THE RELATIONSHIP BETWEEN BMI AND LBP FOR A POPULATION EXPOSED TO WBV IN FARM MECHANIZATION

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ABSTRACT

Vibration can produce a wide variety of different effects to the operators. Farm equipment operators are usually exposed to whole-body vibration which transmitted via the seat or via the floor and feet. This vibration contributes to operator fatigue and can have a detrimental effect on job performance and safety.

The objective of this study was to determine whether body mass index (BMI) influences the risk of low back pain (LBP) in a population exposed to whole body vibration (WBV). For this a survey conducted in nine farm machinery-servicing stations belong to the Ministry of Agriculture (MOA), Farm machinery station in Gemiza, Egyptian Project for improving the main crops production in Sakha, and the local sector of farm machinery during the years of 2008-2009 through periodic visits. Vibration measurements were performed according to ISO 2631-1, 1997. Two measurements were taken: stand height, and weight the results revealed that the tractor (Nasr model) which has no suspended seat and range of 60-65 horse power in the sample under study considers the highest equipment gives WBV data the frequency weighted RMS acceleration magnitude of the largest single orthogonal axis is in the vertical axis (Z) and also for VDV of weighted RMS acceleration. This constitutes a high risk on the labor body, followed by UTB tractor and rice combine. On the other hand, the WBV emission levels recorded during the harvesting by wheat combine and threshing tasks were low which constitute no risk on the labor body

The results revealed that the highest number of injured labors was in the age group of (41-45) years (46.4%), followed by (46-50) years (28.6%),

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but the least number of injured labors was in the age group of (34-40) years (14.3%), and followed by (51-55) years (10.7%). Type of pain indicated that the highest number of pain was (47%) for temporary LBP, followed by (22.6%) for healthy body, and (8.3%) for chronic LBP. Results showed that there are significant differences between the different types of equipment during the variation of farm operations, significant correlation, and significant relationship between accidents factors.

Keywords: Ergonomics, Low back pain (LBP), whole body vibration (WBV), body mass index (BMI).

INTRODUCTION

Vibration can produce a wide variety of different effects to the operators. Farm equipment operators are usually exposed to two types of vibration: whole-body vibration transmitted via the seat or via the floor and feet, and hand-arm-transmitted vibration. Both forms of vibration contribute to operator fatigue and can have a detrimental effect on job performance and health. To asses the effect of vibration, the vibration intensity and frequency must be taken into account together with exposure time **Goglia et al. (2003).**

Dias and Phillips (2002), (HSE) (2005) mentioned that:

Vibration**:** can be considering as the energy diverted from a useful purpose to a destructive end. It is a periodic motion which takes place when any elastic system is displaced from its initial position and released.

Whole-Body Vibration: caused by machinery vibration passing through the buttocks of seated people or the feet of standing people. The most widely reported WBV injury is back pain. Prolonged exposure can lead to considerable pain and time off work and may result in permanent injury and having to give up work.

Exposures towards the lower levels are given in Table (1).

Table (1): Some WBV levels in agriculture and exposure periods (in brackets) that present risk of injury (Health and Safety Executive, 2005).

Task	Range of likely WBV levels ($m.s^{-2}$) and corresponding suggested maximum total daily exposure period
Combining	0.4 (24 hrs) – 0.8 (6)
Power harrowing	0.2 (24) – 1.2 (3)
Baling	0.3 (24) – 1.5 (2)
Forage harvesting	0.5 (15) – 1.5 (2)
Hedging, ditching	0.5 (15) – 1.5 (2)
Seed drilling	0.9 (5) – 1.5 (2)
Spreading, spraying	1.0 (4) - 1.6 (1.5)
Ploughing	1.0 (4) - 1.6 (1.5)
Harrowing	0.7 (8) – 2.1 (1)
Mowing	0.9 (5) – 2.1 (1)
Hay tedding	1.1 (3) – 2.7 (0.5)
Transport	1.0 (4) – 2.7 (0.5)

Gierke and Brammer (2002) stated that the combination of soft tissue and bone in the structure of the body together with the body's geometric dimensions results in a system which exhibits different types of response to vibratory energy depending on the frequency range: At low frequencies (below approximately 100 Hz), the body can be described for most purposes as a lumped parameter system; resonances occur due to the interaction of tissue masses with purely elastic structures. At higher frequencies, through the audio-frequency range and up to about 100 kHz, the body behaves more as a complex distributed parameter system—the type of wave propagation (shear waves, surface waves, or compressional waves) being strongly influenced by boundaries and geometrical configurations. Physical properties of human body tissue are summarized in Table (2) for frequencies less than 100 kHz.

Pope et al. (2002) stated that there is strong epidemiological evidence that occupational exposure to WBV is associated with an increased risk of low back pain (LBP), sciatic pain, and degenerative changes in the spinal system, including lumbar intervertebral disc disorders.

Table (2): Physical Properties of Human Tissue at Frequencies Less Than 100 kHz.

Property	Tissue, soft	Bone, compact	
		Fresh	Embalmed, dry
Density, g/cm^3	1-1.2	1.93–1.98	1.87
Young's modulus, dyne/cm^2	7.5*10^4	2.26*10^{11}	1.84*10^{11}
Volume compressibility, dyne/cm^2	2.6*10^{10}	---	1.3*10^{11}
Shear elasticity, dyne/cm^2	2.5*10^4	---	7.1*10^{10}
Shear viscosity, dyne-sec/cm^2	1.5*10^2	---	---
Sound velocity, cm/s	1.5-1.6*10^5	3.36*10^5	---
Acoustic impedance, dyne-s/cm^3	1.7*10^5	6*10^5	6*10^5
Tensile strength, dyne/cm^2	---	9.75*10^8	1.05*10^9
Shearing strength, dyne/cm^2	---	4.9*10^8	---
Shearing strength, dyne/cm^2	---	1.16*10^9	5.55*10^8

Dhingra et al. (2003) mentioned that overall seating comfort is influenced by both static and dynamic characteristics of seat system. Whole body vibration and shocks are recognized as important factors, causing low back pain. This however, can be reduced by provision of lumbar support, side support and suitable cushion type**.**

Hostens and Ramon (2003) stated that all on- and off-road vehicles are exposed to vibrations caused by unevenness of road or soil profile, moving elements within the machine or implements. A higher prevalence of low back pain is found in drivers of off-road machinery than in other drivers.

Zein- ELdin et al. (2003) estimate the vibration levels of tractor alone and tractor with hithed machines. The results indicated that with increasing tractor speed, the amplitude decreases, but the frequency increases under the same conditions. Sandy loam soil was more affected on tractor vibration levels compared with clay loam soil.

Kittusamy and Buchholz (2004) stated that exposure to whole-body vibration (WBV) and the postural requirements of the job have been identified as important risk factors in the development of musculoskeletal disorders (MSD) of the spine among workers exposed to a vibratory environment.

Fritz et al. (2005) mentioned that long-term vibration stress can contribute to degenerative changes in the joints of the human body, especially in the lumbar spine.

Bovenzi et al. (2006) stated that the prevalence of low back pain (LBP) was investigated in 598 Italian professional drivers exposed to whole-body vibration (WBV) and ergonomic risk factors (drivers of earth moving machines, fork-lift truck drivers, tractor drivers, bus drivers). High intensity of LBP, and LBP disability significantly increased with increasing cumulative vibration exposure.

Burdorf and Hulshof (2006) stated that background: Exposure to whole-body vibration (WBV) is a well-known risk factor for the occurrence of low-back pain (LBP).

Gallais and Griffin (2006) mentioned that this review investigates whether there is evidence of an association between car driving and low back pain, and evidence that whole-body vibration contributes to low back pain in car drivers.

Okunribido et al. (2006) conducted a cross-sectional study to investigate the relative role of whole-body vibration (WBV), posture and manual materials handling (MMH) as risk factors for low back pain (LBP). Using a validated questionnaire,

Wang et al. (2006) mentioned that a well-designed tractor seat should be able to accommodate conveniently operators of various sizes (5th–95th percentile) and shapes. It should provide adequate body support and geometric parameters of seat with respect to anthropometric data of seating users. The design of a tractor seat should give due consideration to static and dynamic performance requirements.

Mayton et al. (2007) mentioned that Vehicle vibration exposure has been linked to chronic back pain and low-back symptoms among agricultural tractor drivers.

Tiemessen et al. (2007) mentioned that musculoskeletal disorders (MSD) at the workplace cost a lot. These MSD, low back pain in particular, can be caused by exposure to whole body vibration (WBV).

Preventive strategies to reduce vibration exposure may contribute to a decrease in MSD.

Guo et al. (2008) mentioned that the long-term whole body vibration might induce the degeneration of human spine at the relevant spinal motion segments.

Li et al. (2008) stated that occupational whole-body vibration has long been associated with low back injuries.

Mehta et al. (2008) mentioned that tractor driving imposes a lot of physical and mental stress upon the operator. If the operator's seat is not comfortable, his work performance may be poor and there is also a possibility of accidents. The optimal design of tractor seat may be achieved by integrating anthropometric data with other technical features of the design.

The objective of this study was to determine whether body mass index (BMI) influences the risk of low back pain (LBP) in a population exposed to whole body vibration (WBV).

MATERIAL AND METHODS

To assess the influence of BMI on the relation between LBP and WBV exposure, a survey was conducted to collect data and information on such incidents specially back pain that happened from farm equipment operating during the years 2008-2009 through periodic visits in nine selected farm machinery-servicing stations and the local sector belong to the ministry of agriculture (MOA), from five governorate; Sharkia, Kafer ElShiekh, Kalubia, Gharbia, and Ismaellia and Egyptian project for improving the main crops production in Sakha, and the local station in Gemeza. The governorates were selected on the basis of highest number of labors who had back pain related to equipment and farm machines and the highest tractors and farm machines density in the region (Equipment and farm machinery bulletin, 2008). The selected farm machinery-servicing stations for the surveys were; Elkasasin, Kafer Sakr, Hehya, Abokaber, Sakha, Kellen, Kotour, Toukh, and Benha.

The collected data were divided in two major categories:

1- Data of the labors personal information and anthropometrics data measurements were taken for 337 subjects chosen randomly among farm machines operators, equipment operators, farm mechanistics, and farm labors working at the nine farm machinery-servicing stations. The sample included 28 subjects had chronic low back pain. Data were collected by interviewing persons using a questionnaire format as shown in figure (1), and were also collected from archives. Two measurements were taken; stand height, and weight, weighing balance and measuring tape were used for the measurements, figure (2). The measurements posture was such that the subject stands with his feet closed and his body vertically erected.

2- Data of the whole body vibration and occupational history related to equipment and farm machines measurements were taken for 306 labors that operate different types of equipment and machines (Nasr, UTB, Massy Ferguson, Ford, John Deere, Kubota, Lamborghini, Fiat New Holland, Kubota & Yanmer combine, Wheat combine, and Thresher) included with high vibrating mechanism, in different types of farm operations (Primary tillage, Secondary tillage, Harvesting with tractor and mower, Harvesting with rice combine, Transportation off/on road, Land leveling, Precision land leveling (Laser), Ditching, Threshing, and Harvesting with wheat combine), chosen randomly among farm machines, and equipment operators. Data were collected by interviewing persons using a questionnaire format as shown in figure (3). Stop watch, and Human vibration analyzer type 4447 were used for the measurements Figure (4).

Human exposure to whole-body vibration should be evaluated using the method defined in International Standard ISO 2631-1:1997. The root mean square, r.m.s vibration magnitude is expressed in terms of the frequency-weighted acceleration at the seat of a seated person or the feet of a standing person, it is expressed in units of metres per second squared (m/s^2). The r.m.s vibration magnitude represents the average acceleration over a measurement period. It is the highest of three orthogonal axes values (1,4awx, 1,4awy or 1.0awz) that are used for the risk assessment. Measurements should be made over periods of at least 20 minutes.

The vibration dose value (or VDV) provides an alternative measure of vibration exposure. The VDV was developed as a measure that gives a better indication of the risks from vibrations that include shocks. The units for VDV are metres per second to the power 1,75 ($m/s^{1,75}$), and unlike the r.m.s vibration magnitude, the measured VDV is cumulative value, it is therefore important for any measurement of VDV to know the period over which the value was measured. It is the highest of three orthogonal axis values (1,4*VDV*wx, 1,4*VDV*wy or *VDV*wz) that are used for the risk assessment. Measurements should be made to produce vibration values that are representative of the average vibration throughout the operator's working period. It is therefore important that the operating conditions and measurement periods are selected to achieve these **Griffin (1990), Scarlett et al. (2005), (ISO 2631-1, 1997)**.

They mentioned that WBV emission levels are evaluated in terms of frequency-weighted root-mean-square (r.m.s.) acceleration (aw) (units: m/s^2). This technique generates a single value to represent a period of vibration measurement

$$a_w = \left[\frac{1}{T} \int_0^T a_w^2 (t) dt \right]^{1/2} \tag{1}$$

where:-

$a_w(t)$ = frequency-weighted acceleration time history (m/s^2).

T= duration of measurement (seconds).

Where vibration exposure consists of two or more periods of exposure to different magnitudes and durations, the (frequency-weighted) energy-equivalent acceleration (A_{eq}) corresponding to the total duration of exposure may be derived. This is effectively an overall average r.m.s. acceleration value for the total period in question (ΣTi)

$$A_{eq} = k \left[\frac{\sum a^2_{wi} . T_i}{\sum T_i} \right]^{1/2} \tag{2}$$

where:-

A_{eq} = axis-weighted energy-equivalent continuous acceleration (r.m.s. acceleration (m/s^2))

a_{wi} = vibration magnitude (r.m.s. acceleration (m/s^2)) for exposure period *T*i

***ΣT*i** = total duration of exposure / measurement

k = orthogonal (measurement) axis multiplying factor specified by ISO 2631-1:1997 (see Table 3)

Table (3): Frequency weightings and multiplying factors for health aspects of whole body vibration (WBV) as specified by ISO 2631-1:1997 for seated persons.

Measurement axis	Frequency weighting	Multiplying factor (k)
Longitudinal (X) axis	Wd	1.4
Transverse (Y) axis	Wd	1.4
Vertical (Z) axis	Wk	1

For comfort evaluation ISO 2631-1:1997 recommends multiplying factors of 1 in all axes.

For whole-body vibration (WBV), as opposed to hand-arm vibration (HAV), the PA(V)D has proposed two alternative methods of vibration exposure assessment and European Member States have the option to implement the Directive using either technique. The Exposure Action Value (EAV) and/or the Exposure Limit Value (ELV) may be defined either as a daily vibration exposure, expressed as frequency weighted, energy-equivalent continuous r.m.s. acceleration over an eight-hour period (A(8)), or as a vibration dose value (VDV) of the frequency-weighted acceleration (see Table 4).

Table (4): Vibration exposure values specified by ISO 2631-1:1997.

		8-hour energy-equivalent r.m.s. acceleration – A (8) (m/s^2)	Vibration Dose Value ($m/s^{1.75}$)
Whole-Body Vibration	Exposure Action Value (EAV)	0.5	9.1
	Exposure Limit Value (ELV)	1.15	21
Hand-Arm Vibration	Exposure Action Value (EAV)	2.5	-
	Exposure Limit Value (ELV)	5	-

In either case, the vibration exposure levels are evaluated individually from the acceleration time histories recorded in each of three orthogonal axes (X-longitudinal, Y-transverse & Z-vertical), following application of the frequency-weightings (Wd or Wk) and axis weighting factors (k), as stated in ISO 2631-1:1997 regarding "Effect of Vibration on Health" (see Table 1). The resulting A (8) or VDV values for each (X, Y & Z) axis are then compared individually with the EAV and ELV. The axis-weighting (or multiplying) factor (k) effectively increases the magnitudes of the horizontal (X & Y) axes WBV values.

The daily vibration exposure level (A(8)) (units: m/s^2), expressed as eight-hour energy equivalent continuous, frequency-weighted r.m.s. acceleration (A(8)) may be derived from the equivalent continuous r.m.s. acceleration (Aeq) as below:-

$$A(8) = A_{eq}\sqrt{\frac{t}{8}} \tag{3}$$

where:-

t = daily exposure period (hours)

$\mathbf{A_{eq}}$ = the energy-equivalent continuous r.m.s. acceleration which is representative of the exposure period (m/s^2)

Alternatively, if the equivalent continuous r.m.s. acceleration (Aeq) value (effectively the overall average r.m.s. value) for a period of vibration exposure has not previously been derived (thereby permitting the use the previous equation), the daily vibration exposure A(8) value may be derived directly from the frequency-weighted acceleration time history using the formula:-

$$A(8) = k\left[\frac{1}{T_o}\int_0^T a_w^2(t)dt\right]^{1/2} \tag{4}$$

where:-

$\mathbf{a_w}(\boldsymbol{t})$ = frequency-weighted acceleration time history at the supporting surface (m/s^2)

T = total duration of exposure within any period of 24 hours

To = reference duration of 8 hours (28,800 seconds)

k = orthogonal (measurement) axis multiplying factor specified **by ISO 2631-1:1997.**

The daily vibration dose value (VDV) (units: $m/s^{1.75}$) of a person may be derived from the formula:-

$$VDV = k\left[\int_0^T a_w^4(t)\,dt\right]^{1/4} \quad (5)$$

where:-

$\mathbf{a_w}(t)$ = frequency-weighted acceleration time history at the supporting surface (m/s^2)

T = total duration of exposure (seconds) within any period of 24 hours

k = orthogonal (measurement) axis multiplying factor specified by **ISO 2631-1:1997**.

The data were processed for Frequencies procedure, Crosstabs (X^2), Analysis of variance, and Correlation's matrix **(Snedecor and Cochran, 1980).**

1. Date :-
2. Governorate :-
3. Farm machinery-servicing station name :-
4. What is your name?
5. What is your healthy status?
   - Injuried
   - Not Injuried
6. What is your age?
7. What is your qualification?
   - Without
   - Less than intermediate
   - Intermediate
   - More than intermediate
   - Graduate
8. How is your education?
   - Illiterate

Fig. (1): Personal and anthropometrics data questionnaire of Labors.

Read and write

9. What is the kind of training course do you attend?
   - Maintenance, operating training course
   - Maintenance, operating, and occupational safety training course
   - No training course
10. What is your marital status?
    - Single
    - Married
    - Divorced/Separated
    - Widowed
11. What is your age at injury time?
12. Do you smoke? Yes No
13. Do you have more than one job? Yes No
14. What is your current occupation?
    - Tractor driver
    - Combine operator
    - Thresher operator
    - Farm mechanistic
    - Farm labor
15. How many years have you spent working in your present job?
16. What is your anthropometrics measurement?
    - Stand height ( ),cm
    - Weight ( ),kg
    - BMI

Contin. to Fig (1).

Fig. (2): The labors anthropometrics measurements status.

1. Date :-
2. Governorate :-
3. Farm machinery-servicing station name :-
4. What is your name?
5. What is the vibration value of your equipment during this farm operation in X, Y, and Z axis?
6. Which postures do you adopt when driving?
   - Bent forward
   - Twisted
   - Lean against backrest
   - Any other constrained posture?
7. What kind of transportation do you use to get to and from work?
   - Car
   - Bus
   - Train
   - Bicycle
   - Walk
8. How long does it take you to get to work?
   - Less than 20 min
   - 20-40 min
   - 41-60 min
   - More than 1 hour
9. On which type of ground surface do you drive regularly?
   - Clayey soil
   - sandy soil
   - asphalt soil
10. What is your normal style/speed of driving?
    - Smooth
    - slow
    - fast
    - accelerating/braking
11. How often does your vehicle jerk or jolt so much that you are uplifted from your seat?
    - Never
    - More than 5 times a day

More than 5 times an hour
More than 5 times a minute

12. Do you experience discomfort by mechanical vibration or shock in your work?

Vertical vibration	Yes	No
Fore/aft vibration	Yes	No
Side-to-side vibration	Yes	No

13. How many hours a day do you spend sitting without vibration on the job?

Fig. (3): The whole body vibration and occupational history related to equipment and farm machines questionnaire.

How many days a week do you spend sitting? Days
How many weeks a year do you spend sitting? Weeks

14. Do you have to maintain a twisted posture without vibration often and/or for prolonged times? Yes No

15. How many hours on a typical day do you spend standing/walking on the job?
hours

How many days a week do you work? Days
How many weeks a year do you work? Weeks

16. Does your job include manual lifting? Yes No

17. Does your job include (on an average working day) any of the following conditions? Prolonged or recurrent work done with your back:

Bent forwards, backwards or sideways	Yes	No
Twisted	Yes	No
Bent and twisted simultaneously	Yes	No
Any other constrained posture?		

18. Does your job include repeated, prolonged or uncomfortable carrying, pushing or pulling of loads? Yes No

19. Are there any other duties required in your job that stress your low back?

20. How many breaks do you usually take during the workday (this means getting out of your vehicle)?

21. How long are your breaks? minutes

22. What do you do during your breaks?
    - Walk around
    - Sit
    - Stand
    - Other

23. What was/were your previous occupation(s)?

    ----------- For ---------- years

24. Did you drive in your previous jobs on vehicles like: trucks, buses, car, earth moving equipment etc.?

    If Yes vehicle

    Year (s) on a on average

    hours/day

25. Did your previous job(s) involve?

Prolonged sitting?	Yes	No
Heavy physical demands?	Yes	No
Any other constrained postures?	Yes	No

26. Did you ever have low back pain in your previous job/s? Yes No

27. Did or do you drive on a regular basis any kind of vehicle in your spare time (outside work)? Yes No

28. Did you have low back, neck, or shoulders pain/troubles?

    Yes No

29. What is its degree?

Contin. to Fig (3).

- Chronic LBP
- Temporary LBP
- Healthy body

30. How much time did you have to take of work due to the low back, neck, or shoulders pain?

31. Has a doctor told you what was wrong with your back, neck, or shoulders, i.e., given a diagnosis?

32. Have you ever had a trauma to your back, neck, or shoulders that required a medical visit?

33. What treatment did your doctor prescribe? (Anti-inflammatory drugs, painkillers, physical therapy, surgery, other?)

34. Is there any movement or activity that causes your pain?

Yes No

35. Is there any movement or activity which aggravates your pain?

Yes No

36. Do you usually get back, neck, or shoulders pain during or shortly after driving a vehicle? Yes No

37. Have you at any time had trouble in the other parts of your body? (Such as ache, pain, discomfort, numbness) in:

Elbows

No Yes

in the right elbow

in the left elbow

in both elbows

Wrists/hands

No Yes

in the right Wrists/hands

in the left Wrists/hands

in both Wrists/hands

Hips/thighs/buttocks

No Yes

in the right hip

in the left hip

in both hip

Knees

No Yes

in the right Knees

in the left Knees

in both Knees

Ankles/feet

No Yes

in the right Ankles/feet

in the left Ankles/feet

in both Ankles/feet

Upper back No Yes

Cont. to Fig (3).

38. Did you suffer from the following disorders? - Inguinal (groin) rupture (hernia). - Digestive disorders (a specific stomach complaints, gastritis, stomach ulcer, intestinal complaints). - Circulatory problems (varicose veins, hemorrhoids, hypertension, heart complaints). - Raynaud's phenomenon, i.e., vibration white finger syndrome (white and/or cold fingers). Urinary disorders (prostatitis, renal disorder) Vestibular disturbances (dizziness)

Cont. to Fig (3).

Fig. (4): Human vibration analyzer type 4447.

USES:-

- Hand-arm vibration measurements (2 to 1250 Hz).
- Whole-body vibration measurements (1 to 80 Hz).
- Low-frequency whole-body vibration measurements down to 0.4Hz.

Type 4447 simultaneously measures and calculates the following parameters:

- Three components of the running RMS vibration, weighted or unweighted, ax, ay, az.
- Three components of the peak vibration, weighted or unweighted, ax, peak, ay, peak, az, peak.
- The crest factor for each axis.
- The frequency-weighted whole-body vibration a_{Wx}, a_{Wy}, a_{Wz}.
- The combined vibration on all 3 axes as a vector sum a_{Wv}, with implementation of the *k*-factors for whole-body.

RESULTS AND DISCUSSION

Data obtained from survey were statistically analyzed and plotted in the following Figs (5-16). the labors personal information and anthropometrics data were classified according to age at injury time, healthy status, qualification status, education status, training, marital status, and current occupation. Fig. (5) showed that the highest number of Labors who had low back pain related to equipment and farm machines was in the age group of (41-45) years (46.4%), followed by (46-50) years (28.6%), (36-40) years (14.3%), and (51-55) years (10.7%). This may be due to the highest percentage of workers lay in this group

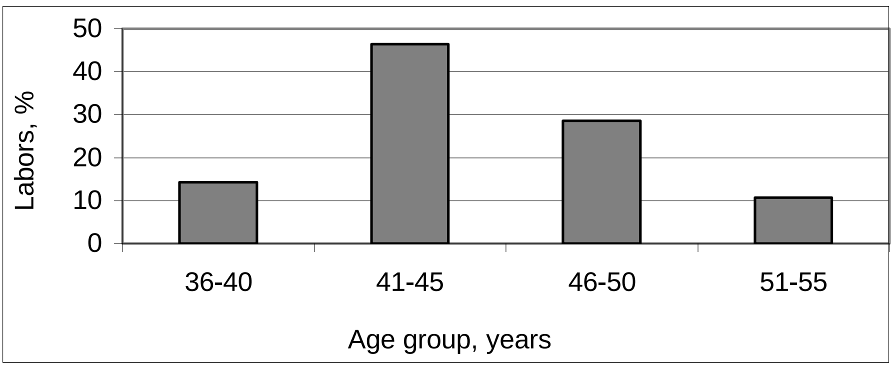
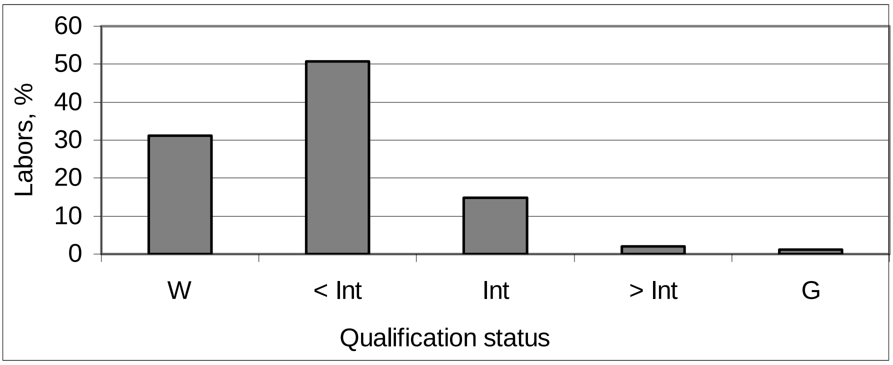


Fig. (5): Labors who had low back pain related to equipment and farm machines distribution by age group.

Figs. (6 and 7) showed that the highest percentage of subjects who had qualification was less than intermediate (50.7%), followed by without qualification (31.2%), intermediate (14.8%), more than intermediate (2.1%), and (1.2%) for graduate, on the other hand, there was (89.9%) read and write, and (10.1%) illiterate. The trend of decreasing injuried number with increasing level of qualification and education status is logically accepted, the difference between the status of illiterate and person who can read and write only is not technically significant under the Egyptian circumstances. Therefore one may say that the training on operating or utilizing machines may be the effective factor for these cases.



W = Without < Int = Less than intermediate Int = Intermediate
> Int = More than intermediate G = Graduate

Fig. (6): Qualification status of labors

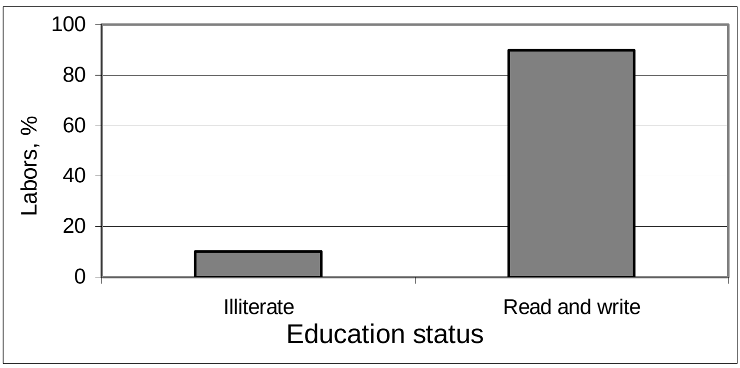


Fig. (7): Education status of labors.

Fig. (8) showed that (54.9%) had no training course about tractors and farm machines, followed by (40.1%) had training course in maintenance and operation, and (5%) had training course in maintenance, operation, and occupational safety.

Fig. (9) showed that the highest number of current occupation was (51.3%) for tractors drivers, followed by (21.4%) for combine operators, (18.1%) for Thresher operator, (5.3%) for farm mechanistic, and (3.9%) for farm labors.

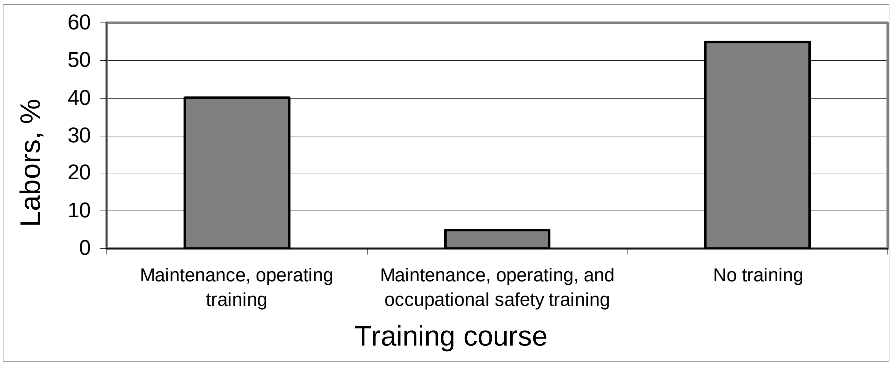


Fig. (8): Training course of labors.

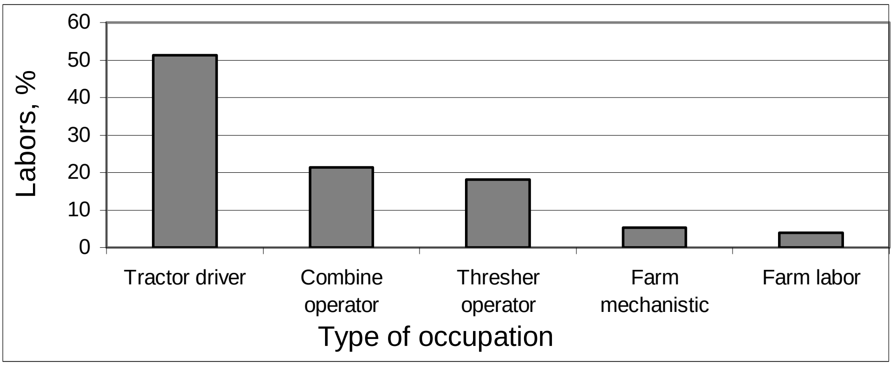


Fig. (9): Type of current occupation for labors.

Fig. (10) showed that there was (96.7%) of labors were married, and (3.3%) was single.

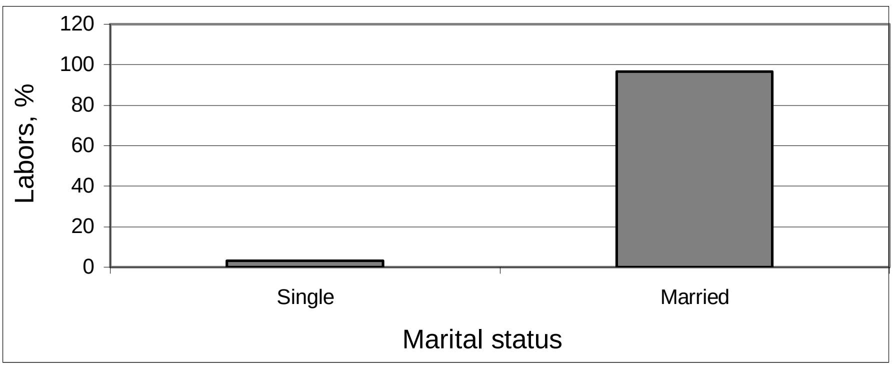


Fig. (10): Marital status of labors.

It is worth to state that the body mass index divided into five categories;

less than 18 consider thin,

18-24 is ideal,

25-29 is over weight,

30-39 is obesity,

more than 40 is over obesity.

Height and weight were used to calculate a participant's BMI according to the World Health Organization **(WHO, 2000),** which defines BMI as: the weight in kilograms divided by the square of the height in metres (kg/m^2).

Fig. (11): showed that the highest number of body mass index was (47%) for over weight body, followed by (27.5%) for ideal body, and (25.5%) for obesity body.

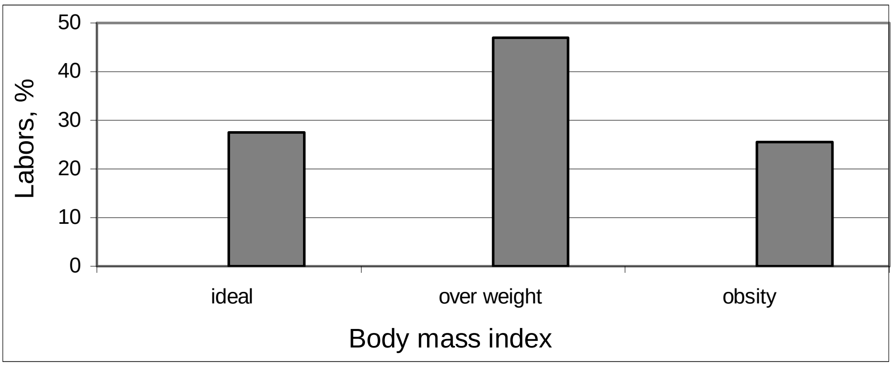


Fig. (11): Labor body mass index with low back pain distribution.

Fig. (12) showed that the highest number of type of pain was (47%) for temporary LBP, followed by (22.6%) for healthy body, and (8.3%) for chronic LBP.

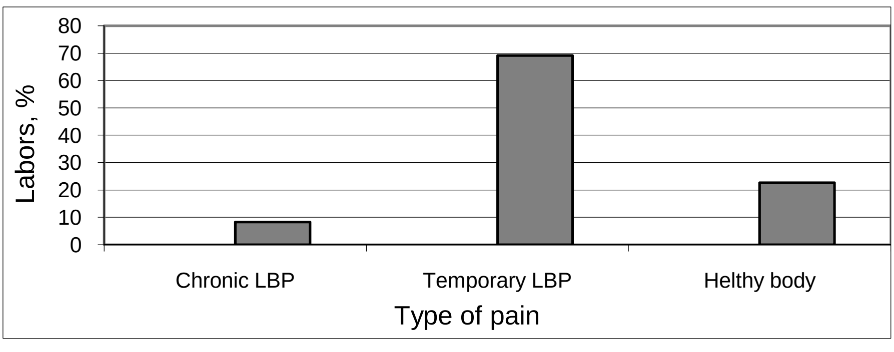


Fig. (12): Low back pain distribution.

Human exposure to whole-body vibration was evaluated using the method defined in the International standard ISO 2631-1-1997. In situation where vibration is transient i.e. is of short duration caused by shocks, the RMS value tends to underestimates the vibration and therefore the crest factor (maximum peak value divided by RMS) best describes the vibration. When the crest factor is more than 9, it is recommended to use additional evaluation methods like the running r.m.s or the forth power vibration dose method which is more sensitive to peaks' than the basic method because it uses a forth power instead of a second power of acceleration time history. The forth power vibration dose value is expressed in $m/s^{1.75}$. If the crest factor is below or equal to 9, the basic evaluation method is normally sufficient.

Fig. (13) showed that the basic vibration measurement parameters were for the x, y, z-direction and vector sum, the maximum frequency weighted RMS (root mean square) acceleration of (0.86 m/s^2) was in vertical (Z) axis, crest factor (CF) is more than the threshold limit and above the critical ratios, it was (61.6) in vertical (Z) axis, MTVV (maximum transient vibration value) of (8.8 m/s^2) was in vertical (Z) axis, VDV (vibration dose value) of (21.16 $m/s^{1.75}$) was in vertical (Z) axis, this in considerably in excess of the WBV exposure action value (EAV) and also exposure limit value (ELV) proposed by ISO 2631-1-1997.

Fig. (14) showed that the daily vibration exposure level (A (8)) (units: m/s^2), expressed as eight-hour energy equivalent continuous, frequency-weighted r.m.s. acceleration of (0.52 m/s^2), (0.44 m/s^2), and (0.86 m/s^2), were for the x, y, z-direction respectively. The daily vibration dose value (VDV) of (26.2 $m/s^{1.75}$), (23.2 $m/s^{1.75}$), and (57.16 $m/s^{1.75}$), were for the x, y, z-direction respectively. It is clear that the values are exceeded than both of exposure action value and exposure limit value proposed by ISO 2631-1-1997, especially in vertical (Z) axis. So there is a need to provide good suspension for the seat (which get the final transmitted force then to the operator) to ensure operating in safe conditions.

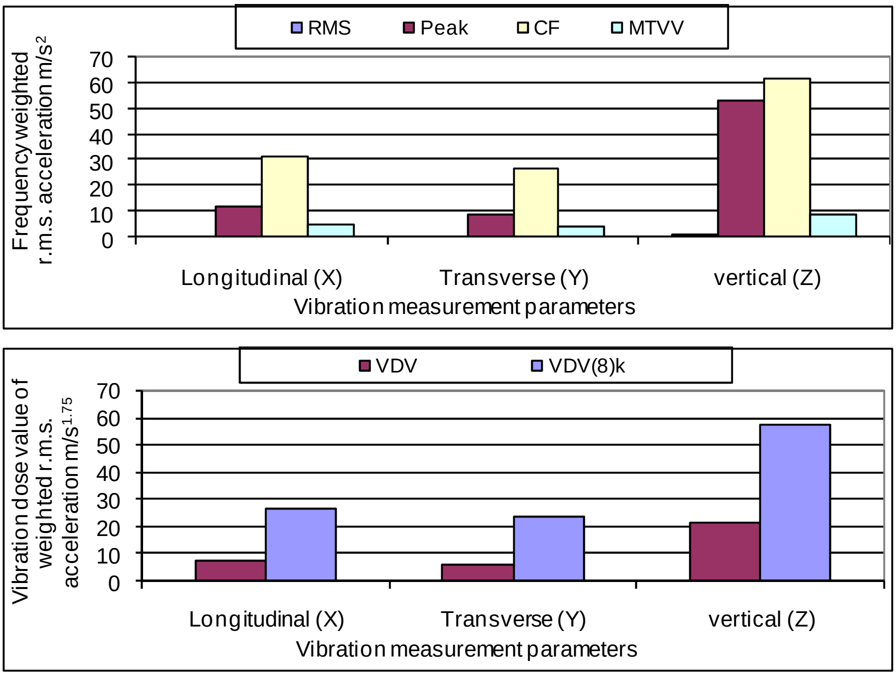


Fig. (13): Vibration measurement parameters for tractor Nasr model during measuring time in primary tillage.

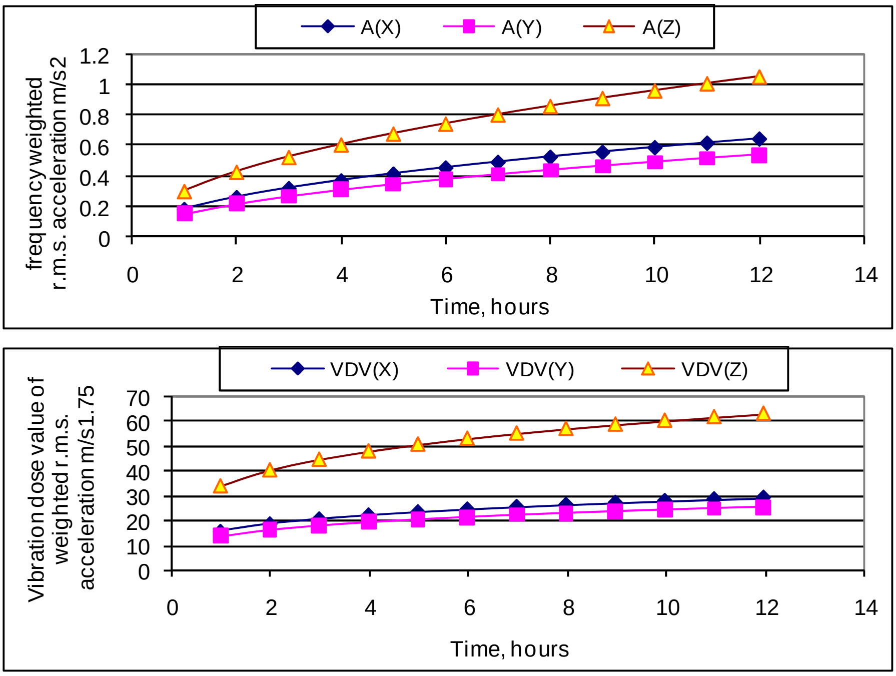


Fig. (14): Vibration measurement parameters for tractor Nasr model during twelve hours in primary tillage.

Fig. (15) showed that the basic vibration measurement parameters were for the x, y, z-direction and vector sum, the maximum frequency weighted RMS(root mean square) acceleration of (0.33 m/s^2) was in vertical (Z) axis, crest factor (CF) is less than the threshold limit and under the critical ratios, it was (5.6) in vertical (Z) axis, MTVV (maximum transient vibration value) of (.77 m/s^2) was in vertical (Z) axis. VDV (vibration dose value) of (1.2 $m/s^{1.75}$) was in vertical (Z) axis.

Fig. (16) showed that the daily vibration exposure level (A (8)) (units: m/s^2), expressed as eight-hour energy equivalent continuous, frequency-weighted r.m.s. acceleration of (0.2 m/s^2), (0.26 m/s^2), and (0.33 m/s^2), were for the x, y, z-direction respectively. The daily vibration dose value (VDV) of (4.43 $m/s^{1.75}$), (5.37 $m/s^{1.75}$), and (7.85 $m/s^{1.75}$), were for the x, y, z-direction respectively. It is clear that the values are less than both of exposure action value and exposure limit value proposed by ISO 2631-1-1997, especially in vertical (Z) axis.

Statistical analysis was thoroughly and in details performed to test the significance of all the interactable factors which affect injuries. The Chi-Square test was performed to check the interaction between the injuried factors. The analysis revealed that there were highly significant relationships between the studied factors. On the other hand, insignificant relationship was found between the other factors.

Table (5) showed that the statistical analysis for correlation matrix between low back pain (LBP), whole body vibration (WBV), and body mass index (BMI). Data analysis showed that there was highly significant correlation between LBP & weight, LBP & BMI, LBP & RMSX, LBP & VDVX, LBP & VDVY, LBP & VDVZ, height & weight, height & BMI, weight & BMI, RMSX & RMSY, RMSX & RMSZ, RMSX & VDVX, RMSX & VDVY, RMSX & VDVZ, RMSY & RMSZ, RMSY & VDVX, RMSY & VDVY, RMSY & VDVZ, RMSZ & VDVX, RMSZ & VDVY, RMSZ & VDVZ, VDVX & VDVY, VDVX & VDVZ, VDVY & VDVZ, VDVZ & soil type and showed that there was significant correlation between LBP & height, weight & VDVX, weight & VDVY, BMI & VDVX, BMI & VDVY, BMI & VDVZ, RMSZ & soil type.

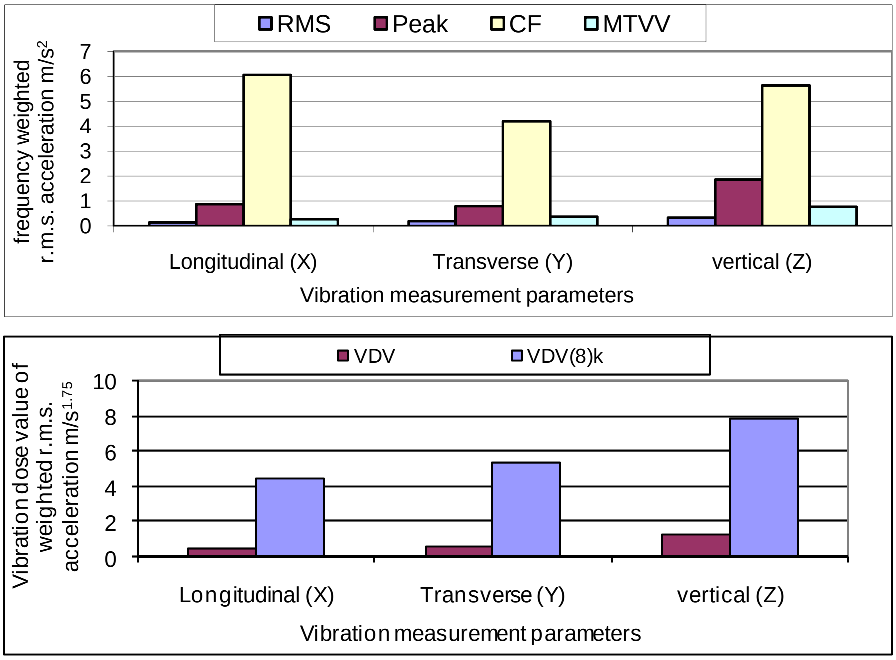


Fig. (15): Vibration measurement parameters for harvesting by wheat combine during measuring time.

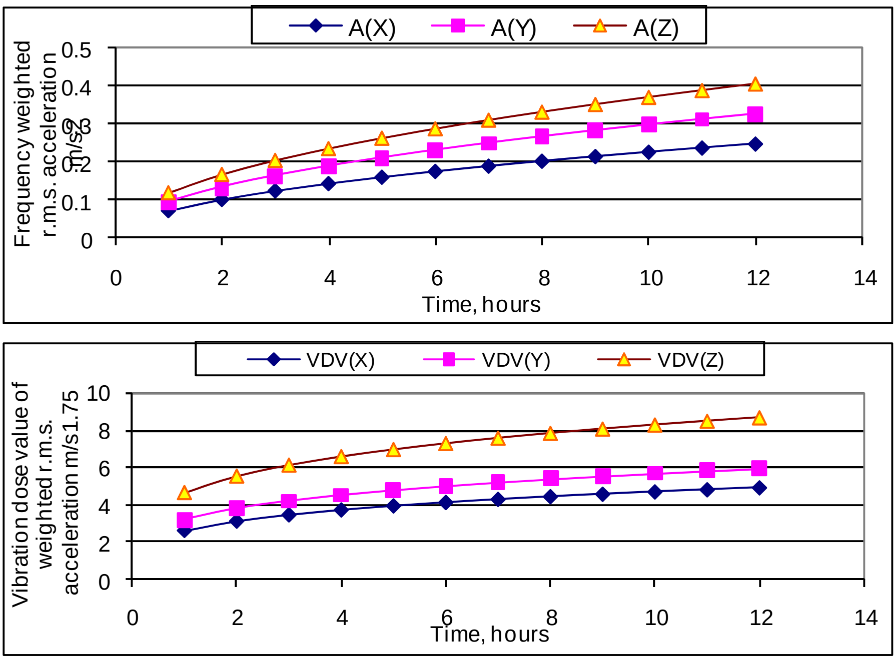


Fig. (16): Vibration measurement parameters for harvesting by wheat combine during twelve hours.

Table (5): The correlation matrix between low back pain (LBP), whole body vibration (WBV), and body mass index (BMI).

injured factors	LBP	height	weight	BMI	RMSX	RMSY	RMSZ	VDVX	VDVY	VDVZ	soil type
LBP	1										
height	.144*	1									
weight	.479**	.592**	1								
BMI	.504**	.291**	.942**	1							
RMSX	.151**	0.049	0.104	0.107	1						
RMSY	0.083	0.02	0.052	0.056	.852**	1					
RMSZ	0.097	0.024	0.029	0.028	.599**	.669**	1				
VDVX	.257**	0.063	.138*	.141*	.694**	.506**	.325**	1			
VDVY	.233**	0.054	.116*	.119*	.674**	.616**	.392**	.958**	1		
VDVZ	.291**	0.018	0.107	.122*	.544**	.424**	.469**	.843**	.841**	1	
soil type	0.043	0.006	0.075	0.091	0.047	0.094	.143*	0.078	0.099	.170**	1

** Highly Significant * Significant

Table (6) showed that the statistical analysis of ANOVA for the anthropometric characteristics of farm workers who injuried and not Injuried. Data analysis showed that there was highly significant difference on the mean of height, on the mean of weight, on the mean of BMI, on the mean of RMSX, on the mean of VDVX, on the mean of VDVY, and on the mean of VDVZ for injuried and not Injuried labors, on the other hand, there was insignificant difference on the mean of RMSY, and on the mean of RMSZ. So it is clear that the mean of BMI and mean of VDVZ for a labor working in farm machinery which cause LBP were between (25.614, 26.4057) (over weight), (20.6577, 23.4686) m/s^2, respectively, are considering safely under operating conditions according to the equipment functional parts (suspension posture of seat) in the sample under study.

Table (6): The statistical analysis of ANOVA for the anthropometric characteristics of farm labors that had LBP and exposed to whole body vibration (WBV).

Labor anthropometrics with WBV	healthy status	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	F	Sig.
height	Injuried	175.429	4.6222	0.8735	173.6363	177.221	6.42	0.012**
	Not Injuried	172.82	5.2432	0.3145	172.2011	173.439		
weight	Injuried	100.536	10.3476	1.9555	96.5233	104.548	90.63	0**
	Not Injuried	77.8957	12.1429	0.7283	76.462	79.3294		
BMI	Injuried	32.5839	2.0335	0.3843	31.7954	33.3724	103.62	0**
	Not Injuried	26.0098	3.3527	0.2011	25.614	26.4057		

Contin. To Table (6).

RMSX	Injuried	0.5729	0.4641	8.77E-02	0.3929	0.7528	7.05	0.008**
	Not Injuried	0.448	0.2017	1.21E-02	0.4242	0.4718		
RMSY	Injuried	0.5232	0.3676	6.95E-02	0.3807	0.6658	2.09	0.149
	Not Injuried	0.4627	0.1888	1.13E-02	0.4404	0.485		
RMSZ	Injuried	0.8821	0.4482	8.47E-02	0.7083	1.0559	2.896	0.09
	Not Injuried	0.7684	0.3242	1.94E-02	0.7301	0.8067		
VDVX	Injuried	22.5814	34.7745	6.5718	9.0973	36.0656	21.446	0**
	Not Injuried	11.8358	5.6957	0.3416	11.1634	12.5083		
VDVY	Injuried	19.8825	26.0931	4.9311	9.7646	30.0004	17.407	0**
	Not Injuried	12.2973	5.0902	0.3053	11.6963	12.8983		
VDVZ	Injured	39.0261	38.4328	7.2631	24.1234	53.9288	28.119	0**
	Not Injuried	22.0632	11.9039	0.7139	20.6577	23.4686		

** Highly Significant

SUMMARY AND CONCLUSSION

The aim of this research is to determine whether body mass index (BMI) influences the risk of low back pain (LBP) in a population exposed to whole body vibration (WBV), the results indicated that:-

1- The highest number of Labors who had low back pain related to equipment and farm machines was in the age group of (41-45) years (46.4%), followed by (46-50) years (28.6%), (36-40) years (14.3%), and (51-55) years (14.3%). This may be due to the highest percentage of workers lay in this group.
2- The tractor (Nasr model) in the sample under study considers the highest equipment gives WBV data the frequency weighted RMS acceleration magnitude of the largest single orthogonal axis is in the vertical axis (Z) and also for VDV of weighted RMS acceleration. This constitutes a high risk on the labor body, followed by UTB tractor and rice combine. On the other hand, the WBV emission levels recorded during the harvesting by wheat combine and threshing tasks were low which constitute no risk on the labor body.
3- A Chi-Square Test was used to determine whether there were any statistically significant relationships between accidents factors revealed that there are need to provide training courses for labors who working in farm machinery, suitable interaction between labor anthropometrics and the equipment functional parts which cause LBP, and modify suspension posture of seat which cause LBP in the sample under study.
4- The statistical analysis for correlation matrix between injured factors revealed that there are highly significant and significant correlations.
5- There are significant differences between the height, weight, BMI, RMSX, VDVX, VDVY, and VDVZ for injured and not injured labors.

RECOMMENDATION

1- A mean BMI of (25.614, 26.4057) and a mean VDVZ of (20.6577, 23.4686) $m/s^{1.75}$, are consider the most suitable anthropometric characters and WBV for labors to perform safely.

2- The seat (which get the final transmitted force then to the operator) must be modified and be easy to adjust for the operator's weight and body size, height, fore-aft and backrest adjustments are especially important. The seat cushions should be ergonomically designed.
3- Provide training course in maintenance, operating, and occupational safety in farm machinery. With providing and holding training programs for the labors in farm machinery.

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نشرة الآلات والمعدات الزراعية ، 2008 . قطاع الشئون الاقتصادية ، وزارة الزراعة واستصلاح الأراضى ، جمهورية مصر العربية .

الملخص العربى

العلاقة بين دليل كتلة الجسم وآلام أسفل الظهر (الانزلاق الغضروفى) لمجتمع يتعرض لإهتزاز كامل للجسم فى الميكنة الزراعية

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احمد رجب حامد****

يتسبب الاهتزاز الميكانيكى فى حدوث تأثيرات مختلفة لمشغلى وسائقى الجرارات والمعدات الزراعية ، حيث يتعرض هؤلاء الى اهتزاز كامل للجسم والذى ينتقل من خلال مقعد المعدة او عن طريق الأقدام فى حالة الوقوف على جسم مهتز ، هذا الاهتزاز يسبب تعب وتاثيرات ضارة على أداء وسلامة العاملين فى مجال الهندسة الزراعية . لذا تهدف هذه الدراسة الى تحديد ما اذا كان لدليل كتلة الجسم علاقة وآلام أسفل الظهر (الانزلاق الغضروفى) لمجتمع يتعرض لإهتزاز كامل الجسم فى الميكنة الزراعية من خلال حصر أجرى على 9 محطات للخدمة الآلية التابعة لوزارة الزراعة الى جانب المشروع المصرى لتحسين انتاجية محاصيل الحبوب الرئيسية والمحطة الاقليمية للبحوث الزراعية بالجميزة والعاملين بالقطاع الخاص فى الميكنة الزراعية من خلال الزيارات الميدانية خلال عامى 2008 ، 2009 وقد تضمن البحث قياس بعدين جسميين هما الطول واقفا و وزن الفرد وحساب دليل كتلة الجسم منهما .

وقد أظهرت النتائج أن الاصابات تتركز بنسبة عالية عند الفئة العمرية 41-45 سنة (46.4%) ، ويليها 46-50 سنة (28.6%) ، وتقل عند كل من الفئة العمرية 36-40 سنة (14.3%) وعند 51 – 55 سنة (10.7%) . وتصل نسبة الاصابة بالانزلاق الغضروفى المزمن الى (8.3%) , بينما تصل نسبة الاصابة بالانزلاق الغضروفى المؤقت الى (47%) ،

وأوضحت النتائج ان هناك علاقات وارتباطات معنوية بين عوامل الاصابات تتطلب الحاجة الى توفير التدريب الكاف للعمال للتعرف على معايير السلامة والصحة المهنية وتجنب التعرض للمخاطر ، هناك فرق معنوى بين الطول واقفا والوزن ودليل كتلة الجسم للعمال المصابين وغير المصابين بالانزلاق الغضروفى الذين يتعرضون لإهتزاز كامل الجسم وأيضا نوع العملية الزراعية (الحرث ثم عملية التسوية وأقلها الدراس يتبعها حصاد القمح بالكومباين) والمعدة الزراعية الأكثر تسجيلا لأعلى قيمة لإهتزاز كامل الجسم (الجرار النصر يتبعه الجرار الرومانى وأقلهم كومباين حصاد القمح) وهذه الجرارات لا تحتوى على تعليق مناسب للمقعد يمتص الاهتزازت أثناء العمل مما يستلزم اجراء التعديلات اللازمة على مقعد الجرار وأسلوب تعليقه لإمتصاص أكبر قدر من الاهتزازت و التى تتسبب فى حدوث إصابات الانزلاق الغضروفى فى العينة محل الدراسة نتيجة طول فترات التشغيل وذلك لتوفير بيئة عمل آمنة للعامل أثناء التشغيل .

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