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Research article

Neuromusculoskeletal disorders in the neck and upper extremities among drivers of all-terrain vehicles – a case series

Börje Rehn*[1], Tohr Nilsson[1,2] and Bengt Järvholm[1]

Address: [1]Occupational Medicine, Department of Public Health and Clinical Medicine, Umeå University, Sweden and [2]Department of Occupational and Environmental Medicine, Sundsvall, Sweden

Email: Börje Rehn* - borje.rehn@arbetslivsinstitutet.se; Tohr Nilsson - tohr.nilsson@lvn.se; Bengt Järvholm - bengt.jarvholm@envmed.umu.se

* Corresponding author

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Abstract

Background: The purpose of this study was to investigate whether professional drivers of all-terrain vehicles (ATVs) with neck pain have a different array of neuromusculoskeletal disorders in the neck and upper extremities than a referent group with neck pain from the general population. It is hypothesized that exposure to shock-type vibration and unfavorable working postures in ATVs have the capacity to cause peripheral nervous lesions.

Methods: This study was based on a case series analyzed according to a case-case comparison design. The study population consisted of 60 male subjects, including professional drivers of forest machines (n = 15), snowmobiles (n = 15), snowgroomers (n = 15) and referents from the general population (n = 15) all of whom had reported neck pain in a questionnaire and underwent an extensive physical examination of the neck and upper extremities. Based on symptom history, symptoms and signs, and in some cases chemical, electroneurographical and radiological findings, subjects were classified as having a nociceptive or neuropathic disorder or a mix of these types.

Results: The occurrence of asymmetrical and focal neuropathies (peripheral nervous lesion), pure or in a mix with a nociceptive disorder was common among cases in the ATV driver groups (47%–79%). This contrasted with the referents that were less often classified as having asymmetrical and focal neuropathy (27%), but instead had more nociceptive disorders. The difference was most pronounced among drivers of snowgroomers, while drivers of forest machines were more frequently classified as having a nociceptive disorder originating in the muscles.

Conclusion: This study found a high prevalence of assymetrical and focal neuropathies among drivers with pain in the neck, operating various ATVs. It seems as if exposure to shock-type whole-body vibration (WBV) and appurtenant unfavorable postures in ATVs may be associated to peripheral nervous lesions.

Background

Among drivers, complaints concerning the musculoskeletal system are most frequently reported from the neck, shoulders and lower back [1-4]. Whole-body vibration (WBV) is associated with low back pain and studied with epidemiological [5,6], laboratory [7-9] and clinical [10,11] methods. Musculoskeletal disorders in the neck and shoulder regions have not been as extensively studied as the lower back and the association with exposure to WBV is considered weak [12,13].

Rehn et al [14] found that drivers of all-terrain vehicles (ATVs) such as forest machines (harvester and forwarder), snowgroomers and snowmobiles are at increased risk of developing symptoms of musculoskeletal disorders primarily in the neck and shoulder area. It is, however, unclear whether there is/are any specific tissue(s) that might be affected by this type of work. Symptoms such as pain, aches or discomfort can arise from soft tissues, tendons, muscles, joints, bones or nerves [15]. Symptoms can be classified as nociceptive or neuropathic depending on the source of pain. Nociceptive pain can be defined as local pain originating in C-fibers from muscle, bone, joint, tendon or tendon insertion [16]. Neuropathic pain can be defined as pain originating in nerves, exhibiting clinical manifestations of 1) positive symptoms (dysaesthesia, pain and paraesthesia), 2) negative symptoms (numbness, reduction or absence of sensitivity, loss of proprioception) and 3) provocative symptoms (dysaesthetic symptoms when the nerve is stressed by compression, tapping or stretching) [16]. Classification of disorder type is essential for making the right choice of therapeutic approach [17,18]. Specific morbidity patterns will be helpful in clarifying feasible associations between disorder type and the physical working environment, a necessity if directed preventive actions are to be enacted.

All drivers are, to varying degrees, exposed to seated WBV. However, ATV drivers are exposed to WBV with special characteristics such as high magnitude, considerable shocks and vibration in horizontal directions (*personal communication*). Operating ATVs may also involve prolonged seated postures, elevated arms, extreme wrist postures and pronated forearms which all constitute risk factors for the development of various neuromusculoskeletal disorders in the neck and upper extremities [19,20].

The purpose of the present study was to investigate the array of neuromusculoskeletal disorders in the neck and upper extremities among professional drivers of various ATV types with neck pain. The types of disorders were compared with those from a referent group with neck pain, but with no exposure to WBV.

Methods

Study population/Design

This is a follow-up, case-comparison study based on cases derived from a previous cross-sectional study of 431 drivers and 167 referents, all males [14]. A semi-randomised geographical selection of the study population in that cross-sectional study was performed to reduce the number of subjects to a manageable size. The first step in the selection process restricted possible participants to affiliation in one of the following driver groups; i) forest machine, ii) snowmobile, iii) snowgroomer, or iv) referent group, not employed as ATV drivers. All drivers had to have at least three-years exposure in their respective ATVs, while referents reported no more than one year of driving a terrain vehicle. The second step of the selection process restricted drivers and referents to those who had reported pain specifically in the neck region during the previous 12 months in the cross-sectional study (Standardised Nordic Questionnaire). In the third step, all remaining subjects were given a random number and were then drawn, one by one, from the first to the last number. All subjects living within approximately 20 kilometres of 13 fixed larger population centres, which had access to consulting rooms at primary health care facilities, were selected. Further smaller centres were added until there were 20 subjects in each group. In the fourth and last step of the selection process, the first 15 subjects in each group (total: 60 subjects) were contacted by regular mail and if they still had problems were offered an appointment with a physician for a physical examination. All selected subjects agreed to participate (100% participation rate). The time period between answering the questionnaire and undergoing the physical examination was approximately 6 months. Thus, all subjects had persistent pain when they agreed to participate. About two thirds of the referents were blue-collar workers. A basic description of the study population is presented in Table 1.

Clinical assessment

The clinical assessment of musculoskeletal disorders in the neck and upper extremities entailed both taking a history and a physical examination that was carried out according to a checklist based on work from a review article on management of neurological diagnosis in workers exposed to vibration [16]. The examining physician (TN), a specialist in occupational medicine, was blinded as to the subjects' exposure characteristics. In order to facilitate for symptom history, subjects began by completing a form containing pain drawings concerning the quality of their physical symptoms (dull, tingling, pricking, radiating, burning, throbbing, numbness or other) and a form concerning the nature of the symptoms in their left and right hand respectively (numbness, reduced hand power, prone to drop objects, pain in wrist, pain in finger, coldness in hand or finger, white fingers, reduced dexterity, tremor, feeling of cramp, hand perspiration). Customary medical anamnesis was then applied towards the symptom history and other diseases (current complaints, general condition, previous sickness, medication and heredity). Subsequently, the physical examination was conducted following a predetermined study protocol. Tests for the presence of neurologic symptoms were conducted in line with methods presented in the review article by Nilsson [16]. The nerve provocative tests were 1) Neck compression test (Spurling's test); 2) Nerve stretch test (Armlaségue); 3) Plexus brachialis compression (gentle pressure in fossa supraclavicularis elicits a tingling sign over

Table 1: Basic description of the subjects. Total number, age, exposure time, vibration characteristics, smoking habits, reported sick leave and number of painful regions for the subjects included in this study. Units in number of people if not stated.

	Driver categories and referents			
Personal factors	Forest machine	Snowmobile	Snowgroomer	Referents
Total number	15	15	15	15
Age (mean ± sd)	51 ± 9	49 ± 8	42 ± 7	46 ± 8
[a]Exposure time (mean ± sd)	44 ± 26	4 ± 5	9 ± 4	0.7 ± 2
[b]Mean vibration total value (ms^{-2})	1.5 (y-axis dominant)	1.7 (x-axis dominant)	0.9 (z-axis dominant)	-
Smoker: -currently	2	1	0	4
-previously	6	5	9	8
[c]Reported sick leave	5	6	5	3
[d]Number of painful regions:				
-none	2	1	0	5
-one	7	10	8	5
-two or more	6	4	7	5

[a]Driving ATVs (cumulative duration / *10^3 hours) [b]Reported in a study on WBV exposure (Personal communication). [c]Due to pain in the neck or upper extremities during a 12-month period [d]Additional pain regions, apart from the neck, reported in upper extremities during a 12-month period (shoulder, elbow, wrist or hand)

the plexus area, radiating and following the nerve distribution in arm and hand); 4) Tingling sign (Tinel); 5) Wrist flexion test (Phalen); 6) Pronator compression test at the elbow; 7) Test for thoracic outlet syndrome (Abduction External Rotation test- AER). Motor function (deltoideus, wrist extensors, finger extensors, finger spread) and tendon reflexes (biceps, triceps, brachioradialis) were also examined using four alternatives (0–3), where 0 means no reflex, 1 reduced, 2 normal and 3 increased. Superficial sensibility was measured on dig II and dig V, both hands, by van Frey hairs (Semmes-Weinstein monofilaments, described in [21]).

Grip strength was tested using a dynamometer that measures air pressure in a bulb (Martin vigorimeter, large bulb for men). The best of three strength tests as noted. Quantitative sensory testing (QST) of thermal perception was carried out (Termotest®, Somedic Sales AB) according to the "thermal sensory limen"(TSL). Neutral zone was defined as the range in which the sense of temperature had adapted i.e. there was no sensation of warmth and cold – indifferent. Lundström has presented, in a review article [22], the fundamental neurophysiological bases for QST as well as associated methodological and practical aspects of importance in the diagnostic process regarding vibration-induced neuropathy and applied in this study. In addition, ordinary clinical tests for muscles, tendinitis and joints for the neck, shoulders, elbows and wrists/hands were used and included 1) Inspection – posture, movement patterns, asymmetries, muscle, bone and skin abnormalities; 2) Range of motion (ROM) – subjects wore eyeglasses with straight pegs attached and sticking out. Active and passive ROM as well as pain arches were then determined by analysis of video registration executed simultaneously from the side and from above; 3) Testing for muscle contraction pain and muscle strength; 4) Palpation of muscle tendons and insertions. All provocative tests were executed for both left and right side where appropriate and classified as negative or positive. A memorandum was written and a complete case record was assembled. Finally, each subject was classified as having a nociceptive or neuropathic disorder based on the subject's symptom history, symptoms and signs. In uncertain cases, subjects were further investigated using chemical, radiological or electroneurographical methods. The diagnostic procedure followed the strategy suggested in a review article on examination of neuropathy in workers exposed to vibration [16]. The examiner also had access to results from earlier radiological tests. The origin of a nociceptive disorder (muscle, tendon, joint or unknown) was classified in this study and neuropathic pain was further distinguished using the classification system presented by Koltzenburg [17]. Koltzenburg divides neuropathic pain into 1) asymmetrical and focal neuropathy; 2) symmetrical painful neuropathy; 3) central neuropathic pain. A subject could have a disorder classified as a combination of both nociceptive and neuropathic disorders (mixed disorder). If the investigation did not show conclusive symptoms and signs of a neuromusculoskeletal disorder, the subject was not classified. The ethical committee of Umeå University has reviewed the study (Ref no. 00-241).

Statistical analysis

Fischer's exact test was utilized to compare differences between occurrence of asymmetrical and focal neuropathy for drivers and referents (2 × 2 table). SPSS 11.0.1 for

Table 2: Classification of disorder type. Classification of neuromusculoskeletal disorder type in the neck and upper extremities, origin of nociceptive disorder and further classification of a neurogen disorder for drivers of ATVs and for referents in this study. A subject diagnosed as having a nociceptive disorder could have several origins of pain (muscle, tendon, joint). Units in number of people if not stated. P-values for Fischer's exact test between driver categories and referents concerning the prevalence of asymmetrical and focal neuropathy.

	Driver categories and referents				
Disorder type	Forest machine (n = 15)	Snowmobile (n = 15)	Snowgroomer (n = 15)	All drivers (n = 45)	Referents (n = 15)
Nociceptive – only	**8**	**5**	**3**	**16**	**8**
- Muscle pain	8	4	2	14	5
- Tendonal pain	0	1	0	1	0
- Joint pain	1	1	2	4	2
- Unknown	0	1	0	1	1
Neuropathic – only	**2**	**1**	**1**	**4**	**4**
- Asymmetrical and focal neuropathy	2	1	1	4	1
- Symmetrical painful polyneuropathy	0	0	0	0	2
- Central neuropathic pain	0	0	0	0	1
Neuropathic and nociceptive – mixed	**5**	**9**	**10**	**24**	**3**
No longer any pain	**0**	**0**	**1**	**1**	**0**
Prevalence of asymmetrical and focal neuropathy	47% (7/15)	67% (10/15)	79% (11/14)	64% (28/44)	27% (4/15)
- P-value	0.450	0.066	0.009	0.018	-

Table 3: Manifestations and specific diagnoses. Manifestations and specific diagnoses for cases with neuropathic disorders (pure and mixed). Units in number of people.

	Driver categories and referents				
Provocative test	Forest machine (n= 15)	Snowmobile (n = 15)	Snowgroomer (n = 15)	All drivers (n = 45)	Referents (n = 15)
Positive manifestation[a]	4	4	4	12	2
Negative manifestation[b]	3	3	2	8	1
Provocative manifestation[c]	7	10	10	27	3
CTS	0	1	4	5	0
TOS	2	0	0	2	0
Radialis entrapment	0	1	0	1	0
Medianus entrapment[d]	0	0	1	1	0

[a]Dysesthesia, Pain, Paresthesia [b]Numbness, Reduced sensibility or proprioception [c]From nerve provocative tests [d]Pronator teres syndrome

Windows was used for the statistical calculations (2001©SPSS Inc, Chicago, IL, USA).

Results

The dominant direction of vibration differed between the three ATV categories, Table 1. The exposure time was much longer for forest machine drivers. Table 2 shows the distribution of neuromusculoskeletal disorder types. A mix of a nociceptive and neuropathic disorder was in general more common in the driver groups (55% (24/44) vs. 20% (3/15)) especially among drivers of snowmobiles and snowgroomers. All cases in the mixed group had an asymmetrical and focal neuropathy. The total prevalence of cases diagnosed as asymmetrical and focal neuropathy were 47%, 67%, 79% and 27% for drivers of forest machines, snowmobiles, snowgroomers and referents respectively. In general, ATV drivers had a higher prevalence of asymmetrical and focal neuropathy compared to referents (p = 0.018). Differences were most pronounced for drivers of snowgroomers (p = 0.009) but less clear for the other ATV driver categories (p = 0.450 for drivers of forest machines and p = 0.066 for drivers of snowmobiles). Drivers of forest machines and referents had the highest prevalence of pure nociceptive disorder in comparison to the other disorder types (8 cases out of 15 for both groups). The most common origin for a nociceptive disorder was the muscle tissue (Table 2). The most common specified types of asymmetrical and focal neuropathy were carpal tunnel syndrome (CTS) and thoracic outlet syndrome (TOS). Seven drivers compared to zero referents had at least one of these diagnoses (Table 3). More drivers than referents had symptoms and clinical findings of a neuromusculoskeletal disorder of the left side of the body (27% compared to 7%). Referents had more problems from a combination of both left and right sides compared to the ATV driver groups (66% compared to 42%). There was one case, a driver of a snowgroomer who was not classified as having a neuromusculoskeletal disorder and was not included in the analysis. Although he had pain when he agreed to participate in the study, it had since ceased.

Typical case description

A fifty-five-year-old driver of forest machines had constant neck pain. He had since he was 40 years old a burning sensation on both sides of the neck and he felt that his trapezius muscles were stiff and painful. The problems increased when he worked with forest machines but were reduced during weekends and rest. His problems have subsequently become aggravated and at the examination he had difficulties in rotating his neck due to stiffness and pain in end positions. He also had a feeling of discomfort in his upper extremities and hands and sometimes loses the strength in his right arm. In addition, he had problems when he sneezed which evoked a sensation of severe pain radiating from the neck to the side. He was also troubled about his financial situation and as a consequence sometimes suffered sleep disturbances. He worked about 60 hours a week, sometimes away from his place of residence and had reduced holiday periods. Thirty years ago he had an accident involving a tree falling over him and was treated medically. The clinical findings were tenderness during palpation of the trapezius, some spinal processus in the neck, lateral epicondyle dex and n.radialis dex. Severe pain from elbow to fingers was present during supination of the forearm. Armlasegué and test of plexus brachialis was positive bilaterally. Magnetic resonance imaging (MRI) showed a bulging disc and stenosis in the foramina intervertebralia at the C5/C6 level dex. Electroneurography showed no pathological signs for a lesion in the n.radialis dex. He was classified as having a combination of both neuropathic and nociceptive disorders. Affected primarily at the cervical level and with the nociceptive disorder originating from the neck muscles.

Discussion

The results of this study demonstrate that occurrence of an asymmetrical and focal neuropathy, pure or together with a nociceptive disorder, in the neck and upper extremities was more common among cases of ATV drivers than among cases of referents from the general population. Although drivers of forest machines had longer exposure times to seated WBV, there were fewer cases of asymmetrical and focal neuropathy compared to drivers of snowmobiles and snowgroomers which questions a trend between exposure and response. Drivers of snowmobiles and snowgroomers were similar regarding the occurrence of asymmetrical and focal neuropathy, although there are some differences between the ATV types concerning WBV characteristics and the seated posture of the driver (see Table 1, personal communication).

Other clinical studies of neuromusculoskeletal disorders

Work-related symptoms and disorders in the neck and upper extremities has lately been reported for various occupations involving mostly women e.g. slaughterhouse workers [23], dental personnel [24], sewing machine operators [25], assembly-line workers [26], VDT workers [27] and milkers [28]. To our knowledge, the present study is the first on neuromuscululoskeletal disorders in the neck and upper extremities among male drivers of ATVs. Apart from CTS, studies on work-related musculoskeletal disorders have reported relatively few cases with specified asymmetrical and focal neuropathy. Pronator syndrome has however been reported among milkers [28], dental personnel [24] and slaughterhouse workers [23]. Radial tunnel syndrome has been reported among dental personnel [24] and TOS has been reported among slaughterhouse workers [23]. Disorders in the earlier studies have mostly been categorised according to screening methods and criteria for diagnosis suggested by Waris and co-workers [29] and to additional tests and questions suggested by Viikari-Juntura [23]. Earlier studies tend to call these disorders musculoskeletal although some disorders could be classified as neuropathic. In this study the term 'neuromusculoskeletal' is used. A criteria document for case definitions when evaluating the work-relatedness of upper-extremity musculoskeletal disorders was recently introduced by Sluiter and co-workers [30]. Like in the present study, the screening methods and criteria in earlier studies are based on symptoms and signs and some also involve specific nerve provocation tests. The focus of this study was to investigate the existence of particularly neuropathic disorders in the neck and upper extremities as accurately as possible and that is why additional chemical, electroneurographical and radiological findings were used for the diagnostic process.

Outcome in relation to exposure

Drivers of forest machines execute high precision tasks with their hands and fingers that can result in static work for the neck muscles. This might explain why the majority of these cases were classified as nociceptive. The typical exposure for ATV drivers in general is however relatively high magnitudes of seated WBV (Personal communication). Further, the characteristics of WBV exposure among drivers of ATVs are the high influence of horizontal vibration and the occurrence of shock-type vibration. There are some differences in the dominant vibration direction between forest machines, snowmobiles and snowgroomers (Table 1), which may be an explanation for the small differences in the array of neuromusculoskeletal disorders between the driver categories in this study. The underlying pathogenesis for asymmetrical and focal neuropathies in ATV drivers could be repeated pressure to and stretching of peripheral nerves in the neck and upper extremities due to exposure to shock-type vibration. Other suggested risk factors for neuropathy and relevant for drivers is local compression and entrapment of peripheral nerves in the upper extremities. For example, strain of the brachial plexus might be a result of elevated arms [31]. Full extension of the elbow and holding the forearm in an extreme position could cause radial tunnel syndrome [32,33]. This may occur during lever work. Using steering devices on the snowmobiles may involve persistent, high grip force, which can also cause radial tunnel syndrome [34]. Focal compression of the ulnar nerve in the cubital tunnel is feasible if the exposed site of the elbow is in contact with an incorrect or unadjusted arm support [19]. Excessive work with extreme wrist postures is another risk factor that may be involved in operating ATVs and that can cause CTS [35]. The neuropathic manifestations in the elbow/wrist/hand regions for ATV drivers could also be caused by exposure to hand-arm vibration (HAV) from the steering devices. The HAV magnitudes are high in snowmobiles and snowgroomers [36,37].

Aspects of validity

Neuromusculoskeletal symptoms and disorders are often of relatively short duration, which is why a cross-sectional study has less power to study neuromusculoskeletal disorders. Since exposure to WBV in ATVs is inherently associated with other ergonomic risk factors, it is also difficult to draw firm conclusion about any single causative factor. This study used randomly assigned cases that all had persistent pain for a period of six months i.e. a disorder of chronic character. Given this, it could also be expected that long-term sensitisation of the nervous system might have influenced the array of disorders. Persons with certain disorders may have difficult to continue to work with ATV, e.g. rhizopathia, which may cause a different distribution of disorders among cases still at work. It may also be difficult to determine the site of a neuromusculoskeletal disorder in the neck and upper extremities due to the phenomena of referred pain and double crush syndrome [39]. These features make specific diagnosing of chronic neuromusculoskeletal disorders difficult and use of the term 'dominant' disorder type rather than 'pure' disorder type may therefore be more accurate. An examination of the work history for referents revealed that one subject had long exposure time to seated WBV from military vehicles i.e. similar exposure as ATV drivers. Analysis was also performed after excluding of this referent, but it did not reveal any differences that altered the present conclusion. Because there were some differences in the distribution of accidents and diseases, a prevalence bias could have been introduced. Volunteer bias could be eliminated, as the participation rate after randomisation was 100%. Obviously, there is always a chance of suspicion bias, but this study tried to reduce suspicion bias by blinding the examining physician for the subjects' exposure characteristics and using a standardised study protocol. Reproducibility of this type of investigation on a larger population may be questioned, since the methodology employed in this study was very detailed and time consuming, as well as dependent on the competency of an experienced physician. A low validity may lead to a low diagnostic precision meaning lower chance to detect differences. Thus, the risk of asymmetrical and focal neuropathy may be underestimated in this study.

List of abbreviations

All-terrain vehicle – ATV

Carpal tunnel syndrome – CTS

Hand-arm vibration – HAV

Magnetic resonance imaging – MRI

Range of motion – ROM

Statistical package for social sciences – SPSS

Thoracic outlet syndrome – TOS

Whole-body vibration – WBV

Authors' contributions

BR carried out the analysis, participated in the design and drafted the manuscript. TN planned the design, coordinated and made all examinations and case records. BJ participated in the design of the study. All authors read and approved the final manuscript.

Competing interests

None declared.

Additional material

Additional File 1

Appendix 1. Results from nerve provocative tests
Click here for file
[http://www.biomedcentral.com/content/supplementary/1471-2474-5-1-S1.pdf]

Additional File 2

Appendix 2. Results from clinical tests
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