Date: 02 Feb 2021
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Subject: Your Submission IAOE-D-20-00480R1

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We are pleased to inform you that your manuscript, "Present Status of Occupational Safety and Health in Traditional Date Palm Crown Access", has been accepted for publication in International Archives of Occupational and Environmental Health.

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Best regards,

Edwin van Wijngaarden, Ph.D.
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COMMENTS TO THE AUTHOR:

Reviewer #1: I think the corrections performed sufficiently answered all comments previously given.

Reviewer #2: Thank you for actively improving the manuscript and considering all the comments provided

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International Archives Of Occupational And Environmental Health

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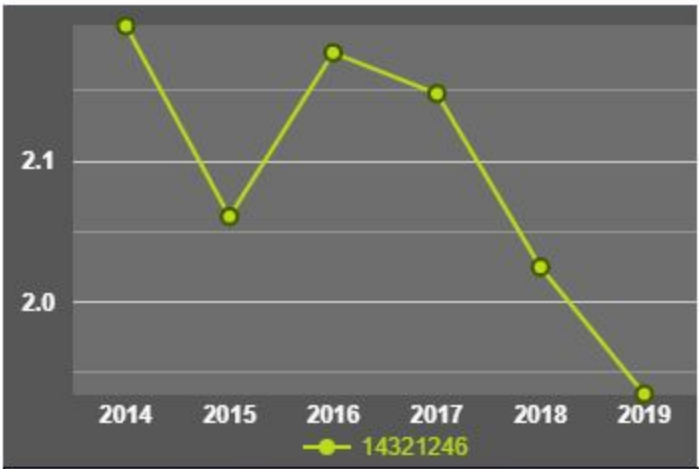

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Present Status of Occupational Safety and Health in Traditional Date Palm Crown Access

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Abstract

Objective: Date palm is mostly cultivated in Western Asia and North Africa and is the main wealth for the people of these regions. Traditional date palm crown access via manual climbing, as the main activity in date fruit production, suffers from occupational hazards. Mitigation of these problems through interventions or new designs initially needs to complete knowledge of safety and health aspects and relationships between them and characters of date palm climbers. This study provided detailed information about this concern.

Methods: A questionnaire consisting of personal, operational, safety, satisfaction, financial and ergonomic demographics was used for data collection. 117 climbers participated in the studyNonparametric correlations using Spearman's coefficient and logistic regressions investigated the linkage between characters obtained by the questionnaire.

Results: The annual mortality rate of falls from height was calculated by 3.4 per one thousand men. Fall was a major challenge in traditional date palm crown access and its rate was highly greater in comparison with the estimation of International Labor Office (ILO) about fatal agricultural injuries. Safety and health condition was the main contributing factor in the status of date palm climbing and was significantly linked to job satisfaction. Safety risk-taking and non-awareness of technology had a significant linkage with together (r= -0.195, p = 0.035). Safety risk-taking, also, had significant correlations with discomfort in back (r= -0.201, p = 0.030). Regressions showed heavier climbers (>75 kg) were expected about 4.3 (1/0.230) times than more lightweight ones to have an upper leg discomfort with high severity relative to low severity (p = 0.018).

Conclusion: Obesity, senescence, and awareness of technology as three personal characteristics of climbers need to be addressed. Future strategies are required to improve the safety condition of climbing and manage the workforces as well as governmental decision making to address the financial aspects of climbers for sustainable date production and reduction in reasons causing unemployment. Considering current status and modification of the present tool and equipment is recommended.

Keywords: Agricultural mechanization, Developing countries, Ergonomics, Fatal accident, Fall from height, Traditional date palm climber

DECLARATIONS

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Conflicts of interest

The authors declare that they have no conflict of interest.

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Author contributions

Conceptualization: Abdollah Hayati, Afshin Marzban, Majid Rahnama; Methodology: Abdollah Hayati, Afshin Marzban; Formal analysis and investigation: Abdollah Hayati; Writing - original draft preparation: Abdollah Hayati; Writing - review and editing: Afshin Marzban, Majid Rahnama; Funding acquisition: Afshin Marzban; Resources: Abdollah Hayati; Supervision: Afshin Marzban, Majid Rahnama

Ethics approval

Informed consent from the participants was considered in the study. In the case of participants under 16 years, the consent was obtained from their parents or legal guardians. Privacy was considered about their personal information. The rules, protocol, and validity of the questionnaire were evaluated in the pre-study and were approved by the HSE committee of Agricultural Sciences and Natural Resources University of Khuzestan (ASNRUKH). To approve the validity, HSE committee reviewed, investigated and modified questions. In doing so, the questions of questionnaire had been developed by investigator and modified several times based on extensive conversation with date palm climbers and were tested with several climbers to assure clarity (Earle-Richardson et al., 2005). The study was approved by the HSE committee of ASNRUKH and was performed under the ethical standards of the Declaration of Helsinki.

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1 Introduction

Date palm (*Phoenix dactylifera*) as an ancient and beneficial tree is mostly cultivated in Western Asia and North Africa (WANA). The number of date palms in the world and the number of workers occupied in this agricultural sector are in the order of millions. In many date palm growing countries, date palms are the main wealth of the people. Date fruit has been introduced as a nutritional health fruit as well as diverse medicinal properties. Seared leaves of the date palm and its other residues are chopped and used for animal feeding or fertilizing the farm soil. Various products are derived from date fruit such as juice, spread, liquid sugar, syrup, and alcohol. Overall, date palm and its products provide financial aspects of many peoples in developing countries (Abdelouahhab and Arias-Jimenez 2002; Ashraf and Hamidi-Esfahani 2011; Al-Khayri et al. 2015).

Iran as a country in the Western Asia region is the third-largest date producer in the world by 1.2 million tons of annual production after Egypt and Saudi Arabia. Iran is one of the five countries that represent about 70% of the global date fruit. Greatest genetic diversity of date palm with more than 400 cultivars of 3000 cultivars in the world and largest date palm cultivated area by 256000 hectares belong to Iran. Six provinces located in southern regions of this country named Hormozgan, Kerman, Fars, Sistan and Baluchistan, Bushehr, and Khuzestan produce more than 95% of Iranian date fruit that has a fine quality (Jain et al. 2011; Al-Khayri et al. 2015; FAO 2020).

Date fruit production consists of several operations (Fig. 1). Some of them include date crown access. Meanwhile, some of the date orchard workers should climb the tree and access the date palm crown several times to prune, pollinate, balance and cover the bunches, and harvest the fruit, that are mostly carried out in warmer months of the year. Therefore, date palm crown access is the widest and hardest activity among date production operations. Date crown access includes climbing, performing a task, and descending (Marzban and Hayati, 2018). Since a long time ago, date palm climbers use the direct way to access the tree crown; they traditionally use a simple tool like a rope called “parvand” to climb and use the old cut leaves as a ladder to step on them. They should grip the parvand through date crown access tasks (Fig. 2). In this way, climbers must use their physical power, bear a heavy workload, and

work under heat stress due to hot conditions. These may result in musculoskeletal disorders (MSDs), physiological strain, sunlight-related illnesses, fall from a height, and lowering worker productivity Mokdad et al. 2019).

In recent decades, agricultural mechanization has attempted to mitigate the worker drudgery and dangerous conditions in date palm orchards, especially in crown access. For example, date palm service machine using an elevator and electrical pollinators were designed and tested. They replaced the necessity of manually climbing and supplied climbers with safer circumstances (Al-Suhaibani et al. 1992; Mostaan et al. 2010). However, they were not properly adopted by date palm growers, and therefore traditional crown access is current yet almost in all date palm orchards. It may be because service machines and some other mechanized tools have technical or operational limitations (Al-Suhaibani et al. 1992). Moreover, date palm farmers' financial capacity is often not capable of purchasing or hiring the mechanized equipment that is often expensive. Consequently, they suffer from safety and health problems as poverty is one of the factors determining a population's health (Rocha et al., 2007). On the whole, date palm crown access is a labor-intensive activity similar to some agricultural works in which laborers had to face safety and health problems and drudgery (Momeni et al. 2020; Hansen et al. 2020).

As considered, a few studies have been undertaken about occupational safety and health in date palm crown access and none of them covered these gaps and the present status of date palm climbers is still not entirely clear about safety and health problems. Mitigation of aforementioned problems in date palm crown access initially needs to complete knowledge of safety and health aspects and relationships between them and characters of date palm climbers. To improve occupational safety and health in date palm crown access, detailed information about occupational safety and health background and how they are linked to each other is required. Priorities of climbers' concerns and problems related to personal, operational, safety and health, job satisfaction, and financial aspects must be cleared. Thus, the objective of this study was to provide detailed information in this area to provide the fundament to better decide and potentially design ergonomic interventions in the future.

2 Material and methods

2.1 Data collection tools

Data for the present study were collected from six major date fruit producer provinces of Iran. Date palm orchards are often located in arid and tropical regions of these provinces. There was not the official census about the numbers of

date palm climbers. Therefore population size was not achievable to calculate the sample size. Besides, there was not any official way to find date palm climbers (for example documented home/workplace addresses in any organization). However, with surveying and inquiring, a number of them were identified. Result of this inquiring was finding 117 date palm climbers with following inclusion criteria: full consent to take part in the study, at least two years work experience in date palm climbing, and being occupied in date palm crown access during performing the study (i.e. not a disabled or retired climber). Data calculation was performed in the date fruit harvesting period (September, see Fig. 1).

2.2 Developing a questionnaire

The required background of participants was recorded using a questionnaire. The questionnaire consisted of several parts as follows: personal and operational information, job satisfaction, safety risk-taking, financial risk-taking, body discomfort, difficulty, and fatigue resulted from climbing, the prevalence of MSDs and sunstroke, and fall and its subsequent injuries in date palm crown access backgrounds. These parts in detail were as follows:

Personal background included questions about age, height, mass, marital status, smoking status, type of climber, educational level.

Operational background included work experience in date palm orchard, work experience in date palm climbing, doing date orchard work tasks in addition to climbing, percentage of date orchard's cycle time in one year consumed in date crown access (using the visual analog scale (VAS)), second job, contributing factor(s) in the improvement of date palm climbing status, fall from date palm in past one year (with subsequent injuries consisting of temporary disabilities only), awareness of date palm orchard service machines, and use of date palm orchard service machines. Job satisfaction background included asking the participants about relative satisfaction from date palm climbing, relative satisfaction from parvand, unwilling to be introduced another simple tool better than parvand, being sufficient the climbing's income for living costs, unwilling to have another job (a job instead of date orchard working), and reasons to continue climbing while awareness of its dangerousness.

Safety risk-taking background included asking the participant about the use of free hands to climb (climbing without parvand).

Financial risk-taking background included asking the participant about willing to purchase an expensive service machine that makes work very easy when to be introduced to them.

Body discomfort background included asking the participants discomfort in body regions consisting of neck, shoulder, arm, back, upper leg, knee, calf, and foot sole using VAS when performing crown access.

Background of difficulty and fatigue resulted from climbing included asking the participant about the rate of difficulty and fatigue when performing crown access using VAS.

Prevalence of MSDs and sunstroke background included asking the participant about MSDs and sunstroke complaints in the past one year.

Fall and its subsequent injuries (consisting of temporary injuries, permanent injuries, and death) in date palm crown access: Data collected from participants in the case of "fall from date palm in the past one year" in the occupational background part in the questionnaire was considered only to be entered in the correlation analysis. It was because participants of the study occupied in date palm crown access during performing the study (based on the study's inclusion criteria). At most, they bore only temporary disabilities and did not experience other subsequences (permanent disabilities or death). In this condition, statistics of falls may be incomplete and underestimate concerning the severity of injuries. Therefore we presented fall and its subsequent injuries consisting of temporary injuries, permanent injuries, and death (FTPD) in this study.

FTPD's background included asking the participants whether they know past one year fall and its subsequent injuries (temporary injuries, permanent injuries, and death) in some known areas of date palm orchard considering to numbers of climbers worked in them or not. If they knew it, their reports were recorded. Repeated reports about the same orchards were removed.

2.2.1 Visual analog scale rating

Body discomfort, difficulty, and fatigue resulted from climbing were measured using VAS (Wilson and Sharples 2015), a 10-centimeter horizontal bar with two anchors of zero and ten expressing none and severe respectively, in the workplace immediately after climbing and descending the date palm trunk. "Percentage of date orchard's cycle

time in one year consumed in date crown access" was also measured using VAS with a difference– two anchors were zero and 100. Before conducting the study, participants were instructed to mark the appropriate point on the VAS.

As the studies design a questionnaire to achieve their goals (Chapman et al. 2008), a questionnaire was developed for the present study. Designing the questionnaire was based on the recommendations that should be completed in about 20 minutes (Chapman et al. 2008). An example of the questionnaire has been shown in Fig. 3. In the pre-study, it was identified that averagely 13.5 minutes is required to complete the Persian version of the questionnaire. The questionnaires were filled through a face-to-face interview. The interviewer read the questions and wrote the participants' answers. Wherever marking a point on the VAS bar was required, participants marked by themselves.

2.3. Calculations and encodings

All the calculations and encodings expressed in this section were performed using Microsoft Excel ver. 2010. Answers including no or yes were encoded as 0 and 1 respectively. Answers including ≤50 or >50 was encoded as 0 and 1 respectively. Answers excluding or including "being interested" (in job satisfaction background) were encoded as 0 and 1 respectively. Answers including >3 or ≤3 years (in safety risk-taking background) was encoded as 0 and 1 respectively. Answers including "no", "benefit-cost must be estimated" or "absolutely yes" (in financial risk-taking background) were encoded as 0, 1, and 2 respectively and showed the financial risk-taking order of each participant. Answers including low ($VAS\ score \leq \frac{10}{3}$), moderate ($\frac{10}{3} < VAS\ score \leq 2\frac{10}{3}$), and high ($VAS\ score > 2\frac{10}{3}$) (in body discomfort, difficulty and fatigue backgrounds) were encoded as 0, 1, and 2 respectively. Finally these codes were entered in the analysis. Following sections expressed more calculations connected to some of the backgrounds:

2.3.1 Calculations related to personal background

Body mass index (BMI) was calculated with body mass divided by square of height (kg/m^2) (Pizzol et al. 2020).

2.3.2 Calculation related to operational background

"Being a participating worker" was calculated as follows: answer to "doing date orchard work tasks in addition to climbing" for each participant was "yes" or "no". "Being an active worker" was calculated as follows: answer to "percentage of date orchard's cycle time in one year consumed in date crown access" for each participant was >50 or

≤50. Summation of encoded answers showed the order of a participant regarding "Being a participating and/or active worker".

2.3.3 Calculations related to job satisfaction background

For "satisfaction from current status (job satisfaction)", summation of six encoded answers showed the order of each participant concerning job satisfaction and was entered in analysis on behalf of him/her.

2.3.4 Calculations related to safety risk-taking background

Answer to the question "use of free hands to climb (climbing without parvand)" was "yes" or "no". Also, a feature related to occupational background was used in safety risk-taking calculations. For each participant, "years from beginning date orchard work to beginning climbing" was calculated as follows (Eq. 1):

$$y_{o-c} = y_o - y_c \qquad (1)$$

where y_{o-c}, y_o and y_c were years from starting date orchard work to starting climbing, work experience in date orchard, and work experience in climbing respectively. y_{o-c} showed how long after dealing with date palm orchards, the worker accepts the risk of climbing. Resulted values were >3 or ≤3 years. Finally, the summation of these two encoded values for each of the participants showed their safety risk-taking order. This was an innovative method to obtain safety risk-taking status.

2.3.5 Calculations related to fall and its subsequent injuries

FTPD's background was used to compare with the fall in other agricultural sectors in the discussion. Formulas brought below were innovative but mathematically rational and understandable. The average of each subsequent injury was expressed as the number per 1000 men per year. It was calculated using a weighted arithmetic average multiplied by 1000 where the area was considered as weight Eq. 2-5):

$$\mu_t = \frac{\sum_1^n \frac{t_i}{c_i}(a_i)}{\sum_1^n a_i} \times 1000 \qquad (2)$$

$$\mu_p = \frac{\sum_1^n \frac{p_i}{c_i}(a_i)}{\sum_1^n a_i} \times 1000 \qquad (3)$$

$$\mu_d = \frac{\sum_1^n \frac{d_i}{c_i}(a_i)}{\sum_1^n a_i} \times 1000 \qquad (4)$$

$$\mu_f = \frac{\sum_1^n \frac{f_i}{c_i}(a_i)}{\sum_1^n a_i} \times 1000 = \mu_t + \mu_p + \mu_d \qquad (5)$$

where μ_t, μ_p, μ_d and μ_f were averages number of temporary disability, permanent disability, death, and fall respectively, t_i, p_i, d_i, f_i and c_i were the numbers of temporary disability, permanent disability, death, fallen climbers, and total climbers in i^{th} area of the orchard (a_i) respectively. a_i was in hectare. Proportions of subsequent injuries of each 100 falls were calculated with dividing each of μ_t, μ_p, μ_d by μ_f. Considering date palm yield of 7.0153 tons per hectare in Iran (FAO 2020), the average of temporary disability, permanent disability, death and fall per each 10000 tons date produced was calculated (Eq. 6-9):

$$\mu_{t_t} = \frac{\sum_1^n \frac{t_i}{a_i} \times \frac{10000}{6.98}(a_i)}{\sum_1^n a_i} \qquad (6)$$

$$\mu_{p_t} = \frac{\sum_1^n \frac{p_i}{a_i} \times \frac{10000}{6.98}(a_i)}{\sum_1^n a_i} \qquad (7)$$

$$\mu_{d_t} = \frac{\sum_1^n \frac{d_i}{a_i} \times \frac{10000}{6.98}(a_i)}{\sum_1^n a_i} \qquad (8)$$

$$\mu_{f_t} = \frac{\sum_1^n \frac{f_i}{a_i} \times \frac{10000}{6.98}(a_i)}{\sum_1^n a_i} \qquad (9)$$

where μ_{t_t}, μ_{p_t}, μ_{d_t} and μ_{f_t} were the average of temporary disability, permanent disability, death, and fall per each 10000 tons date produced respectively.

2.4 Ethics approval

Informed consent from the participants was considered in the study. In the case of participants under 16 years, the consent was obtained from their parents or legal guardians. Privacy was considered about their personal information. The rules, protocol, and validity of the questionnaire were evaluated in the pre-study and were approved by the HSE committee of Agricultural Sciences and Natural Resources University of Khuzestan (ASNRUKH). To approve the validity, HSE committee reviewed, investigated and modified questions. In doing so, the questions of questionnaire had been developed by investigator and modified several times based on extensive conversation with date palm

climbers and were tested with several climbers to assure clarity (Earle-Richardson et al., 2005). The study was approved by the HSE committee of ASNRUKH and was performed under the ethical standards of the Declaration of Helsinki.

2.5 Data analysis

IBM SPSS Statistics 24 program (IBM Corporation, USA) was used to statistically analyze. Kolmogorov-Smirnov test was used to evaluate the normality of distribution of data. Normality tests showed that the variables' data have not the normal distribution except body BMI data. Spearman's nonparametric correlation coefficient was used to determine the potential correlation between rationally-related variables with considering 0.05 and 0.01 significant levels. According to the resulted significant correlations, logistic regressions were investigated.

3 Results

3.1 Personal and operational backgrounds

Fifty-nine climbers (50.4%) were in the normal range regarding BMI (Table 1). Safety and health problem is the most common contributing factor in view of climbers (70.9%) that its improvement caused to mitigate the climbing problems of eighty-three of 117 participants (Table 2). This table showed that the prevalence of falls from date palm in the past one year, which was entered in the investigation of correlation, was 15.4%.

Table 1. Personal background of date palm climbers (n=117)

	No. (%)
Gender	
Male	116 (99.1)
Female	1 (0.9)
Age	
Child (0-12 years old)[1]	0 (0)
Adolescence (13-18 years old)	5 (4.3)
Adult (19-59 years old)	105 (89.7)
Senior adult (>60 years old)	7 (6.0)
Height[2]	
≤1.75 m	66 (56.4)
>1.75 m	51 (43.6)
Mass[2]	
≤75 kg	72 (61.5)
>75 kg	45 (38.5)
BMI	
Underweight (<18.5 kg/m^2)[3]	6 (5.1)
Normal (18.5-24.9 kg/m^2)	59 (50.4)
Overweight (≥25 kg/m^2)	52 (44.4)
Marital status	
Single	30 (25.6)
Married	87 (74.4)
Smoking	
No	86 (73.5)
Yes	31 (26.5)
Type of climber[4]	1: 33 (28.2) 2: 15 (12.8) 3: 56 (47.9) 4: 13 (11.1)
Educational level[5]	1: 5 (4.3) 2: 18 (15.4) 3: 28 (23.9) 4: 39 (33.3) 5: 27 (23.1)

[1]Age groups based on Nithyashri and Kulanthaivel (2012)
[2]Since a standard category, as it has been for BMI or educational level, was not available for height and mass, they were subjectively divided into > and ≤1.75 m for height and > and ≤75 kg for mass
[3]BMI classification based on Pizzol et al.2020)
[4]Participant status regarding type of climber: 1 (hiring laborer), 2 (tenant), 3 (owner), 4 (integrated from three mentioned type)
[5]Educational levels: 1 (Illiterate), 2 (Primary school), 3 (Middle school), 4 (Diploma), 5 (Academic).

Table 2. Operational background of date palm climbers (n=117)

	No. (%)
Work experience in date palm orchard (years)	
≤15	51 (43.6)
>15	66 (56.4)
Work experience in date palm climbing (years)	
≤15	68 (58.1)
>15	49 (41.9)
Being a participating worker (Doing date orchard work tasks in addition to climbing)	
No	22 (18.8)
Yes	95 (81.2)
Being an active worker (Percentage of date orchard's cycle time in one year consumed in date crown access (%))	
≤50 (low activity)	73 (62.4)
>50 (high activity)	44 (37.6)
Being a participating and/or active worker	
Active or participating	95 (81.2)
Active and participating	22 (18.8)
Second job	
No	41 (35.0)
Yes	76 (65.0)
Contributing factors in the improvement of date palm climbing status:	
Safety and health	83 (70.9)
Wage	79 (67.5)
Climbing tool	59 (50.4)
Heat repelling	45 (38.5)
Guaranteed purchase of date by government	2 (1.7)
Fall from date palm in past one year	
No	99 (84.6)
Yes	18 (15.4)
Awareness of date palm orchard service machines	
No	91 (77.8)
Yes	26 (22.2)
Use of date palm orchard service machines	
No	117 (100)
Yes	0 (0.0)

3.2 Backgrounds of job satisfaction and safety and financial risks taken

The majority of climbers were willing to have another job with 89.7% (Table 3). "Being interested" was not a reason of greater than half of climbers (69.2%) to continue climbing while awareness of its dangerousness. Almost one-fifth of climbers were risk-takers (Table 4).

Table 3. Job satisfaction among date palm climbers (n=117)

	No. (%)
Relative satisfaction from date palm climbing	
No	46 (39.3)
Yes	71 (60.7)
Relative satisfaction from parvand	
No	21 (17.9)
Yes	96 (82.1)
Unwilling to be introduced another simple tool better than parvand	
No	25 (21.4)
Yes	92 (78.6)
Being sufficient the climbing's income for living costs	
No	108 (92.3)
Yes	9 (7.7)
Unwilling to have another job	
No	12 (10.3)
Yes	105 (89.7)
Reasons to continue climbing while awareness of its dangerousness	
Numbers of reasons excluding being interested	81 (69.2)
Numbers of reasons including being interested	36 (30.8)
Job satisfaction orders[1]	1: 8 (6.8), 2: 32 (27.4), 3: 29 (24.8), 4: 35 (29.9), 5: 11 (9.4), 6: 2 (1.7)

[1]Orders from 1 to 6 showed job satisfaction levels from lowest to highest

Table 4. Safety and financial risks taking among date palm climbers (n=117)

Backgrounds	No. (%)
Safety risk	
Years from starting date orchard work to starting climbing	
≤ 3	72 (61.5)
> 3	45 (38.5)
Use of free hands to climb (climbing without parvand)	
Yes	47 (40.2)
No	70 (59.8)
Order of participants regarding to safety risk-taking	
Risk-averse	28 (23.9)
Risk-neutral	64 (54.7)
Risk-taker	25 (21.4)
Financial risk-taking	
If an expensive service machine that make your work very easy is introduced to you, will you purchase it?	
No	18 (15.4)
Benefit-cost must be estimated	69 (59.0)
Absolutely yes	30 (25.6)

3.3 Backgrounds of body discomforts, difficulty, fatigue, MSDs, sunstroke, and fall and its subsequent injuries

Table 5 shows that neck discomfort had the most common low severity of discomfort among body segments. Close to half of climbers (50.4%) notified that the work perceived difficulty of climbing is high and fifty-two of them (44.4%) reported high severity fatigue for climbing. MSDs and sunstroke as a consequence of climbing in the past one year were recorded among 46.2% and 47.0% of climbers. 19.5 falls per thousand men per year were recorded as the statistic of falls from the date palm tree (Table 6).

Table 5. Rate of body discomforts, difficulty and fatigue and prevalence of MSDs and sunstroke among date palm climbers (n=117)

	No. (%)		
	Low	Moderate	High
Body segment			
Neck	82 (70.1)	25 (21.4)	10 (8.5)
Shoulder	42 (35.9)	52 (44.4)	23 (19.7)
Arm[1]	37 (31.6)	51 (43.6)	29 (24.8)
Back	19 (16.2)	51 (43.6)	47 (40.2)
Upper leg[2]	43 (36.8)	57 (48.7)	17 (14.5)
Knee	21 (17.9)	34 (29.1)	62 (53.0)
Calf	37 (31.6)	44 (37.6)	36 (30.8)
Foot sole	21 (17.9)	22 (18.8)	74 (63.2)
Work perceived difficulty	14 (12.8)	43 (36.8)	59 (50.4)
Work perceived fatigue	20 (17.1)	45 (38.5)	52 (44.4)

	No. (%)	
	Yes	No
MSDs complaints in past one year	54 (46.2)	63 (53.8)
Sunstroke in past one year	55 (47.0)	62 (53.0)

[1]From blow the shoulder to above the elbow
[2] From blow the back to above the knee

Table 6. Background of fall and its subsequent injuries in date palm crown access

Characters	Temporary disability	Permanent disability	Death	Total
No. of falls per 1000 climbers per year (man)	7.6	8.5	3.4	19.5
Injuries resulted from 10 falls (man)	3.9	4.4	1.7	10
No. of falls per 10000 tons (man)	4.4	2.1	1.3	7.8

3.4 Correlations

Significant correlations at level of 0.05 and/or 0.01 were shown with bold-faced type in Tables 7 to 12 and briefly shown in Fig. 4. Difficulty of date palm climbing had a strong positive correlation with fatigue (r=0.554, $p < 0.001$) and positively correlated with age of climbers (r= 0.243, $p = 0.011$) as shown in Table 8. Job satisfaction had a significant negative correlation with fatigue (r= -0.238, $p = 0.010$), MSDs complaints in past one year (r= -0.277, $p = 0.003$), difficulty (r= -0.325, $p < 0.001$) and body discomfort in back (r= -0.192, $p = 0.038$), knee (r= -0.295, $p = 0.001$), calf (r= -0.212, $p = 0.022$) and foot sole (r= -0.277, $p = 0.002$) (Table 9). BMI and knee discomfort had a correlation with coefficient of 0.263 and significance of 0.004 (Table 10). As shown in Table 11, safety risk-taking had a significant negative correlation with awareness of date palm orchard service machines (r= -0.195, $p = 0.035$).

Table 7
Correlation coefficient and significance between MSDs, sunstroke and fall of date palm climbers and related variables

	Age	Mass	Height	BMI	Educational level	Type of climber	Being an active worker	Work experience in date crown access	Being a participating worker	Second job	Safety risk-taking
MSDs complaints in past one year	0.164 0.077	0.043 0.642	0.051 0.588	0.028 0.768	-0.034 0.717	0.018 0.847	-0.117 0.209	0.156 0.092	0.138 0.137	0.105 0.260	0.037 0.691
Sunstroke in past one year	-0.051 0.585	-0.042 0.651	0.001 0.992	-0.036 0.699	-0.100 0.283	**-0.192** **0.038**	0.011 0.905	-0.031 0.736	0.059 0.529	-0.062 0.507	-0.016 0.861
Fall from date palm in past one year	0.052 0.578	-0.045 0.630	0.055 0.555	0.024 0.799	0.032 0.732	0.064 0.491	-0.063 0.498	-0.007 0.938	0.145 0.120	0.065 0.487	-0.088 0.348

]In each cell, upper and lower values are correlation coefficient (r) and significance level (*p*) respectively.
Significant correlations at level of 0.05 or 0.01 are shown as bold.

Table 8
Correlation coefficient and significance between difficulty and fatigue of date palm climbers and related variables

	Age	Mass	Height	BMI	Educational level	Type of climber	Being an active worker	Work experience in date crown access	Being a participating worker	Second job	Smoking	Safety risk-taking	Fatigue
Difficulty	**0.243** **0.011**	-0.041 0.662	-0.024 0.795	-0.035 0.709	-0.180 0.052	0.009 0.927	-0.040 0.630	-0.008 0.933	0.064 0.491	-0.167 0.071	0.072 0.443	0.047 0.616	**0.554** **<0.001**
Fatigue	0.166 0.073	-0.042 0.651	-0.104 0.266	-0.070 0.456	-0.160 0.086	0.107 0.251	-0.070 0.453	0.058 0.537	0.203 0.028	0.034 0.716	0.033 0.727	0.007 0.938	

In each cell, upper and lower values are correlation coefficient (r) and significance level (*p*) respectively.
Significant correlations at level of 0.05 or 0.01 are shown as bold.

Table 9
Correlation coefficient and significance between job satisfaction and body pain and related variables

	Age	Mass	Height	BMI	Educational level	Type of climber	Being a participating worker	Second job	Sunstroke	MSDs	Fall	Difficulty	Fatigue	Awareness of date palm orchard service machines	Safety risk-taking	Financial risk-taking
Job satisfaction	-0.167 0.071	0.017 0.858	0.080 0.390	-0.017 0.857	-0.103 0.269	0015 0.875	-0.012 0.895	-0.014 0.881	0.028 0.766	**-0.277** **0.003**	-0.018 0.846	**-0.325** **0.001**	**-0.238** **0.010**	0.089 0.340	-0.071 0.446	-0.002 0.981

	Body segments							
	Neck	Shoulder	Arm	Back	Upper leg	Knee	Calf	Foot sole
Job satisfaction	0.014 0.878	-0.048 0.605	-0.085 0.364	**-0.192** **0.038**	-0.177 0.057	**-0.295** **0.001**	**-0.212** **0.022**	**-0.277** **0.002**

In each cell, upper and lower values are correlation coefficient (r) and significance level (*p*) respectively.
Significant correlations at level of 0.05 or 0.01 are shown as bold.

Table 10
Correlation coefficient and significance between body discomforts and related variables

	Age	Mass	Height	BMI	Educational level	Type of climber	Being an active worker	Work experience in date crown access	Being a participating worker	Second job	Smoking	Safety risk-taking
Neck	-0.069 0.461	-0.095 0.309	-0.001 0.992	-0.145 0.119	0.066 0.481	0.101 0.278	0.032 0.733	-0.013 0.892	0.081 0.388	0.039 0.677	-0.044 0.641	0.092 0.323
Shoulder	-0.024 0.795	0.097 0.299	0.028 0.764	0.055 0.555	0.044 0.639	-0.075 0.422	0.087 0.353	-0.008 0.932	0.084 0.367	0.003 0.971	**-0.184** **0.047**	-0.058 0.537
Arm	-0.031 0.743	0.145 0.119	0.079 0.399	-0.017 0.859	**0.206** **0.026**	-0.030 0.747	0.067 0.472	-0.007 0.944	0.044 0.634	0.075 0.421	-0.148 0.112	0.034 0.712
Back	0.115 0.218	0.051 0.582	-0.023 0.803	0.082 0.382	0.052 0.574	-0.010 0.915	0.115 0.216	-0.147 0.114	-0.113 0.224	-0.181 0.050	0.026 0.780	**-0.201** **0.030**
Upper leg	-0.108 0.248	**0.224** **0.015**	0.040 0.666	0.160 0.084	0.009 0.923	-0.111 0.235	0.076 0.418	-0.168 0.070	0.153 0.099	-0.104 0.264	**-0.203** **0.028**	-0.094 0.312
Knee	0.095 0.306	0.163 0.079	0.002 0.986	**0.263** **0.004**	0.094 0.312	-0.076 0.416	0.033 0.723	-0.175 0.059	0.024 0.801	0.083 0.375	**-0.207** **0.025**	**-0.305** **0.001**
Calf	0.169 0.068	0.098 0.295	0.165 0.075	0.181 0.051	-0.048 0.604	0.012 0.900	0.008 0.929	-0.099 0.286	-0.006 0.953	-0.098 0.292	-0.018 0.845	-0.129 0.166
Foot sole	-0.068 0.464	0.075 0.422	-0.034 0.716	0.155 0.095	-0.032 0.733	-0.044 0.637	-0.052 0.579	-0.021 0.822	**0.192** **0.039**	-0.080 0.394	**-0.215** **0.020**	-0.002 0.987

In each cell, upper and lower values are correlation coefficient (r) and significance level (*p*) respectively.
Significant correlations at level of 0.05 or 0.01 are shown as bold.

Table 11
Correlation coefficient and significance between awareness of date palm orchard service machines and related variables

	Age	Educational level	Type of climber	Financial risk-taking	Safety risk-taking
Awareness of date palm orchard service machines	-0.029 0.757	0.170 0.066	0.138 0.137	-0.019 0.842	**-0.195** **0.035**

In each cell, upper and lower values are correlation coefficient (r) and significance level (*p*) respectively.
Significant correlations at level of 0.05 or 0.01 are shown as bold.

Table 12
Correlation coefficient and significance between safety risk-taking and related variables

	Age	Mass	Height	BMI	Educational level	Type of climber	Financial risk-taking	Being a participating worker	Being an active worker	Smoking
Safety risk-taking	-0.078 0.404	-0.155 0.096	-0.171 0.065	-0.114 0.222	-0.076 0.418	-0.059 0.527	-0.112 0.227	**0.211** **0.023**	-0.155 0.095	0.081 0.383

In each cell, upper and lower values are correlation coefficient (r) and significance level (*p*) respectively.
Significant correlations at level of 0.05 or 0.01 are shown as bold.

3.5 Regressions

According to the significant correlations, some logistic regressions were investigated (Table 13). Because of lengthy outputs of logistic regression analysis, only the significant regressions were shown and among the variables of these regressions, only the predictor variables with significant β were shown (Table 14). For example, the climbers with normal BMI relative to overweight ones were 1.705 unit lower for having a knee discomfort with high severity relative to low severity (normal BMI's β = -1.705; $p = 0.009$) given all other predictor variables in the model are held constant (Table 14). In this case, climbers with overweight were expected about 5.5 ($\frac{1}{0.182}$) times than normal BMI to have a knee discomfort with high severity relative to low severity (normal BMI's OR = 0.182). This expection ranged from 1.5 ($\frac{1}{0.650}$) to 19.6 ($\frac{1}{0.051}$) times (normal BMI's CI: 0.051-0.650).

Table 13
Logistic regressions investigated in the study according to significant correlations.

	Dependent variable	Independent variable(s)	Significance of model
Binary	Being a participating worker	Safety risk-taking	Yes
	Sunstroke	Type of climber	Yes
Multinomial	Safety risk-taking	Awareness of date palm orchard service machines	No
	Shoulder (Body discomfort)	Smoking	No
	Arm (Body discomfort)	Educational level	No
	Back (Body discomfort)	Safety risk-taking	Yes
	Upper leg (Body discomfort)	Mass + Smoking	Yes
	Knee (Body discomfort)	BMI + Smoking + Safety risk-taking	Yes
	Foot sole (Body discomfort)	Being a participating worker + Smoking	No
	Difficulty	Age + Fatigue	Yes
	Job satisfaction	Back (Body discomfort) + Knee (Body discomfort) + Calf (Body discomfort) + Foot sole (Body discomfort) + Fatigue + MSDs + Difficulty	Yes

Table 14
Logistic regressions with significant model (only the predictor variables with significant β were shown).

Dependent variable	Independent variable(s)	β	*p*	OR[1]	95% CI[2]	Significance
Being a participating worker (No[a])	Safety risk-taking					Omnibus Test of Model = 0.043 Hosmer and Lemeshow Test[3] = 1.000
	Safety risk-taking (No risk[b])					
	Semi-risk	1.222	0.022	3.395	1.193-9.664	
	Risky	1.405	0.050	4.074	0.972-17.071	
Sunstroke (No[a])	Type of climber					Omnibus Test of Model = 0.018 Hosmer and Lemeshow Test = 1.000
	Type of climber (Laborer[b])					
	Tenant	-1.386	0.036	0.250	0.068-0.912	
	Owner	-1.054	0.021	0.348	0.142-0.856	
Job satisfaction[4] (Low[a])	Back (Body discomfort) + Knee (Body discomfort) + Calf (Body discomfort) + Foot sole (Body discomfort) + Fatigue + MSDs + Difficulty + Fatigue×Difficulty					Omnibus Test of Model = 0.012 Hosmer and Lemeshow Test = 0.171
	MSD (No[b])					
	Yes	-1.726	0.001	0.178	0.065-0.484	
Back (Body discomfort), (Low[a])	Safety risk-taking					Likelihood Ratio Tests: Final = 0.002 Safety risk = 0.002
Moderate	Semi-risk	2.562	0.000	12.964	3.180-52.850	
High	No risk	1.631	0.029	5.107	1.177-22.159	
	Semi-risk	2.362	0.001	10.607	2.578-43.640	
Upper leg (Body discomfort), (Low[a])	Mass + Smoking					Likelihood Ratio Tests: Final = 0.027 Mass = 0.052 Smoking = 0.132
High	Mass (≤75 kg)	-1.468	0.018	0.230	0.068-0.776	
Knee (Body discomfort), (Low[a])	BMI + Smoking + Safety risk-taking					Likelihood Ratio Tests: Final = 0.004 BMI = 0.075 Smoking = 0.135 Safety risk-taking = 0.029
High	BMI (Normal)	-1.705	0.009	0.182	0.051-0.650	
	Safety risk-taking (No risk)	2.942	0.011	18.962	1.964-183.037	
Difficulty (Low[a])	Age + Fatigue					Likelihood Ratio Tests: Final = 0.000 Age = -[5] Fatigue = 0.000
High	Fatigue (Low)	-2.773	0.001	0.063	0.012-0.332	
	Fatigue (Moderate)	-1.779	0.036	0.169	0.032-0.890	

Note: In the case of multinomial regressions, the last classification of each independent variable was set to zero (redundant).
[a] Reference category
[b] Indicator (other orders of each predictor variable were compared to the indicator one)
[1] Odd ratio
[2] Confidence interval
[3] Hosmer and Lemeshow test is significant when over 0.05.
[4] Because of unexpected singularities in the Hessian matrix, we converted "Job satisfaction" categories to "Low" (categorized before as 1, 2, and 3) and "High" (categorized before as 4, 5, and 6). Therefore we faced a binary logistic regression.
[5] Unexpected singularities in the Hessian matrix were encountered. This was because of some "Age" categories ("Adolescence" and "Senior adult"). They had very little frequencies. We excluded them to remove unexpected singularities. Additionally, "Child" category was zero. Therefore "Adult" was the only category on behalf of "Age" and had not a role among predictor variables.

4 Discussions

The findings of the present study could be useful to have an appropriate attitude in designing the tool and workplace. A former study reported that children rarely go up to the top of the date palms and they help on the ground and most of the work is done by adult males (ILO 2013), which closed to the present study where the percentage of child and adult ages were zero and 89.7% respectively. The mentioned study introduced womenfolk as on the ground workers, while the present study had one female climber.

According to 77.8% of unawareness of date palm service machines, it could be added to the reasons that these machines have not been enabled to be adopted by farmers. Moreover, the percentage of users of date palm orchard service machines (0%) showed that the usage of those machines was restricted to a few research works. On the existence of a negative correlation between awareness of service machines and safety risk-taking it could be inferred if climbers are aware of date palm service machines, they may never accept safety risks to do date palm crown access even though they could not invest to purchase or rent these technologies providing safety climate. Finding among oil refinery employees confirmed the present study in which a significant positive relationship between awareness of conditions providing safety and making a safe climate was resulted (Uzuntarla et al. 2019).

Back, knee, and foot sole had the greatest frequencies of discomfort in the severity level of high in the present study. It covered the result of a former study where back and feet sole were reported as the body segments having pains among climbers (Marzban and Hayati 2018). In the present study, discomfort complaints were reported for more body segments of climbers compared with the mentioned study. This difference may be partly because of the type of obtaining data from participants.

As resulted in FTPD in the present study, to produce a 10000 tons date fruit, 7.8 climbers fell from date palm resulting in 1.3 deaths. Considering 1204158 and 6624308 tonnages of date produced in Iran and WANA respectively (FAO 2020), it can be easily calculated approximately 157 and 826 deaths resulted from falls during one date fruit production season in Iran and WANA. Ghardaia region represents 5% of Algerian date palm orchards (Petzl Foundation 2014). Regarding 1094700 tons of annual date production in Algeria (FAO 2020), it could be estimated this region produces about 54735 tons. According to mentioned one death per year among Ghardaia's date palm climbers, to produce 10000 tons, only 0.2 deaths occur in this region which was highly less than what occurs in Iran. The number of deaths per one thousand men was calculated 3.4 about date palm climbers in FTPD, which was highly greater in comparison with International Labor Office (ILO) estimation for fatal agricultural injuries 0.0438 per thousand workers (ILO 2019).

These show that date palm climbing is a more hazardous activity compared with the average of the agricultural sector and requires occupational health improvement.

The major contributing factor in the improvement of date palm climbing status was the safety and health condition (n=83 (70.9%)). Some of the safety and health-related variables established the significant negative correlations with job satisfaction. It implied that the improvement of safety and health conditions brings a higher level of job satisfaction (Huang et al. 2016). To improve safety and health conditions and avoid excessive ergonomic exertions, the duration of rest was recommended (Tiwari and Gite 2006).

The second important contributing factor in the improvement of date palm climbing status was the climbers' wage. Industrial sector caused environmental disturbances in some of major date fruit producer regions in Iran, such as Hormozgan and Sistan and Baluchestan provinces, as follows (Iran Newspaper 2019): a large number of date palm trees were cut to begin or develop governmental projects; water transfer from a river providing the required moisture of date palms in a region, to another river caused date palm withering; dust resulted from picking up the sand granules from rivers' floor resulted in sterile date palm trees. These conditions caused lessening date palm orchards and subsequently may cause a less level of wage or even unemployment. Also, statistical reports revealed that Sistan and Baluchestan and Khuzestan provinces have unemployment rates of 15.7% and 16% respectively which are higher than the average rate of the country that was 12% (Ministry of Cooperative, Labor and Social Welfare 2018). Appropriate addressing the factors affecting wage and financial concern of date palm climbers may partially reinforce the level of wage, mitigate the unemployment, and aid to establish a sustainable date production.

Participants represented the climbing tool as the third major contributing factor that if improves, the status of date palm climbing improves. The application of some simple and inexpensive interventions to improve the work tool may ~~improve~~ the work (Bodin et al. 2016). Perhaps future intervention in traditional date palm climbing tool brings more safe conditions as well as enhancement of the rate of work and preference. This is an acceptable strategy in the situation that increasing prices are a barrier to the development of motorized equipment in developing societies' farms (Tiwari et al. 2011), in particular, date palm orchards.

Older climbers were linked to higher perceived work difficulty in the present study. To address the work difficulty in date palm climbing, in particular, safety and health situations, designers must explore means by which age differences

can be moderated as it was recommended by former studies that reported older individuals perceived a greater workload across a short vigil (Bunce and Sisa 2002). Maybe, in the future, designers can provide a safety and health situation in which older climbers are enabled to do work with a similar perceived difficulty level as high as possible to younger ones.

Climbers' BMI was linked to knee discomfort in the same direction (Tables 10 and 14) as those of reports in which participants with a higher BMI had greater knee pain compared with participants with a lower BMI (Holla et al. 2013; Weiss 2014). As 44.4% of climbers were in the overweight range, they should take a possible weight reduction into account for the treatment of potentially knee problems such as knee osteoarthritis because obesity is a robust risk factor for knee osteoarthritis (Zheng and Chen 2015). Generally, there was no any health program for date palm workers in Iran. There is a need for the program applied to the date palm workers to improve workers' accident prevention and health promotion such as improvement climbers' demographic features (e.g. obesity or accommodate their capabilities with the workplace).

Body mass is not addressed without stature. Usually, body mass is not an appropriate meter because it is often varied through variation of stature. These two features are integrated and represented as BMI. Nonetheless, the amount of body mass could be a contributor when a limitation exists. Date palm trunk, old cut leaves, and parvand have relatively a constant size each, but the climbers which deal with them may be in a wide range of body mass and consequently varied body segment sizes. It is imaginable that climbers with different body masses have not the same safety and healthy feedback. Therefore, in the case of a linkage and regression established between body mass and upper leg discomfort (Tables 10 and 14), the mentioned inference could be acceptable. Anthropometric features have an important role in farm laborer and workplace interactions (Dewangan et al. 2010) and should be addressed in date crown access tool designs.

Investigation of body discomfort among date palm orchard workers showed foot sole discomfort was only among climbers not among on the ground workers (Marzban and Hayati 2018). It could mean that if climbers lower the climbing activity and participate in on-the-ground tasks, foot sole discomfort is partly mitigated. Despite it, the present study showed participation of climber in on the ground tasks was positively linked to foot sole discomfort. Maybe the foot sole discomfort is affected by various factors such as the way of cutting dry leaf bases which could be addressed in the further studies.

Although a strong association between low educational level and increased occurrence of musculoskeletal risks was reported (Lal 2008), the present study resulted in a significant positive relation between severity of arm discomfort and high level of education. It may be explained by the fact that school or academic educations may not be sufficient to prevent occupational safety and health risks. Occupational safety and health training are required for more effective prevention of work-related disorders (Oakman et al. 2019).

Near half of the climbers experienced the sunstroke. In line with it, another study presented the agricultural sector as the most dangerous occupation concerning exposure to occupational ultraviolet radiation (Peters et al. 2019). In menfolk, greater exposure to the sun in farmers compared with non-farmers could partly explain their excess mortality from some cancer sites and the other causes of death (Zhao et al. 2019). The sunstroke may increase through inappropriate rest-work schedules (Jacklitsch et al. 2016). The working time duration of farm owners usually is less than farm laborers and tenants because they often consign the work to laborers and tenants to reduce potential safety and health risks and other reasons. Thus, laborers and tenants usually had to work hard and it is more likely that they are posed in inappropriate rest-work schedule conditions in comparison with farm owners. This explanation could partly clear the negative significant correlation between the type of climber and sunstroke among climbers as well as result of regression between sunstroke and type of climber (Table 14).

In the present study, financial risk-taking was considered while its correlation with other factors was not investigated. It was because we had gathered the participants' income as the probably most important factor correlated with financial risk-taking, but it strongly seemed that they did not will to express the exact amount of income. It is a tradition in a country like Iran that people often don't express their exact income and attempt to convince others that they are poorer than what they are.

Limitations

Gender variable could not be entered in statistical analysis because only one female climber participated in the study. Therefore scientific discussion around the relationship between gender and other variables was not possible.

5 Conclusion and recommendation

Fatal accidents through date palm production resulted from falls from height is a major challenge in traditional date palm crown access. Safety and health condition is the main contributor aspect in relation to the job satisfaction. In

view of climbers, safety and health condition was the main contributing factor in the status of date palm climbing. Obesity, senescence, and awareness of technology as three personal characteristics of climbers need to be addressed. Remedial programs are required to improve the safety condition of climbing and climbing tools and manage the workforces as well as governmental decision making to address the financial aspects of climber folk to sustainable date production and reduce probable reasons for unemployment. Considering current status and modification of the present tool and equipment is recommended.

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