Ergonomic Assessment of Manually Harvesting Chinese Wolfberry

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Abstract. In recent years, work-related musculoskeletal diseases have become more prominent and have seriously affected workers' ability to operate and quality of life. According to relevant research, ergonomic knowledge training and proper physical exercise can effectively prevent musculoskeletal diseases, but the ergonomic evaluation of Chinese wolfberry harvest has not yet been carried out. In this study, Jack software was used to simulate and analyze the picking of wolfberry and to identify the risk factors in the process. Through the analysis software, the risks of improper picking manipulation can be accurately judged. The results showed that standing pose minimizes worker load and fatigue, but stooping and squatting pose increases the risk of musculoskeletal disorders. The purpose of this paper is to provide a way to identify risk factors in agricultural operations and reduce the incidence of musculoskeletal diseases in the agricultural population.

Introduction

Musculoskeletal disorders (MSDs) are injuries and disorders of muscles, tendons, bones, cartilage, blood vessels, ligaments, and nerves. Work-related musculoskeletal diseases (WMSDs) refer to all musculoskeletal diseases caused or aggravated by work, such as occupational lower back pain, arm vibration disease, shoulder and neck pain, tendonitis, etc. According to relevant epidemiological studies, the prevalence of work-related musculoskeletal diseases of Japanese nurses is up to 85.5%, mainly manifested as low back pain, upper back pain and shoulder and neck pain [1]. In Nigeria, the annual prevalence of musculoskeletal diseases of deep slaughter workers is 74.5% [2], mainly manifested as low back pain. In China, the prevalence of musculoskeletal diseases among middle-aged and elderly vegetable farmers in vegetable greenhouses was 84.62%, mainly including lower back pain, shoulder and neck pain, and joint discomfort. The incidence of shoulder musculoskeletal disease in agricultural population is 1.28 times higher than that in other occupational groups [3]. There is a causal relationship between physical activity at work and work-related musculoskeletal diseases (MSDs) [4].

MSD is associated with repetitive exercise, excessive exertion, and long periods of sitting and standing, all of which are required for agricultural labor. In addition, the salary system of the operating personnel is usually related to the completion of the work, and most people ignore the rest time due to the incentive of this system, which also causes the high risk of musculoskeletal diseases (MSDs) in agricultural operations [5, 6].

Although many studies on prevention of agricultural MSD epidemiology have been carried out, there is no ergonomic evaluation on the manual picking of Chinese wolfberry. In spite of wolfberry harvesting machinery has been developed, at present, there is no feasible machine for picking wolfberry. Therefore, wolfberry harvesting still depends on manual work.

The purpose of this study is to provide a method to identify risk factors in agricultural work, conduct simulation analysis on agricultural work through Jack software, and get rationality of the working posture and the stress situation of each joint. so as to provide theoretical basis for workers to reduce the occurrence of MSDs.
Materials and Methods

We conducted field investigations in northwest China (Yinchuan city, Zhongning county of Zhongwei city, Ningxia province and Jingtai county of Baiyin city, Gansu province) from late June to mid-July 2019. The data were collected by direct observation and video recording of local wolfberry harvesting. Data on participants’ age, education, work experience and anthropometrics were collected. By simulating the picking of wolfberry by JACK software, the lower back analysis module, working posture analysis module and rapid upper limb analysis module of JACK software were used to accurately determine the risk factors in the process of picking wolfberry.

The Harvest Method of Chinese Wolfberry

With the rapid development of Chinese wolfberry industry, the harvest problem has become a major bottleneck restricting the sustainable development of Chinese wolfberry industry. In the production of Chinese wolfberry, the picking cost accounts for half of the production cost. When picking wolfberry by hand, the operator holds the fruit-bearing branch with the left hand, and collects one or several berries in the palm with the thumb and index finger of the right hand, and then puts the wolfberry into the fruit basket gently. A worker normally picks 40-50 kg of wolfberries every day. The working time is as long as 12-13 hours, and the working time is relatively long.

JACK Simulation Analysis Tool

Ovako Working Posture Analysis. Ovako Working Posture Analysis (OWAS) is a quick check of posture to assess inappropriateness of posture based on back, arm, and leg load requirements. Assign an assessment posture score that indicates the urgency of taking corrective action to quickly assess the likelihood of damage or injury to workers in a particular position [7].

Lower Back Analysis. Lower. Back Analysis can analyze the effect of the stress on the lower back of the human spine under certain circumstances [8]. The tool was used to determine whether the simulation task met NIOSH standards and whether it increased the risk of lower back injuries. The lower back analysis used advanced and complex physiological lower back models to calculate the L4/L5 vertebral pressure and compare this pressure with the recommended and ultimate pressure of NIOSH carrying forces.

Rapid Upper Limb Assessment. Rapid Upper Limb Assessment (RULA) analyze hazards in upper limb motion. For a given manual task, RULA was able to evaluate the risk of upper limb movement based on body posture, muscle use, load weight, duration and frequency of the task [9].

The Rapid Upper Limb. Assessment system examined risk factors such as exercise frequency, muscle fatigue at rest, strength, posture, and duration of work without pauses. After weighting all factors, the final score (1 ~ 8 points) of this attitude was given.

Use of JACK Simulation Software

Draw the Operation Environment

Before the simulation of Chinese wolfberry picking, the simulation environment of Chinese wolfberry picking should be constructed. The 3D Max software was used to create a wolfberry tree model (tree height about 150 cm, crown length and width about 100 cm) and a fruit basket model according to the field survey data, and the model was imported into Jack simulation software. The result of the simulation environment of Chinese wolfberry picking are shown in Figure 1 below.
Establish a Digital Person for Simulation

According to the picking posture and operation cycle obtained from the previous statistical analysis, the simulation animation of the human model was edited to complete the picking operation simulation. The process of picking medlar mainly includes picking standing posture, bending over, sitting posture and squatting posture. In the operation, it is mainly about hand and upper limbs. The movement is single and the frequency is faster. Figure 2 shows the simulation results of each posture.

![Figure 2. Picking posture editing.](image)

Conduct Model Analysis with Jack Analysis Software

Firstly, the Ovako Working Posture Analysis module is applied to analyze the above four working postures, and the rationality of the actions is obtained, as shown in Figure 3 below.

![Figure 3. Ovako working posture analysis](image)

(a) (b)

Figure 3. Ovako working posture analysis

(figure (a) is the simulation result of standing posture picking, figure (b) is the simulation result of squatting down picking).

It can be seen that the analysis result of standing posture picking is level 1: the posture is normal and there is no need to correct. The analysis of sitting picking and bending picking is level 2: posture may have some adverse effects that require no immediate action but should be adjusted in the near
future. The analysis result of squatting picking is level 3: posture has bad influence, which should be corrected as soon as possible.

Lower Back Analysis module was used for the lower back analysis, and the mannequin in different working postures was selected. The analysis results were shown in Figure 4 below.

![Figure 4. Lower back analysis chart](image)

Figure 4. Lower back analysis chart (figure (a)) is the simulation result of bending over picking, figure (b) is the simulation result of sitting posture picking).

Lower Back Analysis showed the distribution of L4/L5 spine pressure, L4/L5 torque, muscle stress and torque. There is less pressure on the L4/L5 joints and less torque on each joint in the standing and sitting position. In contrast, the joint pressure was the least under the standing position, about 800N, and the joint torque was the least under the sitting position. The stress and torque of L4/L5 joints under bending and squatting operations were significantly increased.

Rapid upper limb motion analysis module was used for analysis. Rapid Upper Limb Assessment was conducted for four working postures, including standing picking, bending picking, sitting picking and squatting picking. The scoring results of each part of the body were statistically calculated as shown in table 1.

| Project/assignment posture | Standing | Bend over | Sitting position | Squatting |
|----------------------------|----------|-----------|------------------|-----------|
| Body Group A loading(Arm, Wrist) | Upper arm | 2 | 4 | 1 | 4 |
|                             | lower arm | 2 | 3 | 3 | 3 |
|                             | Wrist    | 3 | 2 | 2 | 3 |
|                             | Wrist Twist | 2 | 2 | 1 | 1 |
|                             | total    | 4 | 5 | 3 | 5 |
| Body Group B Loading(Trunk) | Neck     | 1 | 1 | 4 | 4 |
|                             | Trunk    | 2 | 6 | 2 | 3 |
|                             | Total    | 2 | 7 | 5 | 6 |
| The comprehensive score    |          | 3 | 7 | 4 | 7 |

From the above score, it can be concluded that the posture score of body group A under the operation of bending and squatting reached 5 points, which had great influence on upper limbs. The score of trunk under bending operation was 6 points, and the posture score of body B group reached 7 points, indicating that bending operation had a great influence on trunk. On the whole, the comprehensive score of standing posture and sitting posture is 3 and 4 respectively, belonging to (level 2 operation), indicating that the posture needs to be studied and changed after a long time (the color of the analysis results becomes yellow). The overall score for bending and squatting is 7, which
is a level 4 operation, indicating that the current posture should be studied and changed immediately (the analysis results become dark red).

It can be seen from the analysis results of Chinese wolfberry picking by the above analysis tools, standing posture is the best posture for workers to avoid the risk of musculoskeletal diseases in the operation of wolfberry picking. Sitting posture has less influence on human body. Bending down and squatting have a greater negative impact on the human body. Because the time that wolfberry picks a job is longer, in the condition that works for a long time, workers should try to avoid stooping and squatting to pick fruits as far as possible.

Discussion

In this study, we conducted field studies in several locations, conducted animation simulation and ergonomic analysis on the picking of wolfberry through Jack software, and investigated the risk factors of musculoskeletal diseases during the picking of wolfberry. It is concluded that stooping and squatting are high risk actions for musculoskeletal diseases. In this posture, the stress on the waist and the torque on the body are significantly increased. Picking standing posture is the least influence on human body in the picking posture of wolfberry. The application of jack simulation software in agricultural production can effectively identify high-risk actions in agricultural production, so as to guide agricultural production and reduce the risk of musculoskeletal diseases.

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