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MDPI

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Musculoskeletal Risks of Farmers in the Olive Grove (Jaén-Spain)

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Abstract: Spain is the largest producer of olive oil in the world and, consequently, it has the world's largest olive-growing area. Workers are highly exposed to musculoskeletal risks due to the manual nature of most of the tasks they perform. The objective of this study is to assess the musculoskeletal risks faced by olive workers in the province of Jaén (Spain) using the Standardized Nordic Questionnaire. This consists of 28 questions and analyzes the wrists/hands, elbows, shoulders, neck, back, hip, ankles, and knees. In total, 445 questionnaires were completed with variable additions from the workers' environment: Sex, Age, Height, Weight, Body Mass Index, Crop Area, Irrigation System, Cultivation System, Nationality, Years of Experience, Cultivation Tasks, and Risk Prevention Service. The results indicate that 88.76% of workers presented some type of ailment and yet only knee problems prevented them from carrying out agricultural tasks in some cases. Certain recommendations are established to reduce musculoskeletal disorders in workers.

Keywords: musculoskeletal disorders; olive workers; occupational health and safety in agriculture; physical load; agricultural tasks

1. Introduction

There are many workers who suffer work-related illnesses and accidents each day. Annually, about 2.3 million people die worldwide from these causes. The main consequences are suffered by the workers themselves and their families. Companies are also affected (in terms of productivity, competitiveness, and absenteeism, etc.), as are communities and countries (economically and socially). Governments, workers, and employers, among others, are becoming increasingly aware of this problem [1], especially in developing countries. The ILO (International Labor Organization) has many occupational health and safety standards and recommendations [2] that help in the prevention and notification of risk, as well as in workplace inspection.

The adoption of new technologies, along with economic and social changes, lead to frequent modifications in the work environment. This creates new occupational hazards, making it essential to anticipate them and to guarantee occupational health and safety [3]. To promote this, governments must establish laws and services, employers have a responsibility to enforce them in the workplace, and workers must be aware of them and participate in this area [4].

Musculoskeletal disorders (MSD) "affect muscles, bones, joints, and associated tissues such as tendons and ligaments." These disorders cause pain and reduce mobility and dexterity, etc. They can involve occasional discomfort or chronic disease. They develop in people of any age and from

anywhere [5]. The most common MSDs (about 60%) present in the back. They are also frequent in the cervical area and upper extremities, among others [6].

Limitations in the laws (they do not cover all musculoskeletal risks), poor participation in risk assessment and prevention, neglecting ergonomic techniques in the workplace, and not focusing on prevention over the long term might, amongst other factors, explain why MSD is currently a problem in the work environment [7]. Millions of people in Europe suffer from these disorders, which result in very high costs for companies. Perhaps paying more attention to this problem would allow improvements in workers' health while also benefiting the organizations they work for [8]. There are numerous measures that can be adopted to reduce these disorders at work, such as shorter working hours, breaks from repetitive work, the use of ergonomically adapted tools, and workers' training, etc. [9].

MSDs present in workers in all labor sectors: mining [10], refuse collection [11], cleaning services [12], construction [13], and primary school teaching [14], etc.

The methods for assessing physical workload can be grouped into direct (the use of sensors), semi-direct (observation and the use of software), and indirect (the use of questionnaires). Semi-direct methods can be considered the midpoint between the other two in terms of precision and cost [15]. Among the direct methods, the HADA Move-Human Sensors System (Assisted Design and Analysis Tool [16]) and ViveLab Ergo [17] stand out. As for the semi-direct methods, the most widely used are OWAS (Ovako Working Analysis System; [18]), RULA (Rapid Upper Limb Assessment; [19]), and REBA (Rapid Entire Body Assessment; [20]). Regarding indirect methods, the Standardized Nordic Questionnaire [21] and the Michigan Questionnaire [22] are amongst the most representative.

The application of excessive force, load handling, repetitive tasks, harmful postures, vibrations, the climate in the work environment, and lack of muscular activity, etc., are factors that can lead to musculoskeletal disorders developing in workers [6]. These could be classified as physical factors. However, they are not the only factors that cause MSDs. They are also related to psychosocial factors (stress, problems in social relationships, etc., [6,23]), organizational factors (high work rate and low autonomy, etc.), and individual factors (age, weight, etc., [23]).

In short, there is a direct relationship between musculoskeletal disorders and risk factors other than just physical ones [24].

Agriculture is a highly changeable environment due to the climate and the working conditions, etc. This affects workers' health. Although technological advances have been made in different sectors, the workload remains very high in agriculture [25].

Musculoskeletal disorders commonly develop in farm workers [26], among other reasons, due to the high physical work demands [27]. Most of the work is done manually. Factors one can note as being directly related to the onset of these disorders include repetitive movements, harmful postures, and heavy loads [28].

Regarding the parts of the body most affected in farm workers when at work, the one that most stands out is the lumbar region. There is a link between disorders in this body area and the harmful postures adopted [29]. Some authors also state that MSDs in the upper extremities rank second (in terms of frequency) for this sector [30].

The tasks of harvesting, pruning, and handling loads have been some of the most studied in the agricultural sector. For these, the risk factors identified are repetitive movements, harmful postures (mainly in workers who have to kneel or bend), and poor work tool design [31].

Although originally designed for the industrial and healthcare sectors, the MSD assessment methods are generally applied to all fields of knowledge, including agriculture [15,32–34].

Often, several assessment methods are used in the same study. An example of this is described by Dianat et al. [35], where a questionnaire and the RULA method were used to assess farmers growing rice and greenhouse vegetables in Iran. Likewise, with Pal and Dhara [36], who assessed rice cultivation workers in India using the Standardized Nordic Questionnaire, a discomfort scale, and the QEC (Quick Exposure Checklist) alongside the OWAS, REBA, and RULA methods.

On the other hand, new technologies are being adapted to agriculture for MSD-related studies. The digitization of images and their evaluation in real time [37] is now a reality, as is surface electromyography, which is used to measure muscle activity [38].

Olive farmers suffer MSDs because of the tasks they carry out [39]. Some of the most common are tendinitis, and lower back and muscle discomfort. Approaches to combat them include the design of new tools (e.g., tools used in olive harvesting), the implementation of technology (e.g., using robots), or applying organizational measures [40].

Furthermore, farmers use machines that expose them to vibrations and the adoption of harmful postures. In this sector, MSD onset in the upper extremities is very common [41]. Machines such as manual harvesters give rise to these consequences [42].

Some of the tasks carried out by olive workers in which a high MSD risk has been demonstrated include pruning and harvesting. One of the least harmful to which they are exposed is fertilization [43].

The objective of this study is to evaluate the musculoskeletal risks faced by olive workers in the province of Jaén (Spain) using the Standardized Nordic Questionnaire [21].

2. Materials and Methods

2.1. Study Area

Spain has 2.5 million hectares of olive groves [44], with 60.80% being located in Andalusia (1.5×10^6 ha; [45]). The province of Jaén represents 23.12% (578,000 ha; [46,47]) of this production with respect to Spain and 38.53% with respect to Andalusia [45]. In turn, the surface extension is distributed over nine agricultural areas (Figure 1): La Loma (108,739 ha), Campiña Norte (98,054 ha), Campiña Sur (85,015 ha), Sierra Sur (66,754 ha), El Condado (56,018 ha), Sierra Mágina (46,178 ha), Sierra de Cazorla (42,515 ha), Sierra de Segura (41,431 ha), and Sierra Morena (33,218 ha).

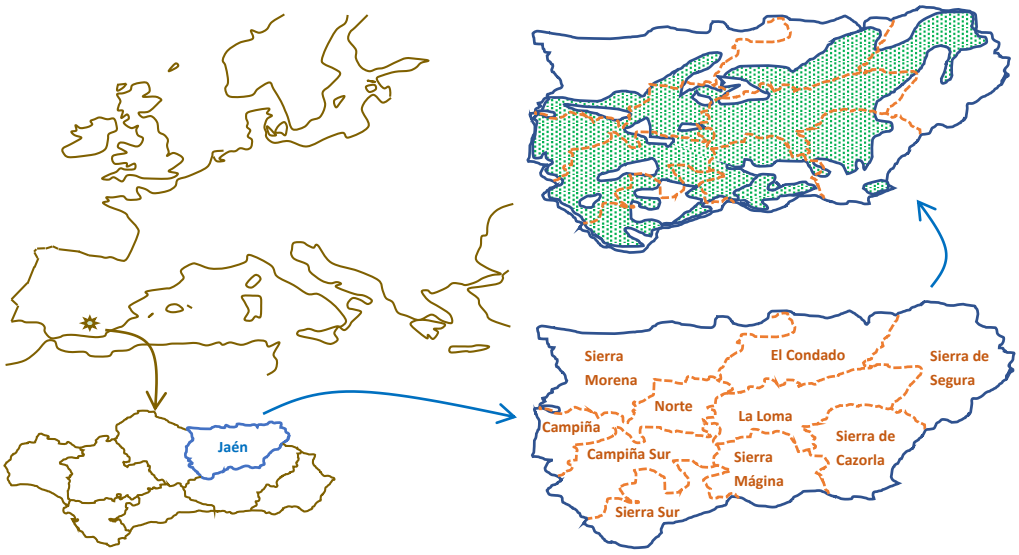

Figure 1. Olive cultivation areas by agricultural region in Jaén (Spain).

2.2. Olive Cultivation Systems and Work

In Jaén, more than 90% of the olive groves cultivate the Picual variety [45]. As a peculiarity, an endemic variety called Royal is grown in the "Sierra de Cazorla".

Six cultivation systems are usually differentiated (Table 1, [44,45,48]).

Table 1. Olive cultivation systems [44,45,48].

System	Stage	Olive Density·ha^{-1}	Production kg Olives·ha^{-1}	Feet	Slope	Harvesting	Observations
Mountain olive grove, high slope (OMAP)	Adult	100–120	1650	2–3	>20%	Very limited mechanization—no mechanization	Difficulty changing crops
Low-yield Dry Olive Grove (OSBR)	Adult	100–120	775	2–4	<20%	Possibility of mechanization	Thick feet, more than 20 cm in diameter
Average yield Dry Olive Grove (OSRM)	Adult	130–150	4750	2–4	<20%	Possibility of mechanization	Conversion process. Lower costs and higher productivity
Non-intensive irrigated Olive Grove (ORNI)	Adult	100–120	6000	2–4	<20%	Possibility of mechanization	Renewal process Possibility of converting into intensive.
Intensive irrigated Olive Grove (ORI)	Adult <30 years	190–300	10,000	1	<10%	Mechanized	Monocone/ vaso-type
Super-intensive Olive Grove (high density; OSI)	Adult in hedgerow	1000 to 2500	11,000	1	<5%	Mechanized with harvesting machines	False palm, in hedgerows

Abbreviations: OMAP (Mountain olive grove, high slope); OSBR (Low-yield Dry Olive Grove); OSRM (Average yield Dry Olive Grove); ORNI (Non-intensive irrigated Olive Grove); ORI (Intensive irrigated Olive Grove); OSI (Super-intensive Olive Grove—high density).

All cultivation systems (Table 1) can be carried out in the conventional olive grove, integrated production, or organic olive grove mode. In addition, the tasks can vary depending on the cultivation system (Table 2, [49]):

Table 2. Tasks of the different olive cultivation systems [49].

System	Planting	Soil Management	Pruning	Phytosanitary Treatments	Fertilization	Irrigation	Harvesting
Mountain Olive Grove, high slope (OMAP)	√	√	√	√	√	-	Manual
Low-yield Olive Grove (OSBR)	√	√	√	√	√	-	Manual
Average yield Dry Olive Grove (OSRM)	√	√	√	√	√	-	Mixed
Non-intensive irrigated Olive Grove (ORNI)	√	√	√	√	√	√	Mixed
Intensive irrigated Olive Grove (ORI)	√	√	√	√	√	√	Mechanized
Super-intensive Olive Grove (high density; OSI)	√	√	√	√	√	√	Mechanized

Abbreviations: OMAP (Mountain olive grove, high slope); OSBR (Low-yield Dry Olive Grove); OSRM (Average yield Dry Olive Grove); ORNI (Non-intensive irrigated Olive Grove); ORI (Intensive irrigated Olive Grove); OSI (Super-intensive Olive Grove—high density).

- Planting: This task is only carried out once during the life of the tree. Depending on the cultivation system, it may be manual or mechanized (Figure 2).

Figure 2. Agricultural tasks during a year (olive grove). Also, cultivation systems.

- Soil Management: The use of herbicides, brush cutting (if necessary, manual or mechanized with a tractor), in addition to tasks to prepare the soil for harvesting (Figure 2). Likewise, this can be manual or mechanized. The use of herbicides, if applicable, is mainly in spring and autumn. The management of the vegetal layer, especially in ecological production, can be done by grazing (a diente). Also, mechanical clearing.
- Pruning: Pruning, cleaning, removal of pruning cuttings and debris (green pruning). Mainly a manual task with the help of tools (Figure 2). In dry olive groves, this is usually done every 2–4 years, whereas in irrigated olive groves, it is performed every year. Pruning crews range from 2–4 people. The pruning debris end up mostly as chopped wood although it might also be burned. Basal shoot clearing (desvareto) is usually the mechanical removal of part of the yearly wood growth in the summer months. Sometimes this activity is replaced by grazing, especially in organic farming. In hedgerow olive groves, mixed clearing is recommended (mechanized and manual), facilitating the flexibility of the tree for harvesting.
- Phytosanitary treatments: The tasks involved in applying phytosanitary products, especially against pests and diseases (Figure 2). Also, foliar fertilizers. This can be performed manually or mechanically. Depending on the terrain, it can be done using atomizers, treatment tubs with pressure hoses, and backpacks. 2–3 foliar fertilizer treatments are usually carried out per year. Phytosanitary treatments will depend on the incidence of the pest/disease (based on the economic damage threshold). It also depends on the cultivation type, whether organic, integrated, or conventional production.
- Fertilization: The application of solid fertilizers or fertigation. With fertigation, this is mainly a manual task (Figure 2). The application of solid fertilizers, especially on dry groves, can be done with a fertilizer spreader or scattered. Fertilization is usually carried out once a year. In organic production, the uses are more restrictive, with no synthetic chemicals allowed. Fertigation is applied each irrigation.
- Irrigation: The use and maintenance of the irrigation installation (Figure 2). Manual labor. The frequency of the irrigation will depend on the farm conditions, fundamentally, the soil and climatic parameters. Irrigation is more frequent from March to October.

- Collection: Harvesting in the field and transport to the olive mill (Figure 2). This can be manual, mechanized, or mixed. This is the operation requiring the most days of work. Harvesting crews range from 5–20 people, generally. The harvesting methods can be using rods and nets, branch vibrators, or trunk vibrators (heads, buggies, and umbrellas). The most common is the use of branch vibrators (the backpack vibrator).

To carry out these various tasks, one will need to use tractors, trimmers, chainsaws, scissors, spacers (ax type), choppers, fertilizer spreader, atomizers, vibrators, and blowers.

2.3. Labor Characteristics of the Workers

The workforce can be family or salaried. The workers assessed comprised both self-employed and employed (whether throughout the year or the 3 months when needed for harvesting, pruning, and treatments). This includes employed people who work exclusively in harvesting tasks [48]. On average, the family makes up around 65% of the workforce in traditional olive grove and 40% in organic groves [49].

In olive-sector work, an occupational risk prevention plan (plan de prevencion de riesgos laborales, PRL) is guaranteed for all workers (whether contracted from an external company or not), which includes PRL training and an annual medical check-up. In addition, there is an employment contract, health care, unemployment benefits, and access to unions [50].

2.4. Assessment Methodology

2.4.1. Method Selection

In the research carried out by Gomez-Galan et al. [15] and Lopez-Aragon et al. [32], direct methods were discarded because they require financing. Faced with this adversity, and in accordance with similar research to this work, Lopez-Aragon et al. [51] carried out a decision matrix in which they evaluated semi-direct and indirect methods. They considered four criteria (with a score of 1 to 4 points each) and twelve methods. They ended up using the 'Standardized Nordic Questionnaires for the Analysis of Musculoskeletal Symptoms (NMQ)' method [21].

2.4.2. Method Description

This is a questionnaire for assessing musculoskeletal disorders in workers. It can be used in interviews and its reliability is acceptable (about 80%) [21].

The questionnaire is classified as an indirect method and can be useful in different fields of knowledge [32]. It is divided into two distinct parts and consists of a total of 28 questions. The body areas analyzed are the wrists/hands, elbows, shoulders, neck, back, hip, ankles, and knees [21,32].

2.4.3. Sample Size and Data Acquisition

In the province of Jaén, the workday in the olive grove can be up to 6.76×10^6 [45]. If it is a UTA (Agricultural Work Unit), this is equivalent to 228 workdays of 8 h each (1826 h) [45], it will have:

$$\text{Number of workers } = 6.76 \times 10^6 \text{workdays} \cdot \frac{\text{UTA}}{228 \text{ workdays}} \cdot \frac{\text{Worker}}{\text{UTA}} = 29{,}619.12 \text{ workers}$$

Therefore, it is estimated that there are 30,000 workers employed in olive grove cultivation in the province of Jaén.

The proposed sample size [52,53] will be:

$$n = \frac{N \times Z_a^2 \times p \times q}{d^2 \times (N-1) + Z_a^2 \times p \times q}$$

where: p is the expected frequency of the factor to study. If not known, use $p = 0.5$ (50%) that maximizes the sample size, $d =$ precision or error admitted, $q = 1 - p$, $N =$ total population, and $Z_a = 1.962$ for a confidence level of 95%.

With values of d = 5.0%, p = 0.5, and a confidence level of 95%:

$$n = \frac{30{,}000 \times 1.962^2 \times 0.5 \times 0.5}{0.05^2 \times (30{,}000 - 1) + 1.96^2 \times 0.5 \times 0.5} = 380.09$$

Thus, the number of workers to study will be 381.

During the field work, 2000 interviews were carried out, the response rate being 22.25%; that is, 445 questionnaires were completed.

For this reason, the admitted error (d') was less:

$$n = \frac{30{,}000 \times 1.962^2 \times 0.5 \times 0.5}{d'^2 \times (30{,}000 - 1) + 1.96^2 \times 0.5 \times 0.5} = 445$$

So, d' = 0.046112, which is equivalent to an accuracy of 4.62%.

The data acquisition phase was carried out in a non-stratified random way throughout the province of Jaén (Figure 1) from 15 October 2019 to 13 March 2020.

2.4.4. Nomenclature and Codification

A codification of the qualitative variables for the workers and their environment has been prepared (Table 3), as well as the questionnaire responses (Table A1—Appendix A).

Table 3. Qualitative variables of the workers and their environment.

Variable	Categories	Coding
Sex	Male	ML
	Female	F
Age	<25 years	T1
	Between 25 and 40 years	T2
	>40 years	T3
Height	<1.60 m	A1
	Between 1.60 and 1.70 m	A2
	>1.70 m	A3
Weight	<70 kg	P1
	Between 70 and 80 kg	P2
	>80 kg	P3
Body Mass Index (BMI = Weight/Height^2)	From 17.00 to 18.49 (kg/m^2)—Low Weight	W0
	From 18.50 to 24.99 (kg/m^2)—Normal Weight	W1
	From 25.00 to 29.99 (kg/m^2)—Overweight	W2
	From 30.00 to 34.99 (kg/m^2)—Chronic overweight	W3
	From 35.00 to 39.99 (kg/m^2)—Premorbid obesity	W4
Crop Area	<5 ha	S1
	Between 5 and 10 ha	S2
	>10 ha	S3
Irrigation System	dry land	R0
	irrigation	R1

Table 3. *Cont.*

Variable	Categories	Coding
Cultivation System	Traditional mountain olive grove	O1
	Traditional olive grove with slopes < 20%	O2
	Traditional olive grove without slope	O3
	Intensive olive grove	O4
	Super-intensive olive grove	O5
	Organic olive grove (traditional)	O6
Nationality	African	Afr
	Asian	Asi
	Spanish	Spa
	Eastern European	EurE
	Hispanic American	His
Years of experience	≤5 years	Z1
	Between 5 and 15 years	Z2
	>15 years	Z3
Cultivation Tasks	Traditional Collection	Rec1
	Mechanized Collection	Rec2
	Pruning	Pod1
	'*Desvaretar*' (another type of pruning)	Pod2
	Manual Phytosanitary Treatment	Tram
	Tractor driver	Trac
	Others	Otr
Risk Prevention Service	Outside	Out
	Own	Own
	Joint	Joi

2.4.5. Data Analysis

A multiple correspondence analysis has been performed along with descriptive statistics using SPSS v.25 and XLSTAT2019, and a Burt table (Supplementary Table S1).

3. Results

3.1. Descriptive Statistics

Table 4 shows the mode and frequencies of all categories of each variable (including those of the workers).

Table 4. Frequency and mode for the different categories of the qualitative variables.

Variable	Category	Frequency	%
Sex	F	77	17.3
	ML *	368	82.7
Age	T1	56	12.58
	T2 *	213	47.87
	T3	176	39.55
Height	A1	43	9.66
	A2	158	35.51
	A3 *	244	54.83
Weight	P1	103	23.15
	P2	154	34.61
	P3 *	188	42.25

Table 4. *Cont.*

Variable	Category	Frequency	%
Body Mass Index	W0	1	0.23
	W1	139	31.24
	W2 *	221	49.66
	W3	73	16.4
	W4	11	2.47
Crop Area	S1	99	22.25
	S2	65	14.61
	S3 *	281	63.15
Irrigation System	R0 *	232	52.14
	R1	213	47.87
Cultivation system	O1	134	30.11
	O2	118	26.52
	O3 *	162	36.4
	O4	10	2.25
	O5	14	3.15
	O6	7	1.57
Nationality	Afr	117	26.3
	EurE	90	20.23
	His	32	7.19
	Spa *	206	46.29
Years of experience	Z1	157	35.28
	Z2 *	183	41.12
	Z3	105	23.6
Cultivation tasks	Otr	4	0.9
	Pod1	2	0.45
	Rec1	199	44.72
	Rec2 *	233	52.36
	Trac	3	0.67
	Tram	4	0.9
Risk Prevention Service	Joi	31	6.97
	Out *	349	78.43
	Own	65	14.61
Q1a	q1an	170	38.2
	q1as *	275	61.8
Q1b	q1bn *	243	54.61
	q1bsa	90	20.23
	q1bsd	76	17.08
	q1bsi	36	8.09
Q1c	q1cn *	330	74.16
	q1csa	50	11.24
	q1csd	45	10.11
	q1csi	20	4.49
Q1d	q1dn *	227	51.01
	q1dsa	99	22.25
	q1dsd	86	19.33
	q1dsi	33	7.41
Q1e	q1en	211	47.42
	q1es *	234	52.58
Q1f	q1fn	183	41.12
	q1fs *	262	58.88

Table 4. *Cont.*

Variable	Category	Frequency	%
Q1g	q1gn *	327	73.48
	q1gs	118	26.52
Q1h	q1hn	209	47
	q1hs *	236	53.03
Q1i	q1in *	339	76.18
	q1is	106	23.82
Q2a	q2aN1	63	14.16
	q2an *	328	73.71
	q2as	54	12.14
Q2b	q2bN1	63	14.16
	q2bn *	324	72.81
	q2bs	58	13.03
Q2c	q2cN1	63	14.16
	q2cn *	339	76.18
	q2cs	43	9.66
Q2d	q2dN1	63	14.16
	q2dn *	310	69.66
	q2ds	72	16.18
Q2e	q2eN1	63	14.16
	q2en *	308	69.21
	q2es	74	16.63
Q2f	q2fN1	63	14.16
	q2fn *	260	58.43
	q2fs	122	27.42
Q2g	q2gN1	63	14.16
	q2gn *	343	77.08
	q2gs	39	8.76
Q2h	q2hN1	63	14.16
	q2hn	187	42.02
	q2hs *	195	43.82
Q2i	q2iN1	63	14.16
	q2in *	333	74.83
	q2is	49	11.01
Q3a	q3aN1	63	14.16
	q3an *	331	74.38
	q3as	114	25.62
Q3b	q3bN1	63	14.16
	q3bn *	301	67.64
	q3bs	81	18.2
Q3c	q3cN1	63	14.16
	q3cn *	342	76.85
	q3cs	40	9
Q3d	q3dN1	63	14.16
	q3dn *	292	65.62
	q3ds	90	20.23
Q3e	q3eN1	63	14.16
	q3en *	268	60.23
	q3es	114	25.62

Table 4. *Cont.*

Variable	Category	Frequency	%
Q3f	q3fN1	63	14.16
	q3fn *	246	55.28
	q3fs	136	30.56
Q3g	q3gN1	63	14.16
	q3gn *	327	73.48
	q3gs	55	12.36
Q3h	q3hN1	63	14.16
	q3hn *	256	57.53
	q3hs	126	28.32
Q3i	q3iN1	63	14.16
	q3in *	328	73.71
	q3is	54	12.14
Q4	q4n *	242	54.38
	q4s	203	45.62
Q5	q5N4 *	240	53.93
	q5n	177	39.78
	q5s	28	6.29
Q6	q6N4 *	240	53.93
	q6n	101	22.7
	q6s	104	23.37
Q7	q7N4 *	240	53.93
	q7a	38	8.54
	q7b	96	21.57
	q7c	36	8.09
	q7d	9	2.02
	q7e	26	5.84
Q8a	q8aN4 *	240	53.93
	q8aN7	36	8.09
	q8an	71	15.96
	q8as	98	22.02
Q8b	q8bN4 *	240	53.93
	q8bN7	36	8.09
	q8bn	70	15.73
	q8bs	99	22.25
Q9	q9N4 *	240	53.93
	q9N7	36	8.09
	q9a	47	10.56
	q9b	66	14.83
	q9c	32	7.19
	q9d	24	5.39
Q10	q10N4 *	240	53.93
	q10N7	36	8.09
	q10n	89	20
	q10s	80	17.98
Q11	q11N4 *	240	53.93
	q11N7	36	8.09
	q11n	96	21.57
	q11s	73	16.4
Q12	q12n *	224	50.34
	q12s	221	49.66

Table 4. *Cont.*

Variable	Category	Frequency	%
Q13	q13N12 *	224	50.34
	q13n	194	43.6
	q13s	27	6.07
Q14	q14N12 *	224	50.34
	q14n	166	37.3
	q14s	55	12.36
Q15	q15N12 *	224	50.34
	q15a	31	6.97
	q15b	122	27.42
	q15c	34	7.64
	q15d	24	5.39
	q15e	10	2.25
Q16a	q16aN12 *	223	50.11
	q16aN15	20	4.49
	q16an	122	27.42
	q16as	80	17.98
Q16b	q16bN12 *	223	50.11
	q16bN15	20	4.49
	q16bn	121	27.19
	q16bs	81	18.2
Q17	q17N12 *	223	50.11
	q17N15	20	4.49
	q17a	92	20.67
	q17b	77	17.3
	q17c	20	4.49
	q17d	13	2.92
Q18	q18N12 *	223	50.11
	q18N15	20	4.49
	q18n	111	24.94
	q18s	91	20.45
Q19	q19N12 *	223	50.11
	q19N15	20	4.49
	q19n	129	28.99
	q19s	73	16.4
Q20	q20n *	290	65.17
	q20s	155	34.83
Q21	q21N20 *	290	65.17
	q21n	125	28.09
	q21sa	8	1.8
	q21sd	9	2.02
	q21si	13	2.92
Q22	q22N20 *	290	65.17
	q22n	113	25.39
	q22s	42	9.44
Q23	q23N20 *	290	65.17
	q23n	41	9.21
	q23sa	33	7.42
	q23sd	59	13.26
	q23si	22	4.94

Table 4. *Cont.*

Variable	Category	Frequency	%
Q24	q24N20 *	290	65.17
	q24N23	41	9.21
	q24a	58	13.03
	q24b	27	6.07
	q24c	16	3.6
	q24d	13	2.92
Q25a	q25aN20 *	290	65.17
	q25aN23	41	9.21
	q25an	72	16.18
	q25as	42	9.44
Q25b	q25bN20 *	290	65.17
	q25bN23	41	9.21
	q25bn	62	13.93
	q25bs	52	11.69
Q26	q26N20 *	290	65.17
	q26N23	41	9.21
	q26a	62	13.93
	q26b	30	6.74
	q26c	11	2.47
	q26d	11	2.47
Q27	q27N20 *	290	65.17
	q27N23	41	9.21
	q27n	10	2.25
	q27s	104	23.37
Q28	q28N20 *	290	65.17
	q28N23	41	9.21
	q28n	72	16.18
	q28sa	18	4.05
	q28sd	12	2.7
	q28si	12	2.7

* Mode; Abbreviations: Please see Table 3 and Table A1—Appendix A.

According to the frequencies of the different categories, the individual "mode" would be a man ("ML") of Spanish origin ("Spa"), between 25 and 40 years ("T2") of age, with experience of between 5 and 15 years ("Z2"), taller than 1.70 m ("A3"), weight greater than 80 kg ("P3"), and a body mass index (BMI) between 25 and 29.99 kg/m^2 ("W2"), carrying out mechanized harvesting tasks ("Rec2") in farms with a surface area greater than 10 ha ("S3") on dry land ("R0") where the cultivation is traditional olive trees without slopes ("O3") and with an external risk prevention service ("Out").

Table 5 shows different mean values of the individuals surveyed according to their nationality and sex.

Regardless of nationality, 75.33% of women are overweight while men are only 67.13% (Table 5).

Table 5. Average values according to origin and sex.

Category	Nationality	Sex	Value
Height (m)	Afr	ML	1.73
		F	1.69
	EurE	ML	1.73
		F	1.68
	His	ML	1.66
		F	1.70
	Spa	ML	1.74
		F	1.66
Weight (kg)	Afr	ML	78.39
		F	80.14
	EurE	ML	81.60
		F	80.36
	His	ML	71.56
		F	86.00
	Spa	ML	83.04
		F	74.53
Body Mass Index (kg/m^2)	Afr	ML	26.16
		F	28.24
	EurE	ML	27.20
		F	28.41
	His	ML	25.72
		F	29.45
	Spa	ML	27.50
		F	27.00
Age (years)	Afr	ML	33.50
		F	35.00
	EurE	ML	35.28
		F	37.79
	His	ML	35.57
		F	42.00
	Spa	ML	41.09
		F	41.55
Experience (years)	Afr	ML	6.50
		F	7.29
	EurE	ML	6.37
		F	5.36
	His	ML	7.43
		F	6.67
	Spa	ML	15.59
		F	14.66

Abbreviations: Please see Table 3.

Descriptive Figures

Figure 3 presents the percentage of people who have suffered discomfort according to the following classification:

- Pain, discomfort, or ill-being at or after work (corresponding to questions Q4, Q12, and Q20). In this section of the questionnaire, data regarding the neck, shoulders (without distinguishing between left or right), and lumbar area have been collected.
- Pain, discomfort, or ill-being in the last twelve months at or after work (corresponding to question Q1). In this case, data have been collected for the neck, shoulders, elbows, wrists/hands, upper back, lower back, hips/thighs, knees, and ankles/feet.

The percentage of subjects is shown for each of these cases according to sex, age, body mass index, farm size, type of irrigation, cultivation system, nationality, years of experience, type of work performed, and type of prevention service.

In subfigure 1 (Figure 3), these results are observed for all the individual categories studied. In the case of pain, discomfort, or ill-being ever, of the three areas studied, the most common discomfort occurs in the neck (49.66%) and the least common in the shoulders (34.83%). For the last twelve months, the most affected area is the neck (61.80%) and the least affected is the ankles/feet (23.82%; Table 4 and Figure 3).

In subfigure 2 (Figure 3; Ever Q4, Q12, and Q20; Supplementary Table S1), it is observed that there is a higher prevalence of women with neck ailments (+6%) and a higher percentage of men with lower back ailments (+7%), but the shoulders are equally affected. Also, regarding Q1, both sexes have very similar percentages (less than 4% difference), except for shoulders (6% more in men) and upper back (7% more in women).

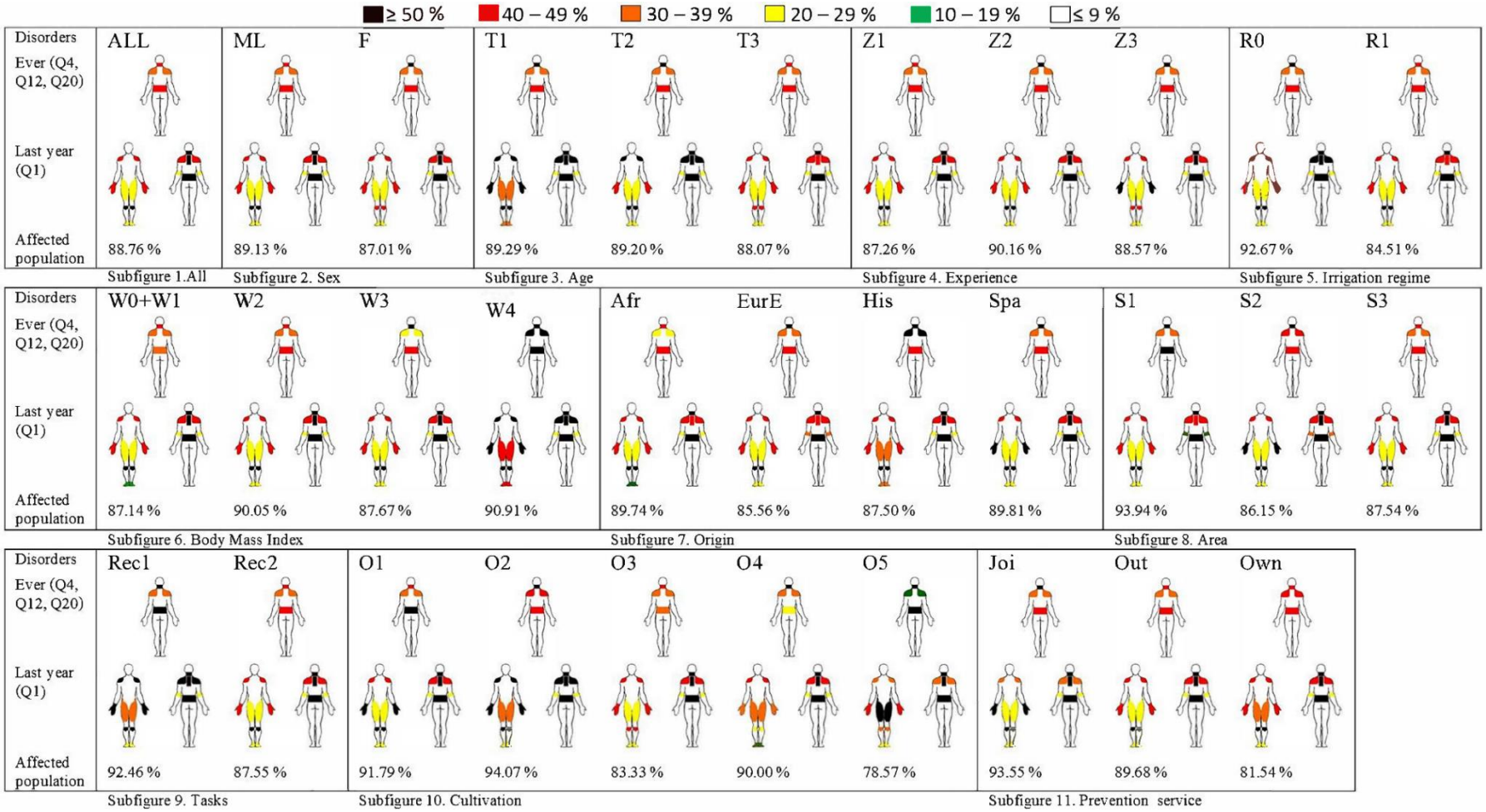

Figure 3. Ailments at some time during the last twelve months. Subfigure 1: All; Subfigure 2: Sex; Subfigure 3: Age; Subfigure 4: Experience; Subfigure 5: Irrigation regime; Subfigure 6: Body Mass Index: Subfigure 7: Origin or nationality; Subfigure 8: Area; Subfigure 9: Tasks; Subfigure 10: Cultivation; Subfigure 11: Prevention service. Abbreviations: Please see Table 3 and Table A1—Appendix A.

3.2. Multiple Correspondence Analysis

The model resulting from analyzing the 3 most relevant dimensions is obtained (Table 6). For the model as a whole, the mean variance explained was 24.186% (by dimension), and the cumulative variance was 72.559% (inertia 0.726), with a mean Cronbach α coefficient of 0.953 and a mean eigenvalue of 16.205. Therefore, the model can be considered very reliable.

Table 6. Summary of the model.

Dimension	Cronbach's α	Variance Accounted		
		Total (Eigenvalue)	Inertia	% Variance
1	0.98	26	0.39	38.8
2	0.94	13.54	0.2	20.21
3	0.9	9.07	0.14	13.54
Total		48.62	0.73	72.56
Mean	0.95	16.21	0.24	24.19

Table 7 shows the discrimination values for each variable (the closer to 1, the more weight the value has in the dimension) with respect to each of the model dimensions.

Table 7. Discrimination values for the variables with respect to the three dimensions.

Variables	Dimension			
	1	2	3	Mean
Sex	0	0	0	0
Age	0	0	0	0
Height	0	0.01	0.01	0.01
Weight	0	0	0.01	0
BMI	0.01	0.02	0.01	0.01
Crop Area	0.01	0	0	0
Irrigation System	0.01	0.01	0	0.01
Cult. System	0.03	0.01	0.02	0.02
Nationality	0.01	0.01	0.01	0.01
Years Exp.	0.01	0	0.01	0.01
Cult. Work	0.09	0.04	0.01	0.05
Risk Pre. Serv.	0.01	0.01	0.01	0.02
Q1a	0.39	0.01	0.03	0.14
Q1b	0.33	0.04	0.14	0.17
Q1c	0.15	0.07	0.11	0.11
Q1d	0.3	0.07	0	0.12
Q1e	0.26	0	0	0.09
Q1f	0.38	0	0.03	0.14
Q1g	0.18	0.08	0	0.09
Q1h	0.23	0	0	0.08
Q1i	0.15	0.09	0.02	0.09
Q2a	0.75	0.57	0.11	0.48
Q2b	0.75	0.54	0.07	0.45
Q2c	0.72	0.44	0.07	0.41
Q2d	0.75	0.43	0.03	0.4
Q2e	0.77	0.54	0.06	0.46
Q2f	0.76	0.47	0.09	0.44
Q2g	0.75	0.51	0.05	0.44
Q2h	0.7	0.24	0.06	0.33
Q2i	0.71	0.43	0.1	0.41

Table 7. *Cont.*

Variables	Dimension			
	1	2	3	Mean
Q3a	0.78	0.48	0.04	0.43
Q3b	0.76	0.44	0.04	0.42
Q3c	0.74	0.42	0.03	0.4
Q3d	0.73	0.34	0.05	0.37
Q3e	0.77	0.45	0.03	0.42
Q3f	0.74	0.4	0.09	0.41
Q3g	0.75	0.43	0.03	0.4
Q3h	0.73	0.37	0.03	0.38
Q3i	0.74	0.45	0.04	0.41
Q4	0.3	0.07	0.08	0.15
Q5	0.31	0.23	0.14	0.23
Q6	0.31	0.16	0.16	0.21
Q7	0.32	0.18	0.21	0.24
Q8a	0.33	0.21	0.19	0.24
Q8b	0.34	0.14	0.19	0.22
Q9	0.32	0.24	0.25	0.27
Q10	0.32	0.16	0.22	0.23
Q11	0.32	0.15	0.19	0.22
Q12	0.38	0	0.2	0.19
Q13	0.39	0.04	0.24	0.22
Q14	0.41	0.18	0.3	0.3
Q15	0.41	0.14	0.27	0.27
Q16a	0.41	0.18	0.31	0.3
Q16b	0.4	0.14	0.29	0.28
Q17	0.42	0.31	0.33	0.35
Q18	0.4	0.1	0.27	0.25
Q19	0.41	0.16	0.3	0.29
Q20	0.35	0.16	0.21	0.24
Q21	0.36	0.27	0.32	0.32
Q22	0.36	0.28	0.38	0.34
Q23	0.35	0.2	0.33	0.29
Q24	0.37	0.28	0.42	0.36
Q25a	0.36	0.25	0.44	0.35
Q25b	0.36	0.21	0.37	0.31
Q26	0.37	0.25	0.42	0.35
Q27	0.35	0.17	0.27	0.26
Q28	0.37	0.23	0.33	0.31
Active total	26	13.54	9.07	16.21
% of variance	38.8	20.21	13.54	24.19

Abbreviations: Please see Table 3 and Table A1—Appendix A.

As can be observed, the leading variable in the explanatory variables ranking of the homogenizing model variance (the "average" column in Table 7) is Q2a (0.477), since it presents the highest discrimination, followed in order of descending explanation by the variables Q2e (0.456), Q2b (0.452), Q2f (0.440), and Q2g (0.438).

The highest discrimination rate in dimensions 1 and 2 is for the type of work (0.089 and 0.04, respectively) and in dimension 3 for the cultivation system (0.021).

Likewise, the multiple correspondence model performed allows one to identify the categories of each variable that most discriminate the objects, these being the most important. For this, the variables are quantified and represented graphically (Figure 4). In the Figure 4 (see video), the green spheres represent the individual categories and the red spheres represent the different questionnaire categories (being less frequent for the less-intense red). In the labels, one can read the codes for each category.

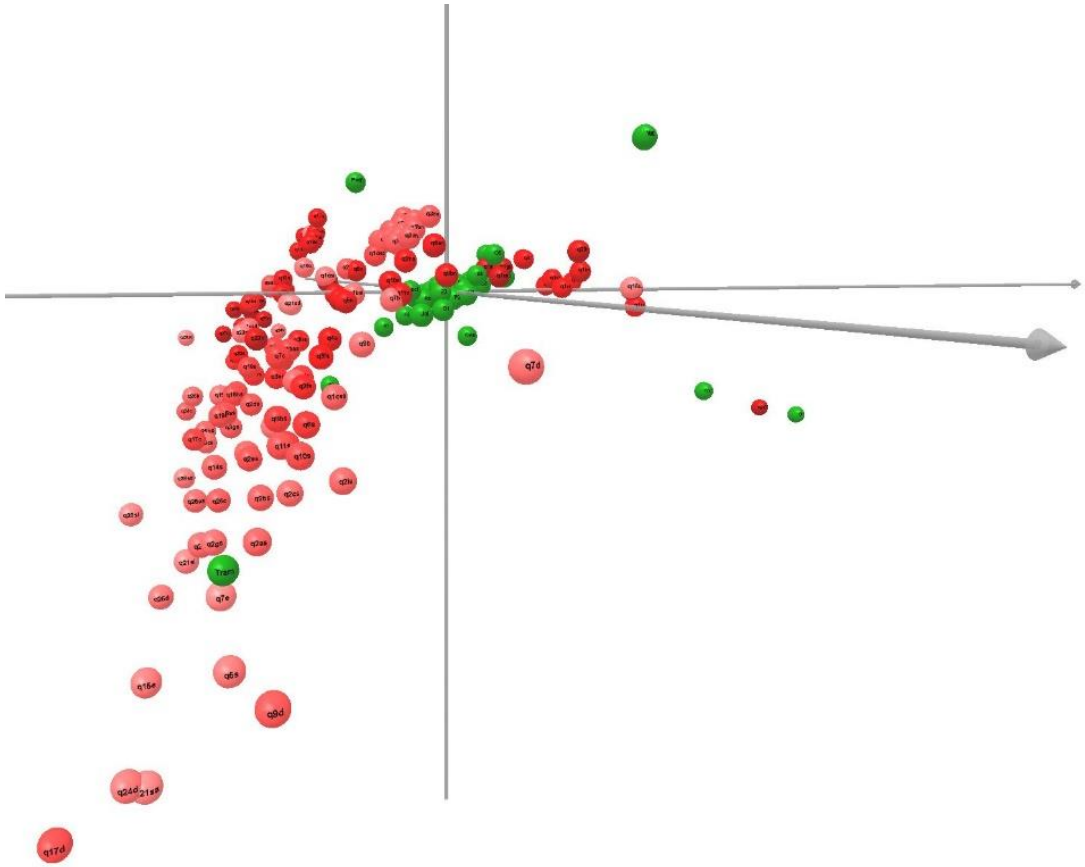

Figure 4. Relationship of all the variable categories with respect to the 3 dimensions (Please see: https://youtu.be/_MX7RO3TlfQ). Abbreviations: Please see Table 3 and Table A1—Appendix A.

In the Figure 5 (see video), the cubes have been used for the categories referring to the presence of ailments, and the cylinders for the individual's own categories. The colors differentiate the areas of the body to which the different categories refer: purple refers to the knees, cyan to the ankles/feet, light blue to the hands/wrists, yellow to the lower back, orange to the shoulders, pink to the upper back, red to the neck, dark blue to the elbows, and burgundy to the hips. Green continues to represent the individual's own categories. The categories can be read in the labels.

The three-dimensional model allows one to identify cases such as that of individuals with obesity grade II (W4) where there is a greater relationship with neck (from q12 to q19 and q1a) and shoulder ailments (q20 onwards and q1b).

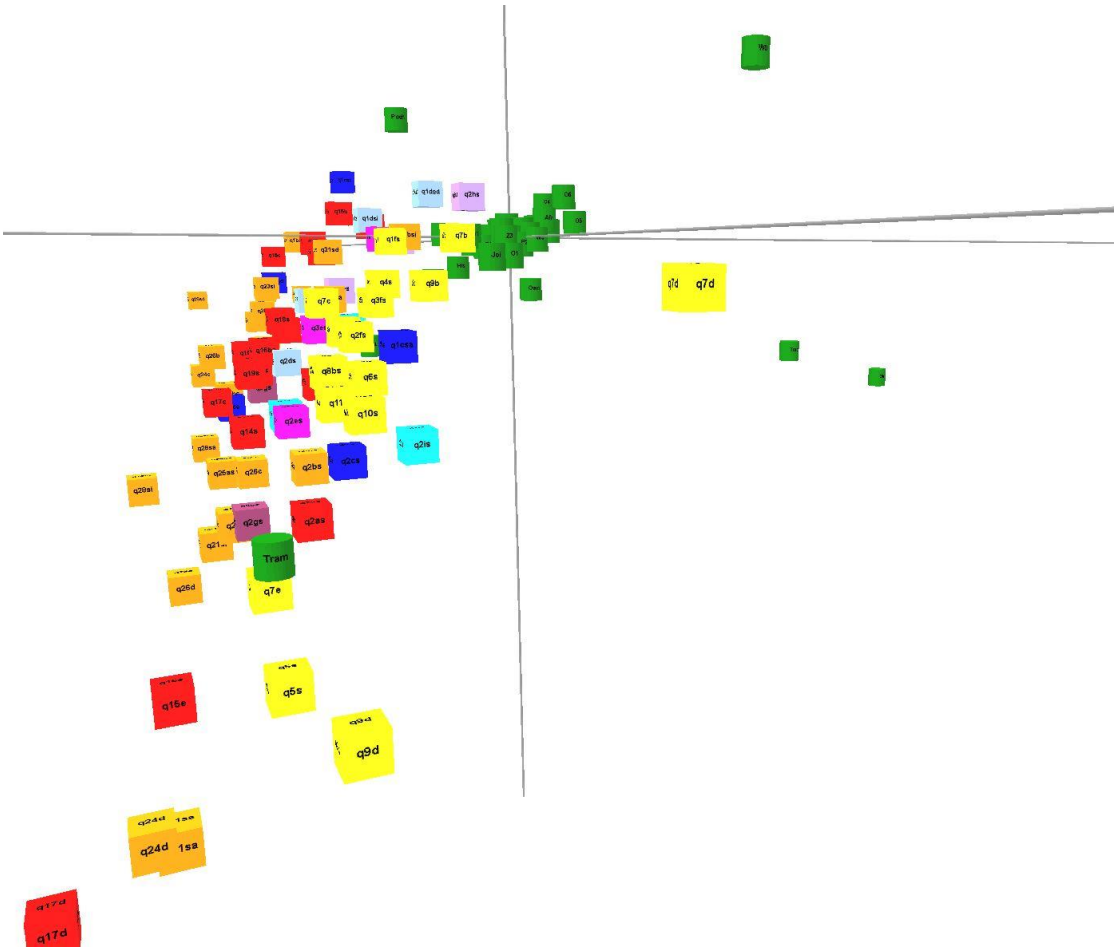

Figure 5. Relationship of all the categories differentiating ailments (shapes) and body areas (colors) without categories referring to the absence of ailments (Please see: https://youtu.be/AmHI6sHSzvE). Abbreviations: Please see Table 3 and Table A1—Appendix A.

Associations between Categories (ACM)

There are several strong associations between the variable categories that can be observed (Table 8; Figure 6):

Table 8. List of categories (associated with the presence of pain) and variables of the main cluster.

Relationship	Code	Zone (Color, Figure 5)	Frequency	Observation	Variables of the Individual
Very close	Q1as	Neck (red)	61.8 *	Pain, discomfort, or ill-being in the last 12 months in the neck.	F, ML
	Q1bsi	Left shoulder (orange)	8.1	Pain, discomfort, or ill-being in the last 12 months in the left shoulder.	T1/T2/T3
	Q1dsd	Wrists and hands (blue)	19.3	Pain, discomfort, or ill-being in the last 12 months in the wrist and/or right hand.	A1, A2, A3
	Q1dsi	Wrists and hands (blue)	7.4	Pain, discomfort, or ill-being in the last 12 months in the wrist and/or left hand.	P1, P2, P3

Table 8. *Cont.*

Relationship	Code	Zone (Color, Figure 5)	Frequency	Observation	Variables of the Individual
	Q1es	Upper back (pink)	52.6 *	Pain, discomfort, or ill-being in the last 12 months in the upper back.	W1, W2, W3
	Q1fs	Lower back (yellow)	58.9 *	Pain, discomfort, or ill-being in the last 12 months in the lower back.	S1/S2/S3
	Q1hs	Knees (purple)	53 *	Pain, discomfort, or ill-being in the last 12 months in the knees.	R0, R1
	Q2hs	Knees (purple)	43.8 *	Inability to work in the last 12 months due to knee problems.	O1, O2, O3, O5, O6
	Q21sd	Right shoulder (orange)	2	Accident, ever, in the right shoulder.	Afr, EurE, His, Spa
	Q7b	Lower back (yellow)	21.6 *	Pain, discomfort, or ill-being between 1 and 7 days in the last 12 months in the lower back.	Z1, Z2, Z3
Medium-Distance	Q1csi	Left elbow (dark blue)	4.5	Pain, discomfort, or ill-being in the last 12 months in the elbows.	Rec1, Rec2
	Q12s	Neck (red)	49.7	Pain, discomfort, or ill-being ever in the neck.	Joi, Out, Own
	Q15b	Neck (red)	27.4	Pain, discomfort, or ill-being between 1 and 7 days in the last 12 months in the neck.	
	Q17b	Neck (red)	17.3	Impossibility of working between 1 and 7 days in the last 12 months due to neck problems.	

* Only 6 questions exceed 20% in very close categories. Abbreviations: Please see Table 3 and Table A1—Appendix A.

From all of the above (Table 8 and Figure 6), and adopting the graphical criteria of proximity and frequency (more than 20%) between categories (Figure 5), six questions (categories) are highlighted from the questionnaire (Table A1—Appendix A) associated with practically all the categories of the olive grove and its environment (Table 3): q1as (61.80%), q1es (52.58%), q1fs (58.88%), q1hs (53.03%), q2hs (43.82%), and q7b (21.57%). It should be noted that the Male and Female categories are very close in the center of the graph and their relationship with the rest of the categories will be similar.

The questionnaire consists of four fundamental parts (general, specific lower back, specific neck, and specific shoulders). Five of the six questions belong to the general part and refer to the neck, upper back, lower back, knees, and the part of the body that makes it impossible to perform the tasks over the last twelve months (knees). All these categories are above 43%. q7b (21.57%) would be specific to the lower back and refers to how long one has had problems (1–7 days over the last 7 months).

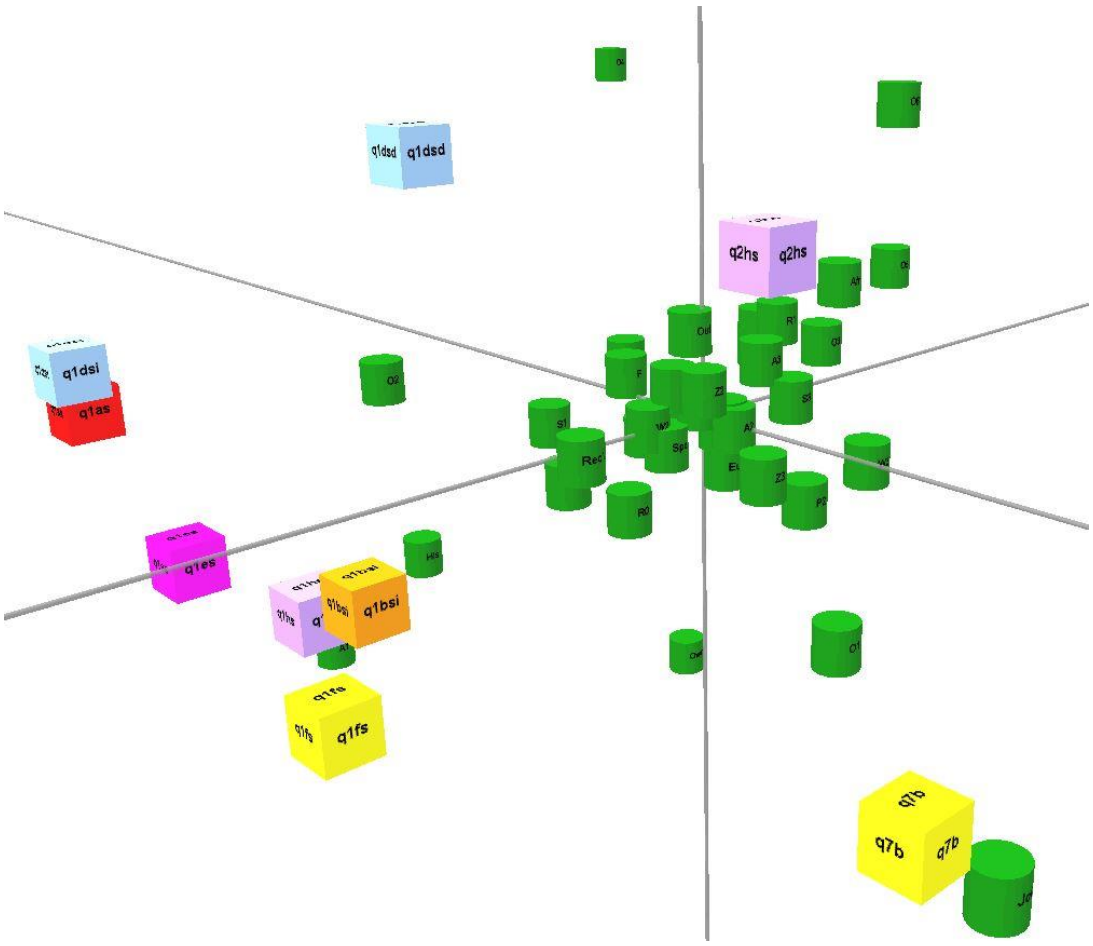

Figure 6. Main cluster of the individual variables with the categories referring to closest ailments (Please see: https://youtu.be/E_zsndLsO-U).

4. Discussion

The objective of evaluating the musculoskeletal risks of olive grove workers in Jaén (Spain) using NMQ [21] has been achieved.

Gender differences depend on numerous interrelated factors such as legislation, salaries, better management positions, types of risks, relationships, housework, childcare, etc. [54]. Our data show that the tasks are carried out mainly by men, that is, about one of every six people is a woman (17.30%). This data is similar to that found in other types of agricultural systems (greenhouse crops in SE Spain), where women in agricultural tasks represent 16.47% [51]. On the contrary, in the agri-food industry that handles/transforms the harvested product, 85% of the workers are women and 15% men [55], which casts doubt on the possible gender discrimination in this sector that they may apparently show in the results. Furthermore, since agriculture is a primary sector, this is not the case of discrimination based on salary or better managerial position. All workers, men and women, work in similar basic position tasks and receive the same salary. Perhaps, housework and childcare have an influence, but more because of sociocultural values than because of the labor and equality legislation of the European Union [56] also in force in Spain.

Overweight workers have an additional 3% of ailments compared to those who are not overweight, and 8.2% of woman are more overweight than men because women tend to be more sedentary that men, especially in the less favored social classes [57]. As already mentioned, sociocultural values could also influence [54,58] and moreso when in our study, 53.70% are immigrant workers. It is precisely the African workers followed by those from Eastern Europe who present the least ailments compared to

the rest. Perhaps, it is due to the fact that they are the youngest group of workers studied (both men and women).

The graphics (Figure 6) show that practically all categories regarding the olive grove and its environment are associated with musculoskeletal disorders of the neck, back, and knees. This coincides with other research that has studied the service, educational, industrial, and agricultural sectors [59], and with the descriptive statistical analysis where the differences found in the questions related to ailments "ever" or "during the last year" do not exceed 7% at most in both men and women. It seems significant that men have greater discomfort in the lumbar area and knees than women, a fact that coincides with previous studies [54], possibly due to the handling of heavier loads (e.g., olive boxes at harvesting).

In addition, the knees are the only part of the body for which the majority of workers (43.82%) have answered that they were incapacitated from carrying out their work in the last twelve months. This data is very significant. Even though the workers have problems in other parts of the body, it is only this part of the body which disables them to such an extent that they cannot carry out their tasks. Therefore, it seems logical that knee protection measures should be given special attention.

Agricultural work stands out for involving high physical load with many manual tasks [60]. In our case, this is evidenced by the reduced discomfort percentages in the more mechanized (intensive) olive systems compared to conventional, traditional ones. Various studies [61,62] are in accordance with these results. What happens is that the "sustainability" balance comes into question. In general, more mechanized cultivation systems (associated with intensive/super-intensive exploitations) will use more fossil fuels and synthetic phytosanitary products. Therefore, even if better occupational well-being is achieved, the "respect for the environment" decreases; nevertheless, sometimes greater mechanization does not have to lead to this decline. Progress could also be made towards sustainable mechanization that reduces the use of synthetic phytosanitary products and takes advantage of other emerging technologies (drones, robots, artificial intelligence, machine learning, big data, infrared sensors, and deep learning, etc.) [63–74], thus helping to maintain the desired balance. A curious and promising piece of data is the feeling of there being fewer ailments in organic olive groves (1.56%) compared to the traditional olive grove, with and without slopes.

As found in other studies carried out in Andalusia [51], despite the ailments manifested by workers (88.76%), they continue to carry out their tasks. This fact indicates that the perception of risks and ailments varies depending on the individual and all the variables in his/her environment [75].

Again, these facts demonstrate the absence of a pain scale in the Standardized Nordic Questionnaire, which may overestimate workers' musculoskeletal disorder symptoms. Perhaps the solution is to be able to assess the severity and intensity of musculoskeletal disorders; however, the NMQ poses questions such as "Has he/she been unable to carry out his/her usual work?" or "Has he/she ever been hospitalized?", among others, which attempt to reduce this deficiency.

A limitation of the study is that on average for questions Q4, Q12, and Q20, 84 respondents contradicted each other in their answers, representing 19% of the total number of respondents. This may be due to different factors:

- The way to ask questions.
- The respondent's lack of understanding.
- Tiredness of the respondent due to an overly long questionnaire design, and with the question regarding "ailments in the last twelve months" coming first.

As a recommendation to improve the state of the knees, the best thing would be to strengthen the hamstring, calf, anterior tibial and, above all, the quadriceps muscles (rectus femoris, medial vastus, vastus lateralis, and vastus intermedius), as well as weight loss in overweight workers and physical therapy in the most severe cases [76]. An exercise table supplied to workers would be a good option. Furthermore, this exercise table could be complemented with other exercises that strengthen neck and back muscles (both upper and lower; [77]).

Also, some of the measures that aim to reduce musculoskeletal disorders include (1) mechanization of certain activities [78], although not always effective, some studies concluded that there is a lower level of risk thanks to this measure [28]. (2) Alternating tasks and rotating between them: for example, in the harvesting task, where it is possible to alternate between collecting and sorting the product. One can also take work shifts, so that workers can alternate [78]. (3) Designing and using new tools [78,79], (4) taking breaks from time to time in an area close to the workplace [78], (5) ergonomic training for agricultural workers [78], and (6) using exoskeletons that avoid harmful postures being adopted and reduce physical effort [80].

Finally, Spain presents legislation on the occupational risk prevention [50] adapted to European Union legislation, which guarantees workers all their labor rights, regardless of the country they are from. However, it does seem logical that said legislation be updated, especially in relation to the agricultural sector [81].

5. Conclusions

Of the workers, 88.76% had manifested some type of ailment; nonetheless, they have continued to carry out their work. All of these ailments were mainly related to the neck, back, and knees.

A decrease in manual agricultural work resulting from changes in the olive cultivation systems (from traditional, conventional systems, to intensive ones) using machinery supported by emerging technologies can decrease the incidence of musculoskeletal disorders in workers without impinging on the sustainable production balance.

Supplementary Materials: The following are available online at http://www.mdpi.com/2077-0472/10/11/511/s1, Table S1: Burt table.

Author Contributions: Conceptualization, M.B.-A., M.D.-P., M.G.-G., J.P.-A. and Á.-J.C.-F.; methodology, M.B.-A., M.D.-P., M.G.-G., J.P.-A. and Á.-J.C.-F.; software, M.B.-A., M.D.-P., M.G.-G., J.P.-A. and Á.-J.C.-F.; validation, M.B.-A., M.D.-P., M.G.-G., J.P.-A. and Á.-J.C.-F.; formal analysis, M.B.-A., M.D.-P., M.G.-G., J.P.-A. and Á.-J.C.-F.; investigation, M.B.-A., M.D.-P., M.G.-G., J.P.-A. and Á.-J.C.-F.; resources, M.B.-A., M.D.-P., M.G.-G., J.P.-A. and Á.-J.C.-F.; data curation, M.B.-A., M.D.-P., M.G.-G., J.P.-A. and Á.-J.C.-F.; writing—original draft preparation, M.B.-A., M.D.-P., M.G.-G., J.P.-A. and Á.-J.C.-F.; writing—review and editing, M.B.-A., M.D.-P., M.G.-G., J.P.-A. and Á.-J.C.-F.; visualization, M.B.-A., M.D.-P., M.G.-G., J.P.-A. and Á.-J.C.-F.; supervision, M.B.-A., M.D.-P., M.G.-G., J.P.-A. and Á.-J.C.-F.; project administration, M.B.-A., M.D.-P., M.G.-G., J.P.-A. and Á.-J.C.-F.; funding acquisition: Á.-J.C.-F. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Qualitative variables of the questionnaire [21].

Variable								
1. Have you at any time during the last 12 months had trouble (ache, pain, discomfort) in:			**2. Have you at any time during the last 12 months been prevented from doing your normal work (at home or away from home) because of the trouble?**			**3. Have you had trouble at any time during the last 7 days?**		
Sub-variable	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**
(a) Neck	No	**q1an**	(a) Neck	No	**q2an**	(a) Neck	No	**q3an**
	Yes	**q1as**		Yes	**q2as**		Yes	**q3as**
(b) Shoulders	No	**q1bn**		No to everything in first Question	**q2aN1**		No to everything in first Question	**q3aN1**
	Yes, in the right Shoulder	**q1bsd**	(b) Shoulders	No	**q2bn**	(b) Shoulders	No	**q3bn**
	Yes, in the left Shoulder	**q1bsi**		Yes	**q2bs**		Yes	**q3bs**
	Yes, in both Shoulders	**q1bsa**		No to everything in first Question	**q2bN1**		No to everything in first Question	**q3bN1**
(c) Elbows	No	**q1cn**	(c) Elbows	No	**q2cn**	(c) Elbows	No	**q3cn**
	Yes, in the right Elbow	**q1csd**		Yes	**q2cs**		Yes	**q3cs**
	Yes, in the left Elbow	**q1csi**		No to everything in first Question	**q2cN1**		No to everything in first Question	**q3cN1**
	Yes, in both Elbows	**q1csa**	(d)Wrists/hands	No	**q2dn**	(d) Wrists/hands	No	**q3dn**
(d) Wrists/hands	No	**q1dn**		Yes	**q2ds**		Yes	**q3ds**
	Yes, in the right Wrist/hand	**q1dsd**		No to everything in first Question	**q2dN1**		No to everything in first Question	**q3dN1**
	Yes, in the left Wrist/hand	**q1dsi**	(e) Upper back	No	**q2en**	(e) Upper back	No	**q3en**

Table A1. *Cont.*

	Yes, in both Wrists/hands	**q1dsa**		Yes	**q2es**		Yes	**q3es**
(e) Upper back	No	**q1en**		No to everything in first Question	**q2eN1**		No to everything in first Question	**q3eN1**
	Yes	**q1es**	(f) Low back (small of the back)	No	**q2fn**	(f) Low back (small of the back)	No	**q3fn**
(f) Low back (small of the back)	No	**q1fn**		Yes	**q2fs**		Yes	**q3fs**
	Yes	**q1fs**		No to everything in first Question	**q2fN1**		No to everything in first Question	**q3fN1**
(g) One or both hips/thighs	No	**q1gn**	(g) One or both hips/thighs	No	**q2gn**	(g) One or both hips/thighs	No	**q3gn**
	Yes	**q1gs**		Yes	**q2gs**		Yes	**q3gs**
(h) One or both knees	No	**q1hn**		No to everything in first Question	**q2gN1**		No to everything in first Question	**q3gN1**
	Yes	**q1hs**	(h) One or both knees	No	**q2hn**	(h) One or both knees	No	**q3hn**
(i) One or both ankles/feet	No	**q1in**		Yes	**q2hs**		Yes	**q3hs**
	Yes	**q1is**		No to everything in first Question	**q2hN1**		No to everything in first Question	**q3hN1**

Table A1. *Cont.*

You should only answer the following questions, 2 and 3, if you have had problems in any area (if a worker answers all the questions in the first question negatively, check this box □ and do not answer questions 2 and 3)—Codes: (q2aN1, q2bN1, q2cN1, q2dN1, q2eN1, q2fN1, q2gN1, q2hN1, q2iN1) and (q3aN1, q3bN1, q3cN1, q3dN1, q3eN1, q3fN1, q3gN1, q3hN1, q3iN1).	(i) One or both ankles/feet	No	**q2in**	(i) One or both ankles/feet	No	**q3in**
		Yes	**q2is**		Yes	**q3is**
		No to everything in first Question	**q2iN1**		No to everything in first Question	**q3iN1**

LOW BACK

Variable

4. Have you ever had low-back trouble (ache, pain, or discomfort)?			**5. Have you ever been hospitalized because of low-back trouble?**			**6. Have you ever had to change jobs or duties because of low-back trouble?**			**7. What is the total length of time that you have had low-back trouble during the last 12 months?**		
Sub-variable	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**
-	No	**q4n**	-	No	**q5n**	-	No	**q6n**	-	0 days	**q7a**
-	Yes	**q4s**	-	Yes	**q5s**	-	Yes	**q6s**	-	1–7 days	**q7b**
If you answered NO in question number 4, you should not answer the following questions 5, 6, 7, 8, 9, 10, and 11 (if a worker answers question 4 negatively, he should check this box □ and not answer questions 5, 6, 7, 8, 9, 10, and 11). Codes: (q5N4, q6N4, q7N4, q8N4, q9N4, q10N4, q11N4).			-	No to fourth Question	**q5N4**	-	No to fourth Question	**q6N4**	-	8–30 days	**q7c**
									-	More than 30 days, but not every day	**q7d**
									-	Every day	**q7e**
									-	No to fourth Question	**q7N4**
									If you answered 0 days in question number 7, you should not answer the following questions 8, 9, 10, and 11 (if a worker answers zero days to question 7, he should check this box □ and not answer questions 8, 9, 10, and 11). Codes: (q8N7, q9N7, q10N7, q11N7).		

Table A1. *Cont.*

Variable											
8. Has low-back trouble caused you to reduce your activity during the last 12 months?			**9. What is the total length of time that low-back trouble has prevented you from doing your normal work (at home or away from home) during the last 12 months?**			**10. Have you been seen by a doctor, physiotherapist, chiropractor or other such person because of low-back trouble during the last 12 months?**			**11. Have you had low back trouble at any time during the last 7 days?**		
Sub-variable	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**
(a) Work activity (at home or away from home)?	No	**q8an**	-	0 days	**q9a**	-	No	**q10n**	-	No	**q11n**
	Yes	**q8as**	-	1–7 days	**q9b**	-	Yes	**q10s**	-	Yes	**q11s**
	No to fourth Question	**q8aN4**	-	8–30 days	**q9c**	-	No to fourth Question	**q10N4**	-	No to fourth Question	**q11N4**
	No to seventh Question	**q8aN7**	-	More than 30 days	**q9d**	-	No to seventh Question	**q10N7**	-	No to seventh Question	**q11N7**
(b) Leisure activity?	No	**q8bn**	-	No to fourth Question	**q9N4**						
	Yes	**q8bs**	-	No to seventh Question	**q9N7**						
	No to fourth Question	**q8bN4**									
	No to seventh Question	**q8bN7**									

Table A1. *Cont.*

NECK											
Variable											
12. Have you ever had neck trouble (ache, pain, or discomfort)?			**13. Have you ever hurt your neck in an accident?**			**14. Have you ever had to change jobs or duties because of neck trouble?**			**15. What is the total length of time that you have had neck trouble during the last 12 months?**		
Sub-variable	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**
-	No	**q12n**	-	No	**q13n**	-	No	**q14n**	-	0 days	**q15a**
-	Yes	**q12s**	-	Yes	**q13s**	-	Yes	**q14s**	-	1–7 days	**q15b**
If you answered NO in question number 12, you should not answer the following questions 13, 14, 15, 16, 17, 18, and 19 (if a worker answers question 12 negatively, he should check this box ☐ and not answer questions 13, 14, 15, 16, 17, 18, and 19). Codes: (q13N12, q14N12, q15N12, q16N12, q17N12, q18N12, q19N12).			-	No to twelfth Question	**q13N12**	-	No to twelfth Question	**q14N12**	-	8–30 days	**q15c**
									-	More than 30 days, but not every day	**q15d**
									-	Every day	**q15e**
									-	No to twelfth Question	**q15N12**
									If you answered 0 days in question number 15, you should not answer the following questions 16, 17, 18, and 19(if a worker answer zero days to question 15 he should check this box ☐ and not answer questions 16, 17, 18, and 19). Codes: (q16aN15, q17aN15, q18aN15, q19aN15).		

Table A1. *Cont.*

Variable											
16. Has neck trouble caused you to reduce your activity during the last 12 months?			**17. What is the total length of time that neck trouble has prevented you from doing your normal work (at home or away from home) during the last 12 months?**			**18. Have you been seen by a doctor, physiotherapist, chiropractor or other such person because of neck trouble during the last 12 months?**			**19. Have you had neck trouble at any time during the last 7 days?**		
Sub-variable	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**
(a) Work activity (at home or away from home)?	No	**q16an**	-	0 days	**q17a**	-	No	**q18n**	-	No	**q19n**
	Yes	**q16as**	-	1–7 days	**q17b**	-	Yes	**q18s**	-	Yes	**q19s**
	No to twelfth Question	**q16aN12**	-	8–30 days	**q17c**	-	No to twelfth Question	**q18N12**	-	No to twelfth Question	**q19N12**
	No to fifteenth Question	**q16aN15**	-	More than 30 days	**q17d**	-	No to fifteenth Question	**q18N15**	-	No to fifteenth Question	**q19N15**
(b) Leisure activity?	No	**q16bn**	-	No to twelfth Question	**q17N12**						
	Yes	**q16bs**	-	No to fifteenth Question	**q17N15**						
	No to twelfth Question	**q16bN12**									
	No to fifteenth Question	**q16bN15**									

Table A1. *Cont.*

SHOULDERS											
Variable											
20. Have you ever had shoulder trouble (ache, pain, or discomfort)?			**21. Have you ever hurt your shoulder in an accident?**			**22. Have you ever had to change jobs or duties because of shoulder trouble?**			23. Have you had shoulder trouble during the last 12 months?		
Sub-variable	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**
-	No	**q20n**	-	No	**q21n**	-	No	**q22n**	-	No	q23n
-	Yes	**q20s**	-	Yes, in the right Shoulder	**q21sd**	-	Yes	**q22s**	-	Yes, in the right Shoulder	q23sd
If you answered NO in question number 20, you should not answer the following questions 21, 22, 23, 24, 25, 26, 27, and 28 (if a worker answers question 20 negatively, he should check this box ☐ and not answer questions 21, 22, 23, 24, 25, 26, 27, and 28). Codes: (q21N20, q22N20, q23N20, q24N20, q25N20, q26N20, q27N20, q28N20).			-	Yes, in the left Shoulder	**q21si**	-	No to 20th Question	**q22N20**	-	Yes, in the left Shoulder	q23si
			-	Yes, in both Shoulders	**q21sa**				-	Yes, in both Shoulders	q23sa
			-	No to 20th Question	**q21N20**				-	No to 20th Question	q23N20
									If you answered NO in question number 23, you should not answer the following questions 24, 25, 26, 27, and 28 (if a worker answers question 23 negatively, he should check this box ☐ and not answer questions 24, 25, 26, 27, and 28). Codes: (q24N23, q25N23, q26N23, q27N23, q28N23).		

Table A1. *Cont.*

Variable											
24. What is the total length of time that you have had shoulder trouble during the last 12 months?			**25. Has shoulder trouble caused you to reduce your activity during the last 12 months?**			**26. What is the total length of time that shoulder trouble has prevented you from doing your normal work (at home or away from home) during the las 12 months?**			**27. Have you been seen by doctor, physiotherapist, chiropractor or other suck person because of shoulder trouble during the last 12 months?**		
Sub-variable	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**	**Sub-variable**	**Categories**	**Coding**
-	1–7 days	**q24a**	(a) Work activity (at home or away from home)?	No	**q25an**	-	0 days	**q26a**	-	No	**q27n**
-	8–30 days	**q24b**		Yes	**q25as**	-	1–7 days	**q26b**	-	Yes	**q27s**
-	More than 30 days, but not every day	**q24c**		No to 20th Question	**q25aN20**	-	8–30 days	**q26c**	-	No to 20th Question	**q27N20**
-	Every day	**q24d**		No to 23rd Question	**q25aN23**	-	More than 30 days	**q26d**	-	No to 23rd Question	**q27N23**
-	No to 20th Question	**q24N20**	(b) Leisure activity?	No	**q25bn**	-	No to 20th Question	**q26N20**			
-	No to 23rd Question	**q24N23**		Yes	**q25bs**	-	No to 23rd Question	**q26N23**			
				No to 20th Question	**q25bN20**						
				No to 23rd Question	**q25bN23**						

Table A1. *Cont.*

Variable		
28. Have you had shoulder trouble at any time during the last 7 days?		
Sub-variable	**Categories**	**Coding**
-	No	**q28n**
-	Yes, in the right Shoulder	**q28sd**
-	Yes, in the left Shoulder	**q28si**
-	Yes, in both Shoulders	**q28sa**
-	No to 20th Question	**q28N20**
-	No to 23rd Question	**q28N23**

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