ORIGINAL RESEARCH

Work-Related Musculoskeletal Disorders in Apple Farmers in Türkiye: Prevalence and Risk Factors

Gullu Aydin Yagcioglu[1*] (iD) Handan Culal Kilic[2] (iD)

[1] University of Health Sciences Gülhane Faculty of Health Sciences Department of Orthotics and Prosthesis, Ankara, Türkiye
[2] Isparta University of Applied Sciences Faculty of Agriculture Department of Plant Protection, Isparta, Türkiye

* Corresponding Author: Gullu Aydin Yagcioglu, e-mail: gullu.aydinyagcioglu@sbu.edu.tr

Abstract

Objective: The strenuous nature of apple growing can be the cause of a number of physical problems. This study was conducted to identify the prevalence of Work-Related Musculoskeletal Disorders (WRMSDs) and ergonomic risks among apple farmers in Türkiye.

Material-Method: Data on WRMSDs were obtained from the Nordic Musculoskeletal Questionnaire Extended Version (NMQ-E), while risk factors were collected using the Rapid Upper Limb Assessment (RULA). Prevalences were established by frequency analysis. The relationships between WRMSD of 9 body regions and age, weight, working hours (per day/per week), working experience and RULA score were analyzed by binomial logistic regression analysis.

Results: A total of 51 volunteers participated in the study including 42 males and 9 females. The knees (53.8%) were the most common WRMSDs reported over a lifetime, followed by the neck (46.2%), lower back (44.2%), and shoulders (38.5%). Participants were working in a medium (40.4%) and high (42.3%) risk posture according to the RULA assessment. Age, weight, working hours (per day/per week), work experience and RULA were associated with WRMSDs in one or more body regions (p<0.05).

Conclusion: WRMSDs were common among the apple farmers in Türkiye and the farmers were working in a high-risk position. The current findings highlight the need to address the high prevalence of WRMSD among apple farmers through appropriate screening and intervention.

Keywords: Work-Related Musculoskeletal Disorders, Rapid Upper Limb Assessment (RULA), Nordic Musculoskeletal Questionnaire Extended Version (NMQ-E), Ergonomic Risk Factors, Apple Farmers

INTRODUCTION

Work-related musculoskeletal disorders (WRMSDs) are injuries to muscles, nerves, ligaments, tendons, spinal cord or joints caused by hazardous situations such as prolonged awkward postures, exposure to trauma, repetitive movements, and psychosocial pressures during work tasks.[1] The International Labour Organization has shown that WRMSDs cause approximately 160 million work-related illnesses worldwide each year, thus making them an important global occupational health and socioeconomic problem.[2] WRMSDs are known to cause pain, fatigue, limitation of movement, loss of muscle strength, and stress as well as reduced quality of life, physical activity levels and work performance.[3,4] The agricultural sector is a major risk factor for WRMSDs as it involves large numbers of workers worldwide and includes hazardous work activities.[5] Agricultural work also is different from other

professions as it involves working in difficult conditions, both indoors and outdoors.[6] Their working conditions include psychological pressures as well as physical challenges such as heavy loads, poor posture, and exposure to vibration from agricultural implements and power tools. These risks make agricultural workers vulnerable to musculoskeletal disorders.[6,7]

Apple is a product that can adapt to different climates so, its cultivation is quite common throughout the world as well as in Türkiye.[8] According to the data provided by the Food and Agriculture Organization in 2015, Türkiye ranked 3rd in the world in apple production in 2012.[9] Pre-harvest, harvest and post-harvest activities of apple farmers include pruning, picking, packing, etc., and these activities may require prolonged and repetitive movements, heavy lifting, prolonged standing/sitting and working in

positions with the upper extremity above the head. Some studies on farmers in different countries have shown that farming can cause musculoskeletal disorders, pain and/or loss of work capacity.[5,6,10-12] For this reason, the risks and prevalence of WRMSDs due to working postures of apple farmers in Türkiye, which covers a wide area of apple growing, should be determined and this study was planned for this purpose.

MATERIALS AND METHODS
Participants
The cross-sectional study was conducted among apple farmers in Türkiye. Ethical approval was granted by the Ethics Committee of the University of Health Sciences (Approval number; 2023/188). An informed consent form was signed by the apple farmers before the physical examination.

Inclusion criteria were: age 18-65 years, apple farmer for at least 1 year, and volunteer for the study. Exclusion criteria were as follows: any history of musculoskeletal surgery in the last two years, chronic musculoskeletal diseases, and cognitive problems.

After recording demographic characteristics (age, body mass index (BMI), gender, work experience, weekly working hours, daily working hours, etc.), the individuals who met the inclusion criteria were assessed using the following assessment tools.

Measurement Tools
Work-related musculoskeletal disorders assessment
The Nordic Musculoskeletal Questionnaire Extended Version (NMQ-E) was used to assess the prevalence of WRMSDs in apple farmers. The NMQ-E covers nine body regions: neck, shoulder, upper back, elbow, wrist/hand, lower back, hip/thigh, knee, and ankle/foot and provides reliable information on the onset, prevalence and consequences of musculoskeletal disorders. For each domain, apple farmers completed questions on prevalence (lifetime, 12-month, 4-week and point prevalence), age at onset, lifetime effects (hospitalisation and activity impairment) and effects within the last 12 months (activity impairment, healthcare use, medication use and sickness absence).[13,14]

Risk factor assessment
The Rapid Upper Limbs Assessment (RULA) was used to evaluate risk factors in apple farmers during work. The RULA assessment divides all parts of the body into two groups: Group A includes the upper arms, forearms, and wrists, while Group B includes the neck, trunk, and legs. Repetitive movements or prolonged static positions during work on the relevant body part increase the risk score. Group-A and Group-B scores are combined to produce a final score on the RULA worksheet. Grand score is listed as follows: Score 1-2= posture is acceptable (Negligible); Score 3-4= further investigation is required, and changes may be needed (Low); Score 5-6= investigation and changes are required soon (Medium); Score 7= immediate investigation and changes are needed (High).[15]

The relationships between WRMSDs of 9 body regions and age, weight, working hours (in a day), working hours (in a week), work experience (in years), and RULA score were analysed.

Statistical analysis
Statistical Package for Social Science (SPSS) version 26.0 software was used to analyse. Descriptive statistics were used to quantify the prevalence and risk factors of WRMSDs. Quantitative data were characterized by mean and standard deviation (X±SD), and qualitative data were expressed as number/percentage (n/%). Binomial logistic regression analysis was used to identify factors associated with WRMSDs in each body region. Odds ratios (OR) and 95% confidence intervals (CIs) are used to present the results of the analysis. The level of statistical significance (p) was accepted as <0.05.

RESULTS
Initially 69 farmers participated in the study, but 18 farmers were illiterate or unable to complete the assessments for some reason and were therefore excluded. A total of 51 volunteers were included in the study, including 42 males and 9 females. The mean age of the farmers was 54.94 (range 18-80) years. Table 1 details the characteristics of the participants.

Of the nine body regions, the knee (53.8%) was the most commonly reported WRMSD over a lifetime, followed by the neck (46.2%), lower back (44.2%), and shoulder (38.5%). These body regions were also the most commonly reported WRMSDs in the last 12 months, last month and today. Table 2 summarizes the distribution of WRMSDs reported by farmers in different parts of body.

The results of the study showed that the majority of the participants worked in a medium (40.4%) and high (42.3%) risk postures according to the RULA assessment. The results of the RULA assessment of the apple farmers are shown in Table 3.

The results of the binomial logistic regression analysis examining the relationships between WRMSD of 9 body regions and age, weight, working hours (in a day), working hours (in a week), work experience (in years), and RULA Grand score are presented in Table 4.

Table 1. The characteristics of the study population

Variables	Min – Max	Mean (SD)
Age (years)	18 – 80	54.94 (14.33)
Height (cm)	155 – 195	169.64 (9.18)
Weight (kg)	53 – 125	80.03 (16.82)
Body Mass Index (kg/m^2)	18.52 – 36.73	27.67 (4.57)
Working hours (in a day)	4 – 12	7.92 (0.91)
Working hours (in a week)	15 – 56	49.72 (11.98)
Working experience (in years)	1 – 50	13.45 (12.69)
	N	**%**
Smoking		
Yes	13	25.5
No	38	74.5
Education level		
Primary school	16	31.4
Middle school	9	17.6
High school	11	21.6
University	15	29.4

Min: Minimum; Max: Maximum; SD: Standard Deviation; cm: centimeter; kg: kilogram; m: meter; N: Participation number

Table 2. Summary of distribution of WRMSDs in different body parts on the basis of NMQ-E

Body region	Lifetime		Last 12 months		Last Month		Today	
	Frequency	(%)	Frequency	(%)	Frequency	(%)	Frequency	(%)
Neck	24	46.2	22	42.3	22	42.3	19	39.5
Shoulders	20	38.5	18	34.6	18	34.6	18	34.6
Upper back	12	23.1	12	23.1	11	21.2	11	21.2
Elbows	11	21.2	11	21.2	11	21.2	10	19.2
Wrists/hands	14	26.9	14	26.9	13	25	12	23.1
Lower back	23	44.2	22	42.3	21	40.4	21	40.4
Hips/Thighs	11	21.2	11	21.2	10	19.2	9	17.3
Knees	28	53.8	25	48.1	24	46.2	22	42.3
Ankles/feet	12	23.1	11	21.2	11	21.2	11	21.2

Table 3. Result of RULA final score

RULA Score	Min	Max	Mean (SD)
Group A	5	9	6.35 (1.26)
Group B	3	7	5.29 (1.52)
Grand Score	4	7	6.33 (0.93)
Risk Level		**N**	**%**
1-2	**Negligible**	4	7.8
3-4	**Low**	4	7.8
5-6	**Medium**	21	40.4
7	**High**	22	42.3

RULA: The Rapid Upper Limbs Assessment, Min: Minimum, Max: Maximum, SD: Standard deviation, Group A: includes the upper arms, forearms, and wrists, Group B: includes the neck, trunk, and legs, N: Participation number

Table 4. Factors associated with lifetime prevalence of WRMSDs in the each body region: binomial logistic regression.

WRMSDs	Age OR	95% CI	p	Weight OR	95% CI	p	Working hours (in a day) OR	95% CI	p	Working hours (in a week) OR	95% CI	p	Working experience (in years) OR	95% CI	p	RULA Grand Score OR	95% CI	p
Neck	0.94	0.86 – 1.03	0.20	**0.48**	**0.24 - 0.98**	**0.04***	0.99	0.95 – 1.03	0.74	0.84	0.67 – 1.03	0.84	0.97	0.89 – 1.04	0.45	0.06	0.00 – 1.54	0.09
Shoulders	**0.89**	**0.81 – 0.97**	**0.01***	1.05	0.99 – 1.12	0.09	0.51	0.19 – 1.38	0.18	1.03	0.96 – 1.10	0.36	0.95	0.90 – 1.01	0.17	**0.30**	**0.10 – 0.83**	**0.02***
Upper back	**0.79**	**0.66 - 0.94**	**0.00***	1.02	0.98 – 1.16	0.11	**0.17**	**0.03 – 0.83**	**0.02***	**1.09**	**1.00 – 1.20**	**0.04***	0.93	0.87 – 1.01	0.08	0.26	0.06 – 1.09	0.06
Elbows	0.99	0.92 – 1.06	0.88	1.00	0.95 – 1.05	0.91	1.07	0.43 – 2.65	0.88	1.04	0.97 – 1.12	0.22	**0.93**	**0.87 – 0.99**	**0.04***	0.95	0.38 – 2.35	0.91
Wrists/hands	1.01	0.96 – 1.07	0.54	1.00	0.96 – 1.04	0.91	1.31	0.53 – 3.24	0.55	1.01	0.94 – 1.08	0.71	0.96	0.91 – 1.02	0.22	1.43	0.68 – 3.02	0.34
Lower back	0.98	0.93 – 1.03	0.57	0.99	0.96 – 1.03	0.95	0.51	0.18 – 1.38	0.18	1.06	1.00 - 1.13	0.05	0.96	0.91 – 1.02	0.23	0.78	0.38 – 1.62	0.51
Hips/Thighs	0.96	0.89 – 1.03	0.34	**0.93**	**0.88 – 0.99**	**0.03***	2.46	0.55 – 10.87	0.23	1.00	0.91 – 1.11	0.87	0.95	0.88 – 1.02	0.18	1.17	0.45 – 3.03	0.73
Knees	0.95	0.90 – 1.00	0.06	0.99	0.95 – 1.03	0.83	0.00	0.00 – 0.00	0.99	0.99	0.92 – 1.06	0.92	1.00	0.95 – 1.06	0.82	0.74	0.36 – 1.51	0.41
Ankles/feet	**0.90**	**0.82 – 0.99**	**0.03***	1.02	0.96 – 1.07	0.49	0.84	0.26 – 2.66	0.77	1.00	0.94 – 1.07	0.88	1.03	0.96 – 1.10	0.38	0.98	0.45 – 2.16	0.97

RULA: The Rapid Upper Limbs Assessment; OR: Odds Ratio; p: Significance Value; 95%CI:Confidence Interval; *: indicates an association

DISCUSSION

The strenuous nature of apple growing, both before and after harvest, can cause a range of physical and mental problems.[16,17] This study was conducted to identify the prevalence of WRMSDs and ergonomic risks among apple farmers in Türkiye. Literature on the assessment of WRMSDs and ergonomic conditions in this population is limited.[11,18-21] To help fill this gap, this study is an attempt to evaluate the WRMSDs and risk factors among apple farmers in Türkiye. The results of the current study showed that musculoskeletal disorders are common in this specific occupational group, that individuals mostly work in high-risk postures, and that musculoskeletal problems in different body regions of individuals increase with age and work experience.

The prevalence of WRMSD symptoms in the study population was very high. The results of the current study showed that 80.4% of the people in the study had experienced a musculoskeletal problem in at least one part of their body during their lifetime. WRMSDs were most common in the knees and least common in the elbows and hips/thighs. The knees were followed by the neck, lower back and shoulders. The current findings show that the results of the present study are consistent with the literature and that apple picking causes problems such as increased pain, discomfort and aching in all parts of the body, particularly in the areas mentioned. In a study of apple growers in Iran, the findings were similar to our study and the most common WRMSDs in Iranian apple growers were observed in the lumbar, knee and neck regions.[16] In another study, the body regions most affected by WRMSDs in American apple growers were the shoulder and back.[11] In a study investigating musculoskeletal symptoms in Japanese female farmers during apple bagging, the shoulder, neck, leg and lower back were the regions with the most stiffness and pain symptoms.[19] Pruning, which is one of the pre-harvest activities in apple growing, is particularly common in positions where the shoulders are above the head. In addition, when picking apples, workers tend to work with their heads up and arms outstretched, which means that the muscles around the shoulders are used excessively and they remain in a static position for long periods of time, putting muscles and tendons at risk. Farmers are also exposed to constant bending and straightening and excessive strain on the lower back when loading and transporting apples in crates. Much of this work is done standing, bending or lying down. This puts strain on the knees. These working conditions may explain the prevalence of musculoskeletal disorders, particularly in the affected parts of the body.

Similar to WRMSDs, work-related risk factors were quite high in this study population. It was determined that 82.7% of the individuals included in the study worked in high-risk positions and their weekly working hours were significantly high despite working in this awkward posture. The fact that these farmers spent an average of about 50 hours per week

in a very awkward posture in agricultural activities would lead to occupational injuries. Very little research has focused on identifying awkward activities/postures of apple growers before or after harvest, and the results in different countries have been similar to those of apple farmers in Türkiye. In a study of working farmers during the traditional apple harvest, participants were assessed using the RULA method similar to our study and documented that pickers spent approximately 64% of their working time in awkward postures.[20] A different study conducted with apple growers from New York and Pennsylvania revealed that every picker was consistently observed reaching above elbow height during the apple picking process.[11] Another study reported that individuals' working posture of elevating the arm more than 90° accounted for 40% of the time to bag apples.[19] The current study also found similar results to the literature and reported that apple growers in Türkiye also worked in high-risk positions that could lead to muscle, tendon and ligament injuries, such as repetitive upper extremity activities with arms extended overhead, mostly standing, or bending and straightening activities. It is also known that working overhead requires not only raising the arms, but also stretching the head.[19] Therefore, working in this awkward posture may explain the musculoskeletal symptoms experienced in many parts of the body, particularly the knees, shoulders, lower back, and neck.

Despite the high prevalence of the risk scores obtained by the RULA method and the WRMSDs obtained by the Nordic assessment, no correlation could be detected, except for shoulders. This can be explained by the wide age range (18-80) of the people included in this study. In future studies with a more homogeneous study population of a similar age, this analysis can be repeated. According to the results of the logistic regression, there was an association between age and musculoskeletal complaints in the shoulders, upper back and ankles/feet; between weight and musculoskeletal complaints in the neck and hips/thighs; between working hours and musculoskeletal complaints in the upper back; between work experience and musculoskeletal complaints in the elbows; and between RULA score and musculoskeletal complaints in the shoulders These findings were consistent with various previous studies of poor working postures among farmers for various agricultural activities.[22-26] This suggests that farmers' working hours and posture need to be adjusted. In addition, farmers who appear to be at risk of becoming overweight should be made aware.

This study attempted to present the demographic variables, WRMSDs and risk factors of apple growers in Türkiye. However, there were a number of limitations. Firstly, the study population consisted of a small number of people as farmers were excluded due to illiteracy or inability to complete the assessments for any reason. Another limitation was the lack of similarity in variables such as age, working hours or work experience in this population. This allows for a more homogeneous study population with larger sample sizes for better and more comprehensive results.

CONCLUSION

In conclusion, WRMSDs were common among the apple farmers in Türkiye, and the farmers were working in a high-risk position. The current findings highlight the need to address the high prevalence of WRMSD among apple farmers through appropriate screening and intervention.

Disclosure Statement: The authors have no conflicts of interest to declare.

Author Contributions: Conceptualization: [GAY]; Design: [GAY, HÇK]; Writing: [GAY]; Investigation/ Data collection: [GAY, HÇK]. All authors read and approved the final manuscript.

Conflict of Interest: There is no potential conflict of interest relevant to this article.

REFERENCES

1. Amiri F, Attari SG, Karimi Y-A, et al. examination of work-related musculoskeletal disorders and their related factors among farmers of Asadabad city in 2015. *Pharmacophore*. 2020;11(1):52-7.
2. Niu S. Ergonomics and occupational safety and health: An ILO perspective. *Applied Ergonomics*. 2010;41(6):744-753.
3. McGorry RW, BSPT BSW, Snook SH, Hsiang SM. The relation between pain intensity, disability, and the episodic nature of chronic and recurrent low back pain. *Spine*. 2000;25(7):834-841.
4. Phajan T, Nilvarangkul K, Settheetham D, Laohasiriwong W. Work-related musculoskeletal disorders among sugarcane farmers in north-eastern Thailand. *Asia Pacific Journal of Public Health*. 2014;26(3):320-327.
5. Naeini HS, Karuppiah K, Tamrin SB, Dalal K. Ergonomics in agriculture: an approach in prevention of work-related musculoskeletal disorders (WMSDs). *Journal of Agriculture and Environmental Sciences*. 2014;3(2):33-51.
6. Walker-Bone K, Palmer K. Musculoskeletal disorders in farmers and farm workers. *Occupational Medicine*. 2002;52(8):441-450.

7. Thelin N, Holmberg S, Nettelbladt P, Thelin A. Mortality and morbidity among farmers, nonfarming rural men, and urban referents: a prospective population-based study. *International Journal of Occupational and Environmental Health*. 2009;15(1):21-28.

8. Oguz C, Karacayir HF. Türkiye'de elma üretimi, tüketimi, pazar yapısı ve dış ticareti. *Tarım Bilimleri Araştırma Dergisi*. 2009;(1):41-49.

9. Ekinci K, Demircan V, Atasay A, Karamursel D, Sarica D. Energy, economic and environmental analysis of organic and conventional apple production in Turkey. *Erwerbs-Obstbau*. 2020;62(1):1-12.

10. Davis KG, Kotowski SE. Understanding the ergonomic risk for musculoskeletal disorders in the United States agricultural sector. *American Journal of Industrial Medicine*. 2007;50(7):501-511.

11. Fulmer S, Punnett L, Tucker Slingerland D, Earle-Richardson G. Ergonomic exposures in apple harvesting: Preliminary observations. *American Journal of Industrial Medicine*. 2002;42(S2):3-9.

12. Earle-Richardson G, Jenkins P, Fulmer S, Mason C, Burdick P, May J. An ergonomic intervention to reduce back strain among apple harvest workers in New York State. *Applied Ergonomics*. 2005;36(3):327-334.

13. Dawson AP, Steele EJ, Hodges PW, Stewart S. Development and test–retest reliability of an extended version of the Nordic Musculoskeletal Questionnaire (NMQ-E): a screening instrument for musculoskeletal pain. *The Journal of Pain*. 2009;10(5):517-526.

14. Alaca N, Safran EE, Karamanlargil Aİ, Timucin E. Translation and cross-cultural adaptation of the extended version of the Nordic musculoskeletal questionnaire into Turkish. *Journal of Musculoskeletal & Neuronal Interactions*. 2019;19(4):472.

15. McAtamney L, Corlett EN. RULA: a survey method for the investigation of work-related upper limb disorders. *Applied Ergonomics*. 1993;24(2):91-99.

16. Houshyar E, Kim I-J. Understanding musculoskeletal disorders among Iranian apple harvesting laborers: Ergonomic and stop watch time studies. *International Journal of Industrial Ergonomics*. 2018;67:32-40.

17. Daghagh Yazd S, Wheeler SA, Zuo A. Key risk factors affecting farmers' mental health: A systematic review. *International Journal of Environmental Research and Public Health*. 2019;16(23):4849.

18. Dilay Y, Özkan A. Makine Yardımıyla Elma Toplamada Çalışma Duruşlarının REBA Yöntemi ile Analizi ve Ergonomik Risk Değerlendirmesi. *Tarım Makinaları Bilimi Dergisi*. 19(1):75-92.

19. Sakakibara H, Miyao M, Kondo T-A, Yamada SY. Overhead work and shoulder-neck pain in orchard farmers harvesting pears and apples. *Ergonomics*. 1995;38(4):700-706.

20. Zhang Z, Wang Y, Zhang Z, et al. Ergonomic and efficiency analysis of conventional apple harvest process. *International Journal of Agricultural and Biological Engineering*. 2019;12(2):210-217.

21. Fulmer S, Jenkins P, Mason C, Bresee C, May J. Ergonomic analysis of New York apple harvest work using a Posture-Activities-Tools-Handling (PATH) work sampling approach. *Journal of Agricultural Safety and Health*. 2004;10(3):163.

22. Munala JM, Olivier B, Karuguti WM, Karanja SM. Prevalence of musculoskeletal disorders amongst flower farm workers in Kenya. *South African Journal of Physiotherapy*. 2021;77(1):1515.

23. Kalra S, Arora B, Pawaria S. Cross sectional survey of work related musculoskeletal disorders and associated risk factors among female farmers in rural areas of Haryana, India. *Indian J Physiother Occup Ther*. 2016;10:149-154.

24. Jain R, Meena ML, Dangayach GS, Bhardwaj AK. Association of risk factors with musculoskeletal disorders in manual-working farmers. *Archives of Environmental & Occupational Health*. 2018;73(1):19-28.

25. Jain R, Meena ML, Dangayach GS, Bhardwaj AK. Risk factors for musculoskeletal disorders in manual harvesting farmers of Rajasthan. *Industrial Health*. 2018;56(3):241-248.

26. Das B, Gangopadhyay S. An ergonomics evaluation of posture related discomfort and occupational health problems among rice farmers. *Occupational Ergonomics*. 2011;10(1-2):25-38.