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TESI DI LAUREA

Prevalence of musculoskeletal disorders in lumberjack: a systematic review

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ABSTRACT

INTRODUCTION: Work related musculoskeletal disorders (MSD) are a complex of inflammatory and degenerative diseases that affect spine, joints tendons, nerves and the muscular system. They are imputable to incongruous posture, joint overuse or overloads, that occur during work, and can lead to pain and functional limitation[1].

METHODS: The literature search and article revision were performed from February to April 2021. The keyword "lumberjack[title/abstract] or lumbermen[title/abstract] or forestry[title/abstract] or forest workers[title/abstract] and risk assessment[title/abstract] or risk management[title/abstract] or occupational medicine[title/abstract] or risk factors[title/abstract] or occupational exposure[title/abstract] and musculoskeletal diseases[title/abstract] or occupational diseases[title/abstract]".

The research was carried out on the online database PubMed and Scopus, no time restriction regarding publication year were applied.

RESULTS: 4956 studies were screened and 4510 abstract were read after the duplicate's remotion. 4200 records were then excluded. Thus, 310 full texts were assessed for eligibility, 292 of them were excluded.

Finally, 18 studies were included in the review

CONCLUSION: The tasks the lumberjacks use to perform are characterized by strenuous work and use of vibration tools, indeed, as a most common exposure factor we highlight chainsaw vibration.

For spine areas, Low Back Pain, neck pain and upper back pain are the most common MSD, shoulder pain, elbow, forearm and wrist/hand for upper limbs, meanwhile knee, hips, thighs, ankle and feet cases were found for lower limb.

RIASSUNTO

INTRODUZIONE: I disturb muscolo-scheletrici lavoro correlati sono un gruppo di disordini infiammatori e degenerativi che colpiscono la colonna, le articolazioni, i tendini, i nervi e il sistema muscolare. Sono imputabili a posture incongrue, sovraccarico ripetitivo dell'articolazione durante il lavoro e possono portare a dolore e limitazione funzionale[1].

METODI: La ricercar bibliografica è stata effettuata da Febbraio ad Aprile 2021. Le parole chiave "lumberjack[title/abstract] or lumbermen[title/abstract] or forestry[title/abstract] or forest workers[title/abstract] and risk assessment[title/abstract] or risk management[title/abstract] or occupational medicine[title/abstract] or risk factors[title/abstract] or occupational exposure[title/abstract] and musculoskeletal diseases[title/abstract] or occupational diseases[title/abstract]". La ricerca è stata portata avanti sui database online "Pubmed" e "Scopus", senza restrizioni in termini di anno di pubblicazione.

RISULTATI: 4956 studi sono stati osservati e 4510 riassunti sono stati letti dopo la rimozione dei duplicate. 4200 studi sono stati esclusi, Quindi 310 articolo sono stati letti e valutati eleggibili, 292 dei quali sono stati esclusi. Alla fine di ciò, 18 studi sono stati inclusi nella revision.

CONCLUSIONI: Le mansion che i boscaioli svolgono sono caratterizzate da lavori strenuanti e uso di strumenti vibratory, infatti, come fattore di esposizione più commune abbiamo individuate le vibrazioni indotte dalla motosega. Per la colonna, il dolore alla zona lombare, il dolore alla regione del collo e alla regione superior della colonna sono i disturbi muscoloscheletrici più comuni. Il dolore alla spalla, al gomito, all'avambraccio e nel complesso polso-mano sono i disturbi più comuni per l'arto superiore. Per l'arto inferior, il ginocchio, l'anca, la coscia. La caviglia e il piede sono i casi più comuni.

1. INTRODUCTION

1.1 WORK RELATED MUSCULOSKELETAL DISORDERS

Work related musculoskeletal disorders (MSD) are a complex of inflammatory and degenerative diseases that affect spine, joints tendons, nerves and the muscular system. They are imputable to incongruous posture, joint overuse or overloads, that occur during work, and can lead to pain and functional limitation[1].

These disorders are defined by the World Health Organization (WHO) as multifactorial onset diseases because they are also caused by extra-working factors such as aging, injuries, chronic disease and repetitive movement during sports or hobbies.

Therefore, in order to identify MSD as a work-related professional disease, it has to be the presence of risk factors that could affect the onset of the pathology. In particular, we can distinguish risk factors related to the job-task and the risk factors related to the environment and the organization, referred to the other causes for the onset of these disorders. Risk factors for work-related MSD are listed in Table 1.

Physical risk factors	*Environmental and organizational risk factors*
Load handling	Work pace
Incongrous posture	Repetitive activities
Repetitive movement	Work time
Manual jobs with heavy lifting	Salary
Mechanical direct pressure on the equipment	Monotone tasks
Vibrations	Fatigue
	Environmental micro-clime
	Perception of work organization
	Work related psychosocial factors

Table 1: Risk factor for work-related MSD. "A. Baldacconi, E. Nocchi, G. Rosci, A. Rossi, Il rischio da danno biomeccanico, Ipsoa, Milano, 2010, 247"

Among the most common diseases we note:

1. Spine diseases
    a. Acute low back pain
    b. Disc spondylarthrosis
    c. Disc bulging
    d. Sciatica
    e. Spondylosis
2. Upper limb repetitive movement
    a. Carpal tunnel syndrome
    b. Epicondylitis
    c. De Quervain syndrome
    d. Snap finger syndrome
    e. Rotator cuff syndrome
    f. Thoracic outlet syndrome
    g. Guyon syndrome
3. Lower limb repetitive movement diseases
    a. Plantar talalgia
    b. Achilles tendinitis
    c. Tarsal tunnel syndrome
    d. Meniscus injury
    e. Pre-patellar bursitis
    f. Knee tendinopathy

These are not well defined, in particular with their onset, showing limits in term of their management, prevention and definition of the cause-effect link as "professional disease"[1].
However, the strong interest demonstrated from the scientific literature, highlights the spread in every work environment and the consequential social factors. Indeed, these phenomena are common among manual workers in different sectors, such as forestry, transport, construction, and manufacturing sector.
The Italian scenario, from the INAIL institute, highlight that last data for musculoskeletal diseases show an increased about 4.000 cases, equal than + 15% compared to 2010, reaching 26.000 complains. Data are showed in table 2.

Osteo-Articular Disease	*2006*	*2007*	*2008*	*2009*	*2010*	*% Var. 2010-2006*
Discs disease	2.828	3.276	4.130	6.629	9.368	231,3%
Tendinitis	3.124	3.842	4.461	6.036	8.525	172,9%
Carpal tunnel syndrome	1.731	1.477	1.668	2.435	4.819	178,4%
Arthrosis and related diseases	1.588	1.938	1.965	2.343	1.971	24,1%
Other	795	907	886	1.057	1.445	83%
Total	**10.066**	**11.440**	**13.110**	**18.500**	**26.138**	**159,7%**

Table 2: INAIL's data for Musculoskeletal diseases from 2006 to 2010

Looking at the different types of disease, we can observe a complex growth: the most increase is the disc diseases with more than 230%, while an increment bigger than 170% is found to the tendinitis and the carpal tunnel syndrome.

The most affected age group is that from 50 and 64 years (more than 50% of the total). Figure 1 shows age-based division groups of MSD.

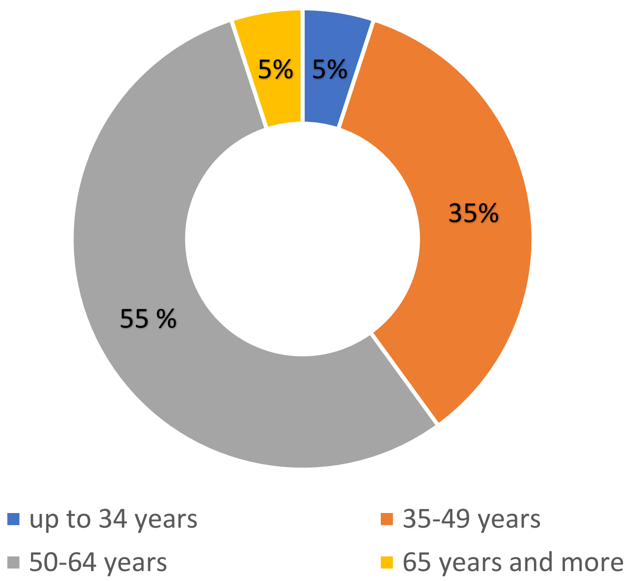

Fig. 1: Age-based division of MSD

The genre composition reflects that of the risk-exposed workers: about 40% of the complaints are made from women, it is a higher share compared to the work-injuries, with values near to 30%.

Nevertheless, in Italy we can observe the majority manifestations of musculoskeletal diseases in Emilia-Romagna, with more than 5.000 complaints in 2010, it is the 19,6% of the total national amount, in Abruzzo, with more than 4.000 cases (15.9%) and in Toscana (3.000 cases, 12,1%)[1].

For what concerns the economic activity, musculoskeletal diseases are particularly spread in those sectors where there is a strenuous and consistent physical demand in lifting, repetitive movement or manual handling of loads[1].

Regarding the economic and social factors, some observations are worth to be done. Firstly, with regard to the dimension the phenomenon could assume in economic terms for the national sanitary system, the fear is a possible excessive movement of insurance and indemnity on multifactorial and not yet sure phenomenon, to the disadvantages to pathological factors whose there are a clear medical and juridical on the onset and etiological mechanisms. Under the social and work aspect instead there are the risk of an exponential growth of one-time indemnities for workers without work eligibility for the specific tasks, for not only work-related causes, with difficulties in a collocation in the work environment, and at the same time, without the possibility of a long-term insurance coverage.

1.2 ABSENTEEISM COSTS

Spine, upper and lower limb musculoskeletal diseases are today a frequent cause of inability or work absenteeism on the major industrialized countries. In the U.S. these disturbs are object of study and analysis from time. In the period of time from 1972 to 1994 they already noticed an increase of claims, up to represent over than 65% of all the professional diseases[1].

According to the National Institute of Occupational and Health (NIOSH USA) these diseases are at the first place on the list of the most relevant health problem on the USA productivity environment, due to the almost 29 days of absenteeism per 100 workers they cause.

The economic analysis instead, shows that these pathologies absorb the 33% of the indemnity total costs for professional diseases, equal to 15-20 billion dollars, causing a total expenditure of 60 billion dollars, considering the direct and indirect sanitary costs, related to the work absenteeism.

In the European environment these diseases are object of analysis only from few decades. The European statistic data are hard to understand and compare for the fact that the concept of professional disease is related to national regulatory system of recognition and compensation that requires a clear proof showing that the job task was the cause of the pathology. However, considering that the that recognition and compensation systems can vary from one country to another, the collection of data on these occupational diseases, as well as others, in the EU is very complicated; so, for the moment, only a few diseases of the spine and upper and lower limbs are recognised at Community level and defined in the European list of occupational diseases issued by the European Commission in 2003. Table 3 shows professional diseases and their relative code.

Code	*Professional disease*
505.01	Hands and wrists osteoarticular diseases induced by mechanical vibrations
505.02	Angioneurotic diseases induced by mechanical vibrations
506.10	Diseases of periarticular bags due to pressure
506.11	Pre and subpatellar bursitis
506.12	Olecranon bursitis
506.13	Shoulder bursitis
506.21	Diseases caused by overshooting of tendon sheaths
506.22	Diseases caused by hyperactivity of the peritendon tissue
506.23	Diseases caused by overshooting of tendon muscle inserts
506.30	Meniscus injuries caused by prolonged work in a kneeling or squatting position
506.40	Nerve paralysis due to pressure
506.45	Carpal tunnel syndrome

Table 3: Diseases caused by physical agents. “raccomandazione della Commissione europea del 19 settembre 2003 sull’elenco delle malattie professionali” (2003/670/CE)

The relevance of musculoskeletal diseases is emerged after the surveys on European workers health and the job conditions, conducted from the European foundation for the work and life condition improvement (Eurofound) and from the information and training campaigns by the European Agency for Health and Safety at Work (EU-OSHA). Data are showed in table 4.

	AU	B	DK	FIN	FR	GE	GR	IRL	IT	LU	PT	SP	SW	NL	UK	EU
Risks at work and health problems																
Back pain	31	21	30	33	29	34	44	13	32	32	39	35	31	17	23	30
Arms and legs pain	14	9	24	29	19	13	37	6	19	13	31	24	24	10	11	17
Work absenteeism																
% absen ces*	36	26	15	30	21	34	18	16	17	29	22	19	13	27	16	23

Table 4: European work conditions and work absenteeism. "Seconda inchiesta europea sulle condizioni di lavoro (1996) – Fondazione europea per il
miglioramento di vita e di lavoro (Eurofound)" *absences due to work related health problems, recorded in the last 12 months

The most claimed disturb is the back pain, with a community average equal to 30%, 17% for the upper and lower limb disturbs, with higher percentages in country where the industrial and manufactory sector are prevailing.

Another element regards the work absenteeism due to temporary invalidity to the tasks job, in 2007 more than 45% of all work-diseases regarded to musculoskeletal diseases where workers were exposed to repetitive manual handling of loads.

Among the main activity sector where musculoskeletal diseases are more impactful there are manufacturing, construction, transport, catering and health. For what concerns ages and genre, in the European environment, MSD are more spread among men and young, among women instead, tunnel carpal syndrome is the most common disturb, especially notable in manual jobs with high velocity and frequency tasks.

Looking at the social and economic burden, even if there are not exactly amount, it is possible to estimate that the sum of all work-related professional diseases ranges from 2,6 to 3,8% of the gross national product, in particular those related to musculoskeletal diseases range from 0,5 to 2%. They are directly responsible of more than 600 million days of work per year, that determine:

- Increase of indemnity and insurance costs;
- Productivity reduction;
- Psychological effect on work's quality of life and loss of work staff experience, to which should be associated the additional costs for the recruitment and training of new workers, if it is not possible to reintegrate those suffering from the disease.

1.3 TECHINCAL RULES FOR MANUAL HANDLING OF LOAD

Pursuant to Article 167 81/2008, we consider "manual handling of load" every task linked to the carriage and the retaining of loads, lifting, laying, push and pull tasks included. This law regulates the protection of the health and safety of workers at the workplace; its goal was to establish rules and preventions measures to make the work environment safer. The objective is to avoid or reduce the exposition to work related risks of injury, accident or professional illnesses.

To summarize: "Safety at work is the condition to let employees work in safety, without exposing them to the risk of accidents or occupational diseases".

1.3.1 UNI ISO 11228

The three technical rules of UNI ISO 11228 series are respectively dedicated to:

1. Manual lifting and carrying activities,
2. Pushing and pulling;
3. Handling of low loads at high frequency.

The first part, UNI ISO 11228.1[2], published in 2003, specify recommended limits for object that can be lifted and carried, considering intensity, frequency and the task last, including a guide for the workers' health and risk assessment. It can be applied for manual handling of 3 kg loads or heavier, characterized by moderate walking speed (0,5 to 1 m/s), in cannot be applied for pushing and pulling, one-hand, and multi person tasks. Finally, it is valid for not more than 8-hour handling period.

With the UNI ISO 11228.2[3], published in 2007 we can evaluate push and pulling risk related performed by an adult worker, standing that uses both hands to apply the force needed to move or stop an object, usually a cart. The protocol involves different assesses:

- Danger identification (strength, posture, distance, characteristics of the object, individual characteristics of the operator, work organisation);
- Risk estimation;
- Risk evaluation and quantification.

For what concern the evaluation step, the law gives the possibility to use two methods of analysis:

1. The first one is used to quickly assess the pushing and pulling risk related;
2. The second one is used only if the result of the first one gives "inacceptable condition" relying on biomechanical risk and it let calculate the limits of acceptability based on muscular strength and low back compression forces.

Starting from these values we can calculate the safety limit, determined by ratio: real pushing/pulling force divided by the forces suggested, that we can find on their tables.
UNI ISO 11228.3[4] deals with lifting and carrying, and push-pulling tasks. It is applied for risk assessment in those operation including upper limb repetitive movements.
These operations, that include the use of instrument or tools, or high frequency operation, handling low loads, presents risks of onset of pathologies of biomechanical overload affecting the osteoarticular, musculoskeletal and neurovascular structures.
There are different ways to assess the biomechanical risk due to the manual handling of loads, below are some of them.

1.3.2 NIOSH method

It is the most used method for the assessment of the manual lifting actions. For each lifting actions there is a "maximum recommended weight" by an equation that consider the maximal weight that could be lifted in an "ideal condition", this weight will be multiplicated to factors that consider the real conditions of the lifting axion performed. The result is a value defined as maximal recommended weight that a worker can handle.
In the NIOSH method risk assessment, the ideal weight is 23kg, then, each multiplicative factors takes on a value from 0 to 1:

- 1= optimal condition, does not lead to a reduction of the ideal weight
- 0= extreme risk, it indicates an absolute inadequate condition of the manual handle of loads considered

Therefore, if the risk is present but not extreme, the multiplicative factor will take on a value lower than 1, with a consequent reduction of the weight to handle.
Thus, comparing the weight the worker is handling to the recommended weight, we can find the lifting index (LI).
Table 5 showed NIOSH maximum recommended weight calculation.

KG		Maximal recommended weight in lifting condition
HEIGHT FACTOR	**X**	Height of the hands from the ground at the beginning of the lifting action
DISPLACEMENT FACTOR	**X**	Vertical displacement of the wrist from the beginning to the end of the lifting action
HORIZONTAL FACTOR	**X**	Maximal weight displacement from the body during the lifting action
ASSIMETRY FACTOR	**X**	Angular dislocation of the weight compared to the sagittal plane of the subject
FREQUENCY FACTOR	**X**	Frequency of the lifting action per minute
GRIP FACTOR	**X**	Grip judgment
	=	**RECOMMENDED WEIGHT (RW)**

Table 5: Calculation of NIOSH method maximum recommended weight. "P. Cinquina, Movimentazione Manuale dei carichi: metodi di valutazione, Ipsoa, Milano, 2009, 36"

There are some conditions that have to happen in order to apply the maximum recommended weight:

- Weight load lower than 3 kg;
- Not occasional actions (mean frequency once per hour);
- Occasional actions, but weight load around the maximum recommended weight, in particular if there are incongruous postures of the spine;
- Standing lifting actions not in small spaces;
- Two-handed lifting;
- Other manual handling loads like pushing, pulling or carrying;

- Static friction coefficient lower than 0.4 (adequate friction between soles and the ground);
- Lifting index performed not in a fast way;
- Load to lift not extremely hot, cold or with instable content;
- Favourable microclimate conditions.

The NIOSH's result is an index (R) that might indicate an elevate or low risk, assessable through 3 areas:

- Green area R<0.85: acceptable situation;
- Yellow area R from 0.86 to 0.99: situation close to the limit, immediate actions not necessary, training and health surveillance suggested;
- Red area R>1: there is a need for a primary prevention.

Therefore, the higher the index, the higher the risk, for index higher than 3, an immediate intervention is necessary.

1.3.3 Snook & Ciriello method

This method was established to assess the risk related to the flat displacement, loads towing and thrusting and it is based on studies carried by Snook and Ciriello who evaluated the worker's perceived effort when lifting, towing and thrusting loads.

The results are summarized in tables that provide threshold values for every sort of action and load the workers will handle, stratify by age, gender and action category.

Tables provide Threshold values also for:

- Action characteristics:
    - Frequency;
    - Level (distance from the floor) of the force application point;
    - Carrying Horizontal displacement
- Load threshold values;
- Force application thresholds:
    - Starting force
    - Maintaining force

The usage of data reported in the tables is simple:

1. Identify the situation which reflected the setting to assess;
2. Select the population by gender;

3. Find the recommended value for weight and force;
4. Compare the recommended weight with the one wich the worker is actually handling;
5. Compare the recommended force with the one which the worker is actually performing (using a dynamometer).

Dividing the actual weight and force used to the values found in the tables, we will obtain a synthetic risk index. In table 6 the Snook and Ciriello Risk assessment method.

Risk synthetic index < 0.75 Any specific intervention is not required
Risk synthetic index from 0.76 and 1.25 Although an immediate intervention is not necessary, it is recommended to enable the training and medical surveillance of staff
Risk synthetic index > 1.25 The situation can be risky, a primary intervention is required

Table 6: Snook and Ciriello Risk Assessment.

1.3.4 Occupational Repetitive Actions index

The Occupational Repetitive Action index (OCRA) is a synthetic index which describe risk factors of upper limb repetitive actions at work. The OCRA index quantifies the relationship between the actual daily movements performed in repetitive tasks, and the number of recommended actions: OCRA = number of technical actions performed / numbers of recommended technical actions during the shift.

The technical actions are all the movements which lead to fulfilment of an operation, while the number of recommended actions results from observed actions multiplied by weights owing to the following conditions: posture of the parts of the limb, use of force, lack of rest periods, duration of the repetitive actions and other factors defined as “additional” (requirement for extreme precision, use of inadequate gloves, required use of rapid or sudden wrenching movements).

The application of the method is also based on the detection of the singles work phases:

- Cycles: group of one or more technical actions which are repeated
- Repetitive task: jobs characterized by cycles
- Work activity: activity formed by one or more repetitive or not repetitive tasks.

The recommended numbers of technical actions are given by the formula:

$\sum^{n}_{j=1} [K_f (F_{Mj} \cdot P_{Mj} \cdot R_{eMj} \cdot A_{Mj}) \cdot t_j] \cdot (R_{cM} \cdot t_M)$ where the values are related to risk factors and job characteristics and can be obtained from the indications provided by the UNI ISO 11228-3 standard.

- K_f constant of frequency: maximal number of technical actions that can be made in ideal conditions (30 actions /minute);
- F_M : number from 0 to 10 which describe the muscular effort (CR10-Borg);
- R_{eM} : relates the job tasks repetitiveness;
- P_m postural factor: considers the different posture of the shoulder, elbow, wrist and hand, and how long is keep for;
- A_m : relates the presence or not of other additional risk factors;
- t time factor: considers the actual last of repetitive movements;
- R_{cM} recovey period factor: considers the distribution of recovery periods and their last:
- t_M: relates to the last of the entire work shift

The OCRA index has to be calculated for each limb, the resulted value expresses the risk level related to repetitive movements. With this value it is possible to quantify the risk by using the next table, where there are different classes of risk. In table 6 the OCRA risk classification.

OCRA Index	*Risk*	*Corrective Actions*
≤ 2.2	Acceptable	None
2.3 – 3.5	Conditionally acceptable	Repeat the assessment; reduce the risk where it is possible
3.5 – 4.5	Low	Risk reduction by priorities; medical surveillance; workers training
4.5 – 9	Medium	Risk reduction as soon as possible by priorities; medical surveillance; workers training
> 9	High	Instant risk reduction; medical surveillance; workers training

Table 7: OCRA risk classification

The risk calculation is the starting point for the implementation of preventive actions by a priorities order, established by the amount of the factors which determine the risk conditions. The factors analysis indeed allows you to select di intervention priority based to the values they assume.

1.3.5 RULA method

RULA method provide a quick practical criterion selection of workers potentially affected by upper limb musculoskeletal disorders, indicating the exposure risk level.

It considers the following factors, quickly assessing the awkward postures and the muscular effort related to these:

- Numbers of performed movements;
- Mainly static work;
- Use of force;
- Assumed posture due to used tools;
- Task repetition.

Based on the obtained score, the method provides an interventions priority order of the activity worth to be analysed, while the score related to the posture and the use of force, indicate which aspects are more affecting the problem.

The RULA method uses diagrams in which there are body postures and three score tables. Based on the combination of the scores it is possible to establish the final score, from 1 to 7, related to four action levels. It is possible to split the progression of the method in three steps:

1. Body postures registration during the task;
2. Score establishment;
3. Risk classification establishment.

First step:

The body has been spitted in two categories:

A. Arm, forearm, wrist;
B. Neck, trunk, legs.

These splits guarantee the whole-body posture assessment and how these postures affect the upper limb posture we want to risk assess.

Second step, showed in table 8 and 9:

Force quantification related to the weight (kg) and its characteristic, including the muscle effort for the static work or repetitive movements.

Force and weight to assess for each hand	No resistance (less than 2Kg and intermittent force)	+ 0
	2-10 Kg intermittent weight	+ 1
	2-10 Kg static or repetitive weight	+ 2
	>10Kg static repetitive weight and/or bouts	+ 3
Muscular usage	Mainly static posture, maintained for more than 1 minute	+ 1
	More than 4 repetitive actions per minute	+ 1

Table 8: RULA second step 1. "Regione Veneto, metodi per la valutazione del rischio da rischio da sovraccarico biomeccanico degli arti superiori, 2008"

Force and weight for neck, trunk and legs	No resistance (less than 2Kg and intermittent force)	+ 0
	2-10 Kg intermittent weight	+ 1
	2-10 Kg static or repetitive weight	+ 2
	>10Kg static repetitive weight and/or bouts	+ 3
Muscular usage	Mainly static posture, maintained for more than 1 minute	+ 1
	More than 4 repetitive actions per minute	+ 1

Table 9: RULA second step 2. "Regione Veneto, metodi per la valutazione del rischio da rischio da sovraccarico biomeccanico degli arti superiori, 2008"

The integrative factors identified allow to determine the C and D scores:

- "A" Posture score + Muscular usage + Force = C score;
- "B" Posture score + Muscular usage + Force = D score

Table 10 reported last step:

This phase allows you to reach the final score, which provide the indication about the situation to analyse. The final score, from 1 to 7, is based on the risk of musculoskeletal disorders, due to the previous assessed stress, and it is determined by comparison between C and D scores.

FINAL SCORE									
D C	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	1	2	3	3	4	5	5	5	5
2	2	2	3	4	4	5	5	5	5
3	3	3	3	4	4	5	6	6	6
4	3	3	3	4	5	6	6	6	6
5	4	4	4	5	6	7	7	7	7
6	4	4	5	6	6	7	7	7	7
7	5	5	6	6	7	7	7	7	7
8	5	5	6	7	7	7	7	7	7
9	5	5	6	7	7	7	7	7	7

Table 10: RULA final score. "Regione Veneto, metodi per la valutazione del rischio da rischio da sovraccarico biomeccanico degli arti superiori, 2008"

Actions levels are determined as below:

- Action level 1

Final score 1-2 indicates an acceptable posture as long as not maintained or repeated for long periods.

- Action level 2

Final score 3-4 indicates that more observations are needed, modifications are necessary.

- Action level 3

Final score 5-6 indicates that more evaluations and short-term modification are needed.

- Action level 4

Final score ≥ 7 indicates the immediate necessity of evaluations and modifications.

1.3.6 Rapid Entire Body Assessment (REBA) METHOD

This assessment tool uses a systematic process to assess whole body postural MSD and risks related to job tasks. A page worksheet is used to evaluate different types of movements, body posture, task repetition and forceful exertion.

The REBA was designed for easy use without need for an advanced degree in ergonomics or expensive equipment. Using the REBA worksheet, the evaluator will assign a score for each of the following body regions:

- wrists,
- forearms,
- elbows,
- shoulders,
- neck,
- trunk,
- back,
- legs,
- knees.

After the data for each region is collected and scored, tables like table 11 is used to evaluate the risk factor variables, generating a single score that represents the level of MSD risk:

Score	*Level of MSD Risk*
1	Negligible risk, no action required
2-3	Low risk, change may be needed
4-7	Medium risk, further investigation, change soon
8-10	High risk, investigate and implement change
11+	Very high risk, implement change

Table 11: REBA MSD Risk Score

The evaluator should observe the worker's movements and postures during several work cycles. Selection of the postures to be evaluated are based on:

- ✓ the most difficult postures and work tasks (based on worker interview and initial observation),
- ✓ the posture sustained for the longest period of time, or the posture where the highest force loads occur.

The REBA method is fast to conduct, so multiple positions and tasks within the work cycle can be evaluated without a significant time cost.

When using REBA, only one side is assessed at a time. The evaluator, after interviewing and observing the worker, can determine if only one arm should be evaluated, or if there is a need of an assessment for both sides.

The REBA worksheet is divided into two body segment sections.

- ✓ Section A (left side) covers the neck, trunk, and leg.
- ✓ Section B (right side) covers the arm and wrist.

This split of the worksheet ensures that any awkward postures of the neck, trunk or legs which might influence the postures of the arms and wrist are included in the assessment.

For each region, there is a posture scoring scale and additional adjustments which need to be considered and accounted for in the score.

1.4 THE WORK OF LUMBERJACK

Nowadays, the work of lumberjack is crucial for the protection of forests, biodiversity, the fauna's control and the prevention of wildfires.

The Lumberjack deals with chopping down branches, rooting out, depilating and stacking timbers.

Despite there are different mechanical tools to perform these tasks, many of them are done by hand, the lumberjack is so called to a strenuous physical strain. In particular, when lumberjacks use a chain-saw or other vibration tools is very demanding, involving musculoskeletal and cardiovascular strain, even if ergonomic guidelines are followed and proper equipment is used. Musculoskeletal disorders, showed in table 12, easily affect the workers and the performance of tree-cutting, moreover, early retirement from the occupation is common.

PHYSICAL AGENT DISEASES EXCLUDING TUMOURS	
AGENTS	*DISEASE*
Mechanical vibrations transmitted to hand-arm system	Secondary Raynaud Syndrome
	Osteoarthropathy (wrist, shoulder, elbow)
	Carpal Tunnel syndrome
	Other neuropathies of upper limb
	Tendonitis-tenosynovies hand-wrist
Manual handling of loads, performed with continuity	Spondylodiscopathies of low back
	Lumbar ernia
Upper extremity microtraumas and incongruous postures for repetitive activities	Tendinitis of the supraspinatus
	Tendinitis of the long head of the biceps
	Dupay’s disease
	Bursitis
	Epicondylitis
	Tendonitis flexors/extenders wrist-fingers
	De Quervain’s disease
	Carpal Tunnel syndrome
	Snap fingers
Knees microtraumas and incongruous postures for repetitive activities	Bursitis
	Tendinopathy of the femoral quadriceps
	Degenerative meniscopatia
Upper limb microtraumas and incongruous postures for repetitive activities	Syndrome of ulnar nerve entrapment
	Tendinopathy distal triceps insertion
	Guyon channel syndrome
Foot microtraumas and incongruous postures for repetitive activities	Plantar talalgia
	Achilles tendonitis
	Syndrome of the tarsal tunnel

Table 12: List of diseases that could affect the lumberjack, considering the nature of their job, for which is mandatory to report under and for the effects of article 139, 30-06-1965 n. 1124.

1.5 OBJECTIVE

We have analysed data present in literature relating to the prevalence of work-related musculoskeletal diseases in lumberjacks, there were difficulties in researching and analysing the literature, due to lack of studies for the evaluation of the prevalence of MSD in this sector, in addition, the terms to identify the specific forestry worker (lumberjack, lumberman, woodcutter, woodman, forester or logger) was not indexed as mesh term, this made more difficult the research, the gather and the analysis of the sample, thus, the objective of this systematic review is to assess the prevalence of MSD in Lumberjacks.

2. METHODS

The literature search and article revision were performed from February to April 2021. The keyword "lumberjack[title/abstract] or lumbermen[title/abstract] or forestry[title/abstract] or forest workers[title/abstract] and risk assessment[title/abstract] or risk management[title/abstract] or occupational medicine[title/abstract] or risk factors[title/abstract] or occupational exposure[title/abstract] and musculoskeletal diseases[title/abstract] or occupational diseases[title/abstract]".

The research was carried out on the online database PubMed and Scopus, no time restriction regarding publication year were applied.

2.1 INCLUSION EXCLUSION CRITERIA

Only studies published in English in peer-reviewed journals were considered eligible. To be included, articles had to meet the criteria in Participants and type of Diseases (lumberjack whose had experienced MSD).

The exclusion criteria were:

a) Type of article: we have not considered eligible letter to the editor, reviews or book chapters;
b) Other types of forest workers: we only considered lumberjack as operator in jobs like chopping down branches, rooting out, depilating and stacking timbers, using chainsaw and vibration tools;
c) Type of diseases: we excluded diseases caused by pesticides, accident or fatalities, cardiovascular disease, or other sort of pathologies that were not considerable a Musculoskeletal Disease as "Diseases of the muscles and their associated ligaments and other connective tissue and of the bones and cartilage viewed collectively".

To perform an initial selection, two researchers independently examined all abstract resulting from the literature search, then, the full texts were read to include them in the revision process. Subsequentially, independent searches were combined, compared and reviewed to identify the included studies. In case of discrepancies, a third researcher was consulted.

3. RESULTS

4956 studies were screened and 4510 abstract were read after the duplicate's remotion. 4200 records were then excluded, the exclusion procedure is showed in the following flow chart diagram, figure 2. Thus, 310 full texts were assessed for eligibility, 292 of them were excluded.

Finally, 18 studies were included in the review.

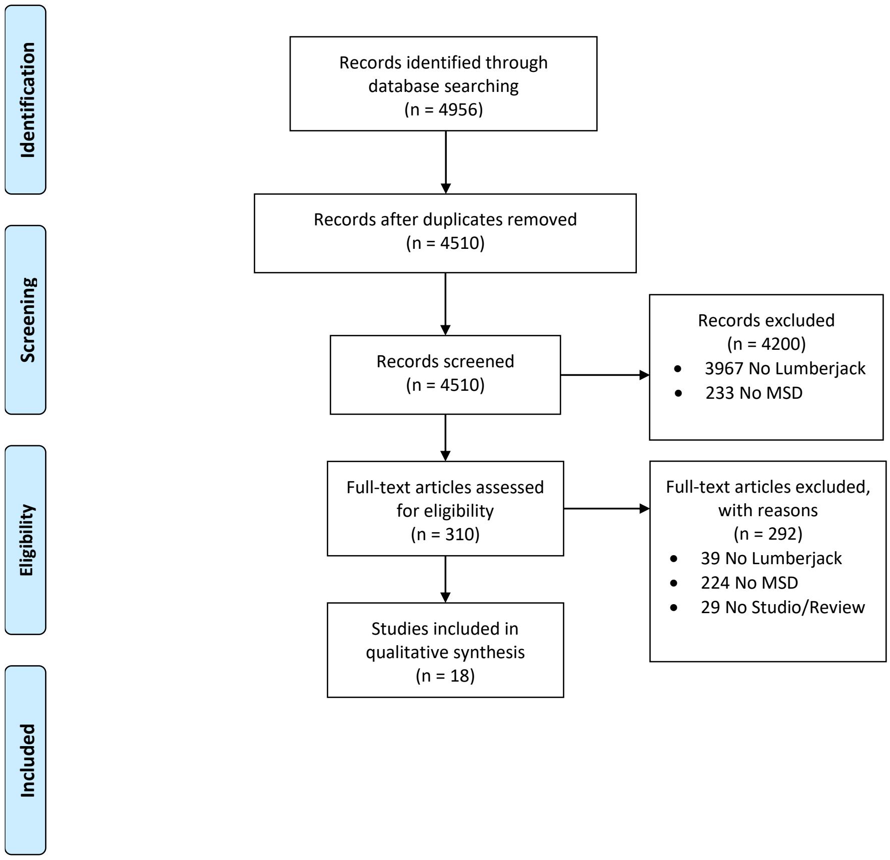

Fig. 2: Flow chart diagram.

The characteristics of the different studies are summarized in Table 13. The sample size of the included studies ranged from 29 to 807 participants, aged 18 to 70 years old.

The most common exposure is the use of chainsaw as a main tool for felling works, however, many studies did not explain exactly tasks the workers used to perform, simply writing, for example, "worked as lumberjack"[5,6], "felling work"[7], "forestry work"[8,9], "task related to manipulating heavy loads"[10,11].

To assess MSD, the most used tools was medical examination or interview, questionnaires like the Standardized Nordic Questionnaire or similar.

Study	*Subjects and grouping*	*Exposure and disease*	*Evaluation*
T. Kumlin (1973)[12]	· 35 · 43.9 a (ranged from 33 to 58)	·85% had used saw for 7 to 20 years, for 8 to 12 months a year, 20 to 29 days a month. 80% worked whit it 5 to 9 hours per day ·Arthrotic changes in radius, ulna, carpal region	Radiological examination
V. Parvi (1975)[5]	· 807 · 8 - 52 a	· worked as lumbermen · back diseases	X-rays
E. Sairanen (1981)[7]	· 226 lumberjack (42, 26-65) a · 98 referents (42 22-64) a	· Felling work for at least 10 years (average 20 years) · Low back pain	Medical Examination
K. Koskimies (1990)[13]	· 125 · 43.6 (8.3) a	· Chain saw vibration 16000 (SD 4400) · Carpal Tunnel Syndrome	Medical Examination
S. Vayrynen(1991)[14]	· 29 · 32 a	· motor manual logging · LBP	
M. Bovenzi (1991)[15]	· 65 forestry workers (44.7 SD13.7) a · 31 controls (44 SD 8) a	· Chain-saw vibration (11.3(SD9.3) years total operation time 9196 (11023) 7.2 (1.2) energy equivalent frequency weighted acceleration for a period of 4h · Neck, shoulder, elbow, wrist, hand pain	Medical interview
K. Koskimies (1992)[16]	· 118-205 (from 1972 to 1990) · 18-63 a	· ≥ 1500h of chain saw operating in the three consecutive years before the examination · Hand, neck and back pain	Questionnaire

P. Leino (1994)[17]	·77-78 lumberjack (41.9 SD6.42) a · 41 control group (40.9 SD6-70) a	· Professional lumberjacks, i.e tree-cutters that use chain saw as a main tool · Low back pain	Questionnaire
O. Kaewbooncho (1998)[18]	·40 chain saw operators (50 SD14) a ·40 aged matched bush cleaner (51 SD15 a)	· Length of job experience as a chain saw operators 20 (16) years · neck, shoulders, elbows, wrist/hand, low back, knees, ankles/feet pain	Standardized Nordic Questionnaire
H. Sandmark (2000)[10]	· 369 men · Of wich 23 forest workers · 380 women · 700 referents	· ≥ 10 years heavy job · Knee osteoarthrosis	Identified through the nationwide Swedish knee arthroplasty register
C. Gallis (2006)[19]	·78 forest workers (41 SD 10.93) a	· Use of chainsaw and farm tractors, special vehicles or mules · Shoulders, elbow, hand/wrist, hips/things, knee, ankle/feet, neck, upper and lower back pain	Standardized Nordic Questionnaire
J. Rantonen (2014)[20]	· 89 intervention group (45 SD8)a · 92 controls (43 SD7) a	· Low back pain	VAS
M. Bovenzi (2016)[21]	· 215 Forestry workers (42.8) a · 34 Stone workers (37.2) a · 138 controls (38.8)	· Vibration tools · Neck, shoulder, elbow/forearm, wrist/hand pain	Medical investigation

S. Rudolph (2017)[8]	· 46 Intervention group (BMI<26) 37.6 a · 22 Control group (BMI<26) 40.3 a · 66 Intervention group (BMI>26) 46.5 a · 59 Control Group (BMI>26) 46.0 a	· Forestry work for 19.6 years · 22.2 years · 28.4 years · 28.9 years	Standardized Nordic Questionnaire
S. Fulmer (2017)[6]	· 395 (50 SD15) a · 271 captains (55 SD13)a · 125 Sternmen (39 SD15)	· Lobstermen · Neck, shoulder, elbow, hand/wrist, back, legs pain	Questionnaire adapted from the Nordic Musculoskeletal Questionnaire on pains, disabilities and related medical care
P. Choina (2018)[9]	· 414 forestry workers (48, 25-65) a · 119 controls (45.8, 23-64)a	· Forestry workers with a duration of employment from 1-48 years (mean 26). ·Neck, shoulders, upper part of the spine, loins, knee, feet, lower back pain	Questionnaire based on the standard Nordic Questionnaire

L. Pesakova (2018)[11]	· 55 (45.6)a · Of which 4 forest workers · 25 males (45.4)a ·30 females (45.8)	· Task related to manipulating heavy loads, abnormal working postures, frequent bending and twisting of the trunk or extreme muscle strain · Low back pain	
A. Rodriguez (2019)[22]	· 88 · 18-60 a	· On average, 5.2 days per week, 10.6 hours per day logging machine operators · neck, upper back, lower back, upper limb, lower limb	Self administered 93 item questionnaire

Table 13: Study characteristics. SD=standard deviation, a=age

Author (year)	*Disease cases*		
	UPPER LIMB	**LOWER LIMB**	**SPINE**
T. Kumlin (1973)	• Arthrotic changes in radius and ulna:1 • in the carpal region:1 • Interphalangeal joint of the little finger:1 • Hand:15		
V. Parvi (1975)			Back diseases: 92
E. Sairanen (1981)			LBP: 141
K. Koskimies (1990)	CTS:25		
S. Vayrynen (1991)			LBP: 29

M. Bovenzi (1991)	• Shoulder:16 • Elbow:28 • Wrist:23 • Hand:15		Neck: 13
K. Koskimies (1992)	Hand: 22		• Neck:34 • Back:35
P. Leino (1994)			LBP: 87
O. Kaewboonchoo (1998)	• Shoulders:15 • Elbows:7 • Wrists/Hands:5	• Knees:2 • Ankles/feet:1	• Neck:1 • LBP:8
H. Sandmark (2000)		Knee OA:23	
C. Gallis (2006)	Shoulder:40		•Neck: 41 • LBP:68
J. Rantonen (2014)			LBP:181
M. Bovenzi (2016)	• Shoulder:70 •Elbow/forearm:47 • Wrist/hand:43		Neck: 84
S. Rudolph (2017)	Shoulder:199		LBP:201
S. Fulmer (2017)	•Shoulders:151 •Elbows:67 •Hands/wrists:115	•Hips/thighs:43 •Knee/shin/calf:105 •Ankles/feet:59	•Neck:53 •Upper back:39 •LBP:199
P. Choina (2018)	Shoulders:144	•Hips74: •Knee:214 •feet:91	•Neck:127 •Upper back:72 •LBP:272
L. Pesakova (2018)			LBP:4

A. Rodriguez (2019)	Upper limb:18	Lower limb:26	•Neck and upper back:30 •LBP:30

Table 14: Split of different lumberjack work-related MSD. CTS= carpal tunnel syndrome, LBP=low back pain

Table 14 shows the prevalence of MSD sorted into regions: upper limb, lower limb and spine.

For upper limbs, the most common area involved was shoulder[15,18,19,21,8,6,9] with number of cases ranged from 15 to 199, followed by hand/wrist and elbow. For lower limbs, knee was the most involved joint[18,10,19,20] with number of cases ranged 2 to 214. Then, almost every study taken in consideration reported spine cases[5,7,14,15,16,17,18,19,20,21,6,9,11,22], in particular, the most common diseases were Low Back Pain (8 to 272 cases) and Neck Pain (1 to 127 cases).

4. DISCUSSION

This systematic review aimed to summarize the prevalence of musculoskeletal disorders in lumberjacks.

The work of lumberjack is characterized by strenuous work and use of vibration tools, while the occurrence of MSD seems increase with the increase of vibration exposure[15], indeed, as a most common exposure factor we found chainsaw vibration. Some analysed studies, additionally, describe more or less precisely the exposure the workers had experienced[12,15,16,18,8,9,22].

Repetitive movement, and use of vibration tool are in fact risk factors for work-related MSD and the chronic exposure to these may lead to onset of spine, upper and lower limb diseases for lumberjacks.

4.1 UPPER LIMB MUSCULOSKELETAL DISORDERS

For what concern upper limb disorders, based on our results, the most common disorder is shoulder pain.

There are many factors which may cause musculoskeletal symptoms, such as working techniques, work organization, awkward posture during tasks execution and loads[19].

For example, the performance of repeated work activities by lumberjacks, who often are in twisted and bent backwards positions, while lifting and carrying loads, and the hand-transmitted vibrations may cause different body areas pain complaints[9].

In particular, shoulders are heavily stressed by carrying the chainsaw and/or working in a forward trunk flexed position while harvesting[8]. Shoulders are overload because of the holding of chainsaw, and also for the static constant load of pushing this tool while cutting the logs[19].

Additionally, hand-transmitted vibrations caused by chainsaw seems to be an important contributing factor to the development of upper limb MSD in workers using vibration tools[15].

Results showing many complaints even in elbow/forearm and wrist/hand areas.

In Bovenzi's study, there was evidence for significant exposure-response relationships between hand-transmitted vibration exposure and occurrence of MSD in these body regions[17]. Kwaebonchoo describes chainsaw forestry tasks as activities requiring static activity to carry and operate the vibration tool, with a bending posture and repeatedly arm flex-extension[13].

Hand and wrist are constantly stressed while supporting, keeping and directing chainsaws, this, in addition to vibrations, could lead to MSD in these anatomical areas[19].
Therefore, our results are justified, considering work activities performed by lumberjacks and their risk factors exposure.

4.2 SPINE MUSCULOSKELETAL DISORDERS

According to our results, Low Back Pain and Neck Pain are the most complained MSD.
Work-related musculoskeletal disorders are multifactorial, involving occupational (for example ergonomic), environmental (for example temperature), and individual factors (like age or injury history)[22].
Referring to occupational factors, repetitive movements, awkward and prolonged static postures may increase MSD risk, in fact, performing the same task over and over and working fast were identified as problematic for the low back area[22].
Personal risk factors, like greater age, body mass index (BMI) and lack of sleep, and environmental, like heat stress, fatigue and dehydration could also contribute to the development of MSD[22].
Lower back disorders are indeed associated with heavy physical work and lifting[19], as a matter of fact, lumberjacks often work in twisted and bent position, lifting and carrying heavy loads and they are exposed to whole body and/or hand-transmitted vibration and this may cause pain complaints especially in lower back[9].
Moreover, in Gallis's study, the results indicate that lower back disorders are a major health issue for this sector, with also a high frequency of pain in neck region, having regard to stresses associated to occupation with maintenance posture and repetitive tasks[19], like that of lumberjacks.
In fact, these findings agree with results based on our review, since neck pain is one of the most common MSD related to spine as well.

4.3 LOWER LIMB MUSCULOSKELETAL DISORDERS

For lower limb, we found knee pain as most prevalent disorder.
Lumberjack's job shows high exposure to lifting, jumping and vibration exposure, likewise, their work tasks lead to physical factors exposure, like incongrous posture, for example

squatting or knee bending and kneeling while cutting logs, or environmental risk factors like monotone and repetitive task with pace and occurrence of fatigue.

Moreover, Sandmark reported a risk of developing knee Osteoarthritis (OA) for those workers who squatting, jumping or who assume kneeling positions[10].

Repetitive knee use, joint loading and heavy lifting are so risk factors for the occurrence of lower limb MSD, and could be also associated with knee OA[10].

Lumberjacks have so high exposure to lifting, jumping and vibration at work[9], having said that, considering their working conditions, musculoskeletal symptoms in knees could be frequent[18], as a matter of fact, our results, which see knee as most affected lower limb area are in line with these studies and with the sort of overloads the workers use to experience.

4.4 PHYSICAL EXERCISE

Regular exercise appears to prevent MSD, in particular back pain[7].

Because forestry work is associated with intensive musculoskeletal stress, and physical exercise reduces musculoskeletal pain[8], the use of physical exercise as an instrument to prevent MSD could be useful.

For example, in S. Rudolph study was investigate the effects of a training intervention on pain perception in overweight forestry workers[8]. The exercise intervention was specifically created as a compensation strategy for the physical requirements in forest work and it was focused on core stability exercise.

A modified version of Standardized Nordic Questionnaire was used to determine the pain perception in different anatomical areas, also, the intervention group with overweight referenced a lower pain perception in every body region, the differences in shoulder (p=0.001, $\tau = 0.22$) and lower back (p=0.004, $\tau = 0.18$) were significant.

Their study results indicate that a specific training intervention has positive effects on pain perception for workers with overweight, especially in low back and shoulder.

Moreover, in P. Leino study[17] the subjects underwent a 1-week work-oriented physical fitness course designed to activate exercising during leisure time, consisted of exercise, walking, jogging, ball games gymnastic, stretching, and so on, lecture on the structure and function of the spine, work ergonomics, nutrition, and fitness tests.

In the intervention group, they report improving in perceived fitness, health and work ability while ergonomic strain at work decreased.

The high prevalence of MSD may impede lumberjacks from doing their work, resulting in work absenteeism, reducing work productivity and might have an effect on health care system costs, on workers themselves and on the employer.

Preventive measures, also based on physical exercise breaks during work, with muscular activities, core stability and strength exercise[17] could be introduced to decrease strain of musculoskeletal system and to maintain work capacity, performance and efficiency[14].

5. CONCLUSION

The objective of this study was to summarize the prevalence of musculoskeletal disorders in lumberjacks. The tasks the lumberjacks use to perform are characterized by strenuous work and use of vibration tools, indeed, as a most common exposure factor we highlight chainsaw vibration.

For spine areas, LBP, neck pain and upper back pain are the most common MSD, shoulder pain, elbow, forearm and wrist/hand for upper limbs, meanwhile knee, hips, thighs, ankle and feet cases were found for lower limb.

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