Paraplegia

The Weight-bearing Upper Extremity in Women with Long Term Paraplegia

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Summary

Bilateral upper limb pain, isokinetic strength, grip strength, range of motion, and activities of daily living (ADL) performance were compared in 11 women with long term paraplegia and 11 activity-level matched able-bodied women of similar age, to determine whether long term wheelchair use is associated with pain and altered function in the upper extremities. The results suggest that the development of pain in the upper limbs is clearly associated with paraplegia in women ($p < 0.01$). Pain was reported most frequently by the paraplegics in the shoulders and secondly in the wrists and hands. ADL where the paraplegics experienced pain most often were work/school, outdoor wheeling, household work/childcare, and loading the wheelchair to and from the car. Whilst paraplegics reported intermittent rather than constant pain, the groups' relatively young age (mean = 43 years) and average duration of injury of only 15 years suggests that preventative and management steps are required to ensure continued independence and quality of life of this group as they age.

Key words: Spinal cord injury; Activities of daily living; Aging; Upper extremity pains.

As a result of improved technology and health care, the survival rate of persons sustaining a major spinal cord injury (SCI) has increased and the life expectancy of those with paraplegia is now close to that of the able bodied population (Trieschmann, 1987). Society's improved awareness of the capabilities and needs of the disabled has removed many physical and attitudinal barriers and has in its turn often created new expectations for this group. More options are now available, and most paraplegics achieve independent and very active life roles including employer, employee, parent, homemaker, and athlete. Maintenance of the high levels of independence normally attained by paraplegics hinges on the integrity of their upper limbs. Life in a wheelchair, including wheeling and repeated lifting of body weight during transfers, places great demands on the bones, joints, and soft

tissues of the upper extremities that exceeds those of able-bodied persons. The focus of rehabilitation and research has traditionally been on the acute restorative and early post-discharge phases of care. Now, as more paraplegics are surviving into later life, a new set of problems have arisen as aging is superimposed on pre-existing disability.

Occupational and sport related overuse conditions have received considerable attention in the literature. There are few studies that examine changes in arm function and the development of overuse related upper limb pathology in long term wheelchair and crutch users. These studies tend to focus on the shoulders or wrists and hands, and the majority report on the diagnoses and prevalence of upper limb pain and degeneration in these areas. A variety of methodologies have been used to study this problem; ranging from mailed questionnaires to interviews and invasive diagnostic procedures.

The earliest studies that investigated upper limb pain secondary to long term mobility aid use were based on questionnaires (Nichols *et al.*, 1979) and interviews (Blankstein *et al.*, 1985; Gellman *et al.*, 1984) administered to 517, 50, and 85 long term crutch and wheelchair using subjects respectively. They showed that these individuals are predisposed toward developing upper extremity problems, particularly in the shoulders. However, there are large discrepancies in the reported prevalences of upper limb pain. These differences are likely a reflection of the heterogeneity and variety of the samples used, which also makes the results difficult to compare. The samples vary in age, gender, duration of injury, diagnosis or lesion level, and method of mobility. These are all potential prognostic variables in the study of the development of overuse related musculoskeletal degeneration in the upper limbs.

Bayley *et al.*, (1987) used a more comprehensive two phase method to study the prevalence and patterns of shoulder problems in 94 SCI wheelchair using persons (gender not specified) including subjects with low cervical lesions. They first asked subjects to perform a wheelchair to bed transfer. Those who reported shoulder pain (30%) during the transfer were subsequently assessed using plain radiographs and arthrograms. The three most common diagnoses were impingement with subacromial bursitis (24%), rotator cuff tear (16%), and avascular necrosis (5%). Average times of onset for these conditions ranged from 12 to 19 years post SCI. The authors noted that the majority of the problems were soft tissue rather than bone related. In their sample, pain on transfer was more likely to be experienced by higher lesion subjects. They found no significant difference in duration of SCI between those with or without shoulder pain. Unlike the previous studies, Bayley *et al.* (1987) did select only wheelchair users, however, their definition of paraplegia is unclear since the sample included low cervical lesions. Upper limb function is already altered in these subjects and their methods of performing activities of daily living (ADL), and often their overall activity-levels, differ from paraplegics who have intact upper limbs. This in turn creates different stresses on the arms and the two groups would be better studied separately.

Wylie and Chakera (1988) examined the problem of shoulder degeneration in the SCI from yet another perspective. As part of a larger investigation of joint abnormalities, they reviewed routine radiographs to assess shoulder degeneration in 38 subjects with SCI of greater than 20 years duration. The sample included a mixture of gender and lesion levels (33% cervical) but no information was provided as to

subjects' usual mobility or transfer methods. There was radiographic evidence of early degeneration at the shoulder in 18%, and moderate to severe degeneration in 13% of the sample. Degeneration was not examined with respect to age, duration of injury, or lesion levels but pathology was more common in less active subjects. Based on these findings the authors suggested that activity appears to have a protective effect on the shoulder joint. Another explanation might be that previously active wheelchair users had reduced their activity level secondary to shoulder problems. Wylie and Chakera's (1988) results are difficult to compare with Bayley *et al.*'s (1987) due to the lack of information about their samples with respect to age, duration, lesion level, and criteria for radiographic evaluation.

There are three principle studies that examine wrist and hand problems which appear as secondary to longterm use of either wheelchair or crutches. (Aljure *et al.*, 1985; Blankstein *et al.*, 1985; Gellman *et al.*, 1988). They all showed an increasing incidence of hand and wrist pain and pathology, ranging from 48 to 63% of the subjects examined.

Attempts to explain the aetiology of shoulder, hand and wrist problems in wheelchair users have been reported in two studies. Bayley *et al.* (1987) suspected that intra-articular pressure increased greatly in the shoulder during wheelchair transfers. They measured intra-articular shoulder joint pressures in 5 pain-free SCI subjects. Pressures in the joints at rest ranged from 40 to 80 mmHg. During the weight bearing phase of transfers it increased up to 280 mmHg. The authors believed that this stress on the joint contributes to the development of shoulder problems in wheelchair users. The effects of raised pressures on internal structures secondary to weight-bearing was also studied by Gellman *et al.* (1988); this time in the carpal tunnel. They attempted to determine to which extent increased carpal tunnel pressure or repetitive median nerve trauma precipitate carpal tunnel syndrome in paraplegics. Invasive testing was conducted to compare pressure in the carpal tunnels of 8 symptomatic and 10 asymptomatic subjects during various wrist movements. Those with CTS had greater pressure than the asymptomatic group during neutral and flexed wrist postures and when lifting the body weight onto the hands, but no tests for significance were reported. The authors concluded that CTS occurs in paraplegics as a result of repetitive trauma from wheelchair use and ischaemia secondary to repetitive rather than chronic increases in pressure in the carpal tunnel.

The research to date suggests that mobility-aid users are predisposed to developing upper extremity pain and pathology over time. However, the variety of sampling methods utilised in the various studies make many of their results difficult to interpret. Many studies are based on data collected from both wheelchair and crutch-users and a variety of diagnostic groups such as cervical and lumbar level spinal cord injured. Upper limb muscle balance and function, activity level, ADL methods, and resultant joint stresses differ significantly between these two groups, and they should be investigated separately for the development of overuse related upper limb pathology.

Studies in the literature report the prevalence of arm pain by anatomical location, duration of wheelchair or crutch-use, and occasionally by diagnosis. Whether upper limb pain prevalence rates in wheelchair users differs from those in an able-bodied referent group would help clinicians to understand if the changes are unusual, particularly in relation to age and activity-level. An appreciation of the

extent to which this pain interferes with usual ADL performance would be of use for treatment and long term service delivery planning for this group.

In the United States, women account for 18% of SCI (Stover and Fine, 1986). Data compiled by Young in 1977 indicated that 54% of the womens' injuries result in paraplegia. Despite the relatively large body of literature on spinal cord injuries, both Trieschmann (1987) and Crisp (1989) noted that the majority of the research is based on male dominated samples; probably a reflection of the difference in gender-specific SCI incidence rates. It is not surprising then, that research into wheelchair and crutch-use related upper limb deterioration has also been based almost solely on the study of men. Men and women differ anthropometrically, and in terms of upper limb strength, activity level, and usual daily tasks, and findings based on the study of the upper extremities in males should not be generalised to women. Since no studies were located that examine changes in women's arms secondary to long term wheelchair use, we decided to examine upper extremity function specifically in this group.

This study was designed to compare upper limb function and pain in wheelchair-using women with paraplegia to an age, gender, and activity-level matched reference cohort. The impact of arm pain on the performance of usual daily living activities was assessed in the paraplegic group.

Materials and methods

The study was conducted in Perth, Western Australia. Eleven otherwise healthy women with complete, traumatic paraplegia and living in the community were matched by age, size, and activity level with 11 able-bodied women. The sample is described in Table 1. Informed consent and medical clearance were obtained.

The paraplegics indicated that they performed an average of 22 transfers per day (range 6–32). None transferred on and off the floor on a regular basis, and all used shower chairs when bathing, rather than transferring to the bottom of a bathtub. The majority ($n=6$) reported that they usually transferred with their palms down and wrists extended rather than on their fists with the wrist in neutral ($n=3$). Three others stated they used both methods equally. Nine of the women classified their usual wheeling as mainly indoors, with occasional short distances outdoors. Two indicated their wheeling was both indoors and outdoors 2 to 3 city blocks, but

Table 1 Description of the sample

	Paraplegic	Able-bodied
Age Mean years (1 S.D.)	42.9 (9.6)	42.8 (11.3)
No. employed outside home	4	9
No. with children	8	9
No. living with partner	5	9
Weight Mean kg. (1 S.D.)	64.5 (12.5)	62.6 (8.5)
Duration of spinal cord injury (SCI) in years (1 S.D.)	15.2 (4.3)	
Range of SCI duration (years)	5–21	
Lesion Levels T1–T5	1	
T6–T10	2	
T11–L3	8	

(N=11 Pairs)

not long distances or over rough terrain. Seven of the SCI women reported that they perform the majority of the household tasks where they live, two share these equally with another, and one performs minimal household duties.

The study assessed both physical and performance parameters of upper limb function. The physical parameters were measured bilaterally and included concentric isokinetic shoulder and elbow flexion/extension strength, and concentric and eccentric isokinetic shoulder adduction strength; grip strength; and active shoulder and elbow ranges of motion. All subjects were interviewed regarding past and present upper limb pain using a scheduled interview format. Upper limb performance parameters were measured by means of a questionnaire designed to determine the impact of upper limb pain on the paraplegics' performance of activities of daily living (ADL). The questionnaire was developed for this study since no instruments designed for this purpose could be found. The activities in the questionnaire were based on those listed in the Barthel Index (Mahoney and Barthel, 1965) and were modified to suit this population. Content and consensual validity were established during the development phase through consultation with clinicians, paraplegics, and researchers. ADL tasks included in the questionnaire are listed in Table III. Subjects were asked to use a 5 point Likert scale (never, rarely, sometimes, usually, always) to indicate how often they experienced arm pain when performing each activity.

Isokinetic strength was measured as average torque at 60°/s and 120°/s using the KIN/COM which is a hydraulic, microcomputer controlled dynamometer designed to resist concentric and eccentric muscle contractions. The movements tested were based on a review of the literature and activity analysis to determine the muscle groups most commonly used in the performance of ADL from a wheelchair. The protocol and subject stabilisation methods were developed specifically for this research since there was no literature found that described an upper limb isokinetic strength testing protocol for paraplegics. For this reason a separate study was conducted first to determine the test re-test reliability of each of the twelve test movements ($n=30$). Reliability was tested using Pearson's correlation coefficient (range $r=0.918-0.982$) and checked using a repeated measures ANOVA (Winer, 1970) which also produced very high reliability estimates (range $=0.921-0.982$).

Grip strength was measured as the peak of three maximal efforts using a Smedley's hand held dynamometer calibrated with standard weights. Test re-test reliability coefficients were calculated for peak and average grip strength ($n=30$), and they were found to be identical. Shoulder and elbow ranges of motion were measured using a clinical assessment method reported by Constant and Murley (1987). The anthropometric characteristics measured were body and arm length, and body weight, using scales built for the study and designed to weigh persons while seated in their wheelchairs (Kofsky *et al* 1984).

Data was collected from the paraplegic women during two sessions; a 1.5-hour interview in their own home, and a second 2 hour session at the Curtin University Exercise Science Laboratory. The purpose of the interview was to gather activity-history data and relevant demographic and ADL information. The questionnaires on upper limb pain and arm pain during ADL were completed. Upper extremity physical parameters were measured during the second session. The ADL questionnaires did not apply to the able-bodied women and this reduced their assessment time, making one measurement session feasible for this group.

Results

The proportions of the paraplegic and able-bodied groups that currently had pain in their arms were tested using McNemar's test for correlated samples. These results suggest that the development of pain in the upper extremity is clearly associated with paraplegia in women. ($P<0.01$). A comparison of the two groups' frequency of reported pain by anatomical region is shown in the Figure. Table II illustrates the comparison of the two groups' description of their upper limb pain in the last week, with respect to prevalence, frequency, and average intensity. Intensity of the pain was measured using a 10 point numerical rating scale. For each of the ADL activities the percentage of paraplegic women experiencing arm pain is presented and ranked in Table III.

Tabulation of the Likert scale scores for all activities (not shown) revealed that the majority of the arm pain reported during ADL (76.5%) was recorded in the 'rarely' or 'sometimes' categories, rather than 'usually' or 'always'. Only during outdoor wheeling did the majority of those reporting pain (63.0%) experience their pain 'usually' or 'always'.

Figure Frequency of reported arm pain for each group by anatomical region

Table II Comparison of upper limb pain experienced by the two groups in the past week

	Paraplegics			Able-bodied		
Shoulder (% with pain)	73			27		
Frequency (%)*	R=0	I=45	D=28	R=18	I=9	D=0
Average NRS**	3.75			1.6		
Elbow	9			27		
Frequency	R=0	I=0	D=9	R=9	I=18	D=0
Average NRS	3			2		
Wrist	55			18		
Frequency	R=9	I=46	D=0	R=9	I=9	D=0
Average NRS	4			1.5		
Hand	45			18		
Frequency	R=9	I=9	D=27	R=9	I=9	D=0
Average NRS	6			3		

*R=Rarely I=Intermittent D=Daily

**NRS=Numerical Rating Scale: 0=No pain, 10=Worst possible pain.

Table III Percentage of paraplegics with pain during activity

	% With Pain	Overall Rank
Mobility:		
Outdoor wheeling	89	2
Load Wheelchair to car	75	4
Bed transfers	73	5
Car transfers	64	8
Toilet transfers	55	9
Bath transfers	55	9
Indoor wheeling	55	9
Self-care:		
Reach & lift item down	82	3
Bowel & Bladder	55	9
Sleep	67	7
Dressing	45	10
Grooming	45	10
Bathing	36	11
General Activities:		
Work/school	100	1
Household work	82	3
Driving	70	6
Social outings	67	7
Hobby/sport	55	9

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Phrases commonly used by the paraplegics to describe their upper limb pain were 'nagging dull ache', 'burning ache deep in the joint', 'joint stiffness in the morning', joint 'tenderness' and 'crunching', 'sharp pain radiating down the arm', and joints (shoulders and wrists) feeling 'weak and giving way' under loads. Four of the subjects complained of numbness in the arms and hands at night that wakens them 2 to 3 times per week, and which can take up to 3 hours in the morning for full sensation to return. Three of the 11 stated they were unable to sleep on one or both sides due to shoulder pain. The general consensus seemed to be that the arm pain was worse in the winter months when it is cool and damp.

Paraplegic and able-bodied subjects' average isokinetic torque values for the shoulder and elbow muscles were compared using the Wilcoxon matched-paired test (alpha set @ 0.05). Significant differences were found for two of twelve muscle groups. Dominant shoulder flexion in the able-bodied women's group was stronger concentrically than in the paraplegic group ($p=0.03$). The paraplegics' elbow extensors were stronger bilaterally than those of the able-bodied group (dominant $p=0.005$, non-dominant $p=0.0454$). The average maximum dominant grip of the paraplegic women was 32.05 (1 S.D.=6.5) kg, and for the able-bodied women was 31.8 (1 S.D.=3.8) kg. Average paraplegic non-dominant maximum grip was 26.9 (1 S.D.=6.3) kg and for the able-bodied women was 28.8 (1 S.D.=3.1) kg. Results for the differences between the two groups for grip strength, the remaining iso-

kinetic tests, and range of motion were non-significant and thus failed to reject the null hypothesis. While the sample size was not large, the differences between the two groups for these variables were trivial and there was no indication to collect further data.

Discussion

Long term paraplegia in women appears to be associated with the development of upper extremity pain and discomfort, particularly in the joints of the upper limbs. In this study pain was described by the paraplegics as being most common in the shoulders (73%), and secondly in the wrists (55%) and hands (45%). Our finding that the paraplegic womens' dominant shoulder flexors were weaker than their able-bodied counterparts' may be explained by their higher pain levels about this joint. The findings of reported hand pain are consistent with those reported by Blankstein *et al.* (1985) in wheelchair and crutch users. Our study showed paraplegic women to report shoulder pain more often than the primarily male samples used in related research on wheelchair and crutch users (Nichols *et al.*, 1979; Bayley *et al.*, 1987; Gellman *et al.*, 1988). This may be due to sample differences in age, duration, and the fact that our study was restricted to wheelchair users. However, our results are based on women only; suggesting that gender may influence the development of shoulder pain in wheelchair users. This may be secondary to activity level, as the majority of our sample were homemakers and caring for small children; both activities involving stresses on the arms. Women in wheelchairs may also be at greater risk than men for the development of shoulder pain since their arms may not have been as conditioned to activity prior to injury, and therefore not as well prepared as mens' arms for the tasks associated with life in a wheelchair. Paraplegics reported pain least often in the elbows. Their significantly stronger elbow extension may exert a protective effect about this joint and may be due to a predominance of resisted elbow extension required during routine wheelchair activities.

The women in this study experienced arm pain during the majority of their mobility, self-care, and general activities, however the pain tended to be intermittent rather than constant. Pain during different types of transfers was reported by 55 to 73% of the women in this study, compared to Bayley *et al.*'s (1987) findings of 30% with shoulder pain during bed transfer. This difference may be explained by a combination of factors, including sample gender differences and the fact that Bayley *et al.* (1987) included cervical level lesions in their study. The most probable explanation is that the present study recorded complaints of pain anywhere in the arm, rather than just in the shoulder, and subjects were questioned about pain during four different types of transfer.

These women are relatively young (mean age 43 years), have been in wheelchairs an average of 15 years, and are already reporting marked levels of pain. This may be an indication of future and more serious upper limb problems. It was apparent from the interviews that while the paraplegic women were concerned about the future implications of the present pain in their arms, they lacked knowledge of how to prevent and manage strains and overuse. Information about preventative and alternative ADL methods would be most useful to them since they indicated that rest was not an option as it meant depending on others and curtailing rewarding

activities. The activities where this group reported upper limb pain the most were work, outdoor wheeling, household duties (including child care), and loading the wheelchair into and out of the car. These are activities allowing interaction in the community and are associated with roles that are important for independence and self-esteem. Increased upper limb pain would likely jeopardize independence in these activities first.

Conclusions

Paraplegic women's development of upper extremity problems secondary to years of wheelchair use is one of the late complications of long term disability that requires consideration. There appears to be a need for both preventative and management treatments. These include ensuring ergonomically designed environments and equipment for women in wheelchairs. Women with paraplegia are likely to benefit from education regarding joint protection as well as upper extremity conditioning techniques since strength in the muscles surrounding the joints is acknowledged as having a protective effect, particularly during unusual or sudden movements (Knight, 1980; Rowe, 1988). There is a need to educate this group regarding work simplification and alternative ADL methods to reduce heavy or repetitive stresses on their arms.

Further research necessary in this area includes the evaluation of overuse related upper limb pain in long term wheelchair using elderly persons and assessment of its impact on their ADL independence. Research into the ergonomics and the biomechanics of routine wheelchair tasks will assist toward eliminating the causes and mechanisms of upper limb injury resulting from long term wheelchair use. There is also a need to evaluate the effect of factors that may influence the development of wheelchair use related upper limb pain, such as activity-level, equipment, and physical environment.

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