




Review

Applications of the Standardized Nordic Questionnaire: A Review

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Abstract: Sustainability seeks to provide economically viable products in an environmentally friendly way while respecting worker rights. Physical wellbeing forms part of these rights. Musculoskeletal disorders (MSD) diminish productivity, cause absence from work, impose costs on the public health system and can cast doubt on the sustainability of a company or a product. The objective of the present work is to review the literature on the application of the Nordic Musculoskeletal Questionnaire (NMQ) on a worldwide level. In this work, the use of the NMQ has been classified by categories of knowledge, countries and years. The search was made using “Web of Science-Core Collection”. In total, 259 articles were chosen from scientific journals and conferences related, according to the title and or abstract, to the practical application of the questionnaire. In conclusion, the NMQ has been applied mainly in three sectors: “activities related to treating human health and social issues”, “manufacturing industries”, and “agriculture, livestock, fishing, and forestry”. The NMQ is an indirect method commonly used individually or complemented with other methods for evaluating the MSD and possible associated psychosocial and labour risks. The use of NMQ can help in the evaluation of the sustainability of a company.

Keywords: musculoskeletal disorders; Occupational Health and Safety; ergonomics; prevention; physical load

1. Introduction

1.1. Sustainability and Occupational Health and Safety (OHS)

In 1987, The General Assembly of the United Nations indicated: “*Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits—not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organization can be both managed and improved to make way for a new era of economic growth*” [1].

Recently, in 2015, the criteria of sustainability were revised, introducing 17 Sustainable Development Goals and Targets to reach by 2030. Objective 8 indicates: “*Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all*” [2].

The sustainability of any company or process is based on the economic, ecological, and social development maintained over time [3,4]. In this way, it could be said that a product of any company

is sustainable if it is economically viable and has been achieved in an environmentally friendly way while respecting worker rights (Figure 1).

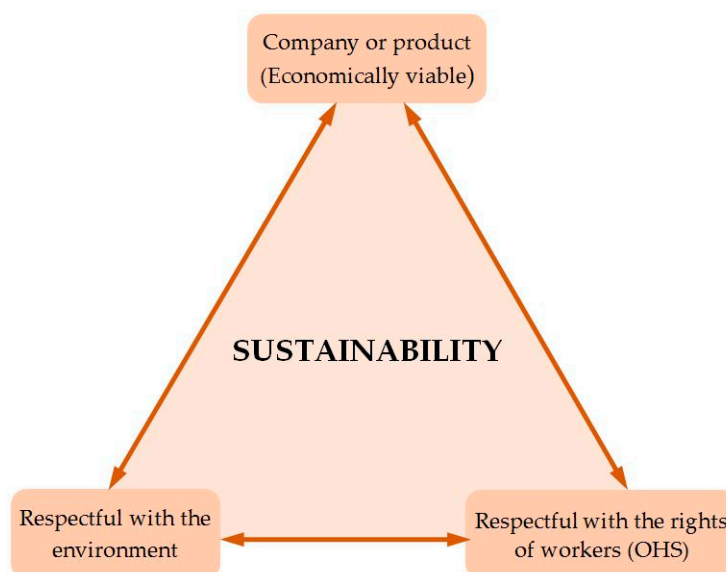


Figure 1. The sustainability of any company or process.

Occupational Health and Safety (enhance workers' physical, mental and social well-being) is directly related to sustainability of a company or product as this depends on respect for the labour rights of the workers.

1.2. Definition and Standards

For the World Health Organization (WHO), musculoskeletal disorders (MSD) are health problems associated with the locomotion apparatus, i.e., muscles, tendons, bony skeleton, cartilage, ligaments, and nerves. These cover all types of complaints, from slight and passing discomfort to irreversible and incapacitating injuries [5].

The Bureau of Labour Statistics (BLS) identifies MSD as the cases in which the nature of the injury or disease is a "pinched nerve, herniated disc, or a torn meniscus; sprains, swellings or tears; hernia (traumatic or nontraumatic), pain, swelling, tumescence; carpal or tarsal tunnel syndrome; Raynaud Syndrome; and in general illnesses and disorders of the musculoskeletal system or of connective tissue" [6]. These are characterized by the appearance of single or multiple symptoms that may include pain, swelling, or the sensation of heaviness and fatigue [7], affecting muscles, nerves, blood vessels, ligaments, and tendons [8].

MSD constitute one of the prime causes of absenteeism in the workplace and bear a considerable cost for the public health system [5]. They are the most frequent health problem at work, causing disability and long-term down time [9–11], representing some 33% of all injuries and illnesses of workers (as of 2013), reducing productivity [8].

Such musculoskeletal health problems occur when the mechanical effort exceeds the capacity of resistance of the components of the locomotor apparatus. This often occurs when workers handle cargo, adopt awkward postures, or perform repetitive tasks, and their capacity as a consequence of their interaction with their environment does not overcome the demands of the task (physical, psychosocial, environmental, and cognitive demands) [12].

1.3. Evaluation Methods

Many methods have been developed through the history of evaluating MSD, from general approaches to specific techniques in each of the subdisciplines of Ergonomics/Safety and Occupational Health in the workplace. Striking among the general approaches are: the laboratory method of Work Economy and Sociology, known as LEST [13], the RNUR or profiles in jobs of Renault [14], the method of the Agence Nationale pour L'Amelioration des Conditions de Travail (National Agency for Improvement of Working Conditions) known as the ANACT [15], the mixed method of FREMAP [16], the FAGOR method [17], and the Ergonomic Workplace Analysis method known as the EWA [18], etc.

These general methods usually determine where the problem is but do not usually quantify it or isolate it with precision. For this reason, specific methods are used and these can be classified into three groups: direct methods, semi-direct methods, and indirect methods [19]. The indirect methods include Standardized Nordic Questionnaire for the Analysis of Musculoskeletal Symptoms (NMQ) [20].

1.4. Objective

The objective of the present work is to review the literature on a worldwide level on the applications of the NMQ in the diverse sectors or fields of knowledge and countries up to 2017.

2. The Standardized Nordic Questionnaire

2.1. Where and How It Arose

The analysis and detection of musculoskeletal symptoms of different individuals in different parts of the planet using indirect methods requires the standardization of the evaluation questions. If it were that way, it would be difficult to compare the results of different studies. Therefore, Kuorinka and his team [20] developed the NMQ with the support of the Nordic Council of Ministers. Its development was based on previous medical questionnaires [21–23].

2.2. What It Consists of

This simple, general questionnaire, recognized/validated internationally, detects symptoms in the neck, back, shoulders, and extremities [24]. It presents 28 multiple-choice questions, sometimes negative, structured in two well-differentiated parts. The first part, the general one, refers to symptoms in 9 parts of the body (neck, shoulders, elbows, wrists/hands, upper back, lower back, hip/thighs, knees, and ankles/feet) during the last 12 months/7 days. The second part, the specific one, refers to symptoms in three parts of the body (neck, shoulders, and lower back) throughout the subject's working life/7 days beforehand. In both cases, complementary information (qualitative variables, sex, age, nationality, etc.) of the workers would be helpful, but not obligatory, to ensure a better evaluation [20,25].

2.3. Advantages

- a Standardization of the questions.
- b Worldwide recognition.
- c Use free of charge.
- d Possibility of self-evaluation.
- e Relatively quick identification of the symptoms.
- f Applicability in large populations.
- g Frequent use together with other evaluation methods such as RULA [26], REBA [27], OWAS [28], etc.

2.4. Limitations

- a Obligatory answering of the questions.
- b Difficulty of determining the truthfulness of the responses.
- c Difficulty of application in countries that do not speak English (for errors in translation, interpretation, and/or validation).
- d Restriction of exhaustive questions to three areas of the body (lower back, neck, and shoulders).
- e Identification only of symptoms.
- f Complex data analysis for large populations.
- g Difference in responses depending on the technician administering the questionnaire.

2.5. Adaptations, Translations and Validations

Kahraman et al. [11] warned of the importance of adapting the questionnaire to different cultures or countries where it is applied, as well as its psychometric evaluation in different places. Nevertheless, Arsalani et al. [29] indicated that it has been broadly used in many countries and sectors, whether adapted/validated or not. After analysing the results of trials with the NMQ in medical doctors, nurses, office staff, and supermarket workers, Dickinson et al. [25], validated a new, improved NMQ. The original questionnaire identified only symptoms and the percentage of the population studied and therefore Dickinson [30] proposed new ways of interpreting the results to help make corrections. Two years later, Baron et al. [31] validated the NMQ, comparing it to a questionnaire of the National Institute for Occupational Safety and Health (NIOSH) de the USA. Similarly, Kaewboonchoo et al. [32] compared the NMQ with the Japanese Questionnaire (JQ). In both cases practically no contradictions were found.

Similarly, in Brazil [33,34], Greece [35], Japan [36], South Korea [37], Italy [38], Poland [39], France [40,41], Iran [29,42,43], Taiwan [44,45], China [46], and Turkey [11], translations, validations, and adaptations were made for the NMQ, with more or less satisfactory results.

3. Applications of the Nordic Questionnaire by Categories of Knowledge

For this section, the data were compiled through electronic access to the University of Almería Library with the license of the Spanish Foundation for Science and Technology (FECYT) of the “Web of Science” (Wos) provided by “Clarivate Analytics”. The search was made by selecting only “Web of Science Core Collection”. By the option “Advanced Search” the term “so = Applied Ergonomics” was used, followed by “Create Citation Report”, and finally 1583 citations of the article describing the NMQ, by Kuorinka et al. [20] to January 2017, were chosen. Of the 1583, 259 studies were chosen for being related directly according to the title and abstract, to the practical application of the questionnaire, consisting of articles from scientific journals and conferences. Those that despite citing the NMQ but without being related to the practical application of the questionnaire were excluded.

Limitations of the bibliographic search include the possibility of overlooking certain citations for searching only the Main Collection of the Wos without considering other, complementary databases. Furthermore, the consideration only of scientific articles and conferences means the elimination of books, book chapters, or other similar formats, not indexed in this database.

The published works that make use of the NMQ do not focus exclusively on the identification of symptoms and musculoskeletal maladies nor is the questionnaire usually the only tool used, but its confirmed validity causes its inclusion in studies of diverse fields of knowledge from health activities (24%) to construction (1%), among others (Figure 2). An adaptation was prepared for the Uniform International Industrial Classification of all economic activities (UIIC) of the UN to characterize the studies reviewed [47].

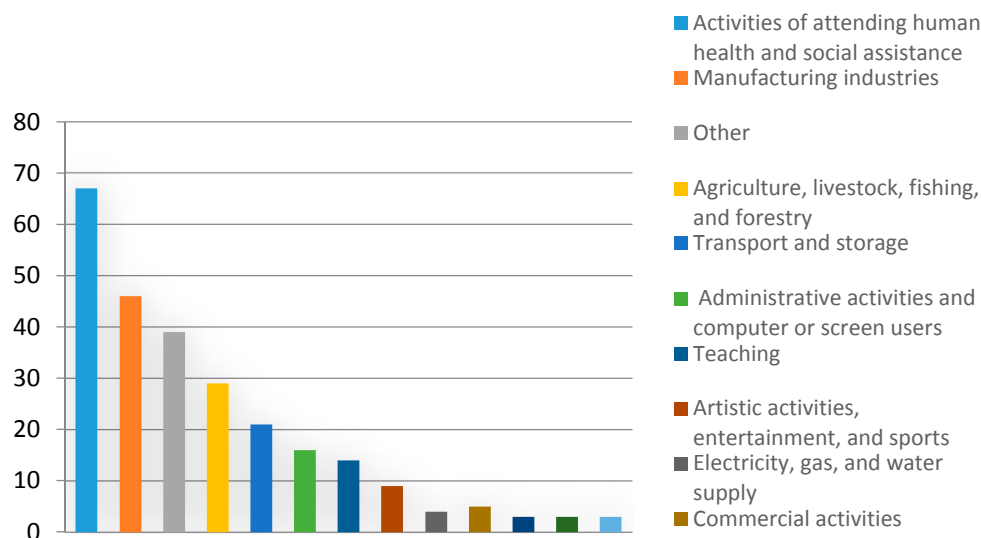


Figure 2. Applications of the Nordic questionnaire by categories of knowledge.

3.1. Activities of Attending Human Health and Social Assistance

Within the health activities, the NMQ has been applied in different disciplines. Table 1 shows the related studies.

Table 1. Use of the Nordic Musculoskeletal Questionnaire (NMQ) in activities and attention to human health and social assistance.

Authors	Location	Observations
Liss et al. (1995) [48]	Canada	Application of the NMQ in dental hygienists and dental assistants.
Lusted et al. (1996) [49]	Australia	Application of the NMQ in nurses of a residential centre.
Palmer et al. (1999) [50]	United Kingdom	Application of the NMQ in patients of an outpatient clinic.
Maul et al. (2003) [51]	Switzerland	Application of the NMQ in hospital male nurses.
Newell y Kumar (2004) [52]	Canada	Application of the NMQ in orthodontists.
Smith et al. (2004) [53]	China	Application of the NMQ in hospital nurses.
Yeung et al. (2005) [54]	United States	Application of the NMQ in hospital nurses.
Hartvigsen et al. (2005) [55]	Denmark	Application of the NMQ in nurses in private homes and assistant nurses.
Glover et al. (2005) [56]	United Kingdom	Application of the NMQ in physiotherapists.
Choobineh et al. (2006) [57]	Iran	Application of the NMQ in university hospital nurses.
Smith et al. (2006) [36]	Japan	Application of the NMQ modified for Japanese hospital nurses.
Ramadan y Ferreira (2006) [34]	Brazil	Application of the NMQ in laboratory workers of clinical pathology.
Tam y Yeung (2006) [58]	China	Application of the NMQ in ambulance workers.
Hartvigsen et al. (2006) [59]	Denmark	Application of the NMQ in twins of 70 to 100 years old.
Schenk et al. (2007) [60]	Switzerland	Application of the NMQ in nurses and office staff.
Kee y Seo (2007) [37]	Korea	Application of the NMQ in nursing personnel.
Feng et al. (2007) [61]	Thailand	Application of the NMQ in assistant nurses.
Fejer y Hartvigsen (2008) [62]	United States	Application of the NMQ to relate disability and neck pain.
Valecillo et al. (2009) [63]	Venezuela	Application of the NMQ in nursing personnel of a military hospital.
Antonopoulou et al. (2009) [64]	Greece	Application of the NMQ in patients in a centre for health care.
Choobineh et al. (2010) [65]	Iran	Application of the NMQ in nurses in the operating room.
Kalichman et al. (2010) [66]	Israel	Application of the NMQ in persons with spinal degeneration.
Kim et al. (2010) [67]	United States	Application of the NMQ in workers in private homes.
Mehrdad et al. (2010) [68]	Iran	Application of the NMQ in nurses.
Plouvier et al. (2011) [69]	France	Application of the NMQ in middle-aged and retired people.
Magnavita et al. (2011) [70]	Italy	Application of the NMQ in hospital workers.

Table 1. Cont.

Authors	Location	Observations
Losa-Iglesias et al. (2011) [71]	Spain	Application of the NMQ in podiatrist.
Costa-Schmidt y Spadoti-Dantas (2012) [72]	Brazil	Application of the NMQ in nursing professionals of surgery units.
Arsalani et al. (2011) [29]	Iran	Application of the NMQ in nursing personnel.
Carneiro et al. (2012) [73]	Portugal	Application of the NMQ in nurses in private homes.
Moreira y Seixas (2012) [74]	Portugal	Application of the NMQ in physiotherapists.
Lin et al. (2012) [75]	Taiwan	Application of the NMQ in dentists.
Mehrdad et al. (2012) [76]	Iran	Application of the NMQ in university hospital doctors.
Chamani et al. (2012) [77]	Iran	Application of the NMQ in dentists.
Ohara et al. (2012) [78]	Brazil	Application of the NMQ in persons with sickle-cell disease.
Hayes et al. (2012) [79]	Australia	Application of the NMQ in dental hygienists.
Rafeemanesh et al. (2013) [80]	Iran	Application of the NMQ and REBA in dentists.
Serranheira et al. (2013) [81]	Portugal	Application of the NMQ in personnel of hospital nursing.
Sembajwe et al. (2013) [82]	United States	Application of the NMQ in workers attending hospital patients.
Darby et al. (2013) [83]	United States	Application of the NMQ in nurses assisting endoscopic procedures.
Yi et al. (2013) [84]	China	Application of the NMQ in professionals of odontology.
Magnusson et al. (2014) [85]	Norway	Application of the NMQ in obese patients.
Raeisi et al. (2014) [86]	Iran	Application of the NMQ in nursing personnel.
Barzideh et al. (2014) [87]	Iran	Application of the NMQ in hospital nurses.
Sadeghian et al. (2014) [88]	Iran	Application of the NMQ in clinical laboratory workers.
Mynarski et al. (2014) [89]	Polonia	Application of the NMQ in nurses.
Maulik et al. (2014) [90]	India	Application of the NMQ in clinical laboratory technicians.
Kim et al. (2014) [91]	Korea del Sur	Application of the NMQ in workers attending hospital patients.
Reed et al. (2014) [92]	Australia	Application of the NMQ in paediatric hospital nurses.
Fenlon et al. (2014) [93]	United Kingdom	Application of the NMQ in women with non-metastatic breast cancer.
Moreira et al. (2014) [94]	Brazil	Application of the NMQ in nursing professionals.
Shadmehr et al. (2014) [42]	Iran	Application of the NMQ in dentists.
Franasiak et al. (2014) [95]	United States	Application of the NMQ in surgeons.
Abedini et al. (2015) [96]	Iran	Application of the NMQ in hospital nurses.
Paula et al. (2015) [97]	Brazil	Application of the NMQ in health workers.
Serranheira et al. (2015) [98]	Portugal	Application of the NMQ in nurses.
Pugh et al. (2015) [99]	Australia	Application and validation of NMQ for on-line use in nurses.
Cho et al. (2016) [100]	Korea del Sur	Application of the NMQ in dental professionals
Genc et al. (2016) [101]	Turkey	Application of the NMQ in hospital staff.
Terzi y Tan (2016) [102]	Turkey	Application of the NMQ in mothers of children with cerebral palsy.
Ratzon et al. (2016) [103]	Israel	Application of the NMQ in hospital nurses.
Bozkurt et al. (2016) [104]	Turkey	Application of the NMQ in dental professionals.
Chanчай et al. (2016) [105]	Thailand	Application of the NMQ in nursing staff.
Velvin et al. (2016) [106]	Norway	Application of the NMQ in adults with Marfan syndrome.
Ogwumike et al. (2016) [107]	Nigeria	Application of the NMQ in post-menopause women.
Feng et al. (2016) [108]	China	Application of the NMQ in ecographists.
Rodarte-Cuevas et al. (2016) [109]	Mexico	Application of the NMQ in nurses.

3.1.1. Activities Related to Odontology

NMQ in odontology was first used by Liss et al. [48], who confirmed the greater likelihood of dental hygienists, as opposed to dental assistants, to suffer carpal tunnel syndrome and other problems of the hands/arms, shoulders, and neck, but these researchers found no differences in the lumbar region. Years later, Newell and Kumar [52] sent the NMQ to orthodontists in Canada, where the response rate reached 52.4%. The results revealed lumbar problems followed by neck and shoulder pain.

Meanwhile, Lin et al. [75] used a modified NMQ in a study made on dentists in Taiwan. The results showed that they suffered a high prevalence of musculoskeletal injuries, especially of the shoulders, neck, and lower back, and several associated factors were identified. In the same year, Chamani et al. [77] found a high prevalence of MSD among dentists in Iran; however, no major differences were found in relation to factors such as age or years of work. These authors recommended more ergonomic training of the workers and the complementary use of other evaluation methods to identify more risk factors. Hayes et al. [79] studied the risk factors that could help predict MSD among Australian dental hygienists. These researchers distributed a modified version of the NMQ and concluded that the causes could be multifactorial. Comparing the NMQ method with the REBA one, Rafeemanesh et al. [80], made a study of 65 dentists and found greater prevalence of neck pain. In turn, only neck and lower-back pain showed a significant relation with the risk levels found by the REBA method.

Yi et al. [84] explored the musculoskeletal injuries of professionals in odontology and of different odontological specialties. The results indicated a high prevalence of MSD symptoms and a relation with specialties, concluding that prevention should be directed to the analysis of the tasks of each specialty. Shadmehr et al. [42] investigated musculoskeletal afflictions among dentists in the city of Teheran (Iran). The data collected with the Iranian version of the NMQ demonstrated that most of the dentists surveyed experienced pain in at least one joint. In South Korea, Cho et al. [100] studied the association between psychosocial stress, work stress, and MSD symptoms in dental professionals. It was found that psychosocial stress significantly influenced the appearance of MSD. Finally, Bozkurt et al. [104] evaluated dental professionals, identifying regions of risk and their relation to the different qualitative variables of the individual. The symptoms of MSD were more frequent in women and research assistants.

3.1.2. Nursing

The first study to use NMQ on nursing was by Lusted et al. [49], in which MSD was evaluated in 30 nurses working in two similar units in a residential centre. Symptoms were found in the lumbar, the neck, and the upper limbs. For eight years, Maul et al. [51] analysed male nurses in a Swiss hospital using a modified version of the NMQ, among other methods. The results indicated that lumbar discomfort is a persistent problem among nurses, indicating a recurrent, not progressive trend.

In China, Smith et al. [53] identified MSD in hospital nurses, lumbalgia being the most reported problem. Also, a relation was found with psychosocial factors. Yeung et al. [54] applied the NMQ to 97 hospital nurses to analyse the psychosocial work environment. By a factorial analysis, these authors revealed a relation between the body regions affected and certain psychosocial factors (workload). At the same time, Hartvigsen et al. [55] evaluated the effectiveness of the NMQ in Danish nurses and assistant nurses in two plans of ergonomic training. One was intensive, of 3 h, while the other was weekly. The results pointed to the same effect with respect to lumbar injuries.

Using both the NMQ and the “Job Content Questionnaire”, Choobineh et al. [57] analysed the relation between musculoskeletal disorders and the demands of nursing work in a university hospital. MSD was found to be related to the demands of physical labour but not to psychological demands. Smith et al. [36] used a modified version of the NMQ in Japanese for nurses in a hospital in order to detect MSD. The study revealed symptoms in the shoulders, followed by the lumbar region, the neck, and the dorsal region. Furthermore, risk factors associated with psychosocial parameters were identified. Schenk et al. [60] used the NMQ in administrative workers and nurses together with scales of measuring pain by pressure. On the other hand, Kee and Seo [37] applied the NMQ adapted in South Korea to detect MSD among nursing personnel. The shoulders were shown to be the most vulnerable area, associated with the type of work unit in the hospital.

In Taiwan, Feng et al. [61] analysed assistant nurses by the NMQ and other methods. The results revealed that the transfer of patients and the psychological demands of the work were the main causes of lumbar pain. Valecillo et al. [63] found a high incidence of MSD in the neck and upper as well as

lower back regions of the nursing staff of a military hospital. Also, they correlated the work stress with these symptoms. Again using the NMQ, Choobineh et al. [65] interviewed 375 nurses from surgery and related MSD to psychosocial risks. The study by Kim et al. [67] involving more than 1000 workers for home care with the NMQ showed that the physical demands of this profession can trigger MSD, especially in the neck, shoulders, and back. Mehrdad et al. [68], using the NMQ and the General Nordic Questionnaire of psychological and social factors in the workplace (QPSNordic), showed a high prevalence of musculoskeletal symptoms associated with psychosocial factors, especially stress. Arsalani et al. [29] evaluated a representative sample of nurses by three questionnaires, one being the NMQ, and concluded that this questionnaire was reliable.

In Brazil, Costa-Schmidt and Spadoti-Dantas [72] used the analogical Visual Scale (EVA) and the NMQ to study professionals in nursing that worked in surgery. The results revealed a statistically significant association between the MSD of the lumbar region and those of the shoulders in the last 12 months. Carneiro et al. [73], using the NMQ in nurses working in the home and others working at a health centre, found that the former were three-fold more exposed to MSD in the lumbar region than were the latter. Similarly, Serranheira et al. [81,98] detected MSD in the lumbar region associated with psychosocial factors in the nursing staff of Portuguese hospitals.

Darby et al. [83], using NMQ on hospital nurses in the endoscopic unit, found MSD in the neck, shoulders, and back. In turn, they related these symptoms to characteristics of the individuals studied. Similarly, Raeisi et al. [86] associated physical demands and work shifts with lumbar troubles among the nursing staff. Barzideh et al. [87], using the "Job Content Questionnaire" and the NMQ in a group of Iranian nurses, identified a direct relation between MSD and work stress. In the same year, Mynarski et al. [89] made a preliminary evaluation on the possible link between sports and the reduction in MSD among nurses, finding this connection to be more than likely.

Reed et al. [92] used the NMQ with nurses in a paediatric hospital in Australia. Curiously, the musculoskeletal affliction occurred in the ankle and foot, sometimes limiting physical activity. Moreira et al. [94], applying the NMQ to a nursing staff warned of MSD due to numerous external factors, proposing the implementation of new prevention measures. Abedini et al. [96] used the NMQ to detect MSD in nurses as a consequence of handling patients. These authors proposed the mechanization of the tasks. Pugh et al. [99] adapted the NMQ to a virtual (online) platform, and found reliable results with respect to MSD used in a group of nurses. An ergonomic intervention in hospital nurses with MSD was undertaken by Ratzon et al. [103] and Chanchai et al. [105] using the NMQ with nursing personnel. It was demonstrated that the studies were effective in reducing risk factors. Finally, Rodarte-Cuevas et al. [109] sought to characterize the quality of work life in the nursing staff of a hospital in Mexico by applying the NMQ and its relation to qualitative variables of the individuals.

3.1.3. Other Fields of Health

Glover et al. [56], studying the MSD of a sample of the Physiotherapist Society of the United Kingdom, concluded that the recent graduates appeared to need fuller ergonomic training to reduce the rates of injuries. The workers in a clinical pathology laboratory were studied by Ramadan and Ferreira [34] using, among other methods, an adaptation of the NMQ. Some of the main conclusions were the association of MSD with strained postures, risk movements, and a prior history of rheumatism or orthopaedic disorders. In the same year, Tam and Yeung [58] used NMQ and other methods to analyse ambulance workers who made programmed trips, not emergencies, concluding that lumbalgia is associated with age, the perception of the effort, job satisfaction, and bending the trunk at 120 degrees. In their study, Magnavita et al. [70], using NMQ, found a strong association of environmental and psychosocial factors with MSD in hospital workers. These researchers concluded that to prevent these injuries, new prevention programmes were needed.

In Spain, Losa-Iglesias et al. [71], applying the NMQ of MSD to podiatrists, found that the areas of the body most affected were the lower back, the upper back, and the neck. Moreira and Seixas [74] used the NMQ to study the MSD related to the work of Portuguese physiotherapists. The results

indicated that in the last 12 months 89.4% of the youngest physiotherapists had experienced some discomfort. Mehrdad et al. [76] applied the NMQ, together with work-related questions to Iranian doctors who worked in university hospitals. These doctors presented less MSD than did doctors in other settings. Sembajwe et al. [82] used the NMQ for workers in two hospitals and related the MSD to psychophysical factors. Both Sadeghian et al. [88] as well as Maulik et al. [90] investigated the incidence of MSD among clinical laboratory workers. The most frequent pains detected were back and neck, with significant relations with factors such as age, gender, or domestic activities.

The personal perception of physical pain was evaluated by Kim et al. [91] with the use of the NMQ in workers caring for patients in two university hospitals. Frasiak et al. [95] used the NMQ to evaluate the MSD of surgeons during robotic surgery before and after an ergonomic improvement. The improvement programme was easily implemented and was well received. Paula et al. [97] used NMQ, among other methods, to evaluate the work quality and the MSD among health workers of Uberaba (Brazil). The results indicated that 82% had suffered MSD symptoms in the last 7 days and 93% in the last 12 months. Genc et al. [101] investigated the different MSD related to the physical work load of the hospital staff. The MSD related to the back were the most common and the cause that most impeded the ability to work. Finally, Feng et al. [108] used the NMQ for ecographists in China and concluded that awareness needs to be improved concerning MSD.

3.1.4. Pathologies, Health, and Ageing

Palmer et al. [50] confirmed the validity of a modified NMQ in a study of a population of patients in health centres. A prospective study of twins between 70 and 100 years old was made by Hartvigsen et al. [59] to identify certain risk factors for lumbalgia. These authors indicated the symptoms of depression as a major risk factor. After this study, Fejer and Hartvigse [62] concluded that while the intensity of neck pain and disability were strongly associated (ability to execute tasks), the duration of the pain is a poor indicator of disability.

In Greece, Antonopoulou et al. [64] used the NMQ, among other tools, to analyse patients registered in a rural health centre. The results showed that 71.2% of them presented pain in the knees and in the lower back, all associated with depression and a poor quality of life. Kalichman et al. [66], with the help of the NMQ, among other observations, studied the degeneration of the spinal column in the lumbar area. Only the spinal stenosis showed a statistically significant association with lumbalgia. In France, Plouvier et al. [69] described lumbar pain among middle-aged individuals both active and retired (inactive) from the same company, according to their exposure to labour of certain physical demands. These researchers found high MSD in subjects who were active and exposed to the work demands and in the retired subjects who had previously been exposed.

Ohara et al. [78] verified the relation between musculoskeletal pain in persons with sickle-cell anaemia, and their quality of life, as well as their social and economic characteristics. These researchers used the NMQ and the SF-36 health questionnaire. Fenlon et al. [93] studied women recently diagnosed and treated with surgery for non-metastatic breast cancer to investigate the prevalence, severity, and location of musculoskeletal pain. In the same year Magnusson et al. [85] concluded that an association, though weak, existed between excess weight and multiple pain sites in a general population. Terzi and Tan [102] investigated the diseases of the musculoskeletal system in mothers of children with cerebral palsy. The results showed that MSD and the levels of depression were significantly greater in these mothers than in control groups. The same applied to adults with Marfan syndrome [106]. Finally, Ogwumike et al. [107] investigated musculoskeletal pain in post-menopause women in Nigeria. The conclusions of this study highlight that the symptoms of pain in the extremities and in the lumbar area were more frequent.

3.2. Manufacturing Industries

Table 2 shows the studies where the NMQ has been used in manufacturing industries.

Table 2. Use of the NMQ in manufacturing industries.

Authors	Location	Observations
Blader et al. (1991) [110]	Sweden	Application of the NMQ in sewing-machine workers.
Flodmark y Aase (1992) [111]	Sweden	Application of the NMQ in industrial workers.
Schibye et al. (1992) [112]	Denmark	Application of the NMQ in sewing-machine workers.
Deakin et al. (1994) [113]	Canada	Application of the NMQ in workers of two similar work stations.
Williams y Dickinson (1997) [114]	United Kingdom	Application of the NMQ in locksmiths.
Piedrahita et al. (2004) [115]	Colombia	Application of the NMQ in workers exposed to cold in cold-storage rooms.
Najarkola et al. (2006) [116]	Iran	Application of the NMQ in steel workers.
Macdonald y Waclawski (2006) [117]	United Kingdom	Application of the NMQ in coopers.
Lin y Chan (2007) [118]	Taiwan	Application of the NMQ in industrial workers.
Motamedzade et al. (2007) [119]	Iran	Application of the NMQ in textile workers.
Dovrat y Katz-Leurer (2007) [120]	Israel	Application of the NMQ in workers exposed to cold in cold-storage rooms.
Choobineh et al. (2007) [121]	Iran	Application of the NMQ in workers of a rubber factory.
Alipour et al. (2008) [122]	Iran	Application of the NMQ in automobile workers.
Piedrahita et al. (2008) [123]	Sweden	Application of the NMQ in workers exposed to cold.
Choobineh et al. (2009a) [124]	Iran	Application of the NMQ in sugar-factory workers.
Choobineh et al. (2009b) [125]	Iran	Application of the NMQ in workers of the petrochemical industry.
Garganta et al. (2010) [126]	Portugal	Application of the NMQ in furniture workers.
Ghomari et al. (2010) [127]	Algeria	Application of the NMQ in industrial workers.
Motamedzade et al. (2011) [128]	Iran	Application of the NMQ in workers of a television factory.
Hossein et al. (2011) [129]	Iran	Application of the NMQ in welders of a petrochemical complex.
Choobineh et al. (2011) [130]	Iran	Application of the NMQ in refinery workers.
Aghilinejad et al. (2012a) [131]	Iran	Application of the NMQ in aluminium workers.
Menegon y Fischer (2012) [132]	Brazil	Application of the NMQ in aircraft workers.
Aghilinejad et al. (2012b) [133]	Iran	Application of the NMQ in steel workers.
Eraslan et al. (2013) [134]	Turkey	Application of the NMQ in textile workers.
Nejad et al. (2013) [135]	Iran	Application of the NMQ in furniture workers.
Kamalinia et al. (2013) [136]	Iran	Application of the NMQ in workers assembling a telecommunications factory.
Mohammadi et al. (2013) [137]	Iran	Application of the NMQ in foundry workers.
Grobler (2013) [138]	United Kingdom	Application of the NMQ in automobile workers.
Roja et al. (2013) [139]	Latvia	Application of the NMQ in industrial workers with chronic pain.
Mendes et al. (2014) [140]	Portugal	Application of the NMQ in shoe workers using a cutting machine.
Chang et al. (2014) [45]	Taiwan	Application of the NMQ in workers who prepare betel quid.
Veiga-Quemelo et al. (2015) [141]	Brazil	Application of the NMQ in workers of a dairy company.
González-Muñoz y Avila-Chaurand (2015) [142]	United States	Application of the NMQ in workers of different industries.
Nejhad et al. (2015) [143]	Iran	Application of the NMQ in machinists of replacement parts.
Sanjog et al. (2015) [144]	India	Application of the NMQ in workers in furniture-modelling plants.
Vieira et al. (2015) [145]	United States	Application of the NMQ in footwear workers.
Gangopadhyay et al. (2015) [146]	India	Application of the NMQ in women embroiderers.
Aghilinejad et al. (2016) [147]	Iran	Application of the NMQ in industrial workers.
Monteiro et al. (2016) [148]	Brazil	Application of the NMQ in workers of a chemical plant.
Silva et al. (2016) [149]	Brazil	Application of the NMQ in footwear workers.
Fonte et al. (2016) [150]	Portugal	Application of the NMQ in workers of a packaging line.
Nodooshan et al. (2016) [151]	Iran	Application of the NMQ in workers prosthesis workshop.
Dianat y Karimi (2016) [152]	Iran	Application of the NMQ in workers participating in sewing work.
García-Hernández et al. (2016) [153]	Spain	Application of the NMQ in metal workers.
Chakrabarty et al. (2016) [154]	India	Application of the NMQ in women embroiderers.

3.2.1. Manufacturing Industry of Food Products

Three studies relate MSD symptoms with exposure to low temperatures suffered by workers in cold-storage rooms: Piedrahita et al. [115], Dovrat and Katz-Leurer [120], and Piedrahita et al. [123]. The results reinforce the hypothesis that workers in cold environments have a higher risk of lumbar pain, and the prevalence of MSD is related to cold.

Choobineh et al. [124], studying 116 workers taken at random from an Iranian sugar factory, found more cases of knee and lower-back injury. Chang et al. [45] used the NMQ to investigate MSD among workers who prepared betel quid, and the results showed that the group was at high risk and remediation measures were recommended. In Brazil, Veiga-Quemelo et al. [141] evaluated the MSD among workers in a dairy business, where prevalence of MSD symptoms proved high, with the back and upper extremities being the most affected areas.

3.2.2. Mechanical Industry

Two of the first researchers to apply the NMQ were Flodmark and Aase [111], who used the "Bortner" questionnaire. These researchers concluded that the workers with type-A conduct (excessive competitiveness, impatience, hostility, and urgency) appeared to have a greater incidence of musculoskeletal symptoms. In the United Kingdom, Williams and Dickinson [114] used the NMA to study MSD in a population of locksmiths and revealed the high level of disorders in the upper extremities. Years later, Nejhad et al. [143], evaluating the effects of noise and postural stress in factory workers, concluded that postural stress can increase musculoskeletal disorders to dangerous levels. With the aim of reducing the risk of MSD in a packaging line of a company that produces replacement parts for heating machinery, Fonte et al. [150] studied the process and applied the NMQ. These researchers recommended improvements in the workplace and a rotation programme for the staff.

3.2.3. Metal-Manufacturing Industry

Najarkola [116] studied the MSD of the upper extremities of steelworkers in Iran, finding a significant relation with the tasks carried out and indicating a greater risk in foundry work. Aghilinejad et al. [131,133], using the NMQ, compiled data on the musculoskeletal ailments to evaluate their incidence among workers in Iranian aluminium industries. The results showed that more than 60% suffered physical distress in the last year and recommended the implementation of new prevention programmes. Mohammadi et al. [137] applied the NMQ to workers in foundry workshops in Iran. The symptoms of the hand/wrist were the most frequent problems found (84%). Also, the lifting and setting down of loads were considered risk factors.

In Spain, García-Hernández et al. [153] evaluated the effects of foot braces in workers in the metal industry, suggesting that personalized orthoses can be effective to reduce and prevent MSD in several parts of the body.

3.2.4. Furniture-Manufacturing Industry

Garganta et al. [126] adapted the NMQ to a Portuguese population and the analogical visual scale of pain to analyse the effect of a prevention programme against musculoskeletal injuries. These authors found no differences in the MSD but did in terms of effect/intensity. Later, Nejad et al. [135] studied the workers of small workshops manufacturing furniture and found greater incidences in the knees, lumbar region, and wrists/hands. Sanjog et al. [144], focusing on factories for modelling plastic furniture in India, used the NMQ, OWAS, and REBA. The design of the job, the postures of the workers, and the duration of the tasks were highlighted as the most significant risk factors.

3.2.5. Manufacturing Industry for Chemical and Petroleum Products

The results of the study by Choobineh et al. [125] showed that some 73% of the employees of an Iranian petrochemical industry experienced some type of musculoskeletal symptom during the last 12 months, the greatest prevalence occurring in the knees and lumbar region. Afterwards, Hossein et al. [129] studied the MSD and risk factors in 160 welders in a petrochemical factory in southern Iran. A great majority of these workers suffered some symptom in the upper members, depending on the type of activity and its duration. These authors proposed prevention plants. Again, Choobineh et al. [130] examined the MSD and psychosocial risk factors of refinery workers in Iran, this time before and after ergonomic measures were taken. The findings showed that the psychosocial variables were not affected by the measures, but the physical ones were. Monteiro et al. [148] investigated the overload of the musculoskeletal system in women executing repetitive tasks under time pressure in a chemical plant. After the study, the authors recommended the incorporation of automation technologies and the reassignment of workers to other activities that did not expose them to overloads.

3.2.6. Manufacturing Industry for Textiles and Footwear

The first study published in this field in which the NMQ was used was by Blader et al. [110] in workers with sewing machines of four textile factories. The results showed a positive correlation between tension in the neck, cervicgia, and the hours of work per week. Also, Schibye et al. [112] used the NMQ as the basis for 6 years of monitoring 327 workers who used sewing machines, concluding that the neck and shoulder symptoms are reversible and can be alleviated by reassignment to other tasks. In Iran, Motamedzade et al. [119], after using NMQ and other methods to study the incidence of MSD in the upper extremities of workers in the carpet industry, manual tools were redesigned for ergonomic improvements. Eraslan et al. [134] investigated the effect of resistance of the scapular musculature to chronic pain in the shoulders of textile workers. The results showed that the low muscle resistance is related to pain. Roja et al. [139] evaluated the effectiveness of psychotherapeutic intervention with medical hypnotherapy in workers with chronic pain in the textile industries of Latvia. The results show that this is an effective method to diminish the intensity of muscle pain and fatigue.

Mendes et al. [140], using the RULA and NMQ methods, made an ergonomic evaluation of the task of operating a cutting machine in the footwear industry. The results defined corrective and preventive measures. Vieira et al. [145] compared and evaluated workers of both sexes in the footwear industry with respect to individual characteristics (stress, physical activity, alcoholism, smoking, etc.). The data were compiled using different methods, including the NMQ. It was concluded that the characteristics analysed bore significant differences.

Gangopadhyay et al. [146] analysed the repetitive nature of the work of women embroiderers in India. These researchers measured the pain in the upper extremities and the carpal tunnel syndrome. The results showed that the prevalence of pain in the wrist was 68% and in the forearms 60%. In a similar industry, Chakrabarty et al. [154] also detected discomfort, but in the region of the lower back. Dianat and Karimi [152] made their study of MSD in sewing artesans in Iran. The results indicated a high percentage of physical pain among the workers.

Silva et al. [149] used the NMQ, among other questionnaires, to analyse the relation between psychosocial factors and the MSD of workers in a footwear industry. It was observed that the psychosocial factors such as effort (in women) influence the appearance of pain.

3.2.7. Automobile Manufacturing Industry

Alipour et al. [122] found a rate of 79.8% of response by applying the NMQ to workers in the largest automobile manufacturer in Iran. The study confirmed the effects of physical and psychosocial factors on neck symptoms in men. Later, Menegon and Fischer [132] studied the factors associated

with the symptoms of MSD related to work in aircraft assembly. The results indicated the multifactorial nature of these physical problems.

Meanwhile, Grobler [138] studied whether the isometric force of gripping a tool is a predictor of the risk of musculoskeletal injuries among workers of the automobile industry. The conclusion was that less isometric force is not associated with a greater risk of injury.

3.2.8. Other Industries

Deakin et al. [113] found discrepancies in the data provided by similar individuals in different interviews.

Macdonald and Waclawski [117], using the NMQ and a clinical evaluation, found that coopers are prone to MSD in the upper extremities, with a predominance of epicondylitis. Lin and Chan [118], applying the NMQ proposed that jobs should be redesigned.

Choobineh et al. [121] evaluated workers in a rubber factory in Iran and detected problems of the back and knees, associated with handling loads and with awkward postures. Ghomari et al. [127] evaluated the MSD in workers of the industrial sector in western Algeria. The results showed that almost one of every two workers in the last 12 months, and one of every four in the last seven days had suffered MSD symptoms. In the same year, Motamedzade et al. [128] studied the MSD of the upper extremities in 80 workers of an Iranian television factory. Later these researchers designed and implemented an educational programme and evaluated its effectiveness, concluding that the signs and symptoms significantly reduced. Kamalinia et al. [136] evaluated the posture of assembly workers in a telecommunications factory in Iran. The NMQ, together with the “UBC ergonomic checklist”, were used as tools to compile the data. These authors found severe postural strain and indicated the need for ergonomic measures to be implemented.

González-Muñoz and Avila-Chauran [142], studying workers in different industrial companies, made a comparative analysis of four methods, including the NMQ. The authors concluded that the design of the job influenced the appearance of musculoskeletal problems and their direct relation to stress. Aghilinejad et al. [147] studied industrial workers in Teheran in order to implement an ergonomic programme to minimize musculoskeletal discomfort. These researchers concluded that the interventions can diminish MSD risk over the long term. Finally, Nodooshan et al. [151], using the NMQ and other methods, studied workshops producing orthosis and prosthesis in Iran with the aim of determining the MSD among the workers.

3.3. Agriculture, Livestock, Fishing, and Forestry

Table 3 indicates the studies related to agriculture, livestock, fishing, and forestry in which NMQ was used.

Table 3. Use of the NMQ in agriculture, livestock, fishing, and forestry.

Authors	Location	Observations
Palmer (1996) [155]	United Kingdom	Application of the NMQ in tomato workers.
Hagen et al. (1997) [156]	Norway	Comparison between the NMQ and clinical tests in forestry machinists.
Hagen et al. (1998) [157]	United Kingdom	Application of the NMQ together with the Karasek questionnaire in forestry workers.
Miranda et al. (2001) [158]	Finland	Application of the NMQ in workers of a forest company.
Miranda et al. (2002a) [159]	Finland	Application of the NMQ in workers of a forest company.
Miranda et al. (2002b) [160]	Finland	Application of the modified NMQ in workers of a forest company.
Gallis (2006) [161]	Greece	Application of the NMQ in forestry workers.
Ostensvik et al. (2009) [162]	Norway	Application of the NMQ in forestry workers.
Bernard et al. (2009) [163]	France	Application of the NMQ in vineyard workers.
Scuffham et al. (2010) [164]	New Zealand	Application of the NMQ in veterinarians.
Bernard et al. (2011) [165]	France	Application of the NMQ in vineyard workers.

Table 3. Cont.

Authors	Location	Observations
Hsu et al. (2011) [166]	Taiwan	Application of the NMQ in oyster cleaners.
Rai et al. (2012) [167]	India	Application of the NMQ in agricultural workers.
Milani y Monteiro (2012) [168]	Brazil	Application of the NMQ in agricultural workers that operate machinery.
Kolstrup (2012) [169]	Sweden	Application of the NMQ in dairy workers.
Ng et al. (2014) [170]	Malasia	Application of the NMQ and OWAS in harvesters of palm plantations.
Oliveira et al. (2014) [171]	Brazil	Application of the NMQ in mechanical milkers.
Thinius y Jakob (2014) [172]	Germany	Application of the NMQ to study the operational design of a cattle ranch.
Douphrate et al. (2014) [173]	United States	Application of the modified NMQ in workers of a milking room.
Kozak et al. (2014) [174]	Germany	Application of the NMQ in veterinarians.
Das (2015) [175]	India	Application of the modified NMQ in rice farmers.
Henry et al. (2015) [176]	Malasia	Application of the NMQ in workers on a palm plantation.
Taylor-Gjevre et al. (2015) [177]	Canada	Application of the NMQ in agricultural workers.
Keawduangdee et al. (2015) [178]	Thailand	Application of the NMQ in workers transporting rice.
Kolstrup y Jakob (2016) [179]	Germany/Sweden	Application of the NMQ in milkers.
Douphrate et al. (2016) [180]	United States	Application of the NMQ in milkers.
Phairah et al. (2016) [181]	South Africa	Application of the NMQ in operating forestry machinery.
Grzywinski et al. (2016) [182]	Polonia	Application of the NMQ in the wood industry.
Berg-Beckhoff et al. (2016) [183]	Denmark	Application of the NMQ in fishermen.

3.3.1. Agriculture

Palmer [155] made the first study known with a modified NMQ on workers cultivating tomatoes. Two groups of workers were compared, the first in nurseries and the second in greenhouses. The results indicated greater shoulder problems in the nursery workers in comparison with greenhouse workers. The conclusion was the need for ergonomic measures. Later, in French vineyards, Bernard et al. [163,165] confirmed the relation between MSD and psychosocial risks. These researchers analysed 15 tasks together with psychosocial factors such as effort-reward and commitment.

Rai et al. [167], after evaluating agricultural workers in India by the NMQ and OWAS, concluded that mechanized work in typical manual tasks diminished MSD and therefore improved the quality of life for the workers. This same year, Milani and Monteiro [168] in Brazil found that 47% of the agricultural workers operating machinery had presented MSD in the previous 12 months.

In Malasia, Ng et al. [170] studied the possible MSD in oil-palm plantations. The results revealed that workers with acute pain during the last week diminished their productivity with respect to healthy workers. Also, Henry et al. [176] in identical plantations identified shoulder and back pain as the most common MSD, although the neck was presumably more exposed to injury. Das [175] used a modified NMQ for rice workers in eastern Bengala (India) to identify MSD. This researcher found that the female workers felt greater discomfort than did their male counterparts.

Taylor-Gjevre et al. [177] used the NMQ to collect data on 2473 Canadian agricultural workers. These authors concluded that workers with arthritis completed fewer physical tasks than those without and were more prone to develop shoulder, elbow, hand, back, hip, knee, and ankle disorders.

Finally, Keawduangdee et al. [178] investigated the prevalence of back pain in Thai rice producers during the transplant process. Using a modified NMQ (Thai version) these researchers concluded that back pain in farmers was associated with the weekly duration of the work and with stress.

3.3.2. Livestock

Scuffham et al. [164], who used a modified NMQ with 867 veterinarians in New Zealand, found a very high incidence of work-related MSD.

In Sweden, Kolstrup [169] investigated the physical stress in dairy farmers, concluding that, despite the techniques developed, a high prevalence of disorders and discomfort persists, particularly

in female workers. Similar results were found in Germany by Thinius and Jakob [172], highlighting furthermore a direct influence of anthropometric factors of females. In the same year, Kozak et al. [174] related the tasks of German veterinarians with MSD of the upper extremities and neck. The evaluation with the NMQ was carried out by postal mail.

Oliveira et al. [171] analysed mechanical milking of cattle in “Campo Mourao” (Brazil). From the results, the authors recommended ergonomic innovations to design a better system for the milking room. Similar problems in design were reported by Douphrate et al. [173,180] in the United States, in addition to related MSD with an increase in the size of the herd. The same occurred in the studies of Kolstrup and Jakob [179] in Germany and Sweden. Not only did they recommend modifications of the design of the milking rooms but also technical and organizational improvements in the job.

3.3.3. Fishing and Fish Farming

Hsu et al. [166] used the Chinese version of the NMQ to study oyster cleaners in Taiwan and found pain in the back, hands, wrists, shoulders, and elbows as well as kyphosis.

Berg-Beckhoff et al. [183] used the NMQ to estimate the incidence of osteomuscular problems among Danish fishermen. These authors concluded that fishing is physically very demanding.

3.3.4. Forestry

Hagen et al. [156] studied forestry machinists, combining clinical cervical tests with the NMQ. Their findings indicate a high coincidence between the results of clinical tests and responses to the questionnaire. In a different study, Hagen et al. [157] used a new NMQ, this time together with “Karasek’s Demand/Control Questionnaire” in a group of forestry workers. The conclusion was that MSD was associated with the bad environmental and psychosocial conditions. They also warned that is very difficult to reduce these ailments.

In commercial forests in Finland, the NMQ was used in several studies by Miranda et al. [158–160]. These researchers related soreness in the shoulders and knees as well as sciatic pain to the handling of heavy loads, age, awkward postures, stress, and overweight. Also, in the case of the knees, pain was associated with previous injuries and excess strain. Finally, the persistence of all the musculoskeletal symptoms was related to psychosocial factors and advised that good physical condition could protect against MSD.

Gallis [161] analysed MSD in the forest sector in Greece, Ostensvik et al. [162] in Norway, Phairah et al. [181] in South Africa, and Grzywinski et al. [182] in Poland. In all cases, the NMQ was used with similar procedures, and the conclusions were that vibrations, contorted postures, repetitive movements, formation and organization of the work are the major factors determining the appearance of MSD.

3.4. Transport and Storage

Table 4 indicates the studies related to transport and storage in which NMQ is used.

Table 4. Use of the NMQ in transport and storage.

Authors	Location	Observations
Andersson et al. (1987) [184]	Sweden	Application of the NMQ in bus drivers and switchmen.
Magnusson et al. (1996) [185]	United States/Sweden	Application of the NMQ in drivers.
Gourdeau (1997) [186]	Canada	Application of the NMQ in school-bus drivers.
Porter y Gyi (2002) [187]	United Kingdom	Application of the NMQ in drivers.
Chen et al. (2004) [188]	United States	Application of the NMQ in taxi drivers.
Lee et al. (2006) [189]	United States	Application of the NMQ in stewardesses of long-distance international flights.
Tamrin et al. (2007) [190]	Malasia	Application of the NMQ in drivers of commercial vehicles.

Table 4. Cont.

Authors	Location	Observations
Joubert y London (2007) [191]	Australia	Application of the NMQ in forklift drivers with and without a lumbar brace.
Raanaas et al. (2008) [192]	Norway	Application of the NMQ in taxi drivers.
Alperovitch-Najenson et al. (2010) [193]	Israel	Application of the NMQ in city bus drivers.
Gangopadhyay y Dev (2012) [194]	India	Application of the NMQ in city bus drivers.
Gangopadhyay et al. (2012) [195]	India	Application of the NMQ in bus drivers.
Fernandez-D'Pool et al. (2012) [196]	Venezuela	Application of the NMQ in university bus drivers.
Janwantanakul et al. (2012) [197]	Thailand	Application of the NMQ and Job Content Questionnaire in airline pilots.
Anjomshoae y Rani (2013) [198]	Malasia	Application of the NMQ in bus drivers.
Fernandez-D'Pool et al. (2014) [199]	Venezuela	Application of the NMQ in crew members of an oil tanker.
Tamrin et al. (2014) [200]	Malasia	Application of the NMQ in bus drivers.
Bergsten et al. (2015) [201]	Sweden	Application of the NMQ in baggage personnel at airports.
Murray et al. (2015) [202]	Denmark	Application of the NMQ in military helicopter pilots.
Sarkar et al. (2016) [203]	India	Application of the NMQ and OWAS in workers handling heavy loads.
Tafazzol et al. (2016) [204]	Iran	Application of the NMQ in baggage personnel at airports.

3.4.1. Bus and Taxi Drivers

Andersson et al. [184] used the NMQ with bus drivers and switchmen in Sweden, concluding that there were differences when the questionnaire was applied before or after a health exam. Using the NMQ, Gourdeau [186] found neck and shoulder discomfort in school-bus drivers and proposed more studies in the sector to detect risk variables.

For taxi drivers, Chen et al. [188] related knee pain for more than a year with the number of hours of daily driving. Raanaas and Anderson [192], in Norway, with a sample of almost 1000 taxi drivers, related the MSD not only to the hours of driving but also to work shifts, sleeping on breaks in the taxi, the body-mass index, poor eating habits, and little physical exercise. Also, women drivers and non-Western immigrants presented higher risks together with the unsalaried drivers (in comparison with the owners of the license of the taxi).

Alperovitch-Najenson et al. [193], in Israel, reported a significant association between lumbar pain and the job of driving a city bus, relating this malady to ergonomic factors such as the seat and job stress. The same ailment was described by Gangopadhyay and Dev [194] and Gangopadhyay et al. [195] among bus drivers in India, which worsened job Fernández-D'Pool et al. [196] used the NMQ and other methods to study MSD among bus drivers for a public university. The MSD from greater to lesser importance were neck, lower back, upper back, and knees. These symptoms could be related to the absence of a head rest, lack of lumbar support, unadjustable seat, vibrations, and noise.

Anjomshoae and Rani [198], using NMQ and other methods to study bus drivers, found a directly proportional relation between MSD and psychosocial parameters such as control of work, demands, motivation, and role. In the same country, and in the same sector, Tamrin et al. [200] compiled data with NMQ and other methods, detecting lumbar pain as the most notable symptom. Variables such as age, time with the company, educational level, tasks, non-ergonomic seats, vibrations, noise, smoking, hours of work, stress, fatigue, and worry were related to MSD.

3.4.2. Others

Magnusson et al. [185], in studies made in the United States and Sweden on professional drivers, used a modified NMQ, among other means, to find discomfort such as back, neck, and shoulder pain, attributing these ailments to vibrations and handling loads. With respect to automobile driving in general, Porter and Gyi [187] found clear results that driving leads to lumbar MSD, increasing with the hours of driving. Also, these researchers pointed out the importance of ergonomic characteristics of the vehicle in the appearance of these complaints.

In the aircraft sphere, Lee et al. [189] found that stewardesses of long-distance flights suffered lumbar problems. Later, Janwantanakul et al. [197] used the JCQ and the NMQ for airline pilots. Bergsten et al. [201], using the NMQ and the Copenhagen psychosocial questionnaire, analysed baggage workers in 6 Swedish airports. These authors demonstrated the relation of MSD with psychosocial risks. Murray et al. [202] proposed physical exercise to diminish neck and shoulder pain in helicopter pilots and crews in order to reduce ailments. Tafazzol et al. [204] used the NMQ, among other methods, to study the symptoms of MSd among luggage handlers in airports. More training was recommended, together with the standardization of baggage weight.

Tamrin et al. [190], using a modified NMQ among other methods, found that drivers of commercial vehicles in Malasia had back troubles. Joubert and London [191] administered the NMQ in forklift drivers. Experiments on workers with and without lumbar braces indicated surprisingly that the lumbar discomfort was greater in workers with the braces.

Fernández-D'Pool et al. [199] applied a modified NMQ to crew members of a Venezuelan oil tanker. These authors emphasized the need to implement new prevention programmes for labour risks.

Sarkar et al. [203] used the NMQ and OWAS to investigate the postures during handling loads by workers in India, and concluded that it was necessary to mechanize for tasks and offer training courses in handling loads.

3.5. Administrative Activities and Computer or Screen Users

Table 5 lists the studies using NMQ in administrative activities and users of computers or screens.

Table 5. Use of the NMQ administrative activities and users of computers or screens.

Authors	Location	Observations
Johansson (1994) [205]	Sweden	Application of the NMQ in office workers and others.
Jepsen y Thomsen (2006) [206]	Denmark	Application of the NMQ in workers who use a computer mouse.
Klussmann et al. (2008) [207]	Germany	Application of the NMQ in workers who viewing digital material.
Arvidsson et al. (2008) [208]	Sweden	Application of the NMQ in air controllers who use a computer mouse.
Zejda et al. (2009) [39]	Polonia	Application of the NMQ in office workers with computers.
Lapointe et al. (2009) [209]	Canada	Application of the NMQ in users of screens to record videos.
Malinska y Bugajska (2010) [210]	Polonia	Application of the NMQ in workers with a laptop computer.
Ayanniyi et al. (2010) [211]	Nigeria	Application of the NMQ in computer users.
Griffiths et al. (2011) [212]	Australia	Application of the NMQ in workers who use a computer.
Griffiths et al. (2012) [213]	Australia	Application of the NMQ in employees who use a computer.
Prodanovska-Stojcevska et al. (2012) [214]	Macedonia	Application of the NMQ in employees who use a computer.
Tavafian et al. (2012) [215]	Iran	Application of the NMQ in workers with a computer.
Kalinienė et al. (2013) [216]	Lithuania	Application of the NMQ in workers who use a computer.
Habib et al. (2015) [217]	Bangladesh	Application of the NMQ in office workers who do not use a computer.
Alavi et al. (2016) [218]	Iran	Application of the NMQ in office workers.
Piranveysseh et al. (2016) [219]	Iran	Application of the NMQ in office workers.

3.5.1. Administrative Activities

Johansson [205] evaluated office workers by an expanded NMQ, differentiating the symptoms of MSD related to work and not related to that work. The work-related MSD were more debilitating than those not related. Zejda et al. [39], studying MSD in Polish office workers, especially the upper extremities and the neck. The position of the computer screen and the type of seat could also contribute to back pain. Prodanovska-Stojcevska et al. [214], in Macedonia, analysed office workers that used computers at least one hour per day. The results showed a high prevalence of neck and back pain, likely due to the lack of ergonomic training.

Habib et al. [217] detected MSD in office workers of Bangladesh. These researchers found an incidence of 76% of MSD in the 12 months preceding the research, especially in the lumbar region.

Alavi et al. [218] determined that MSD in the upper extremities in office workers were related to the state of mental health. Therefore these authors recommended the implementation of new prevention programmes for labour risks. Similarly, Piranveyseh et al. [219] associated MSD with psychosocial risks in Iran.

3.5.2. Computer Users

Jepsen and Thomsen [206] examined the effect on the nervous system in the arms of workers who used the computer mouse and found problems of nerve transmission in three areas of the upper arm. Arvidsson et al. [208] also found musculoskeletal problems in the elbow and hand of the right arm as a consequence of using the computer mouse in air controllers.

Klussmann et al. [207] related musculoskeletal symptoms of the upper extremities and neck in workers who viewed digital material for more than an hour per day. Also studying workers who use screens, Lapointe et al. [209] investigated the interaction between the awkward posture and the MSD symptoms of the neck, shoulders, back, and upper members. Similar MSD were appreciated by Malinska and Bugajska [210] together with head pain. Ayanniyi et al. [211] found a greater incidence of lumbar and neck pain in workers who used a computer than in those who did not.

Griffiths et al. [212] combined three questionnaires, one being the NMQ, to study public workers in Australia who used a computer. A year later, Griffiths et al. [213] confirmed the prevalence of musculoskeletal discomfort in the neck, wrist, and hand associated with hours of work at the computer. Tavafian et al. [215] evaluated two groups of workers who operated computer equipment, implementing better ergonomics. These measures proved beneficial in the group investigated compared to the control group.

Finally, Kaliniene et al. [216] collected data using the NMQ, the Copenhagen psychosocial questionnaire, and RULA for workers in three companies in the public sector who used a computer. The results confirmed that the neck disorders were associated with individual factors and with the work conditions, calling for ergonomic improvements.

3.6. Teaching

Table 6 lists the studies that used NMQ in teaching.

Table 6. Use of the NMQ in teaching.

Authors	Location	Observations
Crawford et al. (1998) [220]	United Kingdom	Application of the NMQ together with the OWAS and Borg RPE-scale in nursery-school workers.
Siivola et al. (2002) [221]	Finland	Application of the NMQ in a sample of teenage students.
Fjellman-Wiklund et al. (2003) [222]	Sweden	Application of the NMQ in music teachers.
Nyland y Grimmer (2003) [223]	Australia	Application of the NMQ in physiotherapy students.
Smith et al. (2009) [224]	Australia	Application of the NMQ in odontology students.
Shamsoddini et al. (2010) [225]	Iran	Application of the NMQ in secondary-school students.
Carregaro et al. (2012) [226]	Brazil	Application of the NMQ in functionaries in higher education.
Nawrocka et al. (2014a) [227]	Polonia	Application of the NMQ in students in a music school.
Abledu y Offei (2015) [228]	Ghana	Application of the NMQ in nursing students.
Guimaraes-Souza et al. (2015) [229]	Brazil	Application of the NMQ regarding the suitability of school furniture.
Dockrell et al. (2015) [230]	Ireland	Application of the NMQ in university students analysing computer use.
Koch et al. (2015) [231]	Germany	Application of the NMQ in child-care workers.
Mohd et al. (2016) [232]	Malasia	Application of the NMQ in secondary-school teachers.
Vijay e Ide (2016) [233]	United Kingdom	Application of the NMQ in odontology students.

Crawford et al. [220], using the NMQ, OWAS, and the Borg RPE-scale in nursery-school workers, found troubles in the back and other body regions. The most harmful activities were identified and improvements were proposed.

Guimaraes-Souza et al. [229] used the NMQ to determine at what level postures adopted by the students were harmful. These researchers discovered that the furniture was not adapted to the anthropometric measurements of the students.

Koch et al. [231] investigated how psychosocial factors influence MSD, in addition to the risk of burnout among infant caretakers within the German labour system.

Siivola et al. [221] studied a sample of teenage students to ascertain the way in which neck and shoulder pain is related to cervical alterations found by nuclear magnetic resonance. The herniated disc was the only ailment detected that was associated significantly with neck pain.

Fjellman-Wiklund et al. [222], using the NMQ, investigated MSD among music professors in Sweden and found differences between men and women.

Nyland and Grimmer [223] analysed the prevalence of lumbalgia of physiotherapy students in Australia. The results showed the presence of lumbalgia among the students, the worst cases appearing in the last year. Also in Australia, Smith et al. [224] used a modified version of the NMQ with odontology students. More than half of the students had suffered some symptom in the preceding week and more than 80% in the preceding year. In Iran, Shamsoddini et al. [225] found a strong relationship between the weight of student backpacks among secondary and musculoskeletal problems in the shoulders, neck, back, and extremities. Afterwards, Carregaro et al. [226] evaluated functionaries in an institution of higher education, whereupon the subjects reported musculoskeletal complaints, especially the lower back. Also, Nawrocka et al. [227], using the NMQ and the visual analogical scale, studied the intensity of musculoskeletal pain in the students of a music school. The results showed greater pain in the neck and wrists, reflecting early prophyllaxis.

Abledu and Offei [228] analysed the degree of musculoskeletal discomfort among first-year students in a nursing school in Ghana. The results indicated greater pain in the neck, dorso, wrists, hands, and lower back. In the same year, Dockrell et al. [230] studied the use of computers by university students in Ireland and the effects on the musculoskeletal system. Parameters such as the year in school, average daily use, and dominance of right hand were related to MSD.

Groups of the education sector such as secondary-school teachers in Malasia [232] and British students of odontology [233] were the object of study by NMQ, and in both cases, ergonomic improvements were recommended.

3.7. Artistic Activities, Entertainment, and Sports

Table 7 indicates the studies which have used the NMQ in artistic activities, entertainment, and sports.

Table 7. Use of the NMQ in artistic activities, entertainment, and sports.

Authors	Location	Observations
Mansfield y Marshall (2001) [234]	United Kingdom	Application of the NMQ in rally drivers and co-driver.
Bahr et al. (2004) [235]	Norway	Application of the NMQ adapted to sports in athletes of different sports.
Foss et al. (2012) [236]	Norway	Application of the NMQ in athletes of different sports.
Mehrparvar et al. (2012) [237]	Iran	Application of the NMQ in instrumentalists.
Fotiadis et al. (2013) [238]	Greece	Application of the NMQ in musicians of a symphonic orchestra.
Ajidahun y Phillips (2013) [239]	South Africa	Application of the NMQ in instrumentalist.
Pandy (2013) [240]	United Kingdom	Application of the NMQ in librarians.
Nawrocka et al. (2014b) [241]	Polonia	Application of the NMQ in instrumentalists.
Tunas et al. (2015) [242]	Norway	Application of the NMQ in top football and handball players.

3.7.1. Artistic Activities (Musicians)

The first study related to this category was made by Mehrparvar et al. [237] and used the NMQ to evaluate the frequency of musculoskeletal disorders in Iranians. Improvements and further studies were recommended. Later, Fotiadis et al. [238] investigated the frequency of MSD among musicians of

a symphonic orchestra in Greece. The data collected with the NMQ showed a very high percentage of discomfort of at least once during their professional career. The authors highlighted the need to develop prevention programmes.

Ajidahun and Phillips [239] determined the incidence of musculoskeletal disorders in instrumentalists in South Africa. To collect data, these researchers used the NMQ, EVA, and the questionnaire designed by Blackie, Stone, and Tiernan. The prevalence of discomfort was high, with the upper extremities being the most affected area, although the severity was light. Nawrocka et al. [241] correlated the level of physical activity with the appearance of musculoskeletal pain among young Polish instrumentalists. Soreness in the shoulders, neck, and upper as well as lower back were significantly associated with the participants that did not fulfil the minimum recommended physical activity.

3.7.2. Entertainment Activities

Pandy [240] used the NMQ to estimate weekly and yearly symptoms in the neck and upper members of librarians. The ailments in the upper extremities were severe but there were not sufficient tests to confirm whether the incidence was greater than in the rest of the population.

3.7.3. Sports Activities

Mansfield and Marshall [234] used a modified NMQ to study the musculoskeletal injuries suffered by rally drivers and co-drivers and found that 91% reported some symptom.

Both Bahr et al. [235] as well as Foss et al. [236] studied lumbar complaints in Norwegian stamina athletes such as cross-country skiers, rowers, and guides, in comparison to a control group. The results showed that these sports did not cause new lumbar problems but pain did occur in athletes previously diagnosed with lumbalgia.

Also in Norway, Tunas et al. [242] compared back pain among top football and handball players in comparison with a non-professional control group. The results indicated that there were no differences between the two groups, but to play certain positions bore greater risks.

3.8. Electricity, Gas, and Water Supply

Table 8 lists the studies in which the NMQ was used in activities related to the supply of electricity and water.

Table 8. Use of the NMQ in activities related to the supply of electricity and water.

Authors	Location	Observations
Friedrich et al. (2000) [243]	Austria	Application of the NMQ in sewage-treatment workers.
Plouvier et al. (2009) [40]	France	Application of the NMQ in energy-company workers.
Herquelot et al. (2014) [244]	France	Application of the NMQ in workers and retired workers of an energy company.
Plouvier et al. (2015) [245]	France	Application of the NMQ in workers retired workers of an energy company.

Friedrich et al. [243] analysed the back pains of sewage-treatment workers, demonstrating the influence of psychosocial risks in their wellbeing.

Plouvier et al. [40] monitored the employees of a national French energy company for a year using the French version of the NMA. The results indicated that back pain was significantly higher in workers and employees than among office workers. In the same company, Herquelot et al. [244] and Plouvier et al. [245] analysed the persistence of knee pain and lumbalgias in two groups, i.e., retired and active workers. The results suggest that biomechanical exposure during a worker's career has persistent effects after retirement.

3.9. Commercial Activities

Table 9 lists the studies in which NMQ was used to assess commercial activities.

Table 9. Use of the NMQ in commercial activities.

Authors	Location	Observations
Pinheiro et al. (2002) [33]	Portugal	Application of the NMQ in bank personnel.
Darvishi y Meimanatabadi (2015) [246]	Iran	Application of the NMQ in bank personnel.
Razavi y Behbudi (2015) [247]	Iran	Application of the NMQ in workers in ticket booths.
Anton y Weeks (2016) [248]	United States	Application of the NMQ in food-store attendants.
Darvishi et al. (2016) [249]	Iran	Application of the NMQ in bank personnel.

Pinheiro et al. [33] validated the NMQ in Portugal by comparing the results of the questionnaire with clinical data of the medical histories of the employees of public banks. These authors concluded that the Portuguese version of the questionnaire is a satisfactory tool to measure MSD. Darvishi and Meimanatabadi [246] related mental workload with MSD among the personnel of an Iranian bank. The results confirmed that the mental workload acted as a risk factor for the appearance of MSD.

Razavi and Behbudi [247] investigated the improvement in the ergonomic level of ticket booths. Using NMQ, these researchers determined that the greatest risks were in men, in the wrists, concluding that ticket sellers were exposed to health risks and could improve by relocating the booths and adjusting the furnishings.

Anton and Weeks [248] described the MSD symptoms related to working in a large food shop. Some 78% of the workers reported musculoskeletal symptoms related to the work at least in one region of the body.

The latest study related to this category was by Darvishi et al. [249], who evaluated mental workload and its correlation with the MSD among bank personnel, concluding that the mental workload appeared to be a risk factor for the incidence of MSD.

3.10. Mining

Table 10 lists the studies in which NMQ has been used in mining.

Table 10. Use of the NMQ in mining.

Authors	Location	Observations
Xu et al. (2012) [250]	China	Application of the NMQ in coal miners.
Jahangiri et al. (2015) [251]	Iran	Application of the NMQ in lead miners.
Custodio et al. (2016) [252]	Philippines	Application of the NMQ in workers of small mines and gold extraction.

Xu et al. [250] investigated lumbar problems among coal miners in China for a period of 12 months. Some 65% of the workers reported lumbar pain and identified the most common labour factors associated with repetitive tasks with high physical demand, extreme bending postures, and little recovery time.

Also, lead miners were studied by Jahangiri et al. [251] in an effort to determine the MSD and associated risk factors. To reduce ailments, they proposed the adoption of preventive measures.

Finally, Custodio et al. [252] estimated the MSD in small mines and gold extraction in the Philippines. The results of applying the NMQ showed that some 95% of the interviewees felt symptoms in at least one part of their body.

3.11. Construction

Table 11 shows studies in which NMQ was used in construction.

Table 11. Use of the NMQ in construction.

Authors	Location	Observations
Pandey et al. (2012) [253]	India	Application of the NMQ in construction superintendants.
Ekpenyong e Inyang (2014) [254]	Nigeria	Application of the NMQ in construction companies.
Eaves et al. (2016) [255]	United Kingdom	Application of the NMQ in construction workers.

Pandey et al. [253] studied 22 construction superintendants of the National Institute of Industrial Engineering in Mombay (India). The results indicate that, although they did not carry out field work, they suffered back problems.

Ekpenyong and Inyang [254] analysed Nigerian construction companies and collected data by the NMQ and the work-content questionnaire. The results showed a high prevalence of MSD.

In the United Kingdom, Eaves et al. [255] conducted a study by worker interviews, using the NMQ, to explore the comprehension of the workers concerning health in the workplace, the easiest way to do their work, and the pains associated with their tasks.

3.12. Comparisons of Activities

Table 12 lists the studies in which NMQ was used to compare activities mentioned above.

Table 12. Use of the NMQ in comparisons between activities mentioned above.

Authors	Location	Observations
Mitchell et al. (2008) [256]	Australia	Application of the NMQ in nursing students and recently graduated nurses.
Nordi-Sasso-Garcia et al. (2013) [257]	Brazil	Application of the NMQ in odontology students and odontologists.
Yue et al. (2014) [46]	China	Application of the NMQ in miners and in teachers.

Mitchell et al. [256] demonstrated the rates of lumbar pain are very high in undergraduate students of nursing and recent graduates, and therefore should be a clear group for preventive strategies of back pain.

Meanwhile, Nordi-Sasso-Garcia et al. [257], using the NMQ and other methods, studied MSD in Brazilian odontology students and workers. These researchers concluded that there was a significant relation between injuries and environmental and work factors.

Yue et al. [46] evaluated MSD and associated psychosocial risk factors, comparing miners and teachers in China, using the Chinese version of the NMQ and the Copenhagen Psychosocial Questionnaire. Both groups presented a high incidence of disorders, but different characteristics related to their tasks.

3.13. Others

Table 13 shows the studies that have used the NMQ in spheres other than those examined above.

Table 13. Use of the NMQ in other spheres.

Authors	Location	Observations
David y Buckle (1997) [258]	United Kingdom	Application of the NMQ in laboratory workers.
Kaewboonchoo et al. (1998) [32]	Japan	Application of the NMQ in workers exposed to vibrations.
Leclerc et al. (1999) [259]	France	Application of the NMQ in a varied occupational group.
Alcouffe et al. (1999) [260]	France	Application of the NMQ in small-business employees.
Kilroy y Dockrell (2000) [261]	Ireland	Application of the NMQ in biomedical scientists.
Ozguler et al. (2000) [262]	France	Application of the NMQ in workers of four professional sectors.
Balogh et al. (2001) [263]	Sweden	Application of the NMQ in a large population group.
Malchaire et al. (2001) [264]	United Kingdom	Application of the NMQ in a varied occupational group.
Tsauo et al. (2004) [265]	Taiwan	Application of the NMQ in sedentary workers.
Ostergren et al. (2005) [266]	Sweden	Application of the NMQ in a varied occupational group.
Da Silva et al. (2006) [267]	Brazil	Application of the NMQ in garbage collectors.
Descatha et al. (2007) [268]	France	Application of the NMQ in a varied occupational group.
Leonard et al. (2010) [269]	Malasia	Application of the NMQ in workers with writing tasks.

Table 13. Cont.

Authors	Location	Observations
Natvig et al. (2010) [270]	Norway	Application of the NMQ in a population group.
Plouvier et al. (2010) [271]	France	Application of the NMQ in a population group.
Widanarko et al. (2011) [272]	New Zealand	Application of the NMQ in a population group.
Tschudi-Madsen et al. (2011) [273]	Norway	Application of the NMQ in a population group.
Chang et al. (2012) [44]	Taiwan	Application of the NMQ in cleaning personnel.
Parot-Schinkel et al. (2012) [274]	France	Application of the NMQ in a varied population group.
Roquelaure et al. (2012) [275]	France	Application of the NMQ in temporary workers.
Bruusgaard et al. (2012) [276]	Norway	Application of the NMQ in a population group.
Ditchen et al. (2013) [277]	Germany	Application of the NMQ in a varied occupational group.
Nordander et al. (2013) [278]	Sweden	Application of the NMQ in a varied occupational group.
Poulsen et al. (2013) [279]	Denmark	Application of the NMQ in a varied occupational group.
Curwin et al. (2013) [280]	Canada	Application of the NMQ in governmental functionaries.
Bugajska et al. (2013) [281]	Polonia	Application of the NMQ in a varied occupational group.
Moreira-Silva et al. (2014) [282]	Portugal	Application of the NMQ in a varied occupational group.
Gupta y Tiwari (2014) [283]	India	Application of the NMQ in homemakers.
Paanalahti et al. (2014) [284]	Sweden	Application of the NMQ in a population group.
Ahmad-Nasaruddin et al. (2014) [285]	Malasia	Application of the NMQ in car mechanics.
Roquelaure et al. (2014) [286]	France	Application of the NMQ in a population group.
Legault et al. (2014) [41]	France	Application of the NMQ in young populations.
Habib y Rahman (2015) [287]	Bangladesh	Application of the NMQ in homemakers.
Shankar et al. (2015) [288]	India	Application of the NMQ in kitchen workers.
Singh y Chokhandre (2015) [289]	India	Application of the NMQ in garbage collectors.
Subramaniam y Murugesan (2015) [290]	India	Application of the NMQ in kitchen workers.
Lourenco et al. (2015) [291]	Portugal	Application of the NMQ in workers under 21 years of age.
Lopes y Pinho (2016) [292]	Portugal	Application of the NMQ in workers in a recycling plant.
Tantuco et al. (2016) [293]	Philippines	Application of the NMQ in cleaning personnel.

3.13.1. Varied Occupational Groups

Kaewboonchoo et al. [32] compared the results of the NMQ with those of the Japanese Questionnaire in workers exposed to vibrations in the upper extremities. The results show a high efficiency of the NMQ, although it has deficiencies in symptoms related to the fingers. The British Occupational Hygiene Society [264] studied epidemiology for 3 years to determine the relation between musculoskeletal ailments and neurosensorial stimuli of workers in the wrist/hand area. Mechanical factors were analysed and a modified NMQ was used, resulting in the finding of greater MSD in workers exposed to vibrational tools.

Leclerc et al. [259] used the NMQ in workers of different activities twice in 12 months. These authors found major psychosomatic and psychological factors in the appearance and effects of MSD. In the same year, Alcouffe et al. [260], in small businesses in Paris, evaluated the results of 7010 questionnaires of employees, separating them by gender. These authors concluded that the incidence and severity of the lumbar pain was greater in women, and that special attention should be paid to the weights and uncomfortable postures at work.

For pain, several definitions can be used. In this context, Ozguler et al. [262] reported that lumbar pain in workers from four professional sectors varied from 85 to 45% according to the definition used. This could explain the inconsistencies found in the literature reviews.

The benefits of an exercise program was demonstrated to be useful [265] to evaluate the effectiveness of 3 health-promotion programmes. Neck and shoulder pain diminished in sedentary workers. Regarding neck and shoulder pain in men and women between 45 and 65 years old, in Sweden, Ostergren et al. [266] found a relation between mechanical exposure and psychosocial factors. The effect of the psychosocial factors was predominant in the women.

Meanwhile, Descatha et al. [268] compared the results of the NMQ with those of clinical examinations of two studies on MSD of the upper extremities. The conclusion was that the questionnaire is a very useful control tool and that a clinical exam is essential for an accurate diagnosis. In France, Parot-Schinkel et al. [274] centred their study on the characteristics of multilocalized musculoskeletal symptoms. For this, these researchers used the NMQ on a large sample of a population of workers from different disciplines. Also, Roquelaure et al. [275], in a study on musculoskeletal symptoms of the upper extremities and their main risk factors compared several groups of a large

population of workers in a French region. One of the groups presented greater risk symptoms of the wrist/hand and worse work quality.

Ditchen et al. [277] focused on the time that workers (190 males) were kneeling during their workday and their subsequent knee problems. Nordander et al. [278] analysed the risk factors and musculoskeletal disorders of the elbow and hand of a large sample of workers. The angular speed of the wrist was the most consistent risk factor.

In Denmark, Poulsen et al. [279] studied health complaints and their relation with down time at work. The results showed a direct relation with work absenteeism. Bugajska et al. [281] looked for a relation between the psychosocial conditions and musculoskeletal discomfort of employees of 20 to 70 years of age, but the results were not conclusive. Meanwhile, Moreira-Silva et al. [282] verified the effect of a programme of physical activity with respect to musculoskeletal pain and its associated symptoms. After 6 months of the programme, it was confirmed that in the elbow and hip/thigh regions the pain intensity significantly diminished.

Meanwhile, Lourenco et al. [291] related the psychosocial risks with MSD in a population of young workers. These researchers concluded that workers at the beginning of their careers are associated with responses of no pain.

3.13.2. Population Groups

Balogh et al. [263] sought to design evaluation indices to measure the mechanical exposure in the shoulder-neck region and its relation to pain. These authors emphasize two indices, i.e., referring to postures and to load lifting. In Norway, 3325 persons were polled by Natvig et al. [270] to determine the relation between cervical pain, discomfort in other regions (with NMQ) and functionality (with the Norwegian Function Assessment Scale). These researchers concluded that localized neck pain is rare, as it is almost always part of the pain of a larger or generalized area. Plouvier et al. [271], studying a sample of 3958 females and 4526 males from 30 to 59 years old, concluded that work exposure such as handling heavy items, posture, or high level of demands was strongly associated with recurrent lower-back pain. Widanarko et al. [272] used a modified NMQ in New Zealand to determine the MSD in the active population. These authors also included parameters such as sex, age, and work type. The results indicate that the prevention programmes should centre on females and tasks involving physical work with heavy loads.

Tschudi-Madsen et al. [273] analyzed a sample of the general population by using the NMQ and the Subjective Health Complaints Inventory. These authors found a linear association between non-musculoskeletal ailments (palpitations, accelerated pulse, chest pain, stomach-ache, anxiety, sleeping problems, diarrhoea, breathing difficulties, eczema, constipation, fatigue, and sedentary activity) and the musculoskeletal symptoms. These researchers consider this to indicate that the complaints shared characteristics or common causal factors. Bruusgaard et al. [276] also sent the NMQ and the Subjective Health Complaints Inventory to 7 elderly groups in Norway. The results showed a strong association between the number of symptoms and the functionality of the individuals.

Paanalahti et al. [284], in a population of Stockholm, analysed back pain (using NMQ) and the “psychological help signal” (general health questionnaire 12). The results confirmed the bidirectional association between the two factors. Legault et al. [41] developed a search tool, using the NMQ and its French adaptation, for musculoskeletal symptoms in young populations and afterwards validated it.

Finally, Roquelaure et al. [286] analysed the incidence and the risk factors for acute pain of the spinal column in a large sample of workers in a French region. After gathering data with the NMQ, among other methods, the researchers identified trunk bending as a risk.

3.13.3. Others

Using the NMQ, David and Buckle [258] compared the ergonomic problems of laboratory workers performing pipetting work with those who did not. The results associated this task with elbow and hand disorders and other factors that could affect the worker were identified. Ergonomic measures

were taken using the NMQ and other methods on biomedical scientists by Kilroy and Dockrell [261]. The results were positive in terms of working-posture improvement and reduction in MSD.

In a Brazilian city, Da Silva et al. [267] studied the musculoskeletal problems of garbage collectors. These researchers found MSD especially in the lumbar area. Singh and Chokhandre [289] made a new study of cases and controls among garbage collectors. The results suggest high indices of MSD, particularly in the lower and upper back as well as in the shoulders. Chang et al. [44], with the NMQ and electromyography evaluated cleaners in Taiwan. The results showed almost 90% prevalence of musculoskeletal discomfort due to the work, the hand/wrist region being most affected by lateral movements. Lopes and Pinho [292] used the NMQ to analyse workers in a garbage recycling centre. All the subjects polled reported discomfort or pain in some region of the body during the previous 12 months.

By contrast, Leonard et al. [269], studying subjects who performed writing tasks, compared the activity of the upper trapezius muscle in subjects with neck pain and in subjects without pain, for which the NMQ was used with other methods. The results showed that prolonged writing strained and altered the motor pattern of the upper trapezius in symptomatic subjects. Curwin et al. [280] determined the effect of a program of work wellbeing on MSD in a governmental department in Canada. The NMQ was completed before and after the programme. The measures implemented improved musculoskeletal health.

In India, Gupta and Tiwari [283] determined the lumbar pain in women who were homemakers. The results indicated 93% affliction with restrictions in their daily lives for 71% of the subjects. In Malasia, Ahmad-Nasaruddin et al. [285] used the NMQ together with the RULA to determine the incidence of MSD among mechanics repairing vehicles. After observing an affliction of 87%, the authors recommended ergonomic training. In Bangladesh, Habib and Rahman [287] used the MSD to study women who were homemakers in a rural village. The results indicated a high incidence of limitations.

Shankar et al. [288] as well as Subramaniam and Murugesan [290] studied MSD in kitchen workers. The data were gathered with the NMQ and direct observation. These researchers found differences depending on the position held, with the shoulders and lower back being the areas most affected, especially the head cooks.

Finally, Tantuco et al. [293] sought to determine the MSD of cleaning personnel in the Philippines. The workers were analysed using the NMQ, RULA, and REBA. Discomfort was detected but the RULA and REBA did not correlate.

4. Applications of the Nordic Questionnaire by Country

The country of origin has been considered for each researcher analysed (Figure 3).

A total of 259 publications were studied of NMQ in 42 different countries. In terms of the number of publications per country, the greatest number of studies corresponded to Iran, with a total of 40; followed by the United Kingdom and Brazil, with a total of 16 each; France with 15; United States and India with 14; Sweden with 13; Norway with 11; Portugal and Australia with 10; Malasia with 8; Poland, Canada, and Denmark with 7; China, Taiwan, and Germany with 6; Finland, Israel, Thailand, and Turkey with 4; Venezuela, Nigeria, Greece, and South Korea with 3; Switzerland, South Africa, New Zealand, Japan, Ireland, Philippines, Spain, and Bangladesh with 2, and Mexico, Macedonia, Lithuania, Latvia, Italy, Ghana, Colombia, Austria, and Algeria with 1 (Figure 3).

Figure 4 shows the studies made in each field of knowledge considered by country.

A surprising number of studies were made in Iran, which are equally surprising for their variety of sectors. In this country, the NMQ has been applied to 8 sectors, notably “manufacturing industries”, and “activities related to human health and social assistance”, with 18 and 12 studies, respectively. Similarly, the United Kingdom and Brazil, with the second greatest number of studies (16), also cover a large number of sectors, although without the predominance of any in particular as occurs in Iran.

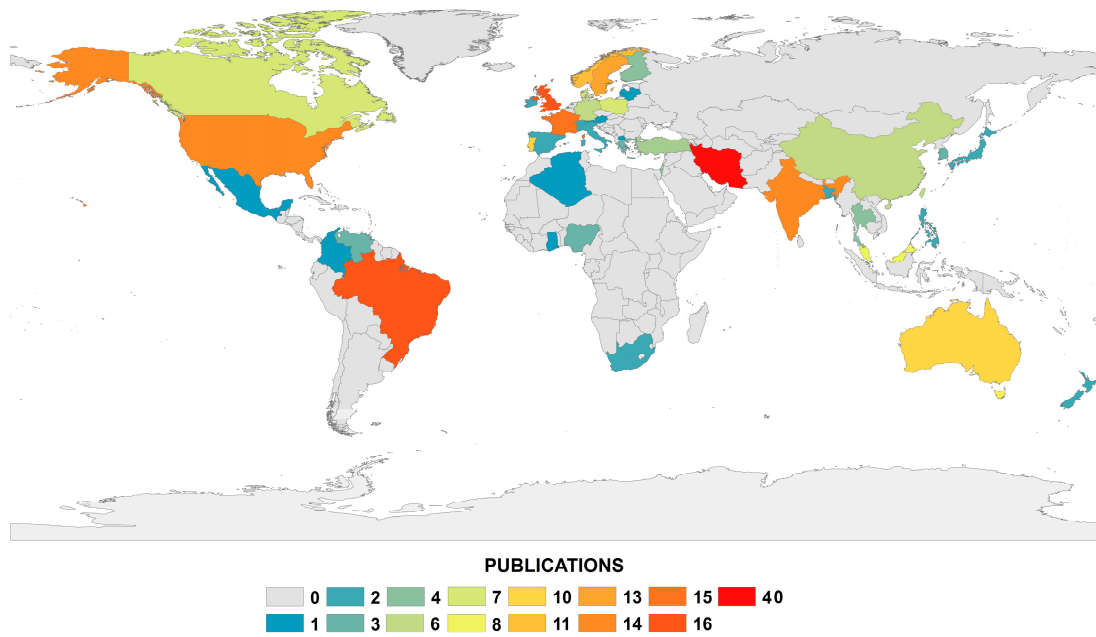


Figure 3. Publications by country.

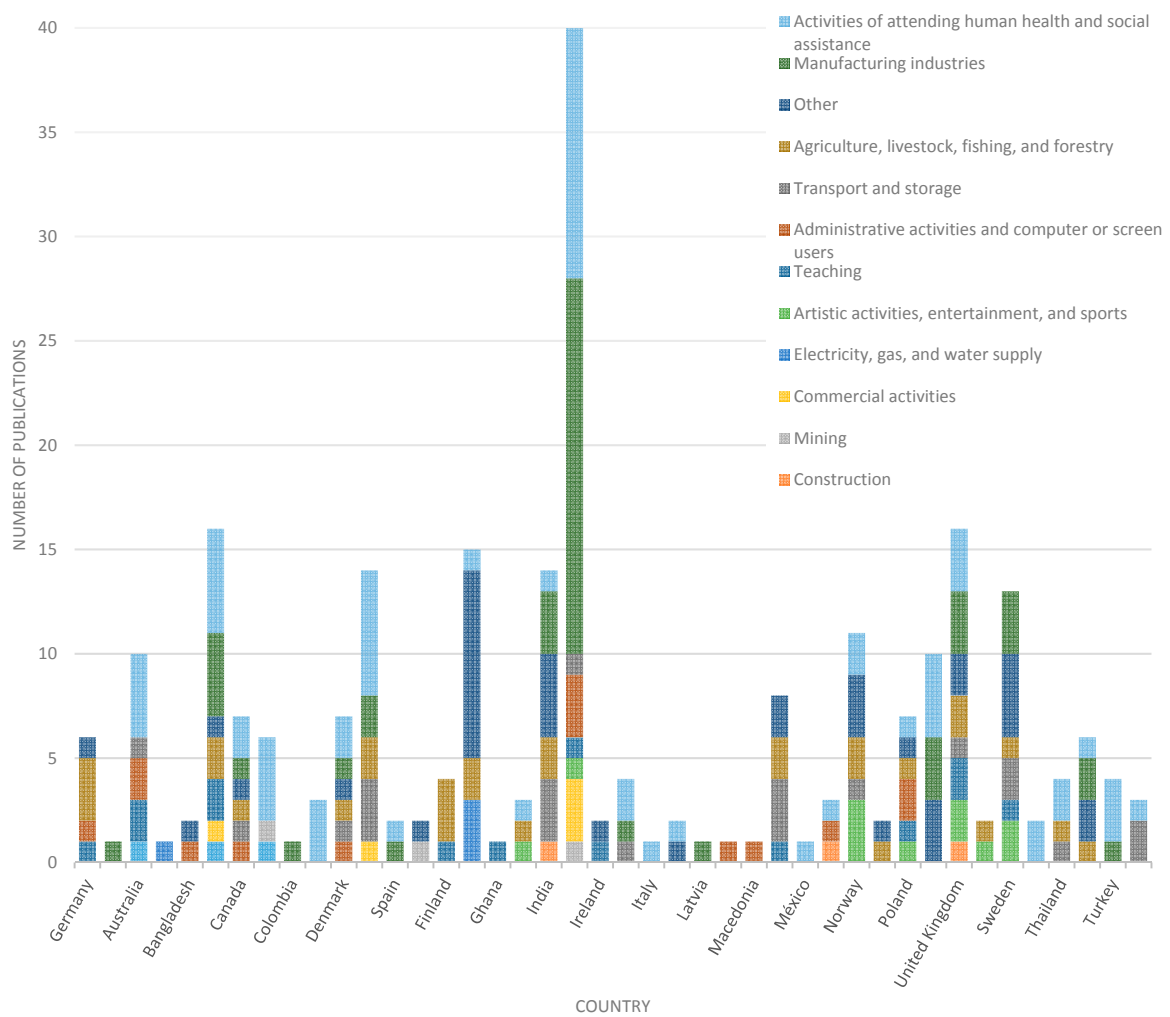


Figure 4. Number of publications in each field per country.

Apparently, most countries have been interested in the health sector at some time, as the 67 studies found on this subject are distributed among 26 different countries. The second sector most studied is manufacturing, studied in 16 countries, and “agriculture, livestock, fishing, and forestry” in 18 countries. The rest of the sectors are well distributed without any country predominating among the publications. It bears mentioning the great number of studies categorized as “others”, which can be seen in France to be due primarily to interest in “diverse population groups”.

5. Applications of the Nordic Questionnaire by Year

Figure 5 shows the number of publications per year as well as the number of fields studied each year.

A clear trend emerged regarding the increase in the number of studies applied during the period analysed, the year 2016 being the year with the highest number of studies registered, with 35 in 10 fields of knowledge, followed by the year 2014 with 32 in another 10 fields of knowledge. On the contrary, during 4 years (1988, 1989, 1990, and 1993) there was no record the NMQ being applied and 3 years (1987, 1991, and 1992) in which it was applied only once. Finally, in the last 4 years, the number of studies that had existed up to that time has practically doubled.

Undoubtedly, the easy access and massive dissemination of scientific contents have played a crucial role in the increased application of the NMQ in recent years. Furthermore, probably the greater number of software tools for data analysis and their steadily more polished interfaces have greatly facilitated the use of indirect methods such as the NMQ.

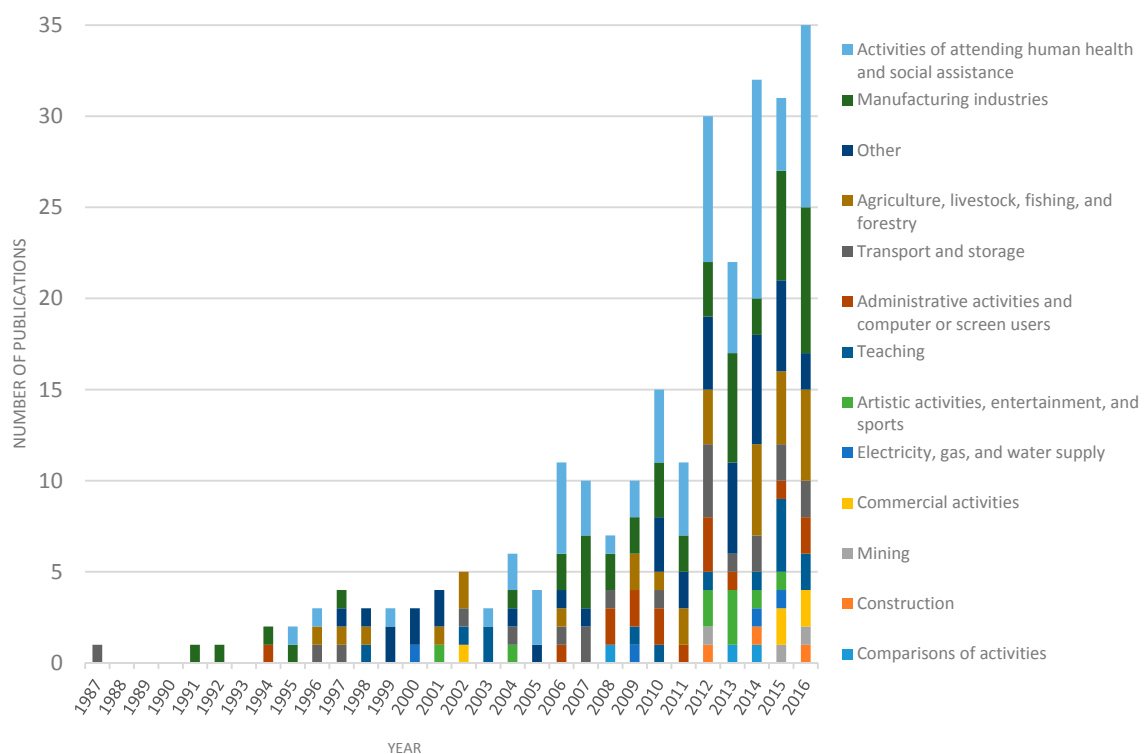


Figure 5. Number of publications in each field of knowledge per year.

6. Discussion and Conclusions

After the present study, despite its limitations due to having focused the literature search only on scientific articles and conferences of the main collection of WOS, the following conclusions can be drawn:

- a The NMQ has been applied mainly in three sectors: “activities related to human health and social assistance”, “manufacturing industries” and “agriculture, livestock, fishing, and forestry”. It is one of the world’s most widely used indirect evaluation methods for symptoms of musculoskeletal disorders and has demonstrated reliability, but more data are needed in order to assess, for example, possible risks using other complementary methods, whether direct or semi-direct.
- b The need to validate the NMQ may be dubious. This is reflected in that most of the studies are not strictly validated. They are direct questions on parts of the body of the individual that could hardly lead to mistakes. It is true that the perception of pain over time can be different in each person at the world level, which could result in erroneous data, but such differences can nevertheless be adapted to the specific areas of research by the additional use of qualitative variables (sex, age, nationality, weight, height, level of studies, etc.) of the workers studied.
- c The NMQ limits the study of the specific body areas to the neck, shoulders, and lower back, leaving out others that could greatly enrich the appraisals (upper back and extremities, mainly). Nevertheless, in its general questions, it encompasses all the areas of the body. It might make sense to broaden the questionnaire to improve these deficiencies although this would also greatly increase the interview/assessment time.
- d Sometimes, the NMQ detects MSD that are difficult to solve, especially in adverse environments such as forestry or agriculture. Clearly, the NMQ finds fewer ailments in workers in better physical condition and even with daily training, not counting top athletes. The NMQ and questionnaires on psychosocial risks demonstrate the direct relation of MSD with these risks (mental workload, compensation, support, stress, etc.).
- e The NMQ has been administrated in different ways, by postal mail, telephonically, polls, and even telematically with tools created specifically for that purpose.
- f Undoubtedly, in the coming years, this method will continue to be used in ergonomic research, increasing considerably the number of studies in different sectors of work that are currently poorly explored.
- g The use of the Standardized Nordic Questionnaire can help in part to evaluate the sustainability of a company.

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