ERGONOMIC ANALYSIS OF BEEKEEPING

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Abstract
In beekeeping, which has high potential for positive contributions to sustainable development and environmental, social, and economic impacts, all work is carried out by human labor. These tasks, which involve different and awkward body postures, can lead to musculoskeletal disorders. Therefore, this study conducted an ergonomic analysis of beekeeping activities and proposed solutions to potential risks. The study administered the Nordic Questionnaire to beekeepers and then used the OWAS to identify risky body postures. Seven frequently repeated body postures were identified. The highest ergonomic risk (score of 4) was found in the forward bending position. Consequently, 60% of participants experienced back pain. The risk score for hive handling and kneeling postures was 3 (dangerous). Participants' neck (30%) and knee (25%) pain corresponded to these results. To mitigate these risks, adjusting hive heights and auxiliary agricultural equipment for hive handling were recommended.

Key words: *beekiping; ergonomic risk; musculoskeletal disorder; OWAS;* agricultural ergonomi

INTRODUCTION

According to 2023 data, Türkiye ranks third in the world (after China and India) with over 9 million (9,224,881) colonies and second in the world (after China and Iran) with approximately 115,000 tonnes (114,886.43) of honey production (FAO, 2025). The beekeeping sector and honey production have always been important to the global economy (Aiyeloja et al., 2015) and our country (Güler, 2017). According to official statements by the Eastern Black Sea Exporters' Association (DKİB), Türkiye's honey exports in the first half of 2025 amounted to 4,577 tonnes, generating revenue of 16,624,000 dollars (Anonymous 1, 2025). In addition to its direct contribution to the Turkish economy, beekeeping indirectly contributes by increasing production quantities and fruit quality through pollination activities (Anonymous 2, 2025). Türkiye is a suitable country for beekeeping due to its long and rich flowering season, which is influenced by its seven different geographical regions (Güler, 2017). With this potential, Türkiye is an important honey producer in the world.

Beekeeping is generally a traditional occupation in Europe; in countries such as Spain, Poland, Hungary, Greece and Türkiye, it is a means of increasing rural income; In East Asian, Central, and South American countries, it is an important source of foreign income, while in countries such as the United States, Canada, and Japan, it is primarily carried out for pollination in plant production (Arslan, 2016). Honeybees are the number one factor in pollination for the continuity of plant production worldwide and have become a necessity for the continuity of humanity (Arslan, 2016). Beekeeping plays an important role in the agricultural sector, but it also poses potential health risks due to the physical postures adopted during the process (Hurst, 2006).

A beekeeping season is divided into four main periods: the critical spring period, the pre-nectar flow period, the main nectar flow period, and the post-nectar flow period (Güler, 2017). The tasks performed during each period vary but mostly require physical strength. The beekeeping aims to ensure that colonies enter the main nectar flow period in a strong condition. In line with this aim, colony maintenance, which becomes more frequent during the pre-nectar flow period, is carried out weekly. During these maintenance activities, colony management practices such as providing combs, feeding syrup, rearranging the hive, adding frames, and removing swarms are carried out. Towards the end of this period, which involves frequent bending and squatting, the colonies are transported to

Proceeding of the 9th International Conference on Trends in Agricultural Engineering 2025
ISBN 978-80-213-3541-7
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designated areas to pass through the main nectar flow period, mostly by loading and unloading them onto trucks using muscle power. The honey harvest takes place at the end of the main nectar flow period.

Depending on the capacity of the operation, harvesting is done with automatic machines, while small family businesses use harvesting machines that operate with manual labour. Migrant beekeepers who follow the nectar flow in multiple regions throughout the year repeat this period multiple times. In the period following the main nectar flow, unlike the period before the nectar flow, practices such as comb removal, frame removal, and colony merging are carried out. During these practices, beekeepers engage in high-risk activities such as heavy lifting, manual carrying, bending, and assuming awkward positions (Fels et al., 2019).

On the other hand, the number of colonies a beekeeper has determines their workload. The more colonies there are, the greater the workload, which means that beekeepers are affected by weather conditions for more extended periods (Mujuni et al., 2012; Zheng et al., 2018). According to the Occupational Safety and Health Administration (OSHA), honey production is considered a high-risk sector in terms of human health (Hurst, 2006).

As is the case worldwide, machinery and technology are used in modern agriculture in Turkey, but human labor still carries out some areas of work manually. During the manual execution of agricultural tasks, unusual body postures and repetitive movements can negatively affect joints in different body parts, leading to injuries and discomfort (Naeini et al., 2014). When these discomforts become chronic, they can develop into Musculoskeletal Disorders (MSDs), significantly contributing to occupational diseases and loss of workforce productivity. A study examining the ergonomics of beekeeping activities by Özgün et al. (2024) reported that the most common health issues were back and neck pain.

Many studies have been conducted on ergonomic risks and scores in the agricultural sector. These studies mainly cover greenhouse farming, fruit and vegetable harvesting, processing grains, and other products. In studies conducted on soil cultivation with motorised hoes (Eminoğlu et al., 2010), olive harvesting (Calvo et al., 2018), and pineapple farming (Singh & Karmakar, 2021), ergonomic risk assessment tables developed to identify improper body postures were used. In all of these studies, it was found that workers exhibited improper body postures, were exposed to strain, and, as a result, had low to high ergonomic risk scores depending on the body region. These risks typically manifested as pain and discomfort in the neck, back, shoulders, and wrists (Fathallah et al., 2008). Most workers were found to have MSDs.

This study aims to identify ergonomic risks caused by beekeeping activities and the resulting MSDs, and to propose solutions if necessary.

MATERIALS AND METHODS

The study consists of two main stages. In the first stage, beekeepers were given the standardised Nordic questionnaire to analyze musculoskeletal symptoms in the context of occupational health and assess whether their work causes ergonomic strain, excessive load, and pressure. The questions in this questionnaire focus on the most common symptoms encountered in the occupational environment (Kuorinka et al., 1987). The questionnaire analyses nine body regions to determine the onset of pain (Motamedzadeh et al., 2022) (Figure 1). For the questionnaire, 20 individuals in beekeeping across Turkey were randomly selected, including 19 men and one woman, who voluntarily participated. Participants were asked whether they had any long-term illnesses or reported illnesses and whether they had chronic pain.

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ISBN 978-80-213-3541-7
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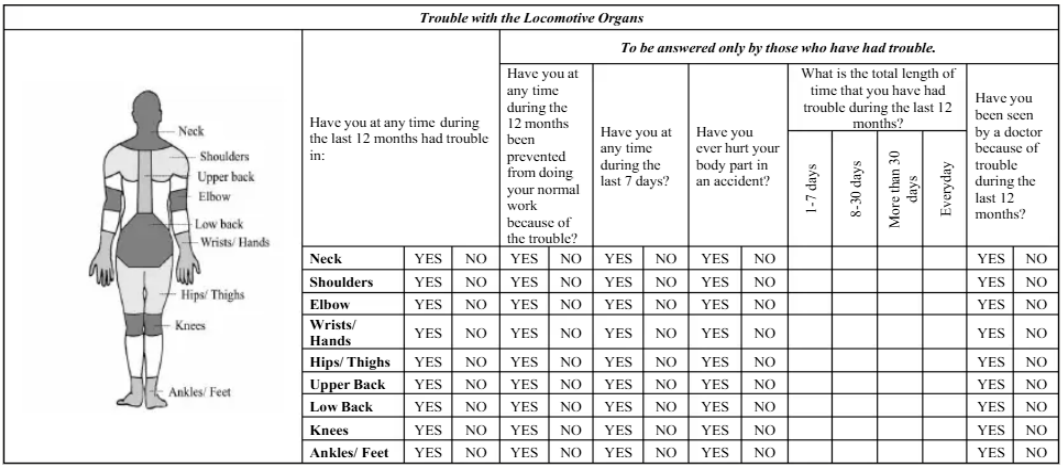

Fig. 1 Nordic Questionnaires (Erdinç, 2019)

The data obtained at the end of the survey were subjected to a chi-square test in the SPSS programme to determine whether there was a significant difference between the variables. Following the survey, video recordings were taken of the beekeepers who participated in the survey during the July 2025 season in Kırşehir Province. Migrant beekeepers were not included in the study. The study coincided with the post-nectar flow period; the most frequently repeated movements were identified and referred to as work stations. The most frequently repeated body postures of the workers during their work were:

- Leaning forward (opening the hive lid, removing and replacing honeycombs)
- Standing (feeding bees with honey and syrup)
- Lifting loads (transferring hives or honeycombs)
- Holding loads while standing (removing honeycombs from the hive and observing them)
- Kneeling (blowing smoke into hives)
- bending forward to lift loads (adding frames to hives) and
- Using a wheelbarrow (transporting other materials) has been observed.

During the lifting operation, the average weight of the empty hives was 15 kg. In comparison, the weight of the honeycomb-filled hives transported during the removal process was approximately 40 kg.

Subsequently, screenshots of each movement were taken. Ergonomic analyses were performed using the OWAS method in the ErgoFellow version 3.0 software package, and the existing strains and associated risks were identified. The OWAS method covers almost all of the body postures exhibited by beekeepers during work, compared to other ergonomic risk analysis methods, which is why this method was preferred. OWAS has been widely used in various fields and professions for decades due to its simplicity, practicality, and proven validity (Tajvar et al., 2009).

RESULTS AND DISCUSSION

The short version of the Nordic questionnaire (Figure 1) was used in the study. Twenty of the 40 randomly selected beekeepers (19 men and one woman) responded to the questionnaire. The demographic values based on the responses to the questionnaire are presented in Table 1.

Tab. 1. Demographic structure of the participants

Variables	Minimum	Maximum	Mean	Std. Deviation
Age	19	70	42,8	10,9
Weight	67	125	87,5	13,4
Height	156	193	176,1	9,0
WorkExperience	2	60	17,1	14,8

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ISBN 978-80-213-3541-7
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WeeklyWorkHours	2	96	25,0	23,4
BMI	24	34	28,1	2,2

When the survey responses were analysed, it was found that only one of the participants was female and that her primary occupation was not beekeeping. Of the 20 participants, only three had beekeeping as their primary occupation, while the others practised beekeeping as a hobby or source of additional income. The person who has been beekeeping for the longest time has been doing this job for 60 years and works an average of 60 hours per week. This shows that beekeeping is a labour-intensive occupation. The oldest beekeeper is 70 years old, while the youngest is 19. The average age of the participants is 42.8, placing them in the younger generation group. Participants engage in beekeeping activities for an average of 25 hours per week. When examining the participants' body mass indices (BMI), the lowest was 24 and the highest was 34. The average BMI was 28.1.
According to the responses to the survey, it has been revealed that all individuals engaged in beekeeping have experienced pain/discomfort in various parts of their bodies at least once in the past year. The widespread distribution of this condition, which we can refer to as MSDs, is shown in Figure 2.

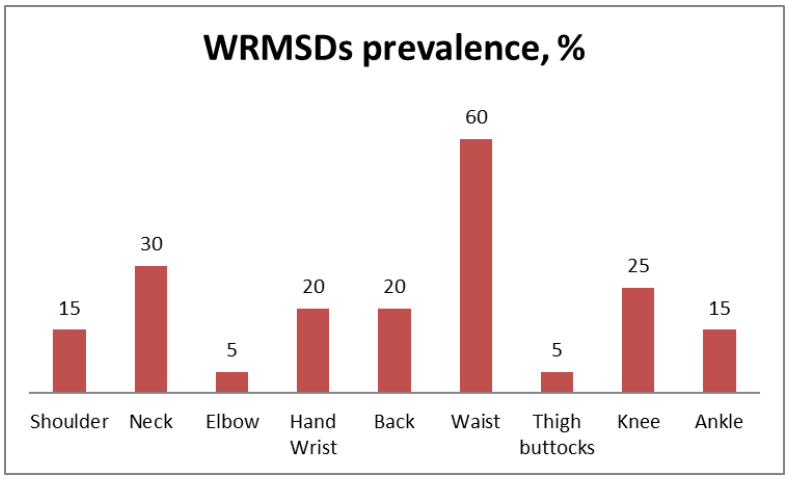

Fig. 2MSDS exposure of employees in the last 12 months, %

When examining Figure 2, it can be seen that the highest strain is in the lumbar region at 60%, followed by the neck at 30% and the knees at 25%. This result is consistent with the results obtained in the OWAS assessments.
The body postures exhibited by participants during work have been categorised as frequently repeated and referred to as workstation postures. Accordingly, the postures examined are leaning forward (a), kneeling (b), standing (c), lifting loads (d), holding loads while standing (e), transporting loads with a handcart (f), and lifting loads while leaning forward (g), as shown in Figure 3.

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ISBN 978-80-213-3541-7
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Fig. 3. Repetitive body postures of beekeepers during work

Tab. 2. The p-values between the demographics and the prevalence of WRMSDs. *p-value less than 0.05 is significant.

Demographics	Body regionswithWRMSDs								
	Shoulder	Neck	Elbow	Hand&Wrist	Back	Waist	Thigh&Buttocks	Knee	Ankle
Work experience	0,819	0,566	0,22	0,465	0,465	0,514	0,22	0,422	0,541
Weekly Workhours	0,548	0,218	0,578	0,921	0,373	0,518	0,876	0,812	0,548
BMI	0,395	0,395	0,414	0,395	0,395	0,395	0,395	0,395	0,395
Age	0,22	0,42	0,304	0,311	0,812	0,65	0,589	0,244	0,53
Weight	0,623	0,343	0,736	0,205	0,471	0,527	0,989	0,39	0,095
Height	0,515	0,428	0,989	0,728	0,392	0,527	0,095	0,602	0,781
Gender	0,028*	0,008*	0,029*	0,077	0,02*	0,005*	0,087	0,16	0,02*

Table 2 shows that gender affects the shoulder, neck, elbow, back, waist, and ankle. However, since these data were collected from individuals whose occupation was not exclusively beekeeping, it cannot be claimed that beekeeping activities directly cause the current pain. Age, weight, and height factors did not have a significant (<0.05) effect on the presence of MSDS. These results are consistent with Kwok et al. (2023).

Tab. 3 OWAS ergonomic risk score for participants' body postures

Body Postures	Ergonomic Risk Skore
Bendingforward	4

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ISBN 978-80-213-3541-7
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Standing	1
Lifting	3
Holding a loadwhilestanding	1
Lifting a loadwhileleaningforward	3
Carrying a wheelbarrow	3
Kneeling	3

The OWAS assessment of participants' body postures is shown in Table 3. According to this, the highest risk score was obtained in the forward bending posture, while the lowest was obtained in the standing and load-bearing postures. The degree of impact of the risk scores and the action plan is shown in Table 4.

Tab. 4. OWAS risk score rating and action plan

Category	Action category/level	Explanation
1	Normal Posture	Normal positions that do not require any special caution
2	Not too much forced	During the next regular check of working methods, stops must be considered
3	Too load and force	Positions must be taken into consideration soon
4	Loading and forcing too much	Positions need to be evaluated immediately

When surveydata and OWAS results are evaluated together, the forward bending posture has the highest risk score (4), corresponding to the survey results showing that the highest strain occurs in the lumbar region (60%). According to the OWAS emergency action plan, a risk score of 4 is considered significantly harmful and requires immediate action to change body posture. Tasks with a risk score of 3, such as lifting loads, lifting loads while leaning forward, kneeling, and pushing a wheelbarrow, fall into the category of tasks with clearly harmful effects that require changes to be made as soon as possible. Standing and lifting loads while standing have a risk score of 1, indicating they have no harmful effects and do not require any action.

The analysis results from the survey data and the ergonomic risk assessment conducted according to the OWAS method revealed that beekeeping activities cause MSDS. The highest strain was found to be forward bending, which is consistent with the study by Kwok et al. (2023).

Forward bending and lifting while bending over at workstations pose the highest risk and strain the back and lumbar region the most. This finding is consistent with a study conducted in Italy, which found that the risk of back injury increases with the duration of risk exposure and varies between acceptable and borderline levels in men (Mania et al., 2016). Bending over beehives during work hurts the skeletal system. Farmers and beekeepers are particularly at risk of work-related musculoskeletal disorders (Osborne et al., 2012; Maina et al., 2016), and studies to identify these risks are ongoing (Colombini et al., 2012).

On the other hand, the average height of the hives in the apiary where the study was conducted is 40 cm above the ground. Considering that the average height of the participants is approximately 176 cm, bending forward is inevitable. However, the high risk score of these movements and their constant repetition may increase exposure to risk and cause the progression of MSDS. In a study conducted in Kenya, it was recommended that the height of hives should be between 80 and 84 cm based on the average height of people working in beekeeping activities (Aiyeloja et al., 2015). Based on this information, installing an ergonomic hive platform with an adjustable height suitable for the average height of workers in each apiary will significantly reduce the risk. Ergonomic work helps reduce physical stress on the worker's body and eliminates musculoskeletal disorders. From a beekeeping perspective, the type and height of hives and ergonomic work practices are crucial for the healthy conduct of the activity (Pocol et al., 2019). Therefore, the ergonomic efficiency of beehives is necessary and important for improving harvesting conditions, reducing stress on beekeepers, and ensuring high-quality bee products (Günbey, 2007).

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ISBN 978-80-213-3541-7
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Although some jobs and postures in the agricultural sector are similar, improvements suitable for one job may not be applicable or practical for another. Each task or job exerts different forces and pressures on the body, so the priority actions to alleviate MSDs vary (Kwok et al., 2023). Although ergonomic risks have been identified and solutions proposed, due to the nature of agricultural work, it is anticipated that manual labour will continue to play a significant role in the agricultural sector in the foreseeable future, despite advances in modern agricultural technology (Benos et al., 2020).

CONCLUSIONS

Beekeeping is an ancient activity that has been practised throughout history. In addition to its environmental, social, and economic impacts, it has a high potential to contribute positively to sustainable development. Bees are an integral part of integrated farming systems regarding their role in food security and biodiversity conservation. Beekeeping activities, which account for a significant share of the economy as a primary and supplementary source of income, can significantly improve the well-being of those working in the field by minimising ergonomic risks and strains to the greatest extent possible. This is one of the key steps in ensuring the work's sustainability. Based on this important information, identifying ergonomic risks and making improvements during beekeeping activities will increase the working well-being and quality of life of those working in this sector. The solution to the identified risks and issues can be achieved by improving the level of mechanisation. Only a limited number of studies are conducted on the ergonomic risks associated with beekeeping activities. However, addressing ergonomic strain, identifying MSDs, and proposing solutions will provide a sustainable and comfortable working environment for the important industry of beekeeping and reduce medical expenses.

The workstation with the highest risk score was leaning forward. The main reason for this posture can be attributed to the height of the hives not being ergonomically balanced with the worker's height. To eliminate this problem, the first suggestion would be to place stool-like heights under the hives, but since moving and placing these stools would require additional work, it may not reduce the ergonomic risk. Instead, a mechanically adjustable hive lifting platform could be designed. Since the working height on this platform can be adjusted according to the worker's height, it will significantly reduce the forward-leaning posture. Therefore, it will lower the ergonomic risk level. This platform will also eliminate the need to stand on one's knees. The most important point here is transporting the hives slowly and carefully. A self-propelled carrier or a wheeled transporter that can be pushed is recommended for transporting the hives. However, to use a self-propelled mobile carrier, the existing terrain must provide suitable conditions for mechanisation. Considering that this condition is rarely feasible in practice, a wheeled transporter operated by human labour may not eliminate ergonomic risks, but can help reduce them.

All mechanisation applications proposed in this study must be designed, manufactured, tested, used, and analysed. Furthermore, identifying MSDs, presenting proposed solutions, and implementing them can only be achieved through interdisciplinary collaboration between physiotherapists, agricultural machinery engineers, and ergonomists. Only in this way can the confidence interval of the proposals be determined. From this point forward, our research group aims to manufacture the proposed mechanisation systems, make them available to farmers, and conduct another ergonomic risk analysis. Nevertheless, it should not be forgotten that no mechanisation device can eliminate ergonomic risks.

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