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Shoulder impairment in wheelchair users with cervical spinal cord injury

An update of the literature the past 10 years

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Abstrakt

Bakgrund: Många personer med ryggmärgsskada använder manuell rullstol för att ambulera och överkroppen för viktbärande aktiviteter, vilket kommer att påverka lederna i övre extremitet. Inverkan av en cervikal ryggmärgsskada påverkar sensorisk och motorisk funktion i skulderområdet. Skulderledsproblematik uppstår vanligtvis som smärta och/eller funktionsnedsättning. Orsaken är ofta multifaktoriell med både yttre- och inre muskuloskeletala faktorer som bidrar. Kliniska riktlinjer, baserad på äldre litteratur, för hantering av skulderledsbesvär används som utgångspunkt i rehabiliteringen. Eftersom det är en utmaning att undersöka och behandla skulderproblematik, kan det finnas behov att utvärdera om de gamla rekommendationerna fortfarande är tillämpbara eller om ny information kan komplettera rehabiliteringen av skulderbesvär.

Syfte: Att undersöka skulderbesvär hos rullstolsbrukare med cervikal ryggmärgsskada, baserat på den senaste litteraturen, för att förbättra diagnostik och behandling.

Metod: En litteratursökning med systematiskt ansats genomfördes i databaserna Pubmed, CINAHL och Web of Science.

Resultat: Nio studier inkluderades i granskningen för kvalitetsbedömning och dataanalys. Resultatet presenterade en lista på åtta domäner. De viktigaste fynden avseende skulderbesvär var vikten av att uppmärksamma god rörlighet i utåtrotation, flexion och abduktion. Förändring av hållning och kinematik på grund av ökad belastning vid rullstolsambulering resulterade i ökad nedåtrotation och protraktion av skuldran. Personer med cervikal ryggmärgsskada löper högre risk för skuldersmärta om de har kontrakturer eller spasticitet. Resultatet bekräftar vanligt förekommande strukturella avvikelser så som AC-leds artros, tendinopati och/eller rotatorkuffskada eller förändringar i bicepssenan.

Slutsats: De kliniska riktlinjerna för övre extremitet kvarstår som gyllene standard som utgångspunkt för hantering av skulderbesvär. Resultatet belyser behov av fortsatta studier om skulderbesvär hos personer med cervikal ryggmärgsskada

Nyckelord
Funktionsnedsättning, Rullstol, Ryggmärgsskada, Skulderbesvär, Tetraplegi.

Abstract

Background: Many persons with spinal cord injury (SCI) use manual wheelchair to ambulate and their upper body for weight-bearing activities, which will affect the upper extremity joints. The impact of cervical SCI affects the sensory and motor function in the shoulder region. Shoulder joint problems usually manifest in pain and/or disability. The cause is often multifactorial with both external and internal musculoskeletal factors contributing. Clinical practice guidelines (CPG), based on old literature, for management of shoulder impairment is used as a starting point in rehabilitation. Since there are challenges in examination and treatment, there might be a need to evaluate if the old recommendations are still applicable or if new information can be added to the management of shoulder impairment.

Aim: To explore shoulder impairment among wheelchair users with cervical SCI, based on the recent literature, in order to improve diagnostics and treatment.

Method: A literature search with a systematic approach was conducted in the databases Pubmed, CINAHL and Web of Science.

Results: Nine studies were included in the review for quality assessment and data analyzes. The results presented a list of eight domains. The main findings regarding shoulder impairment, suggested that range of motion shoulder external rotation, flexion and abduction was important to maintain and to pay attention to. Changes in posture and kinematics due to the increased load from wheelchair propulsion resulted in increased downward rotation and protraction of the shoulder. Persons with cervical SCI have higher risk of shoulder pain if they have contractures or spasticity. The result confirms that common structural deviations as AC-joint arthroses, tendinopathy and/or RC-tear and biceps tendon deviation.

Conclusion: CPG of the upper limb remains the golden standard for shoulder management. The result highlights implication for further research for shoulder impairment among persons with cervical SCI.

Keywords
Impairment, Shoulder problem, Spinal Cord Injuries, Tetraplegia, Wheelchair.

LIST OF ABBREVIATIONS

ADL - Activities of Daily Living

AC- Acromioclavicular

ASIA - American Spinal Injury Association

AIS - ASIA Impairment Scale

CPG - Clinical Practice Guidelines

FIM - Functional Independence Measure

GH - Gleno-humeral

ICF - International Classification of Functioning Disability and Health

ISNCSCI - International Standards for Neurological Classification of Spinal Cord Injury

MMT - Manual Muscle Testing

MRI – Magnetic Resonance Image

NTSCI - Non-Traumatic Spinal Cord Injury

OR - Odds Ratio

PRISMA – Preferred Reporting Items for Systematic review and Meta-Analysis

RC - Rotator Cuff

ROM – Range of Motion

SCI – Spinal Cord Injury

SSE - Scapular Stabilization Exercises

SCIM - International Standards and Spinal Cord Independence Measure

TSCI - Traumatic Spinal Cord Injury

TSI – Time Since injury

WUSPI - Wheelchair Users Shoulder Pain Index

CONTENTS

1 INTRODUCTION

Spinal cord injury (SCI) and its neurological impairment is a devastating condition that affects life dramatically (1). The ability to move and to be able to transfer is central in the rehabilitation process of becoming independent after a SCI (2). Many persons with SCI use a manual wheelchair to ambulate and therefore use their upper body for weight-bearing activities, which will affect the upper extremity joints (3). That might explain why the shoulder joint is the most common location for musculoskeletal pain in individuals with SCI (4). Shoulder joint problems usually manifest in pain and/or disability. The cause is often multifactorial with both external and internal musculoskeletal factors contributing. Shoulder dysfunction has major consequences for the individual. It often leads to reduced activity and participation in life situations, inability to work and sick leave leading to high costs both for the patient and the society. Prevention of shoulder dysfunction should therefore be a highlighted in SCI rehabilitation (5).

Persons from the early stage after SCI and to lifelong follow-up are rehabilitated at our institution at Rehab Station Stockholm, Sweden. For upper limb rehabilitation there are guidelines to follow based on studies performed (6) 10-20 years ago. Results from these studies contain Clinical Practice Guidelines (CPG) with recommendations in ergonomics, equipment use, environmental adaptations training and exercise. This information provides a starting point for shoulder management. However, the CPG is focusing on activity level limitation and not specifically on a structural level.

Shoulder problem gained more attention the last 10-20 years, but the question remains whether shoulder problems have decreased or not. The clinical examination of the tetraplegic shoulder is difficult compared to the paraplegic, because of challenging positioning of the patient and muscle imbalance due to the injury. Despite the recommendations, it is still challenging to examine, highlight the structural and functional deviations in the shoulder joint and to prioritize the interventions. Therefore, there is a need for an update of literature on shoulder dysfunction and impairment in the cervical SCI population, to make the recommendations more specific regarding shoulder management.

With increased knowledge in this area among the caregivers and patients we can improve prevention and minimize risks of the shoulder joint disorder by early diagnosis and treatment. However, from a pilot search, there is a lack of studies among the population with cervical SCI regarding conservative interventions of shoulder dysfunction. The impairments and dysfunctions have to be addressed first to be able to design more intervention studies.

2 BACKGROUND

2.1 SCI

A SCI can occur by traumatic (TSCI) or non-traumatic causes (NTSCI). A TSCI can be caused by a trauma or damage made by external forces, such as traffic related, falls, sport or violence. Traffic related injuries are the most common

cause of TSCI globally, followed by falls (5). A NTSCI is caused by congenital abnormalities or acquired injury, such as bleeding, hemorrhage, tumors etc. A recent report from World Health Organization estimate that the international incidence of new SCI cases are 250.000- 500.000 annually (5). In the United States alone, over 1 million patients live with SCI and more than 12 000 new cases occur every year (7). Approximately 260,000 persons with SCI who reside in the United States, use a wheelchair (3). In Sweden, there are about 6000 persons living with SCI. The numbers of newly injured cases have increased in 2017 from previous years. There were approximately 300 newly injured patients with about 40% having NTSCI (8).

A SCI causes motor and sensory impairment below the level of injury. Depending on the level of injury and the completeness, the disability varies. In addition to reduced muscle and sensory function, a SCI can also affect bladder and bowel function, pain and spasticity (5). International Standards for Neurological Classification of SCI (ISNCSCI), developed by the American Spinal Injury Association (ASIA) (9, 10), is used to evaluate the neurological level and completeness of the injury. The injury can be complete or incomplete determined by the ASIA Impairment Scale (AIS). According to AIS completeness is determined by the sensory and motor function of the anal sphincter (5) (Table 1).

Table 1. AISA- Impairment Scale

A: Complete	No sensory or motor function is preserved in the sacral segments S4-S5.
B: Sensory incomplete	Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5, AND no motor function is preserved more than three levels below the motor level on either side of the body.
C: Motor incomplete	Motor function is preserved below the neurological level and more than half of key muscle functions below the single neurological level of injury have a muscle grade less than 3.
D: Motor incomplete	Motor function is preserved below the neurological level and at least half of key muscle functions below the neurological level have a muscle grade of 3 or greater.”

Cited 2019-05-04 from: ISNCSCI Worksheet (11)

2.2 Tetraplegia

The spinal cord is defined in segments of the vertebras. A cervical SCI (C1-C8) with impairment or loss of sensory and/or motor function is referred to as Tetraplegia. It affects function of the upper limbs, trunk, legs and pelvic organs. Paraplegia is an injury in the thoracic, lumbar or sacral segments (Th1-S5). The upper limbs remain with intact function but the trunk, lower limbs and pelvic organs will be affected depending on the neurological level of injury (5).

Below is a short description of functional expected outcomes for the cervical levels. These results represent young patients with a complete injury. Older

patients or patients with comorbidities may not reach those outcomes (5). Individuals with an injury of C1-C3 are totally depended on a ventilator or a stimulator to breathe. They require complete assistance for activities in daily life (ADL) and use a power wheelchair to ambulate. Individuals with a C4 injury also need assistance with ADL and transfers. They can use a power wheelchair with a specialized control of head movement. With a C5 injury the individual can use their elbow flexors and deltoids. This will allow simple ADL with specialized devices. Some skillful persons can do transfers and bed movement individually but mostly persons with C5 injury requires assistance. They can use a manual wheelchair but usually use powered wheelchair. Individuals with a C6 injury have fully innervated RC muscles and good shoulder stability. They have wrist extensors and passive grip function. With a C7 level of injury, the patient is able to control their triceps and extend their elbow, which facilitates transfers independently. They are also able to lift their own body weight and preform bed mobility. A C8 injured individual has active hand function which facilitates personal hygiene and dressing. Shoulders are therefore exposed in all mobility, including transfers, daily activities, physical activity and is therefore at risk for overuse (5).

2.3 Musculoskeletal Complications

Complications affecting the bones, joints, muscles or the nervous system can develop in years or within a few weeks post injury. It can be a direct consequence of the SCI with decreased muscle activity around the joint or a secondary preventable complication (5). Individuals with SCI, with loss of motor control in the lower libs, use the upper limbs for weight-bearing purposes for the rest of their lives. Persons with tetraplegia are even more vulnerable for shoulder dysfunction due to that their neurological deficits include shoulder muscles. That implies a challenge to the shoulder joints that are primarily designed for facilitating hand placement in several planes and not for heavy weight-bearing (3).

Among the SCI population, 51% have shoulder problems (4). Studies show that common conditions among individuals with SCI, both among para- and tetraplegia, are gleno-humeral (GH) instability, impingement syndrome, capsulitis, degenerative joint disease, recurrent dislocations, rotator cuff (RC) tear, bicipital tendinitis and myofascial pain syndrome (4). Duration of injury, older age, and higher body mass index, the use of a manual wheelchair, poor seated posture, decreased flexibility, and muscle imbalances in the RC and scapular stabilizing muscles are risk factors that increases the incidence of shoulder issues (12).

Shoulder pain is more common among persons with tetraplegia (53%) compared with paraplegia and with complete injuries (5). It also occurs more frequently in women (12). The shoulder movements are an interaction between GH, acromioclavicular (AC) and the scapula-thoracic joints which makes the shoulder the most mobile joint of the human body. The joints work together to create stability for lifting, pulling and pushing (3). The GH joint are not adapted to be weight bearing because of the lack of bony constraint. It contains a small area of bony surface with enclosing soft tissues such as muscles, ligaments and the capsule. The glenoid labrum is primarily responsible for maintaining stability

(13). Repetitive transfers and manual wheelchair use increase the intra-articular pressure in the shoulder joint. The intra-articular pressure can be up to five times the body weight during transfer and will stress the vasculature of the RC tendons which can lead to injury. The extra stress can lead to muscle overuse and abnormal biomechanism (5).

RC impingement can be caused by a joint space narrowing in the shoulder and is present among 18% of the active wheelchair users (5). Inflexibility and tightness of the anterior shoulder and pectoralis muscles can also affect the scapular biomechanism and can contribute to secondary impingement. Anterior tilt, downward rotation and protraction of the scapula reduces the subacromial space (12).

2.4 Physiotherapy management and assessment

2.4.1 International Classification of Functioning Disability and Health (ICF)

The role of the physiotherapist is important in many stages of the rehabilitation after a SCI. The main purpose of the rehabilitation is to reduce secondary complications of the neurological impairment but also focusing on optimizing remaining function to make the patient as independent as possible (13). It is defined in the framework of the ICF to maximize the individuals health and participation (14).

In physiotherapy science there are key concepts that are commonly used in the everyday language, like the human body, movement, function and interaction in relation to health from a bio-psycho-social perspective (15). Specific requirements are set for definition and clarification of the significance of the concepts. ICF provides a standardized international language in description of health in forms of domains. It facilitates the understanding of a health condition in its context to the environment in regard to level of capacity and level of performance. The domains are describing body function and structures, activity, participation in life situations, external environmental and internal personal factors. There is causality in the relationship between the domains. Body functions are physiological functions of body system such as sensory functions, pain, neuromusculoskeletal and movement-related functions. Body structures are anatomical parts like organs, joint and limbs. Impairments are problem in the body function or body structure. ICF describes disability as an umbrella term for impairments, activity limitations and participation restrictions (14).

2.4.2 Physiotherapy Management

The Paralyzed Veterans of America (PVA) (6) have published international CPG: “Outcomes Following Traumatic SCI: Preservation of upper limb function following SCI”. The CPG was conducted 20 years ago and was published in 2005. It describes recommendations to maximize a person’s health and participation after SCI. It is done through education, ergonomics, equipment selection and environmental adaptation, functional training and treating impairments that impose activity limitation (5, 13). It requires an understanding and experience of how persons with different patterns of paralyses moves due to primary or secondary effects of the impairment (5).

The prevalence of shoulder dysfunction in persons with SCI is high and consequences of shoulder dysfunction are significant. It often leads to reduced independency, activity and participation in life situations. Inability to work and sick leave leading to high costs both for the patient and the society(5).

The goals of rehabilitation of the shoulders are to prevent and treat the impairments that impose activity limitation to enable optimal function. The treatment of the shoulder joint, which mainly consists of muscles and ligaments, can be divided into two main domains; non-operative and operative. Non-operative interventions are stability and strength training, sitting ergonomics of the wheelchair, propelling and wheelchair skills, transfer techniques and maintain and/or increase range of motion (ROM) (6, 13). The literature clearly show that a physical shoulder exercise program not only prevent but reduce pain (3).

2.4.3 Assessments associated with shoulder function

The prevalence of shoulder problems differs in the literature which can be explained by the differences in examination and diagnostics among physiotherapists globally. Differentiating symptoms from the neck and shoulder region can be challenging due to the fact that several muscles act both on the shoulder and the neck. Similarly, referred pain is also an issue. The loss of motor- and sensory function in the shoulder complicates the perception of pain and to distinguish between neuropathic pain and neuromuscular pain (12).

To evaluate the location and severity of pain, a complete musculoskeletal examination should be performed, including measurement of the joint ROM, muscle strength, spasticity and sensory examination. To evaluate signs of shoulder dysfunction different assessment can be used. One way is a standardized care program called *Axelina* which consists of various assessments to optimize the care of patients with problems from the shoulder, from examination to rehabilitation plans and home exercises (16). To measure shoulder ROM a goniometry is commonly used. The reliability appear to be high when its measured by the same therapist regardless of position, supine or sitting, indicates high intra reliability for passive shoulder ROM when measuring in the same position (17). Muscle strength measure can be done by for example manual muscle testing (MMT), dynamometry, and weight determined strength. There are various accepted approaches to MMT by observation, palpation and force application. One commonly used assessment is Daniels and Worthingham (18). Other common clinical assessments recommended for persons with SCI are the Wheelchair Users Shoulder Pain Index (WUSPI), Functional Independence Measure (FIM) and International Standards and Spinal Cord Independence Measure (SCIM). WUSPI is an assessment to identify painful activities and problematic movement patterns. It's a questionnaire of 15-items measuring pain in different activities (19). FIM is a clinical tool used to assess the functional status. It is an 18-item questionnaire with gradings from total independence to total assistance in ADL (20). SCIM is a validated outcome measure, recommended by ISCOS for persons with SCI (21). It contains three domains; self-care, respiration and sphincter management and mobility. There is, however, no validated Swedish translation.

The physiotherapist plays a major role in the SCI rehabilitation, but there is a team required for the extensive management of rehabilitation. During investigation of shoulder problems, the clinical examinations can be supplemented by magnetic resonance images (MRI), ultrasound or radiographs. Medication is sometimes needed as well as a consideration of operative interventions.

2.5 Why is this important?

Preventing and reducing the incidence of shoulder impairment is essential because of the major consequences for the individual, such as sick leave and reduced independency. The goal is to maximize the health and participation in life situations for the individuals living with cervical SCI. With a better understanding of which types of shoulder impairments among persons in wheelchair with cervical SCI have, physiotherapists can be in a better position to evaluate, treat, and prevent these disorders.

The CPG (6) for the SCI group, has looked the same for decades and been focusing on the level of activity. Despite the literature reviews and recommendations, there is a wide variety of treatment strategies and clinical examination methods that are used in clinics and what interventions to prioritize. Many of the standardized measurement that are used for cervical SCI is based on studies on persons without SCI. There is a need to evaluate if the old recommendations are still applicable or if new information can be added.

There is a gap in the literature recommendations focusing on the structural level of the shoulder problems. What highlights intervention on level of body function and structure? Therefore, there is a need for an update of literature on shoulder dysfunction and impairment in the cervical SCI population, to make the recommendations more specific regarding shoulder management.

2.6 Aim

To explore shoulder impairment among wheelchair users with cervical SCI, based on the recent literature, in order to improve diagnostics and treatment.

2.6.1 Research questions

1. What types of shoulder impairments are described?
2. What correlations between the impairments and other factors are presented?
3. What outcomes of interventions on shoulder impairment are described?

3 MATERIALS AND METHODS

A literature review with a systematic approach was used as the method. The author (EA) and supervisor (IL) of the present study developed the criteria for the studies to be included. The quality assessment and the summarized results were closely supervised.

3.1 Search strategy

A pilot search was performed in March 2019 with guidance from an experienced librarian at Karolinska Institute library. The keyword spinal cord injuries and Mesh-terms *spinal cord disease, tetraplegia, shoulder* was used to investigate the basis for relevant studies. The literature research with a systematic approach took place 19/03/29 by the author (EA) and supervisor (IL) based on guidelines from Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (22). The search strategy is presented in Appendix 1. The literature search was made in the databases Pubmed, CINAHL and Web of Science. The following keywords and Mesh-terms were used in different combination: spinal cord diseases, spinal cord injuries, spinal cord injury, tetraplegia, shoulder. Due to the Mesh-terms and CINAHL-headings, *spinal cord disease* was used to include all of the aspects with an injured spinal cord, both traumatic and non-traumatic. Other studies use the keyword *spinal cord injuries*, which only include TSCI, why the searched was conducted with both terms. The Mesh-term and CINAHL heading *tetraplegia* included also quadriplegia. The term *shoulder* was used to include wide spectra of shoulder dysfunction. Publications in the last 10 years were used as a search limit. In the database CINAHL, the "suggested subject terms" was used and boxed the headings to a summary search. Experts in the SCI were asked if they knew about any unpublished material accurate to our aim and reviewed a database (www.scireproject.com) (23) of ongoing SCI-projects. No other studies were found for inclusion.

Studies were eligible for inclusion in the present study due to following criteria; 1) Full-length article or report, 2) The published language of the study was in English or Swedish, 3) The study was published between 2009 and 2019, 4) the participants in the studies had a cervical SCI, 5) the cervical SCI patients were reported separately in study population with a mixed sample. Exclusion criteria were surgical interventions and sports injuries. The procedure of inclusion was made by two reviewers (EA & IL). After the systematic search the first selection was done by reviewing the articles title and abstract. The second selection, also made by the two reviewers, was a full-text review compared with the inclusion criteria. Thereafter a discussion to achieve agreement of inclusion and exclusion of the studies (24).

There are minimal ethical risks to consider in this literature study as it is not possible to identify any the individuals in the included studies. During the quality review of included studies, the ethical approval was taken into account. It is important that the studies are reviewed by an ethical committee, when needed, and that careful ethical considerations are made (24).

3.2 Quality assessment

The aim of the quality assessment for the included studies was to identify if each study result depended on systematic errors (bias) (25). There is no golden standard for quality assessment for any study design, nor is there any widely accepted assessment that can be applied equally well across study types. There are separate templates for different study types (26).

To evaluate the quality, we first identified the study type. Interventional studies, also called clinical trials, evaluate the impact of a treatment. Observational studies or epidemiological study design can be conducted in a variety of methodologically ways (25). Observational studies include cross-sectional, retrospective and prospective cohorts. Cross-Sectional Studies is an observation at a single time of a representative study population. Retrospective cohort studies, also called register studies, address common exposures using historical data contained in public statistics and medical databases. Prospective cohort follows a group based on their exposure over time and evaluate the outcome of interest (24, 27). There are standards for each study design which have the purpose to improve the quality of research, results and true conclusions that our medical decision is based on. There are published standards for observational studies (STROBE) (28) and controlled trials (CONSORT) (29).

The quality assessment that was used in this present review was the template for observational studies (30) by the Swedish authority for medical evaluation. The purpose of the template is to evaluate systematic basis to discuss the risk that the estimated outcomes in a particular study are systematically distorted. Each template consists of domains of bias; selection, treatment, assessment, dropout reporting bias and interest conflict. For each study, a total quality score was computed as low, moderate or high quality (25). To assess the risk of bias in the interventional study was the Modified Downs and Black checklist (31) used. The checklist contains domains with, 27 items, of reporting, internal- and external validity, selection bias and power.

3.3 Data collection and analyses

Data collection and analyses were based on methodological aspects of Forsberg & Wengström, 2013. Data were extracted from the aim, study methods intervention characteristics, measurements, patient characteristics, and study results. The author (EA) extracted the data, based on a standardized spreadsheet (25). The study result was extracted into the table considering outcome domains to the study questions guided by the domains of ICF: Body Function and Body Structure (14).

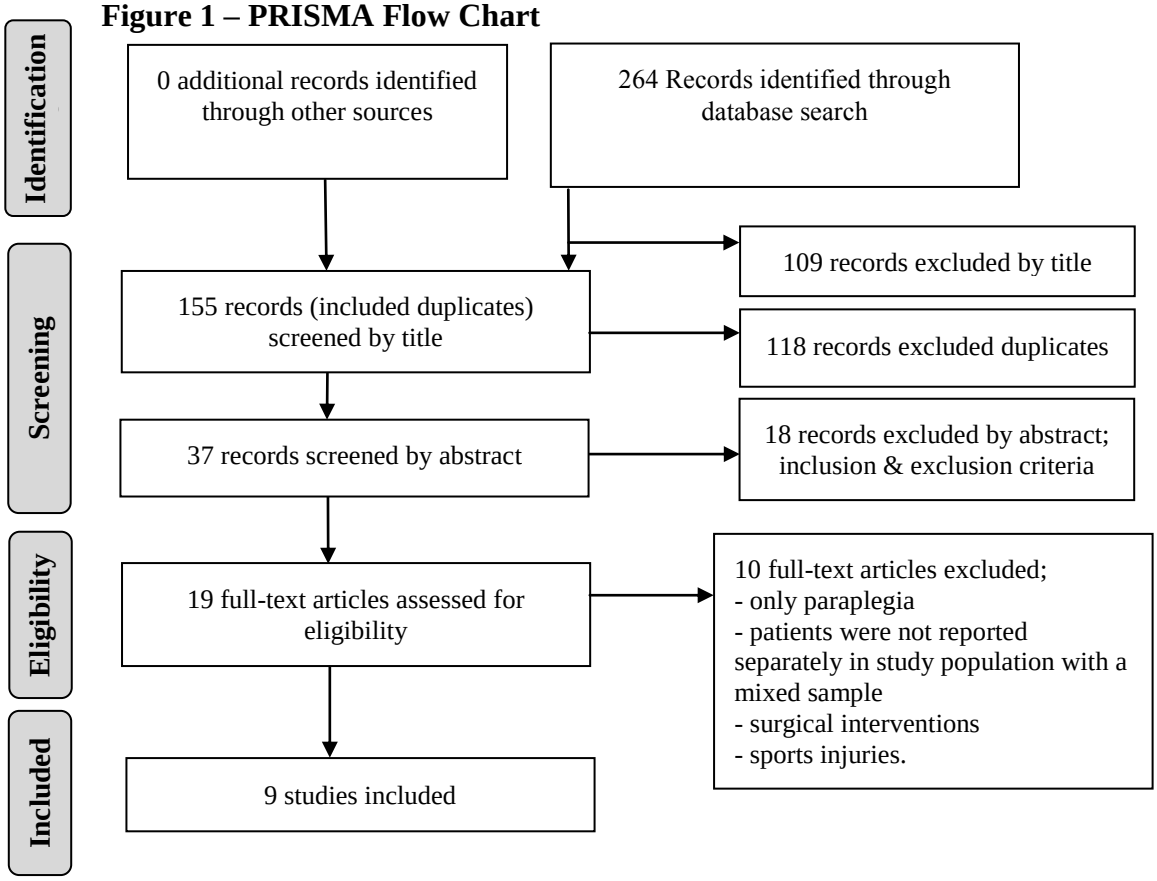
The outcome measure from each study reported positive effect if the p-value was less than or equal to 0.05, considered the result to be statistically significant. A significant result effect was scored as positive or negative when the results were statistically significant and no effect when the results were non-significant (24). An odds ratio (OR) is a relative measure of effect, which is used as a comparison of the intervention group and the control group. If the result is the same and no difference between the groups becomes the ratio 1. If OR is higher than 1 (OR>1), indicates that the exposure are associated with higher odds of outcome (32).

4 RESULTS

4.1 Search results

Database search gave 264 publications for title screening and out of them, 109 were excluded. Of remaining 155 articles, 118 were duplicates. Thirty-seven articles were screened by title and abstract there after 18 records were excluded due to inclusion and exclusion criteria. Nineteen articles were obtained for full text review. Ten full-text articles were excluded because they did not match the inclusion criteria. Finally, nine studies were included in the review. Flow chart of the included studies are presented in Figure 1 (33).

Figure 1 – PRISMA Flow Chart



4.2 Characteristics of included studies

The nine included studies were identified as five cross-sectional studies (34-38), two prospective cohort (39, 40), one retrospective cohort (41) and one interventional (42). The population samples varied with groups with mixed SCI samples and studies with only persons with cervical SCI. The total number of persons with tetraplegia in the included studies was 6-474. A compilation of relevant outcomes resulted the following list of eight domains, Body function: ROM (35-37, 39-41), Shoulder pain (34, 35, 37, 39, 41), Spasticity (35), Muscle strength (42) and Scapulae kinematics (38). Body structure: AC-joint arthroses (37, 41), Tendinopathy (34, 41) and RC-tear (41). Characteristics of the included studies are presented in Appendix 2.

4.3 Methodologic quality

The quality of the included studies was low to high (Table 2). Three (35, 37, 41) studies scored for high quality, five (36, 38-40) for medium quality and two (34, 42) scored for low quality. Risk of drop out was evaluated as not applicable when absent of dropout was presented. The intervention study (42) scored for low quality (14 out of 27) in the modified Black and Down checklist (31). Ethical approval was granted in all of the included studies.

Table 2 - Quality assessment cohort studies

Cohort Studies	**Alves et al. 2010** (34)	**Bossuyt et al. 2017** (35)	**Eriks-Hoogland et al. 2011** (39)	**Eriks-Hoogland et al. 2013** (41)	**Eriks-Hoogland et al. 2016** (40)	**Hardwick et al. 2018** (36)	**Medina et al. 2011** (37)	**Raina et al. 2011**(38)
A1. Risk for selection bias	Medium	Low	Low	Low	Low	Low	Low	Medium
A2. Risk for treatment bias	Low	Low	Medium	Low	Medium	Low	Low	Low
A3. Risk for assessment bias	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium
A4. Risk for drop out bias	NA*	NA*	NA*	NA*	NA*	NA*	Low	NA*
A5. Risk for reporting bias	Medium	Low	Low	Low	Low	Low	Low	Low
A6. Conflicts of intrest	Low	Low	Low	Low	Low	Low	Low	Low
QUALITY SCORE	LOW	HIGH	MEDIUM	HIGH	MEDIUM	MEDIUM	HIGH	MEDIUM

*NA= Not Applicable

4.4 Description of shoulder impairment

4.4.1 Body Function

Passive shoulder **ROM** is a frequently measured as a description of shoulder impairment. In four (36, 37, 39, 40) studies, passive shoulder ROM was measured in sitting position with a goniometer. Three (36, 39, 40) out of the four studies that addressed ROM had medium quality and one high quality (37). If ROM was limited by at least 10 degrees in passive flexion, external rotation and abduction, it was considered as shoulder ROM limitation in two of the studies (39, 40). In three (36, 39, 40) of the studies, 61-100% of the study population had passive shoulder ROM limitations. One study (36) addressed the high percentage (91-100%) of shoulder passive ROM limitation among the 38 individuals in the study population. Abduction, forward flexion and horizontal adduction were commonly contracted movements. There was no statistically significant difference in level of injury and prevalence of joint contractures in the upper limb. Incomplete injuries showed significant less limitation in shoulder ROM compared to those with complete injuries. Time since injury (TSI) had a weak negative relation to the presence of any contractures in the upper limb, while age had a moderate positive relation. Less independency, according to SCIM, and presence of any contractures in the upper limb had a strong significant association (36). FIM motor score was used in two studies (39, 40) to compare transfer mobility and shoulder ROM limitations. This was done at one- and five-years follow-up after discharge from initial rehabilitation. Limited shoulder ROM was significantly associated with lower FIM motor score and ability to transfer independently, both at one- and five years follow-up. No intervention studies focused on ROM were found.

Shoulder pain was highlighted in six (35, 37-39, 41, 42) of the nine reviewed studies. The Swiss cross-sectional observation study (35) with 417 individuals with tetraplegia, present higher odds of shoulder pain with complete or incomplete tetraplegia compared to incomplete paraplegia. Adjusted prevalence of shoulder pain among persons with cervical SCI were 42% with complete tetraplegia versus 38 % with incomplete. Significantly associated variables with shoulder pain were female gender, severity of SCI, contractures, and spasticity. Wheelchair users (both electrical and manual) suggested higher odds of having shoulder pain (35). A low quality cross-sectional observation study (34) assessed complaints of shoulder pain through correlations of clinical data with MRI. Seven shoulders out of 17 (three with tetraplegia), presented with normal MRI although individuals complained about pain (34). In a prospective longitudinal study with follow-up after five years, shoulder pain at discharge was not associated with lower FIM score or ability to transfer (40). In one Cross-sectional observation study (35) with 417 individuals with tetraplegia, higher odds of shoulder pain were described when contractures in upper extremities were present. Also, when **spasticity** was present, the odds of shoulder pain were higher among the group of individuals with tetraplegia (35). No intervention studies were found that focused on spasticity in relation to shoulder impairment.

No descriptive studies focused on muscle function were found. A medium quality interventional study (42) presented a shoulder stabilization exercise (SSE) program to improve **muscle strength**. No significant correlation between TSI, level of injury and changes in external and internal strength were detected. Five exercises, four times a week, improved significantly shoulder stabilizing muscles**.** Bilateral external rotation strength, shoulder flexion endurance and abduction endurance on the dominant hand significantly improved. Internal rotation did not improve. Compared to the estimated effect size the result of shoulder flexion endurance of the dominant side, it was classified as “clinically relevant”.

The domain of s**capulae kinematics** was described in one cross-sectional study (38) through studying dynamic wheelchair propulsion in response to increased load. Two scapula coordination patterns with different angle profiles were exhibited. With increased load, the scapula kinematic was affected and showed significantly higher rate of change in the upward/downward rotation and retraction/protraction. Less retracted scapula was presented at the point of break during loaded push (38).

4.4.2 Body Structure

Three (34, 37, 41) studies highlighted **AC-joint arthroses**. One study (37) measured the distance of the AC-joint space and found that persons with tetraplegia had smaller space compared with controls and persons with paraplegia. There was a moderate linear correlation between passive ROM of external rotation and the distance of the AC-joint space; the greater external rotation, the greater the distance of the AC- joint space. Concerning AC-joint arthroses, there was no difference between TSI, age or gender. However, there was a tendency of correlation with pain symptoms (P=0,0597) (37). Persons with SCI had nearly four times higher risk of severe arthrosis compared to persons

without SCI (41). A higher percentage of more severe and advanced stages of AC-joint arthroses were found in persons with tetraplegia. There was no association with level of injury (41). No intervention studies on AC-joint arthroses were found.

In two (34, 41) of the studies, MRI was used to assess structural shoulder deviation in persons with SCI. A retrospective cohort study listed a description of different diagnostic MRI findings among a SCI group compared to the control group of not injured persons; AC-joint arthrosis (99% P= 0,051), **RC-tear** (74% P= 0,041) **Biceps tendon** deviation (56% P= 0,004) (41). A low quality cross-sectional observation study (34) had no significant results, but a description of potential causes to shoulder pain. In individuals with tetraplegia, structural shoulder deviations were noted; AC-joint arthroses and tendinopathy of supraspinatus which was associated with AC-joint arthroses (34).

5 DISCUSSION

5.1 Result discussion

The present study aimed to investigate an update of the literature over the past 10 years to explore if anything should be added to the examination, diagnostics or treatment of shoulder dysfunction, in order to improve health among persons with tetraplegia. Eight domains based on ICF body function and body structures were identified among the nine reviewed studies. **ROM** was the domain that excelled. The clinical recommendations from PVA (6) only slight address ROM and lack specified instructions in what specifics to address as a risk for shoulder problem. It describes the importance of maintaining shoulder external rotation and promotes stretching. In the present study, the results suggest that ROM in external rotation, flexion and abduction is important to maintain and to pay attention to. However, there are difficulties in measuring ROM. In the reviewed studies (36, 39, 40), ROM was assessed by measuring with goniometer in sitting. Measuring of shoulder ROM with goniometer has showed high reliability when it is measured by the same therapist, regardless of position, supine or sitting, high intra reliability is maintained when measuring in the same position (17). The author was questioning if the cut-off points limitation in flexion, external rotation and abduction was clinically relevant and the intra-reliability of measurements. In two (39, 40) of the studies the cut-off point was set to10 degrees of limitation, measured by different persons. Another study (36) defined contractures as any deviation compared to normative values, meaning no accepted measurement error for passive ROM. On the other hand, the same therapist preformed the measurements (36). There was a significant association between less independency in ADL and transfers and limited shoulder ROM (36). The study authors did not discuss whether there could be other causes, than limitations in ROM, to the reduction of activity level. None the less, there is causality in the relationship between the domains of the ICF. Clinicians should be aware that shoulder ROM limitation can impose a risk for limitations in activities and participation or the other way around (14).

Except for the persons with tetraplegia have higher risk of shoulder pain if they have contractures or **spasticity**, the results of the present study failed to add new

information regarding **shoulder pain** and tetraplegia. Pain is usually measured with different subjective self-score tools. It can be challenging for individuals with tetraplegia to differentiate pain symptoms due to loss of motor- and sensory function in the shoulder dermatomes which complicates the perception of pain (12).

No new information to the clinical recommendations regarding **muscle strength** were found in this review, except from a small sampled intervention study that confirmed that structured strength training improves shoulder stabilization (42).

Clinicians and persons with tetraplegia should be aware of the effect in **scapulae kinematics** propelling with increased load of the wheelchair. This literature review revealed that changes in kinematics due to the increased load from wheelchair propulsion result in increased downward rotation and protraction(38). Literature (12) reveals that this movements reduces the subacromial space. This review confirms that individuals with tetraplegia had a smaller distance of the AC-joint (37).

Structural deviations are known to be more common among individuals with SCI, both with paraplegia and tetraplegia. Common conditions are GH instability, impingement syndrome, capsulitis, degenerative joint disease, recurrent dislocations, RC-tear, bicipital tendinitis and myofascial pain syndrome (4). This review confirms common structural deviations: **tendinopathy** and/or **RC-tear** and biceps tendon deviation (34, 41). It also highlights that persons with SCI have nearly four times higher odds of severe arthrosis compared to not injured persons, with increased risk of more severe and advance stage of **AC-joint arthroses** (41).

5.2 Methodological considerations

The strength of study was that the literature search was conducted by two persons and guided help from experienced librarian at Karolinska Institute. Wide search with mesh-terms and CINAHL headings to cover more articles but was limited by language and only three databases. Search selection, quality assessment and data analyzing have been closely supervised. Findings in this review should be interpreted with caution because of the small size studies, heterogenic samples and that the majority of studies were lacking control groups which can affect study quality. Finally, two different templates were used for the quality assessment, which makes comparison difficult.

Initially, the aim was to find physiotherapy intervention studies but due to the scarce outcome, focus had to change. Some studies were found where the participants had paraplegia and with wheelchair users with a mix of diagnoses. Small studies and mix samples are common in SCI science due to the rarity of this injury. Studies often include participants with paraplegia and tetraplegia, but there are too few participants to make subgroups. The challenge to include enough number of participants with tetraplegia and the impact of difference in variation of injury level may be due to the fact that few studies have been performed.

5.3 Clinical Implications

Existing CPG of shoulder management are still applicable and a starting point of the management of the tetraplegic shoulder, despite the challenges in investigation and treatment. The present study highlights impairments in shoulder passive ROM, changes in kinematics with increased load and high odds of AC-joint arthrosis among persons with tetraplegia. From early stage post-injury to aftercare follow-up there are possibilities to address, examine, inform, prevent and rehabilitate shoulder impairments. Shoulder problem on a level of body structure and body function should be address at an early phase when conservative treatment still can be successful. As a summary, structural deviations often require consulting teamwork, where the physiotherapist has a central role. Decisions regarding supplementary examinations with MRI, treatment drugs and potential surgery are in the optimal case made by the doctor in collaboration with the other team members.

5.4 Implications for further studies

The results of the present study highly demand the need of further studies as the wide literature search lacked high quality studies among the population with tetraplegia. Future research is required among individuals with tetraplegia and shoulder impairment, especially regarding intervention studies with control groups. Due to small samples, a collaboration of multi-center studies to assess comprehensive studies or a registry study including identified data of shoulder measurements in the national SCI register. Examination of the shoulder, among persons with tetraplegia, is complex due to limitation of sensation and muscle activity. Assessment strategies for persons without SCI are therefore not sufficient. There is a need for an assessment protocol for the tetraplegic shoulder which takes level of injury, due to the remaining function, into account. Impairments are not always visible on MRI or in clinical assessment even though the patient complains about shoulder pain and/or disability. Future studies require to measure the structures in activity, simulated when shoulder problem occur.

6 CONCLUSION

As an effort to analyze shoulder impairment in persons with cervical SCI, in order to improve diagnostics and treatment, the present study presents a literature review of recent studies in this topic. To the best of our knowledge, this is the first review conducted with this aim. This review confirms that CPG of the upper limb remains the golden standard for shoulder management. The result presented a list of eight domains, based on ICF body function and body structures. Findings should be interpreted with caution because of small samples and varies in quality. Regarding the recent literature of shoulder impairment in wheelchair users with cervical SCI, the result suggests that ROM in external rotation, flexion and abduction is important to maintain and to pay attention. Persons with tetraplegia have higher risk of shoulder pain if they have contractures or spasticity. Change in posture and kinematics because of increased load result in

downward rotation and protraction of the scapula. Structured strength training improves shoulder stabilization. The result confirms common structural deviations as AC-joint arthroses, tendinopathy and/or RC-tear and biceps tendon deviation. This result highlights implication for further research of intervention studies for shoulder impairment among wheelchair users with tetraplegia.

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Appendix 1: Search strategies

Dates	Database	Search	Filters	Items found	Records screened by title and abstract.	Studies included in quantitative synthesis (with duplicates)
20190329	Pubmed	spinal cord disease	-	152920		
		spinal cord disease tetraplegia	-	3879		
		spinal cord injuries tetraplegia shoulder	-	115		
		spinal cord injuries tetraplegia shoulder	published in the last 10 years	46	13	(34) (35) (36) (39) (40) (41) (37) (38)
		spinal cord disease tetraplegia shoulder	-	111		
		spinal cord disease tetraplegia shoulder	published in the last 10 years	38	8	(35) (39) (41) (40) (37)
		spinal cord injury tetraplegia shoulder	published in the last 10 years	54	13	(38) (34) (35) (36) (39) (41) (40) (42) (37)
		spinal cord injury tetraplegia shoulder pain	published in the last 10 years	25	10	(34) (35) (39) (41) (40) (37)
20190329	CINAHL	"spinal cord injury" OR (MH "Spinal Cord Injuries+")		20893		
		(MH "Spinal Cord Diseases+") OR "spinal cord diseases"		12955		
		(MH "Quadriplegia") OR "tetraplegia or quadriplegia"		2821		
		(MH "Shoulder") OR "shoulder"		26118		
		(MH "Spinal Cord Diseases+") OR "spinal cord diseases" AND (MH "Quadriplegia") OR "tetraplegia or quadriplegia" AND (MH "Shoulder") OR "shoulder"		3		
		"spinal cord injury" OR (MH "Spinal Cord Injuries+") AND (MH "Quadriplegia") OR "tetraplegia or quadriplegia" AND (MH "Shoulder") OR "shoulder"		63		
		"spinal cord injury" OR (MH "Spinal Cord Injuries+") AND (MH "Quadriplegia") OR "tetraplegia or quadriplegia" AND (MH "Shoulder") OR "shoulder"	Published Date: 20090101-20181231	21	6	(39) (37) (38)
	Web of sience	(“spinal cord injur*” and “shoulder” and “tetraplegia)”		147		
		(“spinal cord injur*” and “shoulder” and “tetraplegia)”	Timespan: 2009-2019	80	12	(34) (35) (36) (39) (41) (42) (37)

Grey marked: first time included studies were noted, Injur* = all variations of endings

Appendix 2: Summary of Results

(reference) **Author, year** Country Study design **Study quality**	**Population characteristics**	**Measurement / intervention**	**Aim**	**Description of shoulder dysfunction** (Body Function)	**Description of impairment in musculoskeletal shoulder structures** (Body Structures)
(41)**Alves et al**, **2010 Brazil** Cross-sectional observation study **Low study quality**	Total N= 9 TSI 1-21år Group A Paraplegia N =4 Group B Tetraplegia N=5 All men Level C5-C6 AIS-A+B)	MRI bilateral 17 shoulders (-1). Analyses and the presence of trauma or degenerative alterations. -ACJ - Subacromial space. - Tendinopathy or tear in RC muscles.	Assess complaints of shoulder pain, correlating with clinical data with MRI, for the most prevalent lesions.	Shoulder pain was presented in all examined participants. 2 out of 5 persons with tetraplegia had 40 % had bilateral pain. 3 shoulders of the 10 tetraplegic shoulders examined presented normal MRI result but complained about pain.	MRI findings among persons with tetraplegia: AC-joint degeneration, decreased subacromial space and supraspinatus tendinopathy. When absent of tendinopathy of the supraspinatus the persons also had AC joint degeneration.
(35) **Bossuyt et al. 2018 Switzerland** Cross-sectional observation study **High study quality**	Total N=1549 Tetraplegia N= 474 complete N=160, incomplete N=314 TSI median 13years	Measurements: self-report assessment including questions about musculoskeletal pain and location. Predictor variables: SCI characteristics, health conditions, mobility independence.	Determine the prevalence of shoulder pain and to identify factors associated with shoulder pain among the Swiss SCI community	Individuals with tetraplegia present higher risk of shoulder pain with complete (OR=1,63) or incomplete (OR=1,82) tetraplegia compared to incomplete paraplegia. No significant differences between complete paraplegia and complete or incomplete tetraplegia. Adjusted prevalence of shoulder pain among those with cervical SCI were 42% (128 out of 314) with complete tetraplegia versus 38 % (61 out of 160) with incomplete Significantly associated variables with shoulder pain were female gender, severity of SCI, contractures and spasticity. When spasticity (OR=1,94) and/or contractures (OR= 2,85) was present among the individuals with tetraplegia there was a higher risk of shoulder pain. Wheelchair users, both electrical (OR= 1,32) and manual (OR= 1,40) , suggested higher odds of having shoulder pain. Females had (OR=1,89) higher risk of shoulder pain compared to male.	

(39) Eriks-Hoogland et al. 2011 Switzerland Prospective observational cohort **Medium study quality**	Total N=146 Paraplegia N=94 Tetraplegia N=52	ROM limitation, meaning a decrease in ROM of 10 degrees or more in passive flexion, external rotation and abduction. Measured in sitting position with a goniometer. FIM.	Correlation between limited shoulder ROM in persons with SCI at discharge and performance of activities and participation one year later	32 persons out of 52 with tetraplegia had ROM limitation. Limited shoulder ROM was significant associated with lower FIM motor score (P=0,0054). Limited shoulder ROM was not significant (P=0,443) to shoulder pain among persons with tetraplegia.18 persons out of the 32 with tetraplegia had shoulder pain.	
(41) **Eriks-Hoogland et al. 2013 Switzerland** Retrospective cohort **High study quality**	Total N=173 Control N=105 SCI N=68 SCI group: Paraplegia N=49 Tetraplegia N=1980% AIS-A, TSI mean 23,3 years (0-48years) 78% male	Analyses of the medical records and MRI. AC joint assessment: palpation of the AC joint, cross-body adduction test. RC test: cross-body adduction test, lift off and empty can.	Investigate the prevalence, severity and risk of AC-joint arthrosis by MRI among persons with SCI and shoulder pain.		Persons with SCI have nearly four times higher odds (OR:3:82 P<0,0001) of increasingly severe arthrosis compared to controls. In persons with tetraplegia there were found higher percentage of severity and advance stage of AC-joint arthroses. It was no association with ASIA and level of injury. There was high specificity (100%) in the SCI group of clinical examination, but low sensitivity (71%). Description of different findings of MRI diagnostics among SCI group (N=68) compared to the control group (N=105); AC-joint arthrosis (99% P= 0,051), RC tear (74% P= 0,041) Biceps tendon 56% P= 0,004)
(40) **Eriks-Hoogland et al. 2016 Switzerlan d** Prospective, longitudinal cohort **Medium study quality**	Total N=198 Persons completed measurements N=138 (tetraplegia n=47) Lost to follow-up group n=60: tetraplegia N=18	Assessment: musculoskeletal pain, shoulder ROM, FIM, Wheelchair skill test.	To examine whether musculoskeletal pain and limitation in ROM at discharge from first rehabilitation are associated with activities and participation restriction 5 years later	Corrected from possible confounders, limited shoulder ROM at discharge was associated with lower FIM score (P<0,001) and ability to transfer independently (P=0,004). Significant differences were only found for complete SCI for shoulder ROM limitation in the lost follow-up group (35% have presence of limitation in shoulder ROM>10 degrees) Corrected from possible confounders, shoulder pain at discharge was not associated with lower FIM score (P=0,722) and ability to transfer independently 5 years after discharge from rehabilitation.	

(36) **Hardwick et al. 2018 USA** Cross sectional pilot study **Medium study quality**	Total persons with tetraplegia N = 38 C1-C8 Men: n=35 Women: n=3 75% AIS A/B Median TSI = 10 years	Passive ROM shoulder joint was measured with goniometer in a seated position. Compared to normative data. A contracture means any limitation in ROM. Muscle strength was measured with MMT. SCIM-III to measure independency.	Examine the prevalence of joint contractures in the upper limb and association with voluntary strength, innervation status, functional status, and demographics in persons with tetraplegia	100% of the 38 cervical SCI participant had abduction ROM contractures. Normative value was set to 180 degrees. Forward flexion (99%) and horizontal adduction (91%) were commonly contracted joints. There was no statistically difference (P=0,3731) in level of injury and prevalence of joints with contractures in the upper limb. The participants with C5-7 incomplete injury showed less limitation in shoulder ROM. TSI (r=P=0,0529) had a weak negative relation to percentage of any contractures and age (P= 0,0567) a moderate positive relation to any contractures in the upper limbs.	Association between less independency, according to SCIM, and percentage of any contractures in the upper limb appeared to have a strong significant (P= 0,0094) relation.
(42) **Lins et al. 2019. Brazil** Prospective non-controlled intervention study **Low study quality**	Tetraplegia N=17 C4-C7, physically non-active AIS-A+B Mean TSI:9 Drop-out = 4 Only men	Evaluated at 4 times: baseline 1+2, 6weeks, 12weeks Measurements: Isometric internal and external strength (dynamometer), endurance (goniometer) of shoulder flexion and abduction. SSE program:3x15reps (4times/w) 1)Bilateral external rotation with scapula adduction. 2)external rotation with shoulder in 0 degree of abduction. 3)bilateral low-row. 4)push-up. 5)horizontal abduction	Evaluate the potential benefits of SSE on isometric internal and external rotator strength, endurance and function of the shoulder through a 12-weeks exercise program consisting five resisted exercises with elastic bands.	17 persons out of 17 with tetraplegia reported pain in their shoulders. Bilateral isometric external rotation strength (6w P=0,015,12w P=0,004) and shoulder flexion (6w P=0,035,12w P=0,003) and abduction (6w P=0,03,12w P=0,026) endurance on the dominant hand significantly improved. Compared to the estimated effect size the shoulder result of shoulder flexion endurance, of the dominant side, was classified as “clinically relevant”. Flexion on the not dominant hand and abduction om both sides were considered as “not clinically relevant”. Internal rotation didn’t change significantly (P=0.474) No significant (P>0.05) correlation in TSI, level of injury and changes in external and internal strength	
(37) **Medina et al. 2011. Brazil** Cross-sectional study **High study quality**	Total N=32 Control N=16 SCI group N=9 (32 shoulders) Tetraplegia N=9, all men TSI mean =7,88 years	Passive and active ROM. Test for shoulder pain and shoulder stability. Plain radiography on bilateral shoulders. AC joint space was measured between the medial tip of acromion and the lateral border of the clavicle.	Find signs on plain radiographs that could relate to shoulder pain.	8 out of 9 patients complained about shoulder pain (88,89%) No difference between pain and type of injury (P=0,0597), but a tendency (P=0.0597) to pain symptoms among the group of persons with tetraplegia. Moderate linear correlation between passive external rotation. Geater the external rotation greater the distance of the ACJ (right side P=0,00310, left side P=0,0284). There was no difference between TSI (P=0.4927), age (P=0.3537) and gender (P=0,7612). AC joint space between Right:3-7mm (mean 37mm), Left:15-70mm (mean:41mm. The persons with tetraplegia had ACJ measures smaller than the paraplegics and controls.	

(38)Raina 2011. USA Cross-sectional study **Medium study quality**	Total N= 18 Tetraplegia n=7 (C6-C8) all men TSI= 5-28 years	Each participant performed non-loaded and loaded propulsion in a study-made wheelchair connected to an ergometer roller. 10s each experimental condition. No load condition; without additional load to the ergometer rollers. Loaded condition compared to 4% incline. 4 electromagnetic sensors: Th1 vertebra, acromion, deltoid tuberosity, brachio-radialis.	Quantify and compare the scapular kinematics during dynamic wheelchair propulsion in response to increased load	Two scapula coordination patterns with different angle profiles were exhibited. With increased load was the scapula kinematic affected and significantly higher ($p<0.05$) rate of change in the upward/downward rotation and Retraction/protraction. At the point of break during loaded push showed significantly ($p<0.05$) less retracted scapulae. On the peak of rim fore; 3 out of 7 participants with tetraplegia had upwardly rotated scapula	

Abbreviations: ACJ= Acromio Clavicular joint AIS= American Spinal Injury Association Impairment Scale, C=Cervical, FIM=Functional Independence Measure, MRI= Magnetic Resonance Image, N = number, OR=Odds ratio, P= p-value, RC= Rotator Cuff , ROM=Range of Motion, SCI=Spinal Cord Injury, T/Th= Thoracal, TSI=Time Since Injury