# Occupational Risk Factors for Musculoskeletal Disorders Among Workers in Dairy Diversification

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Posted Date: 19 October 2023

doi: 10.20944/preprints202310.1291.v1

Keywords: Dairy products; Farming diversification; Musculoskeletal disorders; Pain; Risk analysis

*Article*

# Occupational Risk Factors for Musculoskeletal Disorders Among Workers in Dairy Diversification

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**Abstract:** *Background*. In a changing European agricultural context, diversification of dairy farms is gaining attention. This study seeks to (1) assess musculoskeletal pain prevalence associated with tasks such as butter, yogurt, and cheese production; and (2) analyze associated risks. *Methods*. Observing 31 mostly female workers, it utilized the ERGOROM questionnaire, a methodology adapted from the Institut National de Recherche et de Sécurité, and Key Indicator Method forms. *Results*. Findings revealed that tasks like load carrying (42% of workers), manual work (17%), and awkward postures (14%) resulted in musculoskeletal pain, predominantly in the lower back (65%), neck (39%), and dominant upper limb areas (shoulder: 61%, elbow: 26%, and wrist: 65%). While psychosocial risks remained low, concerns arose from workload, hygiene standards, and resource unpredictability. *Conclusion*s. As dairy farming evolves from artisanal to semi-industrial, the study emphasizes the importance of ergonomic adaptations to protect farmer health and prevent musculoskeletal disorders during diversification.

**Keywords:** dairy products; farming diversification; musculoskeletal disorders; pain; risk analysis

## 1. Introduction

Diversification in agriculture, characterized by farmers engaging in non-agricultural economic activities using their existing facilities, is becoming increasingly common among European farmers [1]. For example, the number of farms engaging in direct sales of their products increased by 12.3% between 2016 and 2020 in Belgium [2]. The process of farm diversification can be segmented into two distinct categories: diversification in production modes and types, and diversification through the integration of non-agricultural activities linked to the farm. This study focuses exclusively on the latter category, encompassing endeavors like food production, agritourism, and educational initiatives held on the farm. Of particular interest within this context is the diversification of dairy farms, specifically the on-farm production of butter, yogurt, or cheese using locally produced milk. The authors of [3] have shown the potential of such value-added diversification in fostering resilient pathways of economic development for small dairy farms.

Despite the significant prevalence of musculoskeletal disorders (MSD) among workers in the agricultural sector, ergonomic assessments directed towards dairy farm diversification remain

 doi:10.20944/preprints202310.1291.v1



notably absent. The agriculture industry inherently exposes workers to elevated MSD risks, as highlighted in [4]. According to the systematic review by [5], the most common MSD among farmers mainly affect the back, neck, and upper extremities. The physical demands of dairy practices, including cow milking, have been linked to MSD affecting the knees [6]. Moreover, farmers often exhibit a lower propensity to seek medical advice compared to other occupational groups [7], thereby increasing the risk of chronic pain, and worsening of health within this population.

As farm diversification necessitates a departure from conventional farming activities, a question arises: does the adoption of diversification introduce unique or additional MSD risks among farmers? In the context of dairy farm diversification, tasks inherently involve risk factors such as carrying heavy loads (>20kg), repeated gestures (mixing ingredients, packaging, etc.) or awkward postures induced by space constraints in workshops.

The objectives of the study are: (1) to conduct a comprehensive descriptive analysis of the target population, elucidating prevalent musculoskeletal pain experienced; (2) to carry out an in-depth risk analysis of tasks undertaken by farmers engaging in dairy diversification.

## 2. Materials and Methods

### *2.1. Population*

Farms eligible for inclusion in this study are situated in Wallonia (the French-speaking region of Belgium) and engaged in dairy diversification. Regarding risk analysis, inclusion criteria encompass workers of legal age who are engaged in dairy products processing on the farm involved. Exclusion criteria pertain to workers declining participation, activities unsuitable for comprehensive risk assessment using the chosen ergonomic approach, or workers with visible motor disorders or documented neurologic, neuromuscular, degenerative, or rheumatic disorders that could potentially alter perceived or observed constraints. Farms were contacted by e-mail and telephone among the authors' personal acquaintances as well as contacts of PreventAgri, a Walloon service dedicated to safety and prevention within the green sectors, including agriculture.

### *2.2. Protocol*

The research protocol received approval from the Comité Académique de Bioéthique under file number B200-2022-107. Each participating worker was initially administered the 40-item ERGOROM questionnaire [8], based on the Nordic questionnaire [9]. The ERGOROM questionnaire consists of four sections: (1) A demographic section, which collects information on the respondent's personal characteristics such as age, weight, height, gender, laterality (the dominant limb was the one used to write), smoking status and extra-professional hobbies involving physical effort; (2) A work section, which assesses past and current working conditions; (3) A section on MSD symptoms, with questions on any pain experienced over the past 12 months in the neck, shoulders, elbows, wrists and lower back; (4) A section on perception and appreciation of working conditions. Regarding complaints, ERGOROM mainly assesses complaints and tasks relating to the upper limbs and back, as these are prominent in the agricultural milieu [5]. In the fourth section, the ERGOROM questionnaire also incorporates 5 items grounded in Karasek's job demands-control model [10,11] for the assessment of psychosocial risks: (1) “Are you satisfied with your relations with your colleagues?”; (2) “Are you satisfied with your relations with your superiors?”; (3) “Are you satisfied with your current job?”; (4) “Do you feel appreciated in your work?”; (5) “Do you feel tense, uptight or stressed?”. These items are each scored between 1 and 5, the lowest value being the worst level of satisfaction. The total score of these items generates an "ERGOROM psychosocial risk" composite score. After the questionnaire, an analysis of worker tasks was conducted simultaneously by 2 observers (CDS and JP), whose conclusions were harmonized through consensus.

First, the workers' subjective rankings of the relative physical demands associated with the three key tasks involved in final product production (butter, yoghurt, or cheese) were solicited. From these, the two or three most physically demanding tasks reported by workers were selected for observation – not all workers were involved in at least three tasks.

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Second, a comprehensive analysis of physical workload was undertaken on these tasks by resorting to an adapted version of the risk analysis of workload method by the "Institut National de Recherche et de Sécurité pour la prévention des accidents du travail et des maladies professionnelles" (INRS is the French National Research and Safety Institute for the prevention of occupational accidents and diseases) [12]. Items belongs to five categories: (1) physical efforts (7+4 items), (2) dimensioning (7+3 items), (3) temporal characteristics (7 items), (4) environmental characteristics (5 items), (5) organization and psycho-social aspects (7+2 items). The nine additional items are taken from the FIFARIM method, which focuses on manual handling tasks [13]. The following items have been added for their relevance in dairy milk diversification: (1) physical effort: Sustained effort with arms above mid-trunk, Using the hand as a tool for striking or tearing, Palmar grip (full hand) of loads > 5kg & Digital grip (thumb-index) of loads >1kg, Prolonged static force of hands or fingers; (2) dimensioning: Visible neck flexion, tilt and rotation, Wrist out of neutral position, Highly bent elbow or rapid forearm rotation; (5) organization and psycho-social aspects: Recognition, Good contact with colleagues. The assessment quantified the 42 items according to their severity, encompassing four levels: minimal, acceptable, conditionally acceptable, and unacceptable.

Third, the Key Indicator Method (KIM) was applied. KIM relies on objective indicators, like frequency and duration of movements, weight of loads handled, number of repetitions, etc. [14]. The observer must fill the most relevant KIM forms for a given task, from a range of six options available [15]: LHC (manual Lifting, Holding and Carrying loads), ABP (Awkward Body Postures), MHO (Manual Handling Operations), PP (Pushing/Pulling). Each task was analyzed utilizing the most appropriate KIM form. For example, for the "butter packaging" task displayed in Fig. 1C, corresponded to the MHO KIM form, centered on "manual work". The BF (Whole Body Forces) and BM (Body Movement) forms were deemed unsuitable for observed tasks.

Tasks were ranked based on their corresponding KIM scores. A moderate KIM score (between 20 and 50) indicates that the task being assessed is associated with a physical load that can be physically demanding but remains manageable with appropriate preventive measures and work planning. A KIM score between 50 and 100 indicates that the task assessed is associated with a physical load that may affect workers normally able to work under pressure and that preventive measures should be considered. A high KIM score (> 100) indicates that the task being assessed is associated with a probable physical overload that could lead to MSD if work adjustment measures are not put in place.

### *2.3. Data analysis*

The results of the ERGOROM questionnaire, INRS and KIM methods are summarized using descriptive statistics in the form of summary tables and plots. Note that the raw data are available on the OSF online scientific data repository platform [16]. The Pearson correlation coefficient r has been calculated between the ERGOROM psychosocial risk score and the average weekly working hours.

## 3. Results

### *3.1. Population*

A total of 15 farms, meeting the established inclusion criteria, responded affirmatively to the call for participation and were consequently selected. Among these, 8 produce butter, 4 yoghurt and 3 cheese at the time of the observation. 4 days a week for 4 weeks were allocated to farm visits in November 2022. Visiting a farm and processing the associated data took 1 day, and two observers (C. DS. and J.P.) were always simultaneously present. An average of 6 hours were spent observing and filling questionnaires in for each farm.

The study encompassed a cumulative total of 31 workers and 96h of observation. Several observations were carried out, depending on the tasks performed by the workers: Each worker was asked to list the two or three most arduous tasks they had to perform regarding their professional activity in diversification. 27 workers listed 2 tasks, and 4 workers gave 3 tasks. This led to the completion of 66 KIM forms and 66 INRS forms in total. Observers spent an average of 6 hours in

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each farm, i.e. around 3 hours per worker and 1.5h per task. An example of an observed work situation is shown in Figure 1.


**Figure 1.** Example of a farmer forming butter clods (A) and packing them (B), (C).

The main characteristics of the workers are summarized in Table 1. Most workers were women, aged over 34, working more than 30 hours (median) per week in diversification. This was their only professional activity. The workers worked for a median of 7 years in their current position. A notable observation emerges wherein 15 out of 31 workers were identified as members of the farm owner's family. Worth highlighting is the consistent male representation among farm owners across all 15 farms. Workers presented a low psychosocial risk profile. A significant correlation (Pearson correlation coefficient = -0.45, $p = 0.02$) between the weekly working hours and the ERGOROM score for psychosocial risk was found.

Regarding the location of reported pain represented schematically in Figure 2, it appears that a preponderance of pain localized in the dominant upper limb and the lumbar region is notable. The median number of painful areas reported is 2.

Following the INRS analysis, it appears that 42% of workers identified load carrying as the most physically demanding aspect of their work Manual work and awkward postures were respectively reported as the most physically demanding aspects of the job by 17% and 14% of workers.

**Table 1.** Characteristics of workers included in the study. Results are expressed under the form median [1st quartile-3rd quartile].

| | |
|---|---|
| N | 31 |
| Sex (M/F) | 5/26 |
| Age (years) | 45 [34-54] |
| Weight (kg) | 72 [60-81] |
| Height (cm) | 165 [160-172] |
| Workload in diversification (hours/week) | 30 [24-34] |
| Experience in diversification (years) | 7 [2-16] |
| ERGOROM psychosocial risk (/25) | 23 [22-24] |

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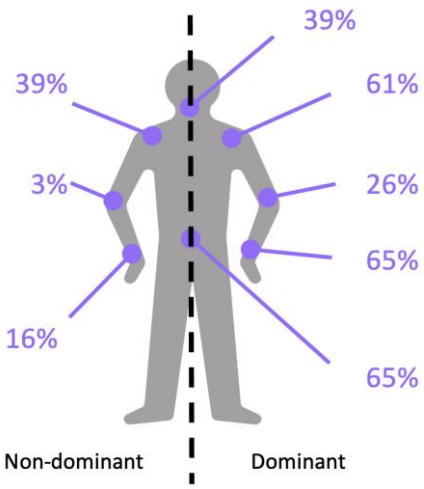


**Figure 2.** Percentage of workers reporting trunk and upper limb pain. The dotted line separates the dominant (D) and non-dominant (ND) limbs. Clockwise from ND wrist: ND elbow, ND shoulder, neck, D shoulder, D elbow, D wrist, lumbar region.

*3.2. Workplace analysis*

The comprehensive analysis of the various tasks scored using the adapted INRS method is presented in Figure 3. The KIM scores calculated for each sheet are given in Table 2 and displayed in Figure 4. They show that the tasks associated with manual handling of loads (LHC) and manual work (MHO) have the highest scores. Example of specific tasks related to different KIM forms are given in Figure 5.

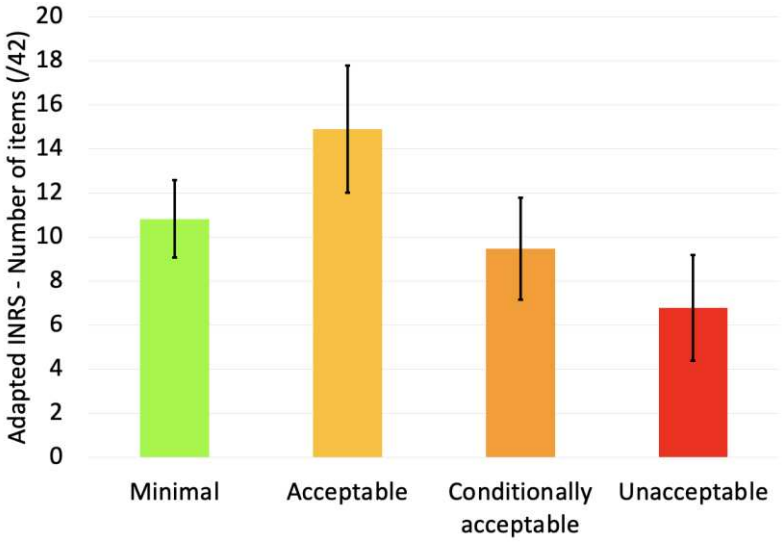


**Figure 3.** Average number of items (± standard deviation) associated with a minimal, acceptable, conditionally acceptable, or unacceptable risk by the INRS method in the workers observed. The 42 items belong to the following categories: (1) physical efforts (7+4 items), (2) dimensioning (7+3 items), (3) temporal characteristics (7 items), (4) environmental characteristics (5 items), (5) organization and psycho-social aspects (7+2 items).

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**Table 2.** KIM scores calculated for the various filled forms. Results are expressed under the form median [1st quartile-3rd quartile]. Only 3 PP forms have been filled, hence the individual values are given in this case. A KIM score between 50 and 100 indicates that preventive measures should be considered. A KIM above 100 indicates that the task could lead to MSD if work adjustment measures are not put in place. Abbreviations: KIM (Key Indicator Method), LHC (manual Lifting, Holding and Carrying loads), MHO (Manual Handling Operations), PP (Pushing/Pulling), ABP (Awkward Body Postures).

| KIM form | Number | Score |
|---|---|---|
| PP | 3 | 17, 22, 42 |
| ABP | 15 | 43 [28-55] |
| MHO | 29 | 44 [27-60] |
| LHC | 19 | 54 [44-74] |

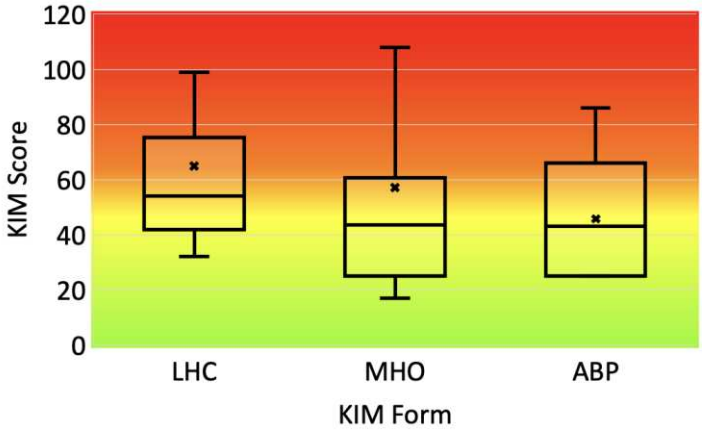


**Figure 4.** Boxplots summarizing the KIM scores calculated for the various filled forms. The color gradient highlights low-risk (green) and high-risk (red) areas for MSD. PP forms are not displayed since too few of them have been filled. Abbreviations: KIM (Key Indicator Method), LHC (manual Lifting, Holding and Carrying loads), MHO (Manual Handling Operations), ABP (Awkward Body Postures).


**Figure 5.** (A) Task related to KIM ABP form: Workers in the churn. (B) Task related to KIM MHO form: Packing butter clods. (C) Task related to KIM LHC form: handling buckets filled with yoghurt.

## 4. Discussion

The historical management of farms has traditionally been dominated by males, while farm diversification has primarily been undertaken by farmers' families, including their wives. This distribution of professional roles persists today. In 2020, a study conducted in Wallonia, revealed that 85% of farm managers were male, while women comprised 29% of the regular workforce, mainly

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holding associate roles on Walloon farms [2]. In line with this finding, our study sample predominantly consisted of women, constituting 84% of the population (Table 2), of which 35% were identified as farm managers' wives. Other workers were mainly employees, with 17 out of 21 being female, including some family members. We can therefore assume that our sample accurately represent the gender distribution in dairy farm diversification in Belgium.

Given that our population showcases a notable prevalence of women engaging in diversification, it raises the question of whether women are more susceptible to developing Musculoskeletal Disorders (MSD) than men. In [17] they used a modified standardized Nordic questionnaire and a rapid musculoskeletal assessment score sheet to collect data, as well as logistic regression methods to detect factors influencing MSD among 138 manual labor farmers in India. Results showed that, except for the shoulders, gender was the most significant factor influencing MSD across all upper body regions. The type of solicitations and constraints in occupational as in private life of women vs men could be at the origin of this result, although it remains to be elucidated.

Among the observed workers, diversification activities hold substantial significance, with a median reported time investment of 30 hours. The main task observed is butter production, which is a limitation due to our protocol: The observed dairy product depended on the visit day due to each farm's distinct weekly production schedule. Although our observations primarily focused on butter production, a more comprehensive study involving observations across farms for a week would have provided a broader understanding of product diversity.

As previously mentioned, 65% of the surveyed workers reported experiencing lumbar region pain, often attributed to load carrying. Several studies, such as [18], confirm the relationship between low-back pain and load bearing among 600 Irish farmers. The results of the study showed that among the 38 farmers with low-back pain due to farming activity, the majority targeted load carrying as the source of injury, followed by repetitive work. Global flexion of the spine could be also associated with the low-back pain described by 65% of farmers. The systematic review [19] established that awkward working postures, including stooping and squatting, correlate with an increased risk of low-back disorders among farmers. According to [20], out of 1130 workers (792 men, 338 women) in the agricultural sector (not only farm diversification), the highest prevalence, over the last 12 months concerned the shoulder in men (37%) and the hand/wrist area in women (49%). These two areas are also among the most painful in our workers too. In our study, lower back (65%), neck (39%) and, on the dominant side, shoulder (61%) and wrist (23%) emerged as the most painful regions, aligning with the findings of [21] in Sweden.

Psychosocial factors play an important role in the onset and/or duration of MSD. Indeed, work-related MSDs originate not only from physical stressors but also from psychosocial risks like job stress and dissatisfaction [22]. In this last work it is also suggested that, once an injury has occurred, psychosocial factors such as depression and inappropriate reactions to pain play a central role in the transition from acute to chronic pain, and in the development of disability. Our assessment revealed low levels of psychosocial risks within dairy diversification (Figure 3). Psychosocial factors seem rather positive in the context of diversification activity and could have a protective effect/represent health-promoting factor on the occurrence of MSD. Stressors identified in worker discussions included weekly workload, fear of not being able to meet demand, compliance with hygiene standards by the Federal Agency for the Safety of the Food Chain (AFSCA), and uncertainties about staff availability or machine operation. However, broader societal contexts were not considered in our questionnaires, such as the current energy crisis, for example. In this regard, it is worth noticing that, according to [23], small farms involved in diversification were more resilient that traditional small farms during COVID-19 pandemic, suggesting that this business model must be encouraged among farmers.

Load carrying emerges as the most challenging task, involving lifting and moving heavy containers of milk, cream, and butter (see Fig. 5C), some weighing up to 20 kg. Lifting is generally performed with lumbar flexion, as the containers are mostly stored on the ground; the loads must be placed precisely on the workshop table, which is an intense effort. This type of constraint in milk production has already been quantified among farmers in Brazil [24]. The perceived difficulty of these

 doi:10.20944/preprints202310.1291.v1



load-bearing tasks is objectified by KIM analysis, which yields the highest average score (Figure 4), partly due to our predominantly female subject group, the KIM method, being based on the ISO 11228-1 standard, differentiates between genders.

INRS analysis reveals a significant risk associated with awkward postures. The repetitive nature of certain frequently observed manual tasks, like butter packaging and sizing (Figure 5B), maintained for several hours with the head bent and arms slightly raised, is a high-risk factor for MSD, and correlates with the pain reported in the lumbar and cervical regions for example. Even if the INRS analysis globally reveals an acceptable risk level, the potential strain of seemingly "light" tasks in the long term must be considered [25]. This can be seen as a limitation of our study since our assessments do not consider the frequency of tasks performed per week, month, or year to assess whether a workstation presents a risk, even if a task is only performed once a week, for example. This is why focus on specific dairy processing tasks rather than the worker's entire workload. Another way of assessing the risk of developing MSDs would be to analyze a dairy processing worker over a full week, considering all the tasks performed in the production of all milk-based products.

Biomechanical strategies and psychosocial factors are intertwined: there is indeed a complex relationship between the response to physiological stress and chronic pain symptoms [26]. This relationship has been demonstrated (observed) in supermarket cashiers [27].

## 5. Conclusions

Our study among workers in dairy farm diversification indicates that manual handling risk emerges as a major constraint through KIM assessment. This risk factor potentially contributes to the high prevalence of lumbar complaints. Immediate adjustments to workspaces and equipment are generally feasible and adapting the workstation is an essential first step. In [16], we proposed pedagogical documents containing guidelines for workers in dairy diversification based on our present risk analysis and on the active participation of the workers. We emphasized the feasibility of adapting the work around the churn: using horizontal rather than vertical churns, using carts with adaptable heights etc. We also introduced resource movements to reduce or prevent pain so that workers may adapt their movements to improve mobility and strength. The dissemination of these guidelines is currently included in training courses given by PreventAgri for the Green Sectors in Wallonia. In Belgium, most farmers are self-employed, which means they are not subject to regular medical surveillance. That is why such training courses are of particular importance.

The shift from artisanal to semi-industrial dairy diversification, without ergonomic modification/adjustments, would greatly increase the risk of MSD due to intensified exposure to constraints. For example, the ABP KIM form has an average score of 46 for an average time factor equal to 1.3 hours per day. If a worker specializes in tasks with awkward postures, the time factor will increase. In this case, we estimate that a time factor of 3 hours per day would lead to a high-risk situation, with a KIM score over 100. While the role of ergonomists is vital in mitigating prolonged or repetitive work in awkward postures, this support remains relatively underrepresented, at least in Belgium. The growing importance of diversification in agricultural activities should, however, be followed by an increase in the resources allocated to this type of prevention, to safeguard farmers' health.

**Author Contributions:** Conceptualization, N.D., F.B. and J.Pa.; methodology, N.D., C.DS., J.P..; validation, F.T., J. Pa.; investigation, C. DS., F. T.; data curation, F.B., C. DS., F.T.; writing—original draft preparation, F.B., N.D., J. Pa., F.T., C.DS, J.P., F.D.; writing- reiew and editing, F.B., N.D., J. Pa., F.T., C.DS, J.P., F.D.

**Funding:** F.B., F.D. and F.T. acknowledge financial support from the European Regional Development Fund as part of the FWVl NOMADe Interreg project. The Interreg programme played no role in the realization of this study and no potential conflict of interest must be mentioned.

**Institutional Review Board Statement:** The study was conducted in accordance with the Declaration of Helsinki and approved by the Comité Académique de Bioéthique under file number B200-2022-107.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** Data are available in the OSF deposit https://doi.org/10.17605/OSF.IO/WXES8.

**Acknowledgments:** The authors thank all the farmers having participated in this study, HELHa's Communication Department for their support and S. Delneufcourt for sharing her adapted INRS method.

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

## References

1. Augère-Granier ML. Farm diversification in the EU [Internet]. European Parliamentary Research Service. 2016 [cited 2023 Sep 7]. Available from https://policycommons.net/artifacts/1333614/farm-diversification-in-the-eu/1938260/
2. Statbel. Chiffres clés de l'agriculture 2022 [Internet]. 2022 [cited 2023 Sep 7]. Available from https://statbel.fgov.be/fr/chiffres-cles-de-lagriculture-2022
3. García-Cornejo B, Pérez-Méndez JA, Roibás D, Wall A. Efficiency and Sustainability in Farm Diversification Initiatives in Northern Spain. Sustainability 2020; 12(10): 3983-4001.
4. Osborne A, Blake C, Fullen BM, Meredith D, Phelan J, McNamara J, Cunningham C. Risk factors for musculoskeletal disorders among farm owners and farm workers: A systematic review. Am. J. Ind. Med. 2012; 55(4): 376-389.
5. Osborne A, Blake C, Fullen BM, Meredith D, Phelan J, McNamara J, Cunningham C. Prevalence of musculoskeletal disorders among farmers. A systematic review. Am. J. Ind. Med. 2012; 55(2): 143-158.
6. Douphrate DI, Lunner Kolstrup C, Nonnenmann MW, Jakob M, Pinzke S. Ergonomics in modern dairy practice: a review of current issues and research needs. J. Agromedicine 2013; 18(3): 198–209.
7. Holmberg A, Stiernström EL, Thelin A, Svärdsudd K. Musculoskeletal Symptoms among Farmers and Non-farmers: A Population-based Study. Int J Occup and Environ Health 2002; 8(4): 339-345.
8. Malchaire J, Piette A, Cock N. Ergorom : cd-rom sur la connaissance et la prévention des troubles musculosquelettiques (TMS). Médecine du Travail & Ergonomie 2002; XXXIX(2): 93 – 96.
9. Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sørensen F, Andersson G, Jørgensen K. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. Appl Ergon 1987; 18: 233–237.
10. Karasek R. Job demands, job decision latitude, and mental strain: implications for job design. Adm Sci Q 1979; 24: 285–308.
11. Karasek R, Theorell T. Healthy Work: Stress, productivity and the reconstruction of working life. New York, N.Y.: Basic Books Inc. 44. Johnson JV, Hall EM; 1990.
12. INRS. Méthode d'analyse de la charge physique de travail [Internet]. 2019 [cited 2023 Sep 7]. Available from : https://ressources.inrs.fr/visionneuse/ED%206161/index.html#page-1
13. Direction Générale humanisation du travail. MANUTENTIONS MANUELLES FIFARIM - Fiche d'identification des facteurs de risques liés à la manutention [Internet]. 2008 [cited 2023 Sep 7]. Available from https://emploi.belgique.be/sites/default/files/content/publications/FR/FicheFIFARIM.pdf
14. Klussmann A, Steinberg U, Liebers F, Gebhardt H, Rieger, MA. The Key Indicator Method for Manual Handling Operations (KIM-MHO)—Evaluation of a new method for the assessment of working conditions within a cross-sectional study. BMC Musculoskelet Disord 2010; 11(1): 272-280.
15. Baua. Risk Assessment with the Key Indicator Methods (KIM) [Internet]. 2019 [cited 2023 Spe 7]. Available from: https://www.baua.de/EN/Topics/Work-design/Physical-workload/Key-indicator-method/Key-indicator-method_node.html?fbclid=IwAR1m5j2ROMXO7SX5C3kF8Luu8nVlXnJN-GnOYtU2KDO-TeAcb7DO1dj0Pbs
16. Buisseret F, Di Santo C, Jocelyn P, Draye N, Pannetier J. Dairy farm diversification & ergonomics. OSF; 2023. https://doi.org/10.17605/OSF.IO/WXES8
17. Jain R, Meena ML, Dangayach GS, Bhardwaj AK. Association of risk factors with musculoskeletal disorders in manual-working farmers. Arch Environ Occup Health 2018; 73(1): 19 28.
18. Osborne A, Finnegan G, Blake C, Meredith D, McNamara J, Phelan J, Cunningham C. An evaluation of low back pain among farmers in Ireland. Occup Med 2013; 63(1): 53 59.
19. Khan MI, Bath B, Boden C, Adebayo O, Trask C. The association between awkward working posture and low back disorders in farmers: A systematic review. J Agromedicine, 2019; 24(1): 74 89.

20. Cercier E, Fouquet N, Bodin J, Chazelle E, Geoffroy-Perez B, Brunet R, Roquelaure Y. Prévalence des symptômes musculo-squelettiques du membre supérieur chez les travailleurs de l'agriculture en France en 2010 : résultats de la phase pilote de Coset-MSA. Bull Epidémiol Hebd. 2015;(8):134-141.
21. Kolstrup C. Work-related musculoskeletal discomfort of dairy farmers and employed workers. J Occup Med Toxico 2012 ; 7(1): 23-32.
22. Menzel NN. Psychosocial Factors in Musculoskeletal Disorders. Critical Care Nursing. Med Clin N 2007; 19(2): 145-153.
23. Benedek Z, Fertő I, Galamba Marreiros C, Aguiar PMd, Pocol CB, Cechura L, Poder A, Paaso P, Bakucs Z. Farm diversification as a potential success factor for small-scale farmers constrained by COVID-related lockdown. Contributions from a survey conducted in four European countries during the first wave of COVID-19. PLoS One 2021; 16(5): e0251715-18.
24. Caldas de Oliveira C, Augusto de Paula Xavier A, Ulbricht, L, Pereira Moro AR, Belinelli MM. Health in the rural environment: a postural evaluation of milking workers in Brazil. Cah Agric 2018; 27 : 35004-35012.
25. Messing K, Lippel K. L'invisible qui fait mal. Travail, genre et sociétés 2013; 1(29): 31 48.
26. Crofford LJ. Chronic Pain: Where the Body Meets the Brain. Trans Am Clin Climatol Assoc 2015; 126: 167-183.
27. Sansone V, Bonora C, Boria P, Meroni R. Women performing repetitive work: is there a difference in the prevalence of shoulder pain and pathology in supermarket cashiers compared to the general female population? Int J Occup Med Environ Health 2014; 27(5): 722–735.