pm) (Spenkelink et al 2002). The week's activity was separated into work days and non-work days. Work days were defined as a day on which some form of paid employment occurred; non-work days were defined as a day on which no paid employment occurred. For those who were not in paid employment, a week day was considered as a work day and a weekend day was considered a non-work day.

Pattern of physical activity was measured as number of steps and cadence during short (< 20 continuous steps), moderate (20–100 continuous steps), long (> 100–499 continuous steps), and extra long walks (≥ 500 continuous steps). These categories were modified from previous research (Clarke-Moloney et al 2007, Eifell et al 2006).

Data analysis

Outcomes are presented as mean (SD) and the comparisons between groups presented as mean difference (95% CI). Statistical significance was determined using multivariate t-tests (Manly 2005). In the event of a significant multivariate t-test, post hoc paired t-tests were performed. The significance level was set at $p = 0.05$.

Results

Participants

Fifteen people with chronic low back pain were recruited. The characteristics of each group are presented in Table 1 and the lack of difference between them suggests that the groups were well matched for gender, employment, age, height, weight and BMI. The occupation and its physical demand for each participant are presented in Table 2 showing that the two groups were well matched for occupation.

Level of physical activity

Over an average 24-hour day, the chronic low back pain group spent 0.7 fewer hours (95% CI 0.3 to 1.1, $p < 0.01$) walking and took 3480 fewer steps (95% CI 1754 to 5207, $p < 0.01$) than the healthy controls. There was no difference between groups for time spent standing (Table 3).

On an average work day, the chronic low back pain group took 137 fewer steps/hr (95% CI 12 to 285) during the evening time than the day time, whereas the healthy controls took the same number. On an average non-work day, the chronic low back pain group took 262 fewer steps/hr (95% CI 73 to 452) during the evening time than the day time compared with the healthy controls who took 483 fewer steps/hr (95% CI 319 to 648) (Table 4).

On an average work day, the chronic low back pain group spent 2 fewer min/hr walking (95% CI 0 to 3) during the evening time than the day time, whereas the healthy controls

Table 5. Mean (SD) level of physical activity for day time and evening time on a work day and a non-work day for each group and mean (95% CI) difference between groups.

Physical activity	Groups		Difference between groups
	Chronic low back pain (n = 15)	Healthy controls (n = 15)	Chronic low back pain minus healthy controls
Day time work day			
Walking (min/hr)	9 (3)	11 (4)	–2 (–5 to –0)
Steps (steps/hr)	613 (203)	800 (295)	–187 (–371 to –2)
Evening time work day			
Walking (min/hr)	8 (3)	11 (3)	–4 (–7 to –1)
Steps (steps/hr)	477 (266)	845 (354)	–368 (–630 to –107)
Day time non-work day			
Walking (min/hr)	10 (4)	13 (5)	–3 (–7 to 0)
Steps (steps/hr)	590 (327)	891 (400)	–301 (582 to –20)
Evening time non-work day			
Walking (min/hr)	6 (3)	8 (3)	–2 (–4 to 0)
Steps (steps/hr)	328 (158)	408 (195)	–80 (–204 to 43)

Table 6. Mean (SD) pattern of physical activity during different length walks over an average 24-hour day for each group and mean (95% CI) difference between groups.

Walks	Groups		Difference between groups
	Chronic low back pain (n = 15)	Healthy controls (n = 15)	Chronic low back pain minus healthy controls
Short (< 20 steps)			
Steps *(steps/day)*	1294 (428)	1368 (344)	–70 (–350 to 210)
Cadence *(steps/min)*	49 (4)	48 (3)	1 (–2 to 4)
Moderate (20–100 steps)			
Steps *(steps/day)*	2830 (1178)	3623 (1015)	–793 (–1591 to 4)
Cadence *(steps/min)*	61 (7)	63 (3)	–2 (–5 to 2)
Long (100–499 steps)			
Steps *(steps/day)*	2046 (914)	3260 (997)	–1214 (–2003 to –425)
Cadence *(steps/min)*	85 (9)	87 (8)	–2 (–8 to 3)
Extra long (≥ 500 steps)			
Steps *(steps/day)*	2165 (2527)	3566 (1446)	–1401 (–3021 to 219)
Cadence *(steps/min)*	103 (10)	113 (13)	–11 (–17 to –4)

spent the same amount of time. On an average non-work day, the chronic low back pain group spent 4 fewer min/hr walking (95% CI 2 to 6) during the evening time than the day time compared with the healthy controls who spent 5 fewer min/hr walking (95% CI 3 to 8) (Table 4).

During the day time on an average work day, the chronic low back pain group spent 2 fewer min/hr walking (95% CI 0 to 5) and took 187 fewer steps/hr (95% CI 2 to 371) than the healthy controls. Likewise, during the evening time on an average work day, the chronic low back pain group spent 4 fewer min/hr walking (95% CI 1 to 7) and took 368 fewer steps/hr (95% CI 107 to 630) than the healthy controls. In general, on an average non-work day, the chronic low back pain group did not take fewer steps than the healthy controls (Table 5).

Pattern of physical activity

Over an average 24-hour day, the chronic low back pain group took 793 fewer steps/day (95% CI –4 to 1591) during moderate walks, and 1214 fewer steps/day (95% CI 425 to 2,003) during long walks than the healthy controls. They also took 11 fewer steps/min (95% CI 4 to 17) during extra long walks than the healthy controls (Table 6).

Discussion

This study found that individuals with chronic low back pain had a lower level of physical activity than age-, gender-, and occupation-matched controls over a mean 24-hour day. They took 29% fewer steps than their healthy counterparts. These findings conflict with previous research which has identified either no difference in level of physical activity (Verbunt et al 2001) or differences of a smaller magnitude (14–17%) (Spenkelink et al 2002, van den Berg-Emons et al 2007). Differences in method between the studies may account for the conflicting findings. The aspects of physical activity measured in the current study (eg, time standing and walking as well as number of steps) differ from those reported in other studies (Spenkelink et al 2002, Verbunt et al 2001, Van den Berg-Emons et al 2007). Furthermore, the current study collected data over a one-week period while some previous studies have only collected data over a single day (Spenkelink et al 2002, van den Berg-Emons et al 2007).

A recent longitudinal study (Bousema et al 2007) followed a group of 106 individuals with subacute low back pain and found that half of the group that still had back pain one year later had lower levels of activity, whilst the other half had higher levels of activity. The authors argued that these findings questioned the existence of disuse in this patient group. Bousema et al (2007) compared level of activity between subacute and chronic low back pain, for the same individual. Despite its commendable longitudinal design, whether physical activity levels are higher during the subacute or chronic pain period does not answer the question of whether disuse exists, since at both stages of the condition, each individual may have had a lower or higher level of physical activity compared with the period prior to pain onset.

When the week's level of physical activity was divided into a work and non-work day, and day time versus evening time, a pattern emerged which is best illustrated by the number of step taken per day. During the day time on an average work day, the chronic low back pain group took 23% fewer steps than the control group. On an average work day, the chronic low back pain group took fewer steps per hour in the evening compared with the day time, whereas the healthy controls took much the same number of steps. This finding supports previous research by Spenkelink et al (2002) who reported that evening time was the period when people with chronic low back pain had the greatest decrease in level of physical activity compared with healthy controls. Spenkelink et al (2002) proposed that the lower level of physical activity in the evening time suggested that the chronic low back pain participants used up all their physical resources during the day time to complete their activities of daily living and as a result had a lower capacity to be active during the evening-time.

The chronic low back pain group took fewer steps over an average 24-hour day. This was due primarily to their taking fewer steps during moderate and long walks. That is, not only did individuals with chronic low back pain take fewer steps in total but the manner in which they accumulated those steps was different. This pattern is similar to previous research comparing patients with venous leg ulceration with healthy controls (Clarke-Moloney et al 2007). Furthermore, the chronic low back pain group walked with a slower cadence during extra long walks than their matched counterparts. This finding is in line with previous research which found that people with chronic pain move with less 'intensity' than healthy controls (van den Berg-Emons et al 2007).

This study has found evidence of a lower level and an altered pattern of physical activity in individuals with chronic low back pain compared with matched controls. This could be interpreted as support for the existence of disuse in this condition which fits with the fear-avoidance model of chronic pain (Leeuw et al 2007). Over an average 24-hour day, the magnitude of the difference was as much as 29%. Currently, there is no consensus as to what constitutes a clinically-important decrease in level of physical activity. Van den Berg-Emons et al (2007) questioned whether 14% was important when compared with decreases of 60–70% found in individuals with conditions such as heart disease and spinal cord injury. Further work is required to establish a clinically-important decrease in physical activity for individuals with chronic low back pain.

The primary limitation of this study is its cross-sectional study design, thus no inferences about cause and effect can be made. The small sample size may have resulted in the study being underpowered and some real differences between groups not being identified. However, the sample size was similar to previous research in the area (Verbunt et al 2001, van den Berg-Emons et al 2007). It was assumed that the disability and pain levels in the control group were zero; however it may have been advisable to have asked the controls to complete the relevant questionnaires.

In conclusion, people with chronic low back pain have a lower level and pattern of physical activity compared to age-, gender-, and occupation-matched controls. The magnitude of the decrease was as large as 44% (steps/hr during evening time on a work day). The chronic low back pain group took fewer steps during moderate and long walks and walked with a slower cadence during extra long walks. ■

Footnote: [a]PAL Technologies Ltd; Glasgow, Scotland, [b]Palstickies™, PAL Technologies

Ethics: The Greater Glasgow National Health Service Research and Ethics Committee and the Glasgow Caledonian University, School of Health and Social Care Research and Ethics Committee approved this study. All participants gave informed consent before data collection.

Competing interests: Professor Malcolm Granat is a co-inventor of the *activ*PAL™ physical activity monitor and a director of PALtechnologies Ltd. The remaining authors declare no competing interests.

Support: This study was funded by the School of Health and Social Care of Glasgow Caledonian University, and no financial support was received from any commercial company.

Acknowledgements: The authors would like to thank the physiotherapists who assisted with the recruitment of participants for this study.

Correspondence: Dr Cormac Ryan, School of Health and Social Care, Glasgow Caledonian University, UK. Email: Cormac.ryan@gcal.ac.uk

References

Bousema EJ, Verbunt JA, Seelen HAM, Vlaeyen JWS, Knottnerus JA (2007) Disuse and physical deconditioning in the first year after the onset of back pain. *Pain* 130: 279–286.

Clarke-Moloney M, Godfrey A, O'Connor V, Meagher H, Burke PE, Kavanagh EG, Grace PA, Lyons GM (2007) Mobility in patients with venous leg ulceration. *European Journal of Vascular and Endovascular Surgery* 33: 488–493.

Eifell RK, Ashour HY, Heslop PS, Walker DJ, Lees TA (2006) Association of 24-hour activity levels with the clinical severity of chronic venous disease. *Journal of Vascular Surgery* 44: 580–587.

Frost H, Klaber Moffett JA, Moser JS, Fairbank JC (1995) Randomised controlled trial for evaluation of fitness program for patients with chronic low back pain *British Medical Journal* 310: 151–154.

Godfrey A, Culhane KM, Lyons GM (2007) Comparison of the performance of the activPAL Professional physical activity logger to a discrete accelerometer–based activity monitor. *Medical Engineering and Physics* 29: 930–934.

Grant PM, Ryan CG, Tigbe WW, Granat MH (2006) The validation of a novel activity monitor in the measurement of posture and motion during everyday activities. *British Journal of Sports Medicine* 40: 992–997.

Jensen MP, McFarland CA (1993) Increasing the reliability and validity of pain intensity measurement in chronic pain patients. *Pain* 55: 195–203.

Leeuw M, Goossens ME, Linton SJ, Crombez G, Boersma K, Vlaeyen JW (2007) The fear-avoidance model of musculoskeletal pain: current state of scientific evidence. *Journal of Behavioral Medicine* 30: 77–94.

Lethem J, Slade PD, Troup JD, Bentley G (1983) Outline of a Fear-Avoidance Model of exaggerated pain perception–-I. *Behaviour Research and Therapy* 21: 401–408.

Manly B (2004) Multivariate statistical methods: a primer (3rd edn). USA: Chapman and Hall.

National Academy of Sciences, Committee on Occupational Classification and Analysis (2003) *Dictionary of occupational titles (DOT): part 1–current population survey, April 1971, augmented with DOT characteristics, and part II–categories.* www.occupationalinfo.org/ [Accessed 21/12/2007].

Philippaerts RM, Lefevre J (1998) Reliability and validity of three physical activity questionnaires in Flemish males. *American Journal of Epidemiology* 147: 982–990.

Philips HC (1987) Avoidance behaviour and its role in sustaining chronic pain. *Behaviour Research and Therapy* 25: 273–279.

Roland M, Fairbank J (2000) The Roland-Morris Disability Questionnaire and the Oswestry Disability Questionnaire. *Spine* 25: 3115–3124.

Roland M, Morris R (1983) A study of the natural history of back pain. Part I: development of a reliable and sensitive measure of disability in low-back pain. *Spine* 8: 141–144.

Ryan CG, Grant PM, Gray H, Newton M, Granat MH (2008) Measuring postural physical activity in people with chronic low back pain. *Journal of Back and Musculoskeletal Rehabilitation* 21: 43–50.

Ryan CG, Grant PM, Tigbe WW, Granat MH (2006) The validity and reliability of a novel activity monitor as a measure of walking. *British Journal of Sports Medicine* 40: 779–784.

Sallis JF, Haskell WL, Wood PD, Fortmann SP, Rogers T, Blair SN, Paffenbarger RS (1985) Physical activity assessment methodology in the Five-City Project. *American Journal of Epidemiology* 121: 91–106.

Spenkelink CD, Hutten MM, Hermens HJ Greitemann BO (2002) Assessment of activities of daily living with an ambulatory monitoring system: a comparative study in patients with chronic low back pain and nonsymptomatic controls. *Clinical Rehabilitation* 16: 16–26.

Van den Berg–Emons RJ, Schasfoort FC, de Vos LA, Bussmann JB, Stam HJ (2007) Impact of chronic pain on everyday physical activity. *European Journal of Pain* 11: 587–593.

Verbunt JA, Seelen HA, Vlaeyen JW, van de Heijden GJ, Heuts PH, Pons K, Knottnerus JA (2003) Disuse and deconditioning in chronic low back pain: concepts and hypotheses on contributing mechanisms. *European Journal of Pain* 7: 9–21.

Verbunt JA, Westerterp KR, van der Heijden GJ, Seelen HA, Vlaeyen JW, Knottnerus JA (2001) Physical activity in daily life in patients with chronic low back pain. *Archives of Physical Medicine and Rehabilitation* 82: 726–730.