Musculoskeletal disorders of agricultural workers in the greenhouses of Almería (Southeast Spain)

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A B S T R A C T

In southeast Spain (Almería), we find the highest concentration of greenhouse crops in Europe, an agricultural sector that directly employs 55,000 people. The objective of this research was to evaluate the musculoskeletal working conditions of greenhouse workers through the standardized Nordic questionnaire. This questionnaire presents 28 multiple choice questions referring to different parts of the body. A total of 1002 questionnaires were completed, and information was collected on nine socio-demographic variables for each worker: sex, age, height, weight, surface area, cultivation, staking, greenhouse and nationality. Although the results show a high overall rate of symptoms of musculoskeletal disorders (MSDs), these findings do not mean that the workers are unable to perform agricultural tasks.

1. Introduction

1.1. Definition and standards

According to the World Health Organization (WHO), MSDs are health problems associated with the locomotion apparatus, i.e., muscles, tendons, bony skeleton, cartilage, ligaments, and nerves. MSDs cover all types of complaints, from slight and passing discomfort to irreversible and incapacitating injuries (WHO, 2004).

The Occupational Safety and Health Administration (OSHA), in its programme against MSDs, makes a similar definition and states that they can be caused by sudden or sustained exposure to repetitive movements, force, vibration and awkward positions (NIOSH, 2017).

The European Agency for Safety & Health at Work (EU-OSHA) indicates that musculoskeletal disorders (MSDs) usually affect the back, neck, shoulders and upper extremities, although they can also affect the lower extremities. MSDs comprise any damage or disorder of the joints and other tissues. The musculoskeletal health problems range from small discomforts and pain to more serious medical conditions that force workers to request sick leave and even to receive medical treat-ment. In more chronic cases, they can result in disability and the need to stop working (EU-OSHA, 2017).

According to the EU-OSHA European Agency for Safety & Health at Work, MSDs are one of the most common occupational diseases, affecting millions of workers across Europe and costing entrepreneurs billions of euros (EU-OSHA, 2017). In Europe, almost one in four workers (23%) believe that their work represents a risk to their health (Eurofound, 2015).

Among the industries and groups with the greatest risk, the fol-lowing stand out: agriculture, forestry and fishing (EU-OSHA, 2017).

1.2. Physical risk in agriculture

Although the share of the agricultural sector in world employment is declining, the sector continues to be an important source of employment, particularly in developing countries (ILO, 2017). Almost one-third of the global labour sector, more than one billion people, are employed in this sector (ILO, 2015).

In agriculture, a considerable amount of labour is physical, mainly due to the manual nature of many of the crops' work (Van der Schilden, 1989). High physical demands coupled with poor postures at work are the cause of MSDs (Van Wely, 1970; Kivi and Mattila, 1991). Protected vegetables, fruits and strawberries, among others, are a clear example of this type of work in Andalusia (southeast of Spain).

In Europe, about 20% of all work related accidents in 2014 are linked to the agriculture, forestry and fishing sector (Eurostat, 2016).

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However, the Ministry of Labour and Social Security (MLSS) in Spain reported a ratio of 6% for this activity group in 2016 (MLSS, 2016), but 48% of all workers of this group informed that they're exposed to painful positions and 67% of them have to perform repetitive movements for long periods of time (INSHT, 2011).

Agricultural workers face numerous occupational risk factors that expose them to musculoskeletal disorders, pesticides and other agrochemicals (ILO, 2017). Stretching when harvesting the fruit, leaning during sowing to remove weeds, collecting products from shorter plants, lifting and transporting heavy loads, operating machines, driving long distances and performing jobs that require pulling or pushing, among others, are tasks that can almost always cause MSDs in diverse field workers (European Commission, 2015). Numerous studies worldwide have analysed and confirmed the presence of musculoskeletal injuries associated with the agricultural sector and have also investigated their risk factors (López-Aragón et al., 2017). Some of those studies conclude that there is a need for mechanized work and ergonomic measures (Palmer, 1996; Rai et al., 2012) in order to prevent the common shoulder and back pain (Henry et al., 2015) usually related to stress and duration of work (Keawduangdee et al., 2015).

Almería (southeast Spain) concentrates the largest area of greenhouses in Europe, with the production of fruits and vegetables (tomato, pepper, eggplant, cucumber, zucchini, melon, watermelon and beans) valued at more than 2500 million euros and providing direct work to some 55,000 workers of different nationalities/cultures (Cajamar-Caja Rural, 2017); however, specific macro-studies on MSDs have not been conducted in this peculiar sector.

Overall, 90% of the work spaces (Almería-type greenhouses) are low cost (Callejón-Ferre et al., 2009), and thanks to the climate of the region, it is not necessary to control the environmental parameters (López-Martínez et al., 2018). In addition, there is no high me-chanization of crops (Callejón-Ferre et al., 2015), which implies that most of the agricultural work is manual. These facts have an impact on the health of the workers that is directly associated with the cultivation system because the production of food is related not only to its quality (Organic agriculture) but also to the way it is obtained (Lotter, 2003).

1.3. Relationship with other risks

According to a report of the World Health Organization (WHO, 2017), a work-related illness is any illness contracted, accelerated or aggravated by exposure to risk factors arising from work activity. Multiple factors are described and are classified as physical, chemical, biological, ergonomic, psychosocial or mechanical stress factors.

Likewise, The Japan Organization of Occupational Health and Safety establishes that the risk factors associated with occupational diseases include the organizational structure, working hours, labour density, handling of heavy materials, repetitive actions, discouraged postures, work stress, chemical products and other physical factors (JNIOSH, 2001). These factors are also indicated by the Finnish In-stitute of Occupational Health and the Occupational Safety and Health Administration. Recent data link musculoskeletal disorders with psychosocial risk factors (especially in combination with physical risks), which include a high level of work demand or low autonomy and poor job satisfaction (FIOH, 2017; EU-OSHA, 2017). Disorders or pain in differtent parts of the body like neck (Cote et al., 2008), back (Hoogendoorn et al., 2000) or shoulders, inter alia (Bongers et al., 2002), are the result of a combination of physical and psychosocial risk factors.

In agriculture, this relation has been confirmed through analysis of psychosocial factors and usual tasks performed by farmers (Bernard et al., 2009, 2011) and is mandatory to consider psychosocial factors crucial elements in order to reduce MSDs among them (Fathallah, 2010).

1.4. Occupational health and safety (OHS)

Under Article 153 of the Treaty on the Functioning of the European Union, a wide variety of Community measures are adopted in the field of occupational safety and health. These European directives are legally binding and have been transposed into the national legislations of the Member States. In Spain, the OHS is managed by Law 19/1995 (BOE, 1995).

Safety and health in agriculture is not covered by a specific EU directive but various EU directives do address certain safety and health issues in the sector. The 'Framework Directive' 89/391/EEC (OJEU, 1989) sets out the risk assessment process and the general principles of risk prevention.

OHS is an extensive multidisciplinary field. International labour standards are designed to achieve a vital objective: work must be performed in a safe and healthy environment (Alli, 2008).

In turn, the OHS, the physical, mental and social well-being of the workers, along with the safety of the environment, are essential requirements for the viable management of farms (European Commission, 2015). Guaranteeing the welfare of workers, and therefore respecting their labour rights, is directly related to the sustainability of a company or product, contributing to their productivity (Zink, 2014).

1.5. Objective

The absence of data on musculoskeletal risks of workers inside greenhouses justifies this study. This research aims to demonstrate which crops and their tasks cause the most musculoskeletal problems for greenhouse workers. For this purpose, the Standardized Nordic Questionnaire (Kuorinka et al., 1987) is used.

2. Materials and methods

2.1. Study area

Spain has 29.37% of the wintering area of the Mediterranean basin (Pardosi et al., 2004), 70% of it concentrated in the Southeast of the Iberian Peninsula. The province of Almería has the highest concentration of greenhouses (62% of 70%), with 29,814 ha (SIGPAC, 2016, Fig. 1):

Regulation CE 1107/2009 of October 2009 on the commercializa-tion of phytosanitary products, repealing Council Directives 79/117/EEC and 91/414/EEC (OJEU, 2009), defines a greenhouse (Fig. 1) as a '…static and closed place intended for the production of crops and usually endowed with a translucent outer cover that allows a controlled exchange of material and energy with the environment…'.

2.2. Characteristics of the workers

The number of workers in the greenhouses of the province of Almeria amounts to approximately 55,000 (Cajamar-Caja Rural, 2017). Labour is divided into three types: family, fixed and seasonal. The majority of the workforce is immigrant (64%), and the costs range between 40% and 60% of the total cost of the crop (Céspedes-López et al., 2009).

The Spanish state, through agricultural entrepreneurs, guarantees employees the same rights as any other worker in the European Union (BOE, 1995).

2.3. Assessment method

2.3.1. Method selection

Gómez-Galán et al. (2017) classify the evaluation methods into three groups: direct, semi-direct and indirect. The direct methods methods are very precise but very expensive, with the evaluation being completely computerized. The semi-direct methods require a first data

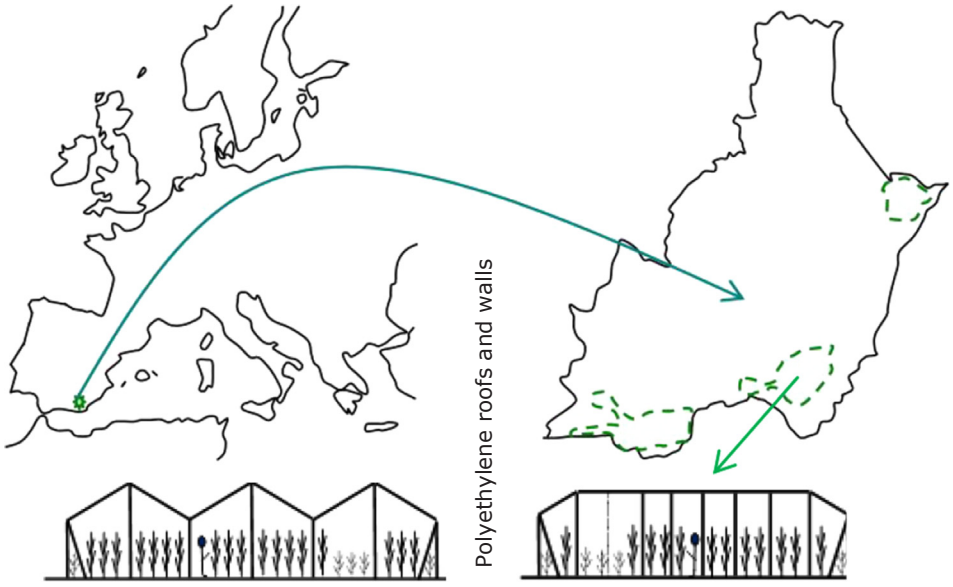

Fig. 1. The location of Almería-type greenhouses (Callejón-Ferre et al., 2015).

collection and subsequent image analysis (software license cost); its cost is not excessively high. The indirect methods are based on questionnaires, they do not require image analysis, and they are very economical, but when studying large populations, they usually require a more or less complex statistical analysis.

In the present investigation, direct methods have been ruled out due to lack of funding. A decision matrix has been prepared (Table 1) in which semi-direct and indirect methods are included. In this matrix, 5 criteria have been considered (with a score of 1 to 4 points each), along with 12 methods. Those methods that are free and fast in their application will be valued more in the scoring criterion.

We conclude by using (Table 1) the '*Standardized Nordic questionnaires for the analysis of musculoskeletal symptoms (NMQ)*' (Kuorinka et al., 1987), an indirect method with standardized evaluation ques-tions that allows analysing and detecting the musculoskeletal symptoms of different individuals in different economic sectors and in different places on the planet (López-Aragón et al., 2017).

This questionnaire includes 28 multiple-choice questions on the neck, shoulders, elbows, wrists/hands, back, hips, knees and ankles (Appendix A). Along with the variables of the method (i.e., answers to the respondents' questions) other qualitative variables were compiled for each worker and the farm where he or she works: sex, age, height, weight, nationality, covered area, crop, type of staking and type of greenhouse.

2.3.2. Sample size and data acquisition

The workers in the greenhouses of the province of Almería amount to approximately 55,000 (Cajamar-Caja Rural, 2017); therefore, the size of the sample (Cochran, 1977, Hedayat and Sinha, 1991) proposed has been:

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

where:

- N = Total of the population
- Z_a = 1.962 at the 95% confidence level (95%CL), 1.645 at the 90%CL, 2.24 at the 97.5% CL, and 2.576 for the 99% CL
- p = the expected frequency; when this is unknown a value of 0.5 (50%) is used, maximizing the sample size.
- q = 1 − p
- d = accuracy or admitted error.

So, considering d = 2.5%, 95% confidence level and p = 0.5:

$$n = \frac{55000 \cdot 1.962^2 \cdot 0.5 \cdot 0.5}{0.025^2 \cdot (55000-1) + 1.962^2 \cdot 0.5 \cdot 0.5} = 1524.81$$

However, because the response rate was 65.71%, 1002 questionnaires were administered. In this way, the final error (d) was 3.07%.

Table 1
Decision matrix for selecting the method.

Method	Speed of application	Variables studied	Applicability in agriculture	Statistical reliability and ease	License costs	Total
RULA (Rapid Upper Limb Assessment; McAtamney y Corlett, 1993)	2	3	3	2	3	13
IBV (García et al., 1997)	1	3	3	3	2	12
OCRA (Colombini, 1998)	1	4	3	3	2	13
PLIBEL (Kemmlert, 1995)	2	3	3	2	3	13
REBA (Hignett y McAtamney, 2000)	2	3	3	2	3	13
OWAS (Karhu et al., 1977)	2	3	3	3	3	14
Corlett (Corlett et al., 1979)	2	3	3	2	3	13
VIRA (Kilbom et al., 1986)	2	2	2	2	3	11
INSHT (INSHT, 1998)	2	2	3	2	4	13
NIOSH equation (NIOSH, 1981)	2	2	3	2	3	12
Liberty Mutual Tables (Liberty-Mutual, 2011)	2	1	3	2	3	11
Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms (NMQ) (Kuorinka et al., 1987)	4	2	3	2	4	15

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Table 2
Qualitative variables collected for each worker.

Variable	Categories	Abbreviation	Variable	Categories	Abbreviation
Sex	Male	ML	Nationality	African	Afr
	Female	F		Asian	Asi
Age	< 25 years old	T1		Spanish	Spa
	25–40 years old	T2		Eastern Europe	EurE
	> 40 years old	T3		Hispanic American	His
Height	< 1.60 m	A1	Stringing/wiring/Staking	'Espaldera'	Esp
	1.60–1.70 m	A2		'Percha alta'	Pea
	> 1.70 m	A3		'Percha baja'	Peb
Weight	< 70 kg	P1		'Tradicional'	Tra
	70–80 kg	P2		'Vertical'	Vert
	> 80 kg	P3	Greenhouse	'Plano'	Pla
Area	< 2 ha	S1		'Multitúnel'	Mul
	2–5 ha	S2		'Raspa y amagado'	RyA
	> 5 ha	S3			
Crop	Eggplant	Eggp			
	Courgette	Cou			
	Bean	Bean			
	Cucumber	Cu			
	Pepper	Pepp			
	Tomato	Tom			

The data acquisition phase was conducted in a randomized, non-stratified manner throughout the province of Almería (Fig. 1) from September 1 to December 30, 2016. Occasionally, surveys were administered to workers in the same greenhouse, though no more than 4 to avoid costly wastes of time for entrepreneurs. The anonymity of the respondents was always maintained, with the permission of the bioethics commission of the University of Almería.

All completed questionnaires were exported to Excel for coding and statistical treatment.

2.3.3. Nomenclature

A coding of the qualitative variables of the workers (Table 2) and the responses to the questionnaire (Appendix A) was prepared for the subsequent statistical treatment of the results.

2.3.4. Data analysis

A multiple-correspondence analysis (MCA), Burt table (Appendix B) and descriptive statistics were performed using SPSS and XLSTAT.

The MCA aims to relate the 33 individual categories and type of exploitation (9 variables) with each of the 195 questionnaire categories (28 variables). The result was 6435 possible relationships (Appendix B). Likewise, the number of data processed was 228,456 as a result of multiplying the total number of categories (195 + 33 = 228) by the total number of questionnaires (1002).

2.3.5. Agricultural tasks in the greenhouse

On greenhouse farms, different types of tasks are performed depending on the crop being worked; therefore, different types of risk are associated (Table 3).

Camacho-Ferre et al. (2003) describe the different agricultural tasks for the most common crops in the province of Almería.

3. Results

3.1. Sample description

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

According to the frequencies of the different categories, the individual 'mode' for all crops would be man ('ML') of Spanish origin ('Spa'), over 40 years old ('T3'), taller than 1.70 m ('A3'), weight over 80 kg ('P3'), working a tomato crop ('Tom') on farms with areas of less than 2 ha ('S1') with greenhouses of the multi-chapel type (raspa y amagado) ('Rya'), where the staking system is traditional ('Tra') (al-though in tomato, the most common was the high perch).

Fig. 2 shows the data for ailments, with colours associated with the incidence with which each ailment occurs and depending on the characteristics of each individual. The section 'Ever (Q4, Q12, Q20)' shows the data collected from questions Q4 'Have you ever had problems in the lower back (discomfort or discomfort)?', Q12 'Have you ever had neck problems (ache, pain or discomfort)?' and Q20 'Have you ever had shoulder problems (ache, pain or discomfort)?', isolating the answers according to the variables of the individual and the type of farming (sex, age, type of crop, etc.). The section 'Last year (Q1)' shows the data collected from question Q1 'Have you ever had during the last 12 months problems (ache, pain or discomfort) in: (a) Neck, (b) Shoulders, (c) Elbows, (d) Wrist/Hands, (e) Upper part of the back, (f) Lower part of the back, (g) One or both hips/thighs, (h) One or both knees, (i) One or both ankles/feet'. The section 'Affected population' shows the percentage of the population that responded affirmatively to at least one issue related to discomfort suffered either in the last year or previously.

3.2. Multiple-correspondence analysis (MCA)

In the resulting 3-dimensional model (Table 5), the first dimension explains 42.465% of the variance (inertia of 0.425), with a Cronbach's α coefficient of 0.978 and an eigenvalue of 27.178; the second dimension explains 18.440% of the variance (inertia of 0.184), with a Cronbach's α coefficient of 0.930 and an eigenvalue of 11.802; and the third dimension explains 16.671% of the variance (inertia of 0.167), with a Cronbach's α coefficient of 0.921 and an eigenvalue of 10.669. For the model as a whole, the mean variance explained was 25.859% (per dimension), and the accumulated variance was 77.576% (inertia of 0.776), with a Cronbach's average α coefficient of 0.954 and an average eigenvalue of 16.550. Therefore, the model can be considered reliable.

Table 3
Agricultural tasks with risks and associated crops.

Agricultural tasks	Risks			Crops					
	LM	RA	FP	Tomato	Pepper	Courgette	Cucumber	Eggplant	Bean
Sowing		*	*			✓	✓		✓
Transplanting		*	*	✓	✓	✓	✓	✓	✓
Formation pruning		*	*	✓	Sometimes			✓	
Earthing up		*	*	✓				✓	
Hoeing weeds		*	*	✓	✓			✓	
Stringing/wiring/staking		*	*	✓	✓	✓	✓	✓	✓
Pruning (1st)		*	*	✓				Sometimes	✓
Trimming of branches		*	*	✓				Sometimes	
Tying and pruning		*	*	✓	Sometimes		✓		
Pruning (2nd)		*	*	✓	✓	✓	✓	✓	✓
Pollination					✓	✓		✓	
Application of phytosanitary products	*	*	*	✓	✓	✓	✓	✓	✓
Cleaning/clearing		*	*		✓	✓	✓	✓	
Regeneration pruning		*	*					✓	
Collection	*	*	*	✓	✓	✓	✓	✓	✓
Removal of plants	*		*	✓	✓	✓	✓	✓	✓

*LM (load movement): lift, push, drag, and carry (a load); RA (repetitive activities); FP (forced postures): static/dynamic.

Table 5 shows the discrimination measures of each variable with respect to each of the three dimensions of the model and the mean; as can be observed, the leading variable in the ranking of explanatory variables of the variance of the homogenizer model is Q26 (0.428) because it presents the highest discrimination, followed in descending explanation order by the variables Q28 (0.421), Q24 (0.417), Q3b (0.416) and Q25b (0.414); the least explanatory variables are Sex (0.002) and Height (0.002), followed by Greenhouse (0.005), Weight (0.006), Surface (0.009), Staking (0.017), Cultivation (0.019), Nationality (0.024) and Age (0.034).

Ideally, a variable has a high value in one dimension and a low value in another, as in the case of Dimension 1 with the variables associated with Q2 (Have you been unable to perform your usual work during the last 12 months (at home or away from home) due to this problem?) and Q3 (Have you had any problems at any time during the last 7 days?) because their subvariables have values of high discrimination range for Dimension 1 and low values for the other two dimensions. Thus, for these subvariables, the following discrimination values have been obtained for Dimension 1: 'Q3b' (0.857), 'Q2b' (0.851), 'Q3a' (0.849), 'Q3f' (0.846), 'Q2f' (0.846)), 'Q2a' (0.845), 'Q3e' (0.839), 'Q2e' (0.835), 'Q2g' (0.834), 'Q3d' (0.833), 'Q3g' (0.833), 'Q3c' (0.832) , 'Q2i' (0.832), 'Q2c' (0.832), 'Q3h' (0.831), 'Q3i' (0.831), 'Q2h' (0.827) and 'Q2d' (0.815). For all of these reasons, these subvariables are more correlated with Dimension 1; therefore, this dimension better discriminates the categories of these subvariables.

In addition, those variables associated with lower back, such as Q7 (How long have you had problems in your lower back during the last 12 months?), Q8 (Has your activity been reduced to cause of problems in the lower back in the last 12 months?), Q9 (How much time have your lower back problems prevented you from doing your usual work in the last 12 months?), Q10 (Have you visited the doctor, physiotherapist, chiropractor or other specialist because of lower back problems during the past 12 months?), and Q11 (Have you had lower back problems during the past 7 days?) have high discrimination values with Dimension 1 but are very close to discrimination values of Dimension 3. These values of discrimination with Dimension 1 contributed by the model are 'Q7′ (0.590), 'Q8b' (0.588), 'Q8a' (0.584), 'Q9′ (0.583), 'Q11′ (0.580) and 'Q10 '(0.579). Likewise, it is noteworthy that the subvariable Q1f presents measures of medium discrimination (0.554) with Dimension 1 and low with the other two dimensions, consistent with what can be interpreted as the discrimination power of Dimension 1 in the model because subvariable Q1f corresponds to having had problems in the lower back during the last 12 months. Therefore, it can be concluded that Dimension 1 discriminates the objects (workers) according to whether they have been unable to perform their usual work during the last 12 months (at or away from home) due to problems in the different anatomical regions studied and if they have had any problems at any time during the last 7 days in some of these anatomical regions, but especially in the lower part of the back.

By positively increasing the value of the discrimination of objects (workers) in Dimension 1, there is a tendency to increase the problems the workers experience in their lower back to a greater extent.

With respect to Dimension 2, as seen in Table 5, there are no variables with large discrimination values; rather, the values are medium, always lower than those reflected for the previous dimension. In the variables Q12 to Q22, the discrimination values for Dimension 2 are greater than for the other two dimensions; however, the values are very similar; that is to say, Dimension 2 does not present variables that discriminate clearly. The variables Q12 to Q19 are all variables associated with the neck, and Q20 to Q22 are the only three variables associated with the shoulders. The discrimination values in Dimension 2 contributed by the model are 'Q15′ (0.434), 'Q19′ (0.428), 'Q16a' (0.428), 'Q16b' (0.423), 'Q17′ (0.419), 'Q18′ (0.416), 'Q13′ (0.389), 'Q14′ (0.388), 'Q22′ (0.388), 'Q12′ (0.384), 'Q21′ (0.382) and 'Q20′(0.382). However, the rest of variables related to the shoulders, vari-ables Q23 to Q28, present average discrimination values with Dimen-sion 2 but lower than the discrimination values contributed to Dimension 3. These discrimination values are 'Q26′ (0.431), 'Q25b' (0.425), 'Q28′ (0.420), 'Q24′ (0.416), 'Q25a' (0.416), 'Q27′ (0.411) and 'Q23′ (0.404). Therefore, it can be concluded that Dimension 2 dis-criminates the objects (workers) according to whether they have pre-sented problems fundamentally related to the neck and sometimes the shoulders.

By positively increasing the values of discrimination of objects (workers) in Dimension 2, there is a tendency to decrease the problems in the workers' necks; more negative values in this dimension indicate greater problems in the neck.

Finally, in Dimension 3, as seen in Table 5, there are no variables with large discrimination values; rather, they are medium, always lower than those reflected for Dimension 1. The variables Q23 to Q28 present higher values of discrimination for Dimension 3, and all are associated with whether workers have suffered or suffer from shoulder

Table 4
Frequencies and modes for the qualitative variables by category.

Variable	Category	Frequency	%
Sex	F	165	16.467
	ML*	837	83.533
Age	T1	122	12.176
	T2	404	40.319
	T3*	476	47.505
Height	A1	105	10.479
	A2	620	61.876
	A3*	577	57.585
Weight	P1	289	28.842
	P2	324	32.335
	P3*	389	38.822
Area	S1*	478	47.705
	S2	340	33.932
	S3	184	18.363
Crop	Bean	10	0.998
	Cou	173	17.265
	Cu	116	11.577
	Eggp	38	3.792
	Pepp	235	23.453
	Tom*	430	42.914
Nationality	Afr	422	42.116
	Asi	6	0.599
	EurE	77	7.685
	His	6	0.599
	Spa*	491	49.002
Stringing/wiring	Esp	20	1.996
	Pea	206	20.559
	Peb	29	2.894
	Tra*	740	73.852
	Vert	7	0.699
Greenhouse	Mul	44	4.391
	Pla	262	26.148
	Rya*	696	69.461
Q1a	q1an*	648	64.671
	q1as	354	35.329
Q1b	q1bn*	695	69.361
	q1bsa	168	16.766
	q1bsd	112	11.178
	q1bsi	27	2.695
Q1c	q1cn*	893	89.122
	q1csa	47	4.691
	q1csd	46	4.591
	q1csi	16	1.597
Q1d	q1dn*	833	83.134
	q1dsa	83	8.283
	q1dsd	66	6.587
	q1dsi	20	1.996
Q1e	q1en*	692	69.062
	q1es	310	30.938
Q1f	q1fn	328	32.735
	q1fs*	674	67.265
Q1g	q1gn*	794	79.242
	q1gs	208	20.758
Q1h	q1hn*	708	70.659
	q1hs	294	29.341
Q1i	q1in*	882	88.024
	q1is	120	11.976
Q2a	q2an*	736	73.453
	q2aN1	176	17.565
	q2as	90	8.982
Q2b	q2bn*	755	75.349
	q2bN1	176	17.565
	q2bs	71	7.086
Q2c	q2cn*	811	80.938
	q2cN1	176	17.565
	q2cs	15	1.497
Q2d	q2dn*	807	80.539
	q2dN1	176	17.565
	q2ds	19	1.896
Q2e	q2en*	802	80.040
	q2eN1	176	17.565
	q2es	24	2.395
Q2f	q2fn*	642	64.072
	q2fN1	176	17.565
	q2fs	184	18.363
Q2g	q2gn*	806	80.439
	q2gN1	176	17.565
	q2gs	20	1.996
Q2h	q2hn*	690	68.862
	q2hN1	176	17.565
	q2hs	136	13.573
Q2i	q2in*	800	79.840
	q2iN1	176	17.565
	q2is	26	2.595
Q3a	q3an*	726	72.455
	q3aN1	176	17.565
	q3as	100	9.980
Q3b	q3bn*	748	74.651
	q3bN1	176	17.565
	q3bs	78	7.784
Q3c	q3cn*	806	80.439
	q3cN1	176	17.565
	q3cs	20	1.996
Q3d	q3dn*	805	80.339
	q3dN1	176	17.565
	q3ds	21	2.096
Q3e	q3en*	780	77.844
	q3eN1	176	17.565
	q3es	46	4.591
Q3f	q3fn*	554	55.289
	q3fN1	176	17.565
	q3fs	272	27.146
Q3g	q3gn*	791	78.942
	q3gN1	176	17.565
	q3gs	35	3.493
Q3h	q3hn*	676	67.465
	q3hN1	176	17.565
	q3hs	150	14.970
Q3i	q3in*	795	79.341
	q3iN1	176	17.565
	q3is	31	3.094
Q4	q4n	190	18.962
	q4s*	812	81.038
Q5	q5n*	759	75.749
	q5N4	190	18.962
	q5s	53	5.289
Q6	q6n	405	40.419
	q6N4	190	18.962
	q6s*	407	40.619
Q7	q7a	134	13.373
	q7b*	264	26.347
	q7c	235	23.453
	q7d	116	11.577
	q7e	63	6.287
	q7N4	190	18.962

Table 4 (*continued*)

Variable	Category	Frequency	%
Q8a	q8an	304	30.339
	q8aN4	190	18.962
	q8aN7	134	13.373
	q8as*	374	37.325
Q8b	q8bn*	443	44.212
	q8bN4	190	18.962
	q8bN7	134	13.373
	q8bs	235	23.453
Q9	q9a*	463	46.208
	q9b	123	12.275
	q9c	73	7.285
	q9d	19	1.896
	q9N4	190	18.962
	q9N7	134	13.373
Q10	q10n*	467	46.607
	q10N4	190	18.962
	q10N7	134	13.373
	q10s	211	21.058
Q11	q11n*	404	40.319
	q11N4	190	18.962
	q11N7	134	13.373
	q11s	274	27.345
Q12	q12n	454	45.309
	q12s*	548	54.691
Q13	q13n*	491	49.002
	q13N12	454	45.309
	q13s	57	5.689
Q14	q14n	319	31.836
	q14N12*	454	45.309
	q14s	229	22.854
Q15	q15a	190	18.962
	q15b	194	19.361
	q15c	99	9.880
	q15d	43	4.291
	q15e	22	2.196
	q15N12*	454	45.309
Q16a	q16an	153	15.269
	q16aN12*	454	45.309
	q16aN15	190	18.962
	q16as	205	20.459
Q16b	q16bn	204	20.359
	q16bN12*	454	45.309
	q16bN15	190	18.962
	q16bs	154	15.369
Q17	q17a	232	23.154
	q17b	88	8.782
	q17c	29	2.894
	q17d	9	0.898
	q17N12*	454	45.309
	q17N15	190	18.962
Q18	q18n	157	15.669
	q18N12*	454	45.309
	q18N15	190	18.962
	q18s	101	10.080
Q19	q19n	151	15.070
	q19N12*	454	45.309
	q19N15	190	18.962
	q19s	107	10.679
Q20	q20n*	547	54.591
	q20s	455	45.409
Q21	q21n	408	40.719
	q21N20*	547	54.591
	q21sa	19	1.896
	q21sd	16	1.597
	q21si	12	1.198

Table 4 (*continued*)

Variable	Category	Frequency	%
Q22	q22n	293	29.242
	q22N20*	547	54.591
	q22s	162	16.168
Q23	q23n	151	15.070
	q23N20*	547	54.591
	q23sa	179	17.864
	q23sd	98	9.780
	q23si	27	2.695
Q24	q24a	102	10.180
	q24b	119	11.876
	q24c	53	5.289
	q24d	30	2.994
	q24N20*	547	54.591
	q24N23	151	15.070
Q25a	q25an	118	11.776
	q25aN20*	547	54.591
	q25aN23	151	15.070
	q25as	186	18.563
Q25b	q25bn	190	18.962
	q25bN20*	547	54.591
	q25bN23	151	15.070
	q25bs	114	11.377
Q26	q26a	224	22.355
	q26b	49	4.890
	q26c	19	1.896
	q26d	12	1.198
	q26N20*	547	54.591
	q26N23	151	15.070
Q27	q27n	246	24.551
	q27N20*	547	54.591
	q27N23	151	15.070
	q27s	58	5.788
Q28	q28n	219	21.856
	q28N20*	547	54.591
	q28N23	151	15.070
	q28sa	48	4.790
	q28sd	22	2.196
	q28si	15	1.497

* Mode.

problems in the last 12 months and in the last 7 days. Thus, the discrimination values for these variables are 'Q26′ (0.527), 'Q28′ (0.515), 'Q24′ (0.508), 'Q27′ (0.493), 'Q25b' (0.491), 'Q25a' (0.483) and 'Q23′ (0.467). Thus, it can be concluded that Dimension 3 discriminates objects (workers) according to whether they have presented problems related to the shoulders in the last 12 months and in the last 7 days. However, this Dimension does not discriminate, with a clear trend, whether increasing or decreasing the values in Dimension 3 indicate greater or lesser problems in the shoulders.

From the indicated correspondences, for the 9 qualitative variables of workers and agricultural exploitation, although they show low discrimination in the three dimensions of the model, it is observed that Dimension 1 discriminates sex, age, weight, nationality and surface, and Dimension 3 discriminates height, crop, staking and type of greenhouse; in contrast, Dimension 2 does not discriminate any of these variables.

A video was made (Fig. 3) to show the relationships between all of the categories of all of the variables studied in the three dimensions. The green areas correspond to categories referring to the individuals and type of exploitation, and the red areas correspond to the questionnaire categories.

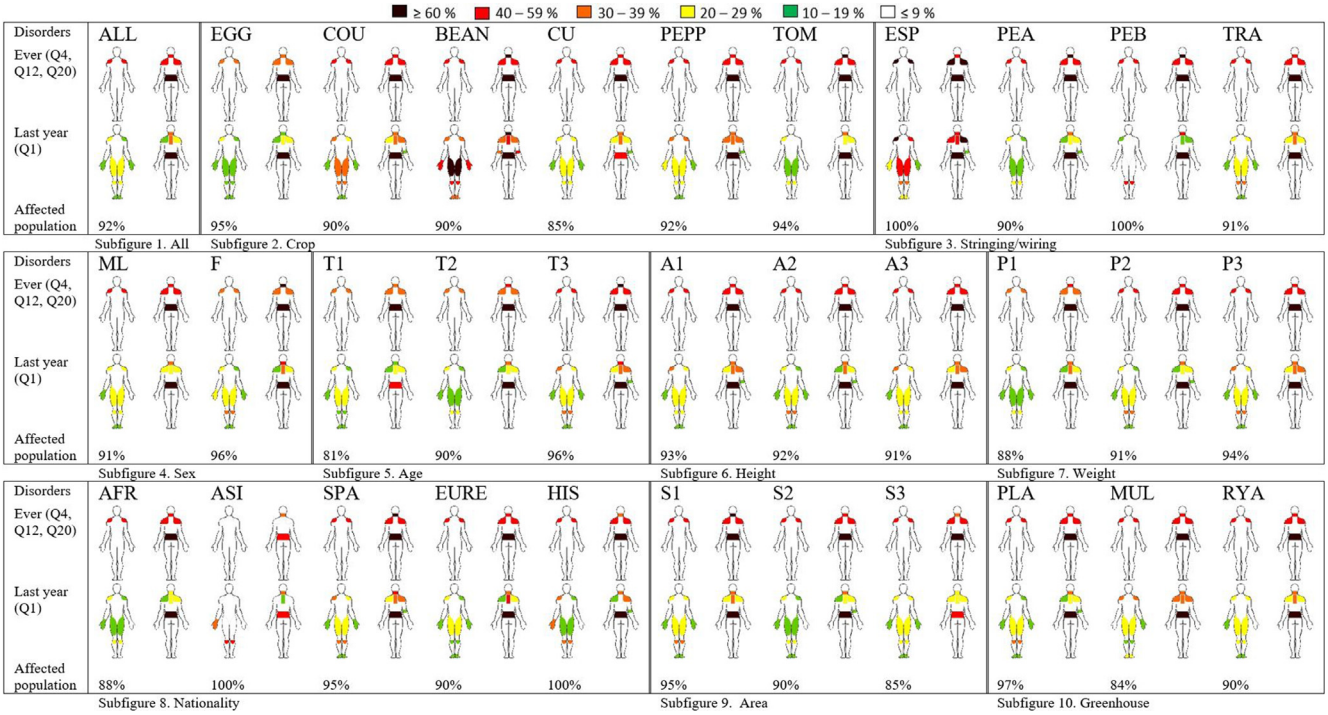

Fig. 2. Percentages of disorders according to crops, sex, age, height, weight, stringing/wiring/staking, nationality, area and greenhouse.

In each octant, certain numbers of individual categories, type of exploitation and questionnaire categories (Table 4) can be seen. Fig. 4 simplifies the model by showing these numbers. The first number (green colour) indicates the individual categories and type of ex-ploitation, and the second number (red colour) indicates the ques-tionnaire categories present in each octant.

Fig. 5 shows the differences between the two-dimensional model (2D) and the three-dimensional model (Fig. 3).

Taking into account Table 5, the spheres of the categories (Fig. 3) are distributed into two different halves: a 'zone of no pain' (octants I, I', III and III') in which there are no positive responses to pain and a 'zone with ailments' (octants II, II 'IV and IV'). Thus, Dimension 1 (coordinate axis) and Dimension 2 (axis of ordinates) can be taken as references to determine if an individual is more prone or less able to register dis-comfort; that is, a greater positive value in Dimension 1 and a greater value negative in Dimension 2 (in the individual categories) are more likely to indicate ailments.

This relationship is easily observed by paying attention to categories related to the age of the individual, which are contrasted as 'T1 (under 25 years, 12.18% frequency; Table 4; Octant I; Figs. 3 and 5)' and 'T3 (over 40 years, 47.51%, Table 4, Octant IV, Figs. 3 and 5)', where the first has very negative values in Dimension 1 and a positive value in Dimension 2, and the second reaches positive values in Dimension 1 and a negative value in Dimension 2.

This contrast is also observed with 'S3 (greenhouse with > 5 ha, 18.36% frequency; Table 4; Octant I; Figs. 3 and 5)' and 'S1 (greenhouse with < 2 ha, 47.7% frequency; Table 4; Octant IV'; Figs. 3 and 5)', with 'Afr (African, 42% frequency; Table 4; Octant I'; Figs. 3 and 5)' and 'Spa (Spanish, 49% frequency; Table 4; Octant IV; Figs. 3 and 5)', and with 'Eggp (eggplant, 3.79% frequency; Table 4; Octant I'; Figs. 3 and 5)' and 'Bean (1% frequency; Table 4; Octant IV'; Figs. 3 and 5)'. The first crop, eggplant, registers the lowest percentages in each body area, on the other hand, bean registers the highest percentages.

Three clusters of categories of the variables are distinguished (A, B, C, Figs. 3 and 5). Cluster A is located in the 'area with ailments' (positive values in Dimension 1 and both positive and negative values in Dimensions 2 and 3) and includes the individual categories and type of exploitation Pla, Pepp, F, Cou A1, S1, P3, Spa and T3 (see Table 2) and the questionnaire categories q6n, Q5N, q1csi, Q4S, q3hs, q3is, q2hs, q6s and Q5s (see Appendix A). Cluster B (positive values in Dimension 1, negative values in Dimension 2 and both positive and negative values in Dimension 3) is also located in the 'area with diseases' and includes the individual categories and type of exploitation Peb and Bean and the questionnaire categories q14n, q13n and q12s. Cluster C is located in the 'zone of no pain' (negative values in Dimension 1 and both positive and negative values in Dimensions 2 and 3) and includes the individual categories and type of exploitation S3, Afr, T2, P1, EurE, P2, A2, Tra, S2, A3, ML, Rya, Tom, Cu, Pea and Mul (Table 2) and the questionnaire categories q1an, q1bn, q1en, q1hn, q1gn, q1dn, q1in and q1cn.

3.2.1. Cluster A

The proximity between the variable 'q4s (81.04% frequency; Table 4; Octant IV'; Figs. 3 and 5)' and 'T3 (47.51%; Table 4; Octant IV; Figs. 3 and 5)' stands out, indicating that workers over 40 (T3) answered mostly (86%) positively to the question 'Have you ever had low back trouble (ache, pain or discomfort)?'.

The variable 'q1csi (1.59% frequency; Table 4; Octant II')' is also close to T3. Its proximity is explained because half (50%) of the individuals who responded positively to the question 'Have you at any time during the last 12 months had trouble (ache, pain, discomfort) in: elbows' belong to the age range over 40 years old (T3).

The variable 'q5s (5.29% frequency; Table 4; Octant IV)' is the next positive response closest to 'T3 (47.51%; Table 4; Octant IV; Figs. 3 and 5)'. This variable refers to the question 'Have you ever been hospitalized because of low back trouble?'.

Somewhat more distant but equally related to 'T3′ are: 'q3hs (14.97% of frequency; Table 4; Octant IV; Figs. 3 and 5)', referring to the question 'Have you had trouble at any time during the last 7 days in

Table 5
Discrimination values for the variables with respect to each dimension via MCA.

	Dimension			
Variable/Subvariable	1	2	3	Mean
Sex	0.006	0.000	0.001	0.002
Age	0.087	0.003	0.013	0.034
Height	0.001	0.000	0.005	0.002
Weight	0.012	0.004	0.002	0.006
Area	0.015	0.006	0.004	0.009
Crop	0.009	0.010	0.039	0.019
Nationality	0.040	0.027	0.004	0.024
Stringing/staking	0.011	0.017	0.023	0.017
Greenhouse	0.005	0.002	0.007	0.005
Q1a	0.290	0.097	0.109	0.165
Q1b	0.277	0.119	0.241	0.213
Q1c	0.048	0.015	0.026	0.030
Q1d	0.098	0.027	0.072	0.066
Q1e	0.159	0.013	0.036	0.069
Q1f	0.554	0.056	0.022	0.211
Q1g	0.105	0.009	0.024	0.046
Q1h	0.123	0.004	0.009	0.045
Q1i	0.055	0.005	0.045	0.035
Q2a	0.845	0.186	0.132	0.387
Q2b	0.851	0.214	0.165	0.410
Q2c	0.832	0.113	0.021	0.322
Q2d	0.815	0.110	0.023	0.316
Q2e	0.835	0.131	0.054	0.340
Q2f	0.846	0.135	0.052	0.344
Q2g	0.834	0.122	0.020	0.325
Q2h	0.827	0.109	0.007	0.314
Q2i	0.832	0.110	0.030	0.324
Q3a	0.849	0.206	0.129	0.394
Q3b	0.857	0.210	0.181	0.416
Q3c	0.832	0.115	0.040	0.329
Q3d	0.833	0.122	0.048	0.335
Q3e	0.839	0.140	0.057	0.345
Q3f	0.846	0.137	0.012	0.332
Q3g	0.833	0.116	0.023	0.324
Q3h	0.831	0.111	0.007	0.316
Q3i	0.831	0.107	0.028	0.322
Q4	0.354	0.001	0.216	0.190
Q5	0.354	0.003	0.222	0.193
Q6	0.384	0.006	0.302	0.231
Q7	0.590	0.216	0.395	0.400
Q8a	0.584	0.174	0.357	0.372
Q8b	0.588	0.199	0.371	0.386
Q9	0.583	0.183	0.358	0.375
Q10	0.579	0.154	0.328	0.353
Q11	0.580	0.171	0.298	0.349
Q12	0.211	0.384	0.016	0.203
Q13	0.212	0.389	0.023	0.208
Q14	0.217	0.388	0.112	0.239
Q15	0.310	0.434	0.419	0.388
Q16a	0.311	0.428	0.412	0.384
Q16b	0.309	0.423	0.387	0.373
Q17	0.308	0.419	0.400	0.376
Q18	0.308	0.416	0.369	0.364
Q19	0.308	0.428	0.384	0.373
Q20	0.279	0.382	0.002	0.221
Q21	0.280	0.382	0.008	0.223
Q22	0.281	0.388	0.098	0.256
Q23	0.326	0.404	0.467	0.399
Q24	0.327	0.416	0.508	0.417
Q25a	0.325	0.416	0.483	0.408
Q25b	0.326	0.425	0.491	0.414
Q26	0.327	0.431	0.527	0.428
Q27	0.325	0.411	0.493	0.410
Q28	0.328	0.420	0.515	0.421
Active total	27.178	11.802	10.669	16.550
% variance	42.465	18.440	16.671	25.859

one or both knees?', 'q2hs (13.57%; Table 4; Octant IV'; Figs. 3 and 5)', referring to the question '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 in one or both knees?', 'q6s (40.61%; Table 4; Octant IV; Figs. 3 and 5)', referring to the question 'Have you ever had to change jobs or duties because of low back trouble?', 'q3is (3.09%; Table 4; Octant IV; Figs. 3 and 5)', referring to the question 'Have you had trouble at any time during the last 7 days in one or both ankles/feet?', and 'q1hs (29.34%; Table 4; Octant IV; Figs. 3 and 5)', referring to the question 'Have you at any time during the last 12 months had trouble (ache, pain, discomfort) in one or both knees?'.

3.2.2. Cluster B

The proximity between the variable 'q12s (54.59% frequency; Table 4; Octant IV'; Figs. 3 and 5)' and 'Bean (0.99%; Table 4; Octant IV'; Figs. 3 and 5)' stands out, indicating that 'bean' workers answered (100%) positively to the question 'Have you ever had a trouble (ache, pain or discomfort)?'.

3.2.3. Cluster C

This cluster stands out for the number of individual categories that it includes, all surrounded by questionnaire categories corresponding to the different sub-variables of the question 'Have you at any time during the last 12 months had trouble (ache, pain, discomfort) in …' answered in a negative way. This finding may indicate that these individual categories are the least likely to have had ailments in the last year.

The proximity of 'T2 (40.32% frequency; Table 4; Octant I'; Figs. 3 and 5)' and 'P1 (28.84% frequency; Table 4; Octant I; Figs. 3 and 5)' to 'q1gn (79.24% frequency; Table 4; Octant I '; Figs. 3 and 5)' and 'q1dn (83.13%; Table 4; Octant I'; Figs. 3 and 5)' indicates that workers between 25 and 40 years old (T2) and workers weighing less than 70 kg (P1) answered negatively to the questions 'Have you at any time during the last 12 months had trouble (ache, pain, discomfort) in one or both hips/thighs?' (q1gn) and 'Have you at any time during the last 12 months had trouble (ache, pain, discomfort) in wrists/hands?'.

4. Discussion

Agriculture, as a primary sector, is generally associated with low-paid workers (Benach and Muntaner, 2007), who require very basic training to perform their tasks. Agriculture is also associated with very high percentages of MSDs (Palmer, 1996, Holmberg et al., 2002), which coincides with the data shown in Table 4 (approximately 90% in all cases). In southeast Spain (Almeria), this situation is observed and is aggravated by the different nationalities/cultures that converge in the same place of work (Montoya-García et al., 2013). For this reason, studies related to health and safety at work are a priority for agricultural entrepreneurs in the southeast of Spain to improve their employees' working conditions (Callejón-Ferre et al., 2015). In particular, for the first time, this research has helped to define the symptoms of MSDs perceived by agricultural workers in the greenhouses of the Southeast of Spain that are associated with different crops.

MCA is usually represented in a two-dimensional chart (2D, Fig. 5) in which all categories or data are included in the four quadrants; however, in this study, the data have been represented in three dimensions (3D; Fig. 3) to avoid data interpretation errors. Two superimposed datapoints in quadrant I can be separated in quadrants I and I' by representing them in a 3D model (Fig. 6).

The result of the MCA performed for the dataset for all crops has provided a model that presents three significant dimensions with very good reliability, which allows researchers to identify the correlations of the categories of the variables, along with the variables themselves and the objects (workers).

As shown in Figs. 3 and 5 (and the accompanying video), the most significant factor is the proximity of the vast majority of the variables of the individual and type of exploitation (green spheres) (Table 4) to the sphere 'q4s' (red sphere), in addition to other less significant factors that do not indicate symptoms. The 'q4s' sphere indicates a high incidence of discomfort in the lower back, a fact that was common in 90% of the individuals interviewed (Table 3, black). Of all variables of the

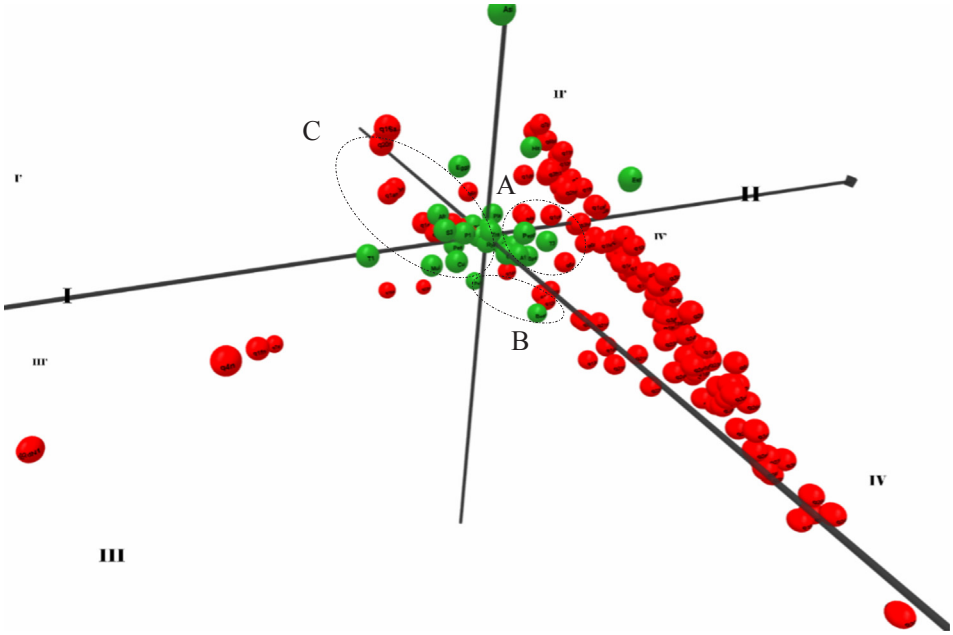

Fig. 3. Video screenshot showing the relationships of all of the categories (https://vimeo.com/249865380).

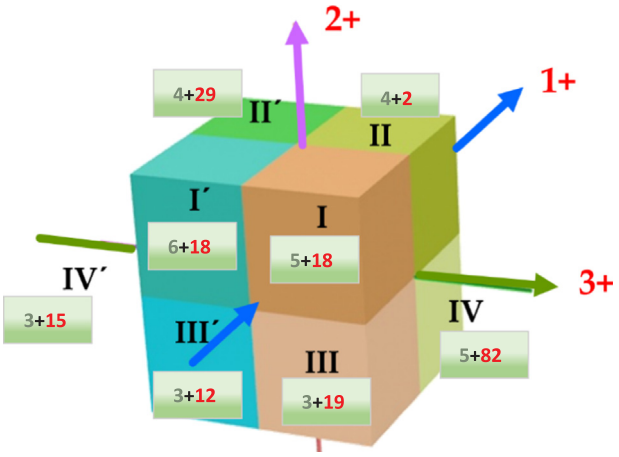

Fig. 4. Simplification of the 3D model by accounting for the individual categories and type of exploitation (green) and the questionnaire categories (red) in each octant. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

individual, T3 (over 40 years old) stands out, which seems logical because it indicates greater discomfort associated with older age. These data coincide with those found by Lee (2012) in agricultural workers in South Korea, although that study was performed with workers of other types of crops, but with tasks very similar to those of the present investigation.

Obviously, the perception of the ailments and the method of executing the agricultural tasks (Marras and Hancock, 2014) will be different in each individual and will depend on many environmental factors (nationality, age, sex, weight, height, relationships, type of crop, type of workplace, etc.). These facts could explain the differences identified among the different workers (Figs. 3 and 5).

Previous studies by Montoya-García et al. (2013) and Callejón-Ferre et al. (2015) regarding workers in the greenhouses of Almería found psychosocial problems in all nationalities (Hispanics, Spaniards, Eastern Europe and Africans), with an incidence of approximately 80% average risk in mental load (on a scale of medium, high and low) and an incidence of 10% high risk. Together, these percentages (80 + 10 = 90%) more or less coincide with the finding of 92% (Fig. 2) of people suffering from any symptom of MSD (in this work). As the relationship between psychosocial and musculoskeletal risks (Bernard et al., 2009, 2011) is sufficiently contrasted, one might think that this was also the case in our study because the population studied is the same. However, this does not mean that workers cannot perform their tasks; in reality, 80% of workers continue to work even if they have problems. Therefore, these discomforts could be considered tolerable (with small corrective measures), that is, equivalent to a medium de-gree of discomfort (mental load) in psychosocial disorders.

The lack of a pain scale in the questionnaire used (NMQ) is evident; thus, the symptoms of MSDs among workers could be overestimated (López-Aragón et al., 2017). It would be interesting to be able to assess the intensity and severity of the symptoms; nevertheless, the NMQ questionnaire tries to solve this issue by asking questions such as ‘Have you been unable to perform his usual job … (Q2)' or 'Have you ever been hospitalized (Q5)', among others.

Work in greenhouses is very physical and requires a high manual load (Van der Schilden, 1989). Therefore, the mechanization of all work, if possible, is recommended for the reduction of MSDs (Rai et al., 2012; Milani and Monteiro, 2012). For now, such a change would be difficult, especially because greenhouse agriculture in the Southeast of Spain (Almeria) does not involve very technical structures (i.e., Al-mería-type greenhouses; Fig. 1), such as those in other countries (i.e., 'Venlo' greenhouses), and the tasks of growing vegetables do not allow for some types of mechanization (i.e., pruning, staking, rolling and uncovering). Perhaps, other tasks such as harvesting, phytosanitary treatments **(Rincon et al., 2017) and cleaning can be improved.

This should help to redesign agricultural tasks for all crops, to provide better physical conditions for workers, to reorganize the work, to improve the safety environment and to provide specific training on each task/working method.

The present study has limitations. Melon and watermelon crops, as spring crops, were not considered, as the data were obtained in the autumn/winter. Such an extension in the study would have required more costs. Nor have certain worker variables been taken into account,

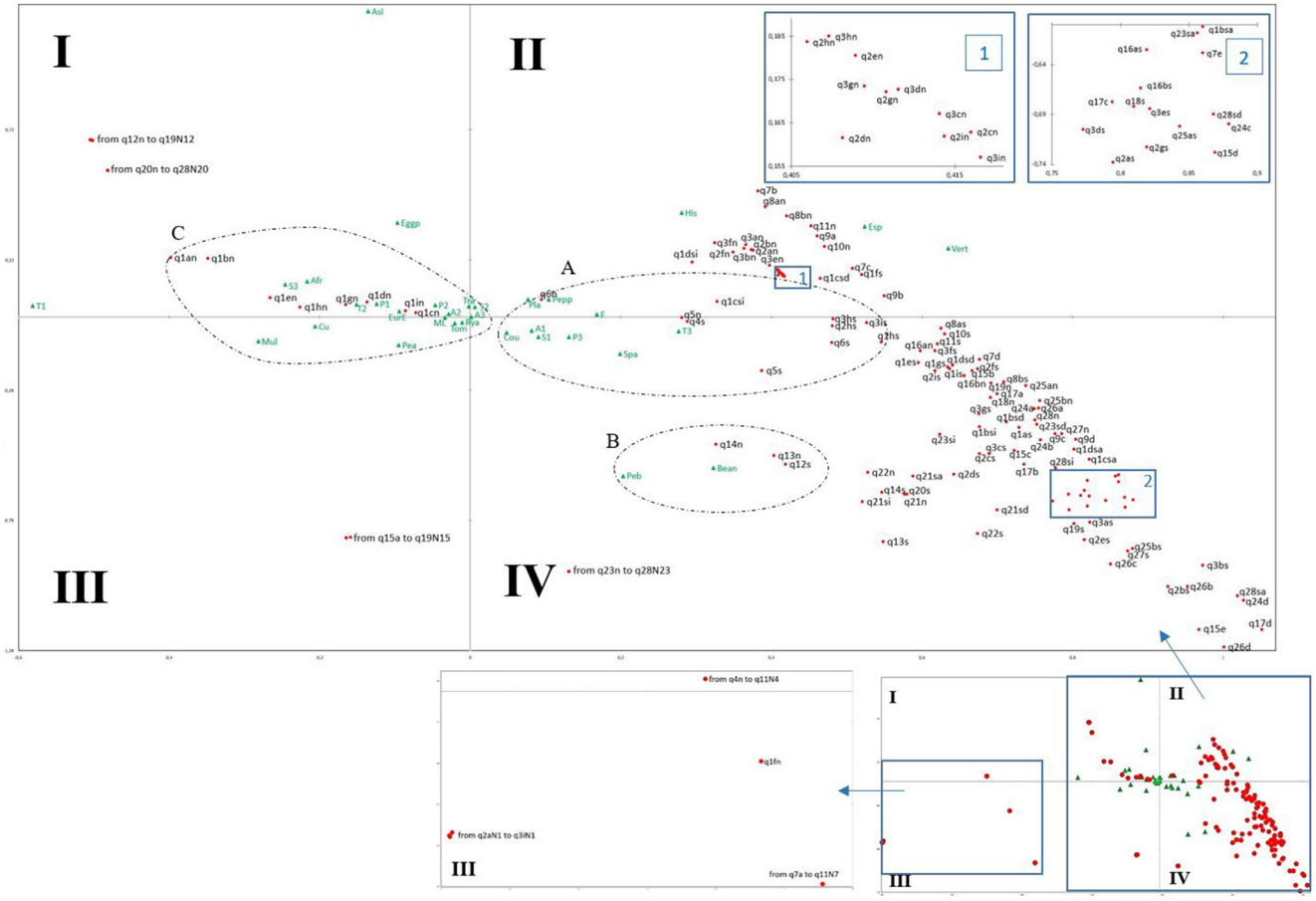

Fig. 5. The relationships among all variable categories (2D).

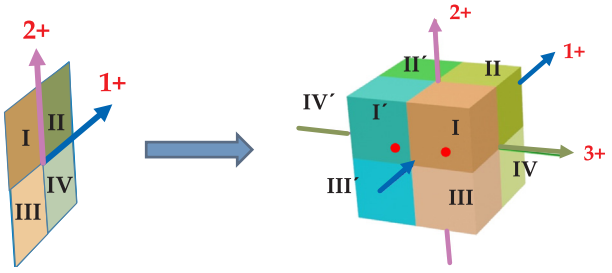

Fig. 6. Representation of superimposed data (red dots) in a 2D model and a 3D model. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

such as educational level, family responsibilities and salaries. Perhaps it would have been interesting to have completed these assessments using other evaluation methods.

5. Conclusions

Within the greenhouse farming industry in the province of Almería, there is an MSD symptom incidence rate of 92% among the population of workers and half of them (55%) have had to change jobs or tasks on occasion due to discomfort in their neck (Q14), shoulders (Q22) or lower back (Q6). The highest rates are presented in the groups corresponding to those over 40 years old (T3), women (F) and eggplant workers (Egg). Even in the under 25 group (T1), the percentage of individuals who have suffered discomfort reaches 81%.

Additionally, 81% of greenhouse workers state that they have suffered discomfort in their lower back at some time (Q4), among which 67% have suffered such pain in the last 12 months (q1f) and 27% claim to have suffered such pain in the last 7 days (q3f).

The most frequent MSDs found in greenhouse farming are located in the neck area, upper back, shoulders, lower back, hips and thighs and knees. MSDs related to the elbows, wrists/hands and ankles/feet are present at lower frequencies.

Finally, although the results show high general rates of MSD symptoms, these findings do not mean that the workers do not perform all of their specific agricultural tasks.

Appendix A

Variable (Q)	Subvariable (Q)	Category	Abbreviation
1. Have you at any time during the **last 12 months** had **trouble** (ache, pain, discomfort) in:	(a) Neck	No	q1an
		Yes	q1as
	(b) Shoulders	No	q1bn
		Yes, in the right Shoulder	q1bsd
		Yes, in the left Shoulder	q1bsi
		Yes, in both Shoulders	q1bsa
	(c) Elbows	No	q1cn
		Yes, in the right Elbow	q1csd
		Yes, in the left Elbow	q1csi
		Yes, in both Elbows	q1csa
	(d) Wrists/hands	No	q1dn
		Yes, in the right Wrist/hand	q1dsd
		Yes, in the left Wrist/hand	q1dsi
		Yes, in both Wrists/hands	q1dsa
	(e) Upper back	No	q1en
		Yes	q1es
	(f) Low back (small of the back)	No	q1fn
		Yes	q1fs
	(g) One or both hips/thighs	No	q1gn
		Yes	q1gs
	(h) One or both knees	No	q1hn
		Yes	q1hs
	(i) One or both ankles/feet	No	q1in
		Yes	q1is
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?	(a) Neck	No	q2an
		Yes	q2as
		No to everything in 1st Question	q2aN1
	(b) Shoulders	No	q2bn
		Yes	q2bs
		No to everything in 1st Question	q2bN1
	(c) Elbows	No	q2cn
		Yes	q2cs
		No to everything in 1st Question	q2cN1
	(d) Wrists/hands	No	q2dn
		Yes	q2ds
		No to everything in 1st Question	q2dN1
	(e) Upper back	No	q2en
		Yes	q2es
		No to everything in 1st Question	q2eN1
	(f) Low back (small of the back)	No	q2fn
		Yes	q2fs

		No to everything in 1st Question	q2fN1
	(g) One or both hips/ thighs	No	q2gn
		Yes	q2gs
		No to everything in 1st Question	q2gN1
	(h) One or both knees	No	q2hn
		Yes	q2hs
		No to everything in 1st Question	q2hN1
	(i) One or both ankles/feet	No	q2in
		Yes	q2is
		No to everything in 1st Question	q2iN1
3. Have you had trouble at any time during the **last 7 days?**	(a) Neck	No	q3an
		Yes	q3as
		No to everything in 1st Question	q3aN1
	(b) Shoulders	No	q3bn
		Yes	q3bs
		No to everything in 1st Question	q3bN1
	(c) Elbows	No	q3cn
		Yes	q3cs
		No to everything in 1st Question	q3cN1
	(d) Wrists/hands	No	q3dn
		Yes	q3ds
		No to everything in 1st Question	q3dN1
	(e) Upper back	No	q3en
		Yes	q3es
		No to everything in 1st Question	q3eN1
	(f) Low back (small of the back)	No	q3fn
		Yes	q3fs
		No to everything in 1st Question	q3fN1
	(g) One or both hips/ thighs	No	q3gn
		Yes	q3gs
		No to everything in 1st Question	q3gN1
	(h) One or both knees	No	q3hn
		Yes	q3hs
		No to everything in 1st Question	q3hN1
	(i) One or both ankles/feet	No	q3in
		Yes	q3is
		No to everything in 1st Question	q3iN1
Low back			
4. Have you ever had low back trouble (ache, pain or discomfort)?		No	q4n
		Yes	q4s
5. Have you ever been hospitalized because of low back trouble?		No	q5n
		Yes	q5s
		No to 4th Question	q5N4
6. Have you ever had to change jobs or duties because of low back trouble?		No	q6n
		Yes	q6s
		No to 4th Question	q6N4

7. What is the total length of time that you have had low back trouble during the last 12 months?		0 days	q7a
		1–7 days	q7b
		8–30 days	q7c
		More than 30 days, but not every day	q7d
		Every day	q7e
		No to 4th Question	q7N4
8. Has low back trouble caused you to reduce your activity during the last 12 months?	(a) Work activity (at home or away from home)?	No	q8an
		Yes	q8as
		No to 4th Question	q8aN4
		No to 7th Question	q8aN7
	(b) Leisure activity?	No	q8bn
		Yes	q8bs
		No to 4th Question	q8bN4
		No to 7th Question	q8bN7
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?		0 days	q9a
		1–7 days	q9b
		8–30 days	q9c
		More than 30 days	q9d
		No to 4th Question	q9N4
		No to 7th Question	q9N7
10. Have you been seen by doctor physiotherapist, chiropractor or other such person because of low back trouble during the last 12 months?		No	q10n
		Yes	q10s
		No to 4th Question	q10N4
		No to 7th Question	q10N7
11. Have you had low back trouble at any time during the last 7 days?		No	q11n
		Yes	q11s
		No to 4th Question	q11N4
		No to 7th Question	q11N7
Neck			
12. Have you ever had neck trouble (ache, pain or discomfort)?		No	q12n
		Yes	q12s
13. Have you ever hurt your neck in an accident?		No	q13n
		Yes	q13s
		No to 12th Question	q13N12
14. Have you ever had to change jobs or duties because of neck trouble?		No	q14n
		Yes	q14s
		No to 12th Question	q14N12
15. What is the total length of time that you have had neck trouble during the last 12 months?		0 days	q15a
		1–7 days	q15b
		8–30 days	q15c
		More than 30 days, but not every day	q15d
		Every day	q15e
		No to 12th Question	q15N12
16. Has neck trouble caused you to reduce your activity during the last 12 months?	(a) Work activity (at home or away from home)?	No	q16an
		Yes	q16as
		No to 12th Question	q16aN12
		No to 15th Question	q16aN15
	(b) Leisure activity?	No	q16bn
		Yes	q16bs
		No to 12th Question	q16bN12
		No to 15th Question	q16bN15

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?		0 days	q17a
		1–7 days	q17b
		8–30 days	q17c
		More than 30 days	q17d
		No to 12th Question	q17N12
		No to 15th Question	q17N15
18. Have you been seen by doctor physiotherapist, chiropractor or other such person because of neck trouble during the last 12 months?		No	q18n
		Yes	q18s
		No to 12th Question	q18N12
		No to 15th Question	q18N15
19. Have you had neck trouble at any time during the last 7 days?		No	q19n
		Yes	q19s
		No to 12th Question	q19N12
		No to 15th Question	q19N15
Shoulders			
20. Have you ever had shoulder trouble (ache, pain or discomfort)?		No	q20n
		Yes	q20s
21. Have you ever hurt your shoulder in an accident?		No	q21n
		Yes, in the right Shoulder	q21sd
		Yes, in the left Shoulder	q21si
		Yes, in both Shoulders	q21sa
		No to 20th Question	q21N20
22. Have you ever had to change jobs or duties because of shoulder trouble?		No	q22n
		Yes	q22s
		No to 20th Question	q22N20
23. Have you had shoulder trouble during the last 12 months?		No	q23n
		Yes, in the right Shoulder	q23sd
		Yes, in the left Shoulder	q23si
		Yes, in both Shoulders	q23sa
		No to 20th Question	q23N20
24. What is the total length of time that you have had shoulder trouble during the last 12 months?		1–7 days	q24a
		8–30 days	q24b
		More than 30 days, but not every day	q24c
		Every day	q24d
		No to 20th Question	q24N20
		No to 23rd Question	q24N23
25. Has shoulder trouble caused you to reduce your activity during the last 12 months?	(a) Work activity (at home or away from home)?	No	q25an
		Yes	q25as
		No to 20th Question	q25aN20
		No to 23rd Question	q25aN23
	(b) Leisure activity?	No	q25bn
		Yes	q25bs
		No to 20th Question	q25bN20
		No to 23rd Question	q25bN23
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?		0 days	q26a
		1–7 days	q26b
		8–30 days	q26c

	More than 30 days	q26d
	No to 20th Question	q26N20
	No to 23rd Question	q26N23
27. Have you been seen by doctor physiotherapist, chiropractor or other suck person because of shoulder trouble during the last 12 months?	No	q27n
	Yes	q27s
	No to 20th Question	q27N20
	No to 23rd Question	q27N23
28. Have you had shoulder trouble at any time during the last 7 days?	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

Appendix B. Supplementary material

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.ssci.2018.05.023.

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