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The effect of pre-injury physical fitness on the initial severity and recovery from whiplash injury, at six-month follow-up

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Objective: To evaluate the effect of pre-injury physical fitness on the initial severity and recovery of motor vehicle-induced neck injury (whiplash injury).
Design: A quantitative experimental design using both retrospective and prospective data.
Setting: Metropolitan Police physiotherapy and rehabilitation department in the UK.
Subjects: One-hundred and two patients with neck pain following whiplash injury.
Interventions: Patients were divided into three groups based on pre-injury physical fitness (low, medium and high). Recovery was compared between the three groups initially then again at three and six months.
Main measures: Three measurement scales were used: the Neck Disability Index, the Problem Percentage, and the Physical Activity Scale.
Results: Pre-injury physical fitness had a marked effect on recovery at three and six months, with the medium and high fitness groups having significantly better recovery than the low fitness group. At three months the Neck Disability Index score for the low fitness group was 12 compared with 7 and 7.5 for the medium and high fitness groups respectively ($P=0.009$). At six months the Neck Disability Index score was 9 for the low fitness group compared with 0 and 3 for the medium and high fitness groups ($P=0.002$). In addition, the return to work rate was almost twice as high for individuals with medium/high fitness.
Conclusion: Early recovery from whiplash injury was significantly more likely for individuals with medium to high levels of pre-injury physical fitness than for individuals with low levels of pre-injury physical fitness.

Introduction

The aim of this study was to evaluate the effect of pre-injury physical fitness on the initial severity and recovery of motor vehicle-induced neck injury (whiplash injury). Whiplash injury affects 250 000 people each year in the UK.[1,2] It is a disabling condition[3,4] which causes a wide range of symptoms.[5,6] There are considerable social costs, with 50% of sufferers requiring more than one month off work.[7] This adds to the injury-related costs, which have been calculated at around

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£10 000 (€14 700) per casualty.[8] This equates to a total annual whiplash-related cost of around £2.5 billion (€3.7 billion) per year in the UK alone. With such high costs, both in human and monetary terms, the importance of research into the condition is evident. It is of particular importance to identify factors that affect the severity and/or recovery of the condition[6,9] – as this could lead to the identification of preventative factors[10,11] and early identification of those at risk of delayed recovery.[12,13]

Physical fitness has not previously been studied with respect to severity and recovery of whiplash injury. However, a number of investigators have studied the relationship between aerobic fitness and injury during other activities. Several studies have linked low levels of aerobic fitness to injury in military recruits,[14–16] occupational settings[17,18] and sports/exercise.[19,20] In addition to injuries during physical activity low aerobic fitness is linked to increased risk of coronary artery disease,[21,22] high blood pressure,[23,24] diabetes[25] and stroke.[26] Low aerobic fitness has also been linked to increased incidence/severity of low back pain.[27] Overall there is a great deal of evidence linking low levels of aerobic fitness to increased incidence of various injuries and diseases. However only one study could be found which linked physical fitness to recovery from injury. Plugge[28] in a postal survey of 8889 randomly selected UK individuals found that subjects with high physical fitness were less likely to have long-standing disability following injury.

The main aim of the study was to determine the effect of pre-injury physical fitness on initial severity and recovery from whiplash injury at three and six months.

The secondary aim of the study was to determine the importance of pre-injury physical fitness as a predictor of recovery from whiplash injury.

Method

Background information

This study is part of an ongoing investigation which is looking at the effect of a range of physical factors, signs, symptoms and crash-related factors on the initial severity and recovery from whiplash injury. Follow-ups are to be made on a monthly basis for six months and then at 9, 12 and 24 months. A total of 35 factors are under investigation. This study concentrates on the effect of one factor, pre-injury physical fitness, on data obtained initially and at three month and six month post injury.

Subjects

Subjects for the study were drawn from individuals referred to the Metropolitan Police physiotherapy service. The physiotherapy service covers the whole of Greater London and serves a total of 41500 employees, almost half of whom are not police officers (civil staff). Civil staff are employed in a wide variety of occupations including clerical, medical, catering, maintenance and photography. As the study was derived from an occupational population, information on job types and activity levels has also been presented to allow comparison with other populations.

Ethics approval for the study was obtained from the Metropolitan Police Service Ethics Committee. Full, informed written consent was obtained from all participants.

Measurement methods

Two questionnaires were devised by the main researcher (MG) for use in the study: the initial questionnaire and the follow-up questionnaire. The initial questionnaire collected retrospective information about the injury and incorperated two measurement scales (the Problem Percentage and Physical Activity Scale, see next section). The follow-up questionnaire comprised two measurement scales (the Problem Percentage and Neck Disability Index, see next section) and was used prospectively at both three and six months. The questionnaires were developed in accordance with the guidelines presented in Portney and Watkins.[29] Content and face validity as well as general useability and clarity were reviewed by a panel of four individuals, including two physiotherapists, a physiotherapy manager and an administrative assistant. Following amendment, the questionnaires were pilot tested on a group of five whiplash patients for clarity and usability and again amended. Further information on the measurement scales follows.

The Neck Disability Index (Appendix 1) is a validated scale[30] used as a measure of neck function, which has been utilized in several previous studies on whiplash injury.[31–34] Due to the level of detail required by this questionnaire it was not suitable for retrospective use and therefore was not included on the initial questionnaire.

The Problem Percentage measures the overall problem caused by the neck and was used to measure initial severity and as an adjunct to the Neck Disability Index at three and six months. Further information about the Problem Percentage can be found in Appendix 2.

The Physical Activity Scale is a 0–8 scale which uses self-reported activity as an estimator of physical fitness. It was used on the initial questionnaire as a measure of subjects' pre-injury physical fitness. The Physical Activity Scale is primarily but not exclusively a measure of aerobic fitness. Further information about the Physical Activity Scale can be found in Appendix 3.

Procedure

All individuals referred to one of the Metropolitan Police Physiotherapy Departments for treatment who met the initial inclusion criteria were asked if they wished to participate by the treating physiotherapist. The inclusion criteria were:

1) Occupant of a motor vehicle (car, van or lorry, but not motorcycle) which was involved in road traffic accident within the three months prior to initial appointment, in which they sustained a neck injury.
2) Not received any other treatment prior to referral other than at A&E or GP consultation.

When the patient attended for treatment they were given an information sheet and consent form. Those who chose to participate signed the consent form and completed the initial questionnaire. Any subject who initially or at a later date fell into the exclusion criteria was removed from the study. The exclusion criteria were:

1) Fracture/dislocation of the cervical spine or related area.
2) Significant injury to a related area, e.g. thoracic spine fracture, shoulder injury (where this was likely to affect neck recovery or obscure symptoms arising from the neck).
3) A medical condition was present that was likely to exacerbate the problem or prevent treatment (i.e. rheumatological or neurological conditions and osteoporosis).
4) Subject unable to recall the required information.

A flow diagram of the overall study procedure is shown in Figure 1.

The initial questionnaire collected retrospective information about the injury, and included the Physical Activity Scale and the Problem Percentage. Once completed, the questionnaires were mailed by the treating physiotherapist to the main researcher (MG). Follow-up questionnaires were mailed to the subjects' home addresses one week prior to the assigned follow-up date, with instructions to complete them on or as close to the follow-up date as possible. A self-addressed envelope was enclosed for return. Follow-up questionnaires included the Problem Percentage and Neck Disability Index which were used as measures of the subjects' current neck severity.

The Neck Disability Index was also used to determine functional recovery, which can be defined as return to normal function but without complete absence of symptoms. This equates to a Neck Disability Index score of 2 or less for headache and 1 or less for all other components (see Appendix 1). Sterling *et al.*[32,33] used a similar method of determining recovery.

Statistical analysis

The information from the three questionnaires was analysed using SPSS version 10 (SPSS Inc., Illinois, USA). To determine if the population could be considered homogeneous two statistical comparisons were made, between police officers and civil staff and between police officers injured during standard driving as compared to blue light call. Blue light call is the term used in the police service for high-speed driving where flashing blue lights and sirens are used. The main analysis employed the Kruskal–Wallis test to determine

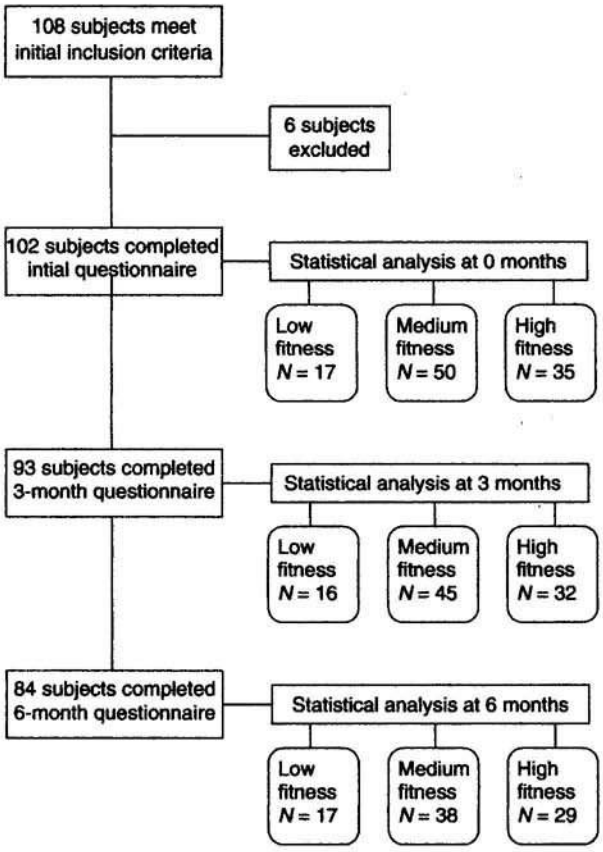

Figure 1 Study procedure flow diagram.

the effect of pre-injury physical fitness on recovery by dividing subjects into three fitness groups depending on their score on the Physical Activity Scale, low (0–2), medium (3–6) and high (7–8). Within-group comparisons were made using the multiple comparison test.[35] Functional recovery was evaluated using chi-square test. Finally, sensitivity and specificity was used to discover the importance of physical fitness as a predictor of failure to recover from whiplash injury. All tests used were non-parametric with the level of significance set at the standard 5% level.

Results

A total of 108 subjects met the initial inclusion criteria and were enrolled in the study. Of these, six subjects were excluded (Table 1), leaving 102 subjects who completed the initial questionnaire. The retention rate at three months was 91% (93 of 102) and at six months was 82% (84 of 102).

Of the initial 102 patients, 35 were female and 67 were male. The mean age was 34 years (SD 7, range 19–51). Eighty-seven of the subjects were employed as police officers and 15 were civil staff. Both the police officers and the civil staff were employed in a wide range of different jobs with activity levels that varied from sedentary to active. To further quantify activity levels, 41 members of staff were surveyed (22 police officers and 19 civil staff). They were asked to rate their work activity levels as either sedentary, sedentary/active or active. Police officers described themselves as sedentary 22.5% of the time,

Table 1 Subjects excluded from the study with reasons

Subject number	Gender	Age	Exclusion number	Details
008	F	37	Exclusion 2	An acromio-clavicular joint injury was found which caused referred symptoms into the neck
043	M	30	Exclusion 2	Patient was under investigation for a head injury causing worsening symptoms
046	F	19	Exclusion 3	Diagnosed possible myalgic encephalomyelitis (chronic fatigue syndrome)
055	M	44	Exclusion 3	Diagnosed sarcoidosis
063	M	27	Exclusion 2	Shoulder problem causing possible referral of symptoms into the arm
108	M	34	Exclusion 2	Diagnosed acute reactive calcific tendonitis causing symptoms in the shoulder and arm

Table 2 Job examples by activity level for police officers and civil staff

Activity level	Staff type	Job example
Sedentary	Police officer	Telephone reporting unit
Sedentary	Civil staff	Personnel officer
Sed/active	Police officer	Uniformed police officer
Sed/active	Civil staff	Physiotherapist
Active	Police officer	Police dog handler
Active	Civil staff	Method of entry instructor[a]

[a]Provide instruction on methods of forced entry into buildings.

sedentary/active 55% of the time and active 22.5% of the time. Civil staff were sedentary 79% of the time, sedentary/active 16% of the time and active 5% of the time. For examples of different jobs for both police officers and civil staff see Table 2.

No significant differences were found in initial severity or in recovery between police officers and civil staff or between police officers injured in a blue light call and those injured during normal driving. These groups were therefore amalgamated for the main part of the analysis.

No significant differences were found between the three physical fitness groups at 0 months. However, significant differences were found in the Neck Disability Index and the problem percentage scores at both three and six months (Table 3). The multiple comparison tests revealed that the medium and high fitness groups had significantly better recovery at both three and six months than the low fitness group, but that there was no significant difference in three- or six-month recovery between the medium and high fitness groups.

Table 4 shows the comparison of the three fitness groups at three and six months for presence or absence of functional recovery. Functional recovery was significantly better for the medium and high fitness groups than for the low fitness group at both follow-ups (three months: $\chi^2 = 14.277$; df $= 2$; $P = 0.001$; six months: $\chi^2 = 12.707$; df $= 2$; $P = 0.002$).

Table 5 demonstrates the effect of Physical Activity Scale score on the Neck Disability Index at three and six months. As fitness level increases, the Neck Disability Index score decreases (fewer symptoms). Recovery is best at level 6 with symptoms increasing slightly at levels 7 and 8.

Table 6 shows the return to 'usual work', rate for the three fitness groups at three and six months post injury. It should be noted that in most cases subjects had returned to reduced work activities prior to this.

The sensitivity (SE) and specificity (SP) of low physical fitness to predict failure to functionally recover at three months was SE: 30%, SP: 100%, and at six months SE: 44%, SP: 90%.

Table 3 Effect of level of pre-injury physical fitness on recovery at zero, three and six months

	Low fitness			Medium fitness			High fitness			Kruskal–Wallis
	n	Median	SIQR	*N*	Median	SIQR	*n*	Median	SIQR	*P*-value
Problem percentage at 0 months	17	40	22.5	50	40	13.8	35	35	15.0	0.889
Problem percentage at 3 months	16	80	13.1	45	90	9.5	32	95	5.0	0.013*
Problem percentage at 6 months	17	90	11.8	38	99	2.5	29	99	3.8	0.004*
NDI at 3 months	16	12	4.0	45	7	4.8	32	7.5	4.9	0.009*
NDI at 6 months	17	9	7.0	38	0	5.3	29	3	3.0	0.002*

*Indicates significance.
NDI, Neck Disability Index

Table 4 Functional recovery at three and six months for the three fitness categories: counts and percentages

Fitness category	Functional recovery at 3 months			Functional recovery at 6 months		
	n	No	Yes	*n*	No	Yes
Low	16	16 (100%)	0 (0%)	17	11 (65%)	6 (35%)
Medium	45	21 (47%)	24 (53%)	38	7 (18%)	31 (82%)
High	32	17 (53%)	15 (47%)	29	7 (24%)	22 (76%)
Total	93	54 (58%)	39 (42%)	84	25 (30%)	59 (70%)

Table 5 Neck Disability Index score at three and six months by physical fitness category[a]

Fitness category	Median Neck Disability Index score			
	Three months		Six months	
	n		*n*	
One	7	12	7	11
Two	9	11	10	7
Three	15	8	12	0
Five	9	7	8	3.5
Six	20	4	17	0
Seven	13	7	12	0.5
Eight	19	8	17	3

[a]Category 0 has been omitted as there were no patients in this group. Category 4 has been omitted as there was only one patient in this group.

Table 6 Return to 'usual work' at three and six months for the three fitness categories: counts and percentages[a]

Fitness category	Return to usual work at 3 months		Return to usual work at 6 months	
	Per cent	*n*	Per cent	*n*
Low	31%	5 of 16	69%	11 of 16
Medium	55%	24 of 44	79%	34 Of 43
High	53%	16 of 30	87%	26 of 30

[a]Return to work data were not available in all cases.

Discussion

The main finding of the study was that individuals with medium to high levels of pre-injury physical fitness were much more likely to recover from whiplash injury than those with low levels of pre-injury physical fitness. Statistical analysis revealed no difference in the initial severity of whiplash injury for differing fitness levels, but a marked difference in recovery at three and six months, with the medium and high fitness groups having significantly better recovery than the low fitness group.

In the current study functional recovery for the whole group at three months was 42% (39 of 93) and at six months was 70% (59 of 84). Four previous whiplash studies have used methods similar enough for some comparison to be made.[32,33,36,37] Gargan *et al.*[36] found a recovery rate of 29% at three months (15 of 52), and Radanov *et al.*[37] found a recovery rate of 56% (66 of 117) at three months and 69% (81 of 117) at six months. Overall, the findings of the current study fall within the range of these two previous studies, however it should be noted that the measurement methods were different in these two studies and recovery was used as the outcome rather than functional recovery.

Two studies by Sterling *et al.*[32,33] used a method similar to that of the current study as a patient was considered to have recovered if they scored less than eight on the Neck Disability Index (although described as recovery by Sterling *et al.*[32], this is very similar to functional recovery in the current study). Sterling *et al.*[32] found a recovery rate of 38% (25 of 66) at three months which is very similar to the current study's 42%. However Sterling *et al.*[33] found a recovery rate of 38% at six months (29 of 76), which is much lower than the current studies 70%. There are no clear reasons for this disparity. The only known noteworthy difference between the studies was that just over 50% of participants in the study by Sterling *et al.*[32,33] received physiotherapy (M Sterling, personal communication) as opposed to all of the subjects in the current study. However it would be speculative to assume that this is the cause for the difference.

Prior to the current study the effect of physical fitness on whiplash injury had not been evaluated. However one previous study has linked exercise to improved recovery from injuries in general. Plugge *et al.*[28] in a postal survey of 8889 randomly selected individuals found that those who exercised vigorously were less likely to report long-term disability as a result of injury.

In this study there was no effect of physical fitness on initial severity, suggesting that pre-injury fitness does not affect the susceptibility of the neck to damage. In contrast, pre-injury physical fitness did have a markedly significant effect on recovery at both three months post injury ($P = 0.009$–0.013) and six months post injury ($P = 0.002$ and 0.004), with recovery being significantly better for the medium and high fitness groups, but not significantly different between the medium or high fitness groups. These findings strongly suggest that individuals with low levels of recreational physical activity are at markedly greater risk of poor recovery from whiplash injury. At three months no (0 of 16) individuals with low fitness had functionally recovered compared with 51% (39 of 77) of individuals with greater levels of recreational physical activity. At six months 35% (6 of 17) of individuals with low fitness had functional recovery compared with 80% (53 of 67) of those with higher physical fitness.

If the fitness categories are scrutinized in more detail (Table 5) it can be seen that overall recovery improves as fitness category increases (up to level 6). Individuals who perform no regular recreational exercise (category 1) recover less well than individuals who perform 10–60 minutes of moderate activity per week (e.g. walking; category 2), thus even moderate levels of activity confer some recovery benefits. In contrast, individuals who did more than 3 hours of heavy physical activity per week (e.g. running) recovered slightly less well than individuals with moderate levels of physical activity. A possible explanation for the improved recovery in more aerobically fit individuals could be due to the physiological effects of aerobic exercise such as increased stroke volume, oxygen uptake[38] and capillary density,[39]

which may promote healing ability. A possible explanation why individuals with very high levels of activity recover less well compared with those with moderate levels of activity may be due to the effect of over training which can inhibit the immune system.[40]

As well as improved recovery, individuals with medium/high pre-injury fitness were almost twice as likely to return to their usual work within the first three months as individuals with low fitness.

The secondary aim of the study was to determine the importance of physical fitness as a predictor of recovery from whiplash injury. The very high specificities imply that in the study population low physical fitness is a very good predictor of failure to recover, particularly at three months. However, the low values for sensitivity indicate that a medium or high level of fitness does not rule out failure to recover.

Limitations of the study

A possible limitation of the study is that subjects were drawn from an occupational population and comprised mainly police officers. This could affect the applicability of the findings to the general population. For this reason civil staff and police officers were compared on all outcome measures for differences and none were found. As there are a wide variety of non-police occupations in the Metropolitan Police Service and there was no difference in severity or recovery between police staff and civil staff this suggests that the findings can be generalized at least to occupational populations. To allow easier comparison with other occupational populations the job types and activity levels of participants were presented.

A further limitation is due to the nature of whiplash studies. The vast majority of whiplash studies obtain patients from one of three sources, individuals who attended A&E departments immediately following road traffic accidents, individuals who visited their GP at some time after their road traffic accident, and individuals who have been referred to physiotherapy or other manual therapies (e.g. osteopathy or chiropractic). These three groups of patients are not necessarily directly comparable and this should be borne in mind when comparing the findings of different whiplash studies.

Implications

This is the first study of its type and is therefore the first time that moderate to high levels of pre-injury physical fitness have been linked to improved chances of recovery from whiplash injury. It is highly important that frequent or prolonged road users are aware of this information. As individuals with medium/high pre-injury fitness are almost twice as likely to return to their usual work within the first three months, it could also be of financial benefit to employers to encourage physical fitness (particularly aerobic fitness) in employees who are frequent or prolonged road users.

Low pre-injury physical fitness is a highly specific predictor of failure to recover from whiplash injury. Therefore targeting these patients for early treatment and rehabilitation may be beneficial. However this should not be implemented to the detriment of other patients with significant whiplash symptoms.

Other similar studies should be carried out to examine the effect of fitness on recovery both in terms of the types of fitness which are most beneficial and the effect of fitness on other types of injury such as low back pain. If pre-injury fitness has a beneficial effect on other types of injury then further studies could be aimed at determining the physiological mechanisms that lead to enhanced recovery.

Clinical messages

- Moderate to high levels of pre-injury physical fitness enhance the chances of early recovery following whiplash injury.
  - Aerobic based fitness should be encouraged in frequent road users.
- Low pre-injury physical fitness (level 0-2 on the Physical Activity Scale) is highly predictive of poor recovery following whiplash injury.
  - Early targeting of rehabilitative treatment should be considered in these individuals.

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Competing interests

None declared.

Contributors

MG: guarantor, initial idea, study conception/design/development, monitoring progress, analytical strategy, interpretation of results, writing the paper, critical revision of paper's contents and final approval of published version.

AM: study conception/design/development, monitoring progress, critical revision of paper's contents and final approval of published version.

EC: analytical strategy, interpretation of results, critical revision of paper's contents and final approval of published version.

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Appendix 1 - The Neck Disability Index

This questionnaire has been designed to give the physiotherapist information as to how your neck pain has affected your ability to manage in everyday life. Please answer every section and mark in each section only the ONE box, which applies to you. We realize you may consider that two of the statements in any one section relate to you, but please just mark the box which most closely describes your problem.

Section 1 – Pain intensity

☐ I have no pain at the moment
☐ The pain is very mild at the moment
☐ The pain is moderate at the moment
☐ The pain is fairly severe at the moment
☐ The pain is very severe at the moment
☐ The pain is the worst imaginable at the moment.

Section 2 – Personal care – washing, dressing, etc

- ☐ I can look after myself normally without causing extra pain
- ☐ I can look after myself normally but it causes extra pain
- ☐ It is painful to look after myself and I am slow and careful
- ☐ I need some help but manage most of my personal care
- ☐ I need help every day in most aspects of self-care
- ☐ I do not get dressed, I wash with difficulty and stay in bed.

Section 3 – Lifting

- ☐ I can lift heavy weights without extra pain
- ☐ I can lift heavy weights but it gives extra pain
- ☐ Pain prevents me from lifting heavy weights off the floor, but I can manage if they are conveniently positioned, for example on a table
- ☐ Pain prevents me from lifting heavy weights, but I can manage light to medium weights if they are conveniently positioned
- ☐ I can lift very light weights
- ☐ I cannot lift or carry anything at all.

Section 4 – Reading

- ☐ I can read as much as I want to with no pain in my neck
- ☐ I can read as much as I want to with slight pain in my neck
- ☐ I can read as much as I want with moderate pain in my neck
- ☐ I can't read as much as I want because of moderate pain in my neck
- ☐ I can hardly read at all because of severe pain in my neck
- ☐ I cannot read at all.

Section 5 – Headaches

- ☐ I have no headaches at all
- ☐ I have slight headaches, which come infrequently
- ☐ I have moderate headaches, which come infrequently
- ☐ I have moderate headaches, which come frequently
- ☐ I have severe headaches which come frequently
- ☐ I have headaches almost all the time.

Section 6 – Concentration

- ☐ I can concentrate fully when I want to with no difficulty
- ☐ I can concentrate fully when I want to with slight difficulty
- ☐ I have a fair degree of difficulty in concentrating when I want to
- ☐ I have a lot of difficulty in concentrating when I want to
- ☐ I have a great deal of difficulty in concentrating when I want to
- ☐ I cannot concentrate at all.

Section 7 – Work

- ☐ I can do as much work as I want to
- ☐ I can only do my usual work, but no more
- ☐ I can do most of my usual work, but no more
- ☐ I cannot do my usual work
- ☐ I can hardly do any work at all
- ☐ I can't do any work at all.

Section 8 – Driving

- ☐ I can drive my car without any neck pain
- ☐ I can drive my car as long as I want with slight pain in my neck
- ☐ I can drive my car as long as I want with moderate pain in my neck
- ☐ I can't drive my car as long as I want because of moderate pain in my neck
- ☐ I can hardly drive at all because of severe pain in my neck
- ☐ I can't drive my car at all.

Section 9 – Sleeping

- ☐ I have no trouble sleeping
- ☐ My sleep is slightly disturbed (less than 1 hour sleepless)

- ☐ My sleep is mildly disturbed (1–2 hours sleepless)
- ☐ My sleep is moderately disturbed (2–3 hours sleepless)
- ☐ My sleep is greatly disturbed (3–5 hours sleepless)
- ☐ My sleep is completely disturbed (5–7 hours sleepless).

Section 10 – Recreation

- ☐ I am able to engage in all my recreation activities with no neck pain at all
- ☐ I am able to engage in all my recreation activities, with some pain in my neck
- ☐ I am able to engage in most, but not all of my usual recreation activities because of pain in my neck
- ☐ I am able to engage in a few of my usual recreation activities because of pain in my neck
- ☐ I can hardly do any recreation activities because of pain in my neck
- ☐ I cannot do any recreation activities at all.

Functional recovery

Early in the study it was discovered that some of the subjects considered themselves to be recovered despite the fact that they were still suffering from some symptoms. In 91% of cases (10 of 11) this related to a Neck Disability Index score of 2 or less for headache and 1 or less for all other components. It can be seen from the Neck Disability Index that this indicates full normal function. Based on these findings functional recovery was defined as a Neck Disability Index score of 2 or less for headache and 1 or less for all other components.

Appendix 2 - The Problem Percentage

The Problem Percentage was developed by the researchers and was used in place of the Neck Disability Index for measuring initial severity, and as an adjunct to the Neck Disability Index at three and six months. The Problem Percentage was validated against the Neck Disability Index in a pilot study of 24 individuals prior to the main study ($r=0.79$; $P<0.01$).

1. Initial questionnaire Problem Percentage

Overall problem is measured as a percentage. Zero (0) is the worst possible problem, 100% is normal (no problem at all). E.g. for your neck to be 100% it would have to be causing no pain, or any other symptoms, movement or functional problem at all. **The greater the degree of the problem the lower the percentage score you should give.**

Please write on the line below the number that best describes the average severity of your neck problem **in the first 24 hours**. A zero would be the worst possible problem and 100% would be normal (no problem).

In the first 24 hours my neck was __ % normal

2. Follow-up questionnaires Problem Percentage

Please write on the line below the number that best describes the severity of your neck problem **on average over the last week**. A zero would be the worst possible problem and 100% would be normal (no problem).

On average over the last week my neck has been __ % normal

Appendix 3 - The Physical Activity Scale

The Physical Activity Scale is a new measure of physical activity. It was initially based on the NASA JSC Physical activity scale,[41,42] and was designed to collect the same information but with enhanced clarity, usability and increased detail. The NASA JSC in a study of 2009 subjects,[41] was found to be significantly correlated to Vo_2 max testing ($r=0.78$, $P<0.01$) and was at least as good and in some cases a better estimator of Vo_2 max than submaximal treadmill testing. The Physical Activity Scale was validated against the NASA JSC in a pilot study of 20 individuals conducted prior to the commencement of the main

study, and was found to be very highly correlated ($r_s = 0.90$; $P < 0.01$).

Physical Activity Questionnaire

Please circle the appropriate number (0 to 8) which best describes your general activity level in the MONTH PRIOR TO YOUR INJURY, using the definitions below.

- MODERATE PHYSICAL ACTIVITY – Participate in recreation or work requiring moderate physical activity, such as walking, golf, horse riding, table tennis or light gardening, e.g. weeding or other comparable activity.
- HEAVY PHYSICAL ACTIVITY – Participate in heavy physical exercise such as, jogging, running, swimming, cycling, tennis, badminton, aerobics classes, circuit weight training, skiing or heavy gardening e.g. digging or other comparable activity.

0 Avoid walking or exertion, e.g. always use elevator, drive whenever possible instead of walking

1 Walk for pleasure, routinely use stairs, occasionally exercised sufficiently to cause heavy breathing or perspiration

2 Regular **moderate** physical activity 10 to 60 minutes per week

3 Regular **moderate** physical activity Over 1 hour per week

4 Regular **heavy** physical activity of less than 30 minutes per week

5 Regular **heavy** physical activity 30–60 minutes per week

6 Regular **heavy** physical activity 1–3 hours per week

7 Regular **heavy** physical activity 3–5 hours per week

8 Regular **heavy** physical activity more than 5 hours per week