



OCTOBER 18–21, 2013

TEHRAN, IRAN

## evaluation of forces applied on selective joints and muscles of drivers during clutching of MF285 and MF399 tractors

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### Abstract:

In this research, the imposed force on three muscles including: Gastrocnemius muscle, Trapezius muscle and Quadratus lumborum muscle of the tractor's driver during clutching has been studied. The number of sample people was assigned 30 and the research was conducted on two domestic tractors: MF285 and MF399 tractors. The clutching forces for these tractors were measured as 437.2 N and 317.2 N, respectively. The angle of knee location in these two tractors at the one percent level was significantly different. The decrease of pain threshold after 30 seconds and 60 seconds clutching and 60 seconds rest after clutching in MF285 tractor in all three muscles were more than MF399 tractor. In order to reduce the imposed force of clutching for MF285 tractor some modifications is required. In this regard the force transfer joint between the pedal and the disc in the mechanism of clutching can be replaced with the one made of cast iron.

Keywords: algometer, ergonomic, muscle, operator, tractor

### Introduction:

Agriculture is one of the important sectors in developed industrial countries and developing industrial countries. Hence an adequate attention should be paid to the practical application of ergonomic measures and changes of activity in agricultural practices in order to reduce work-related accidents and illnesses that result in improved living conditions and increased productivity. According to the International Labor Organization about 2.3 million people die due to occupational accidents and Work-related diseases every year. Latest estimates based on 2003 data indicate that 337 million occupational accidents and 160 million occupational illnesses take place in the whole world every year. According to a study by the European Commission in 2000, more than four percent of gross domestic production (GDP) is wasted in terms of accidents and illness in the world (Niu, 2010). One of the jobs in the agricultural sector which are directly related with machines and different devices, are tractor drivers. Although studies have been done on the condition of the tractor drivers' ergonomics, but because of issues, including difficulty of working conditions, yet these segments of society are in relatively poor health. Moreover, the adversity of their job are affected by geographical location, climatic condition, individual characteristics and the type of machine. It is essential to seriously investigate these realistic working conditions on different machines and in different geographical areas. About 85 percent of the world's total farms have less than two hectares that are classified as small farms, according to the World Bank definition. The average ownership level of agricultural land in Iran is also relatively low (Brian and Kienzle, 2006; Saiedirad and Parhizgar, 2011). For example, the average ownership level for peanuts production in Gilan province is about 0.8 hectares (Nikkhah et al., 2013a). Driving tractor in small farms and doing the agricultural activities within such farms requires more frequent clutching, brake and steering. With no doubt in such circumstances, physical problems and the fatigue of the driver are the main concerns. So paying attention to any of these equipments in highlighting and identifying the causes of drivers' physical problems is effective. According to the report of Agriculture Mechanization Development Center, from 245,989 supplied tractors during years 1371-89, about 67 percent were MF285 tractor and about 9% were MF399 tractor. In other words these two models of tractors dominate the tractor types in Iran (Agriculture Jahad Mechanization Development Center, 2012). Considering the above issues, the aim of this study was to investigate the forces acting on driver's three muscles including Gastrocnemius, trapezius and Quadratus lumborum arising during clutching of tractors MF285 and MF399 which are common tractors in Iran agricultural community and also to provide guidelines in order to optimize and fit the clutch of the tractors with the tractor driver's health condition.

### Methods:

Using the Cochran method the sample size was set at 30 people. The research was conducted in the first half of year 1392 at Agriculture Faculty of Ferdowsi University of Mashhad. In this study, the effect of the independent variables such as BMI index, height, weight, angle of knee, ankle and hip angle on reducing the pain threshold as the dependent variable was examined.

Investigations were performed on three muscles Gastrocnemius (in calf area), trapezius and Quadratus lumborum (around the waist), and trapezius (trapezoid muscle in upper neck line). Measurements were performed by an algometer device for each person on each muscle before clutching, 30 seconds after clutching, 60 seconds after the clutching and after 60 seconds of rest (Fig. 1). The more reduce of pain threshold indicates that clutching has been had more impact on the studied muscle and the lower reduced pain threshold shows lesser effect of clutching on tractor driver's muscle. In all drivers, the selected muscles on the left side (clutch side) have been tested and measurements were performed with appropriate intervals compliance between the different experiments. Data were analyzed by using Software JMP4.

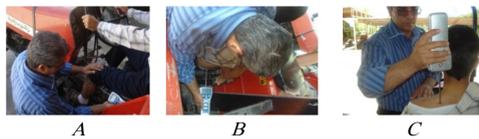


Fig1. Using the algometer in muscles A. Gastrocnemius B. Quadratus lumborum C. Trapezius to determine the decrease of pain threshold

### Results and Discussion:

Average individual's weight and height and BMI index were calculated 62.23 kg, 177.43 cm and 21.91 kg m<sup>2</sup>, respectively. The results of the measured force required for clutching in these two tractors indicated that the required clutching force for tractor MF285 was more than tractor MF399. Such that for clutching in these two tractors, 340 and 290 Newton force is required respectively. In another study it was reported that the maximum force of right and left foot were 665 and 613 N respectively and it was recommended that the maximum stimulus force for brake and clutch were 330 and 280 N respectively (Mehta et al. 2007).

Both tractors MF285 and MF399 utilized more force than the amount recommended in the above report for clutching, which indicates that the tractors can exert unusual pressure to the drivers. The average position angle of the knee in the tractors were calculated 127.83 and 148.83 degree respectively and the difference between position angle of the knee was defined significant at the one percent level in two tractors. However, the position angle difference of hip and ankle in these two tractors was not significant at the one percent level. Since tractor MF285 is a four-cylinder and with 75 horsepower, transfers less torque to the power transmission system than the tractor MF399 that has six-cylinder with 110 horsepower, but in this tractor, more force is required by the operator for clutching. Fig 2 shows the results of the pain threshold by using Algometer in three muscles area. The mean decrease in pain threshold in Gastrocnemius muscle after 30 seconds clutching in tractor MF285 was obtained more than tractor MF399 and they were calculated 3.87 and 3.23 N respectively. As you can see the reduced pain threshold after 30 seconds on tractor MF285 was obtained more than tractor MF399 which the difference between the two thresholds became significant at the five percent level. Decrease in pain threshold after holding the clutch for 60 seconds in tractor MF285 and MF399 were calculated 6.30 and 4.30 N respectively. As it can be seen, the mean reduction in pain threshold after 60 seconds on tractor MF285 was calculated more than tractor MF399 and their difference between the two tractors were significant at the one percent level. Results showed that clutching in the tractor MF285 will lead the tractor's operator feels the pain threshold in Gastrocnemius muscle in a shorter time than the tractor MF399. Our results indicates that the reduction in pain threshold after clutching 60 seconds in the tractor MF285 is more than tractor MF399 and this reduction was significant at the five percent level. The reasons of being more the reduced pain threshold on Gastrocnemius muscle in tractor MF285 than tractor MF399, We can note, more required power for the clutching in tractor MF285 and also significant difference in operator's knee position angle during clutching in these two tractors. The experiments on the trapezius muscle were presented in Fig 2. Decrease in pain threshold after clutching 30 seconds in tractors MF285 and MF399 were 3.50 and 2.73 N, respectively. Decrease in pain threshold after clutching 30 seconds in this muscle like Gastrocnemius muscle in tractor MF285 was obtained more than tractor MF399. Reduced pain thresholds in the trapezius muscle after clutching 30 seconds in these two tractors became significant at the ten percent level. Although reduction in pain threshold after clutching 60 seconds and resting 60 seconds after clutching in the tractor MF285 was obtained more than tractor MF399 but this differences were not statistically significant.

The results showed the decreased pain threshold on Quadratus lumborum muscle after clutching 30 seconds, 60 seconds and resting 60 seconds after clutching on the tractor operators MF285 was more than tractors MF399. However, the only difference in reducing muscle pain threshold after clutching 60 seconds in two tractors was significant at the five percent level. The mean decrease in pain threshold during and after clutching in three muscles is given in Fig 2. Results indicated that Quadratus lumborum muscle has decreased pain threshold more than two other muscles after clutching 30, 60 seconds and 60 seconds of rest after clutching, and clutching in this muscle was more effective in decreasing the pain threshold. However, based on the formal studies, this muscle when bending forward (flexion) and the rest did not been relaxed and in some activities that can be done either manually by the farmers, the waist area have been reported as the common musculoskeletal disorders (Ojha et al., 2012; Nikkhah et al., 2013b). The second muscle that clutching leads to more decrease in the pain threshold is Gastrocnemius muscle. This muscle plays a key role in plantar flexion of ankle (component that is engaged in clutching) (Kendal et al., 1993). Trapezius muscle affected by the reduced pain threshold during and after the clutching less than the other two muscles. As it is seen in Figure 2, reducing the pain threshold after clutching 30 seconds in Gastrocnemius and Quadratus lumborum muscles is the lowest and after clutching 60 seconds clutching, reducing pain threshold reach the highest of its amount. After resting for 60 seconds after clutching, the diminished pain threshold is still more than the lowered pain threshold after clutching for 30 seconds, but it was shown significant reduction than reduced pain threshold after clutching after 60 seconds and it appears that a little rest leads to relative recovery in the muscles. But in trapezius muscle, the average reduction of pain threshold after 60 seconds clutching is the highest amount and then reduction of pain threshold after 30 seconds of rest is the most value. This suggests that the trapezius muscle than both other muscles become close to its original relatively faster and it affected less than the entered pressure during clutching.

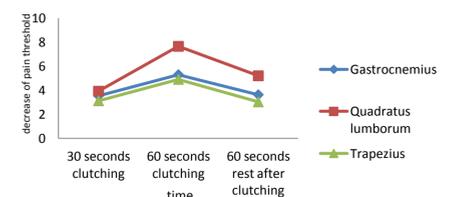


Fig 2. The average decrease of pain threshold after 30 seconds and 60 seconds clutching and 60 seconds rest after clutching of MF 399 and MF 285 tractors

### Conclusions:

The results show that although the clutching mechanism in both types of tractors is that they need the required force much more than the recommended amount, however, this problem in the tractor MF285 is more acute. It is recommended to the manufacturer's tractor, in order to reduce the input power for clutching the tractor MF285 and more welfare of drivers, necessary rearrangements should be done. Given that this tractor is considered as lightweight tractors and its production rate and its usage in Iran agricultural sector much more than tractor MF399, paying attention to its optimization will have more role in occupational health of agricultural sector. It is recommended as an introductory offer, the joint of force transmission between the pedal and disc in clutching mechanism is made of cast iron, because if this piece is made from this material, when applied the force, its state will not change significantly and hence it prevents much more applying force.

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