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## Original research article

# A survey on the actuating force on brake and clutch pedal controls in agricultural tractor in use in Iran



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## ABSTRACT

**Introduction:** The focus of farm tractor operator is on forward and reverse hydraulic arm's movements in addition to leg-pushing on brake and clutch pedals. Performing all these, with respect to the machine model and operator's position, determines the posture and the loading pattern of the operator's body.

**Aim:** The objective here has been the assessment of the pedal control to improve the operator's functionality.

**Material and methods:** In this study, 1500 operators were subject to close interviews by the researcher for 3 years in Isfahan Province. Operators with different anthropometries were involved by sitting on MF285, U650, JD3140 and JD950 combiner seats. The operator's knees were photographed in: free (no force enforcement), ready (beginning of force enforcement) and active (force enforcing) conditions. The thigh and leg angle at the knee joint was measured and the exerted force on the leg during leg-pushing was calculated too.

**Results and discussion:** Analysis of the obtained data indicated that the MF285 tractor clutch exerted less maximum force on the knee due to the clutch mechanism. The JD3140 clutch needed more maximum force in relation to MF285. The least maximum force was exerted on the brake pedal of JD3140. Under operating conditions, the widest knee extension angle in leg-pushing was of the U650 and JD3140 tractors.

**Conclusions:** The U650 and JD3140 model tractors under 'ready' and 'active' conditions need less leg-pushing force. This force exertion from the knee occurs at the widest extension angle. These two models have higher ergonomic level with the least possible disturbance in the knee joint.

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## 1. Introduction

Farm tractor operation includes movements and body segment turns and stretching which can generate discomfort in different parts of the operator's body. Some of the model tractors considered for the investigation in this paper were those sold in the developed countries some years ago and, in some cases, they are still used. Massey Ferguson and John Deere are global companies, selling the same basic concept of an 80–100 horse power (hp) tractor in India for \$150/hp, China for \$250/hp, and Europe and North America for \$1400/hp. The remarkable difference is mainly due to the increasing complexity in safety, comfort and environmental technical solutions adopted.<sup>1</sup> In the developing countries, the tractors used are not designed<sup>1</sup> based on ergonomics, leading to neck and shoulder, arm and leg and knee discomforts.<sup>2–9</sup> These mentioned models are not designed based on considering Iranian human factors and they have been introduced to the Iranian market without any changes since long time ago.

Through interviews conducted by phone in New York State regarding skeleton-muscular pains, it has been revealed that there exists a statistically significant difference in developing skeleton-muscular pains between the farmers operating tractors and those who do not. The investigation has revealed that joint trouble includes: lower back – 41%, neck/shoulders – 35%, knees – 29%, hands/wrists – 28%, and hips – 15% ( $P < 0.05$ ).<sup>10</sup>

Different designs showing where the control arms and proper calculation of forces need to operate controls on farm tractors are of major concern in operator's comfort.<sup>11</sup> Irrational factors such as the panel structure design, paints and design of protective equipment lead to an increase in the costs instead of safety concerns in agricultural equipment.<sup>12,13</sup>

The semi-automatic or full automatic electronic transmission systems could have a positive effect on ergonomic factor while increasing efficiency in farm machinery.<sup>14</sup> The ergonomic principles have a direct effect on the time when the operator senses fatigue.<sup>15</sup> Tractor ergonomics is studied through model simulation at the control arms setup. Several researches have used factor analysis in optimizing the necessary dimensions in tractor and combine in order to achieve better ergonomics.<sup>4–7,16–19</sup>

Widana evaluated the effect of operators work load on generating pain in different parts of the body after fatigue, working hours and reduction in motivation to work and accordingly, introduced a new farm tractor design.<sup>20</sup> Chaturvedi et al.<sup>21</sup> studied the operators physiologic and postures during the transformed vibration in addition to the material from which the seat was made.<sup>21</sup> Zatsirosky solved the clutch leg-pushing model by introducing two closed-loops for seat design based on the operator body segments, seat installation angles and proper diameters.<sup>22</sup>

The knee joint is the mostly applied body member subject to different fluctuating forces when exerting pressure on the control pedals. In this study, the knee joint has been examined during leg-pushing in agricultural machinery.

Since Iran is a developing country, there is the need for developing machinery and agricultural tractors and matching them with Iranian operators' anthropometric characteristics

based on the findings of research. This study could be a new step in the design and modification of the existing tractors.

## 2. Aim

The objective here has been the assessment of the pedal control to improve the operator's functionality. Definitely, using the seats with specific height and anthropometric characteristics in accordance with Iranian operators can play an effective role in reducing the amount of force exerted on the knee of these people. Correcting seat height in tractors and combines, i.e., increasing the height of the seats available in Iran, can be one of the most effective strategies to improve the current situation.

Other measures that could be based on the findings of this study include adding clutch and brake force amplifier (booster) to the existing power transmission mechanism of tractors and combines. The lack of information on Iranians farm population encouraged the current researchers to quantify Iranian data. It should be noted that there are already other useful studies on other populations, but the Iranian society has been somehow neglected.

## 3. Material and methods

The advances made in farm tractors manufacturing industry are more concerned with the properly facilitated operating cabin. This can be observed in farming industry of Iran, where Fergusson, Romany and John Deere tractors are used.

In this study, 1500 operators were subject to close interviews by the researcher for three years in Isfahan Province, where 50 were selected for first stage experimental examinations. Then, in the second stage of supplementary experimental test, 4 out of 1500 were selected to be representative of 95% of the Iranian farm population.

Among these members of the statistical population, 4 expert operators ( $N_1, N_2, N_3, N_4$ ) with very close operational backgrounds and different anthropometry and body mass indexes (BMI) were selected as the subjects of the uniform test candidates. The body descriptions are given in Table 1. To estimate the segmental body mass, the model by Lehto and Buck was employed and for body segment length, the model developed by Shan and Bohem was used.<sup>23,24</sup>

By evaluating the four tractor brands mentioned earlier, the ones with similar test parameters and the average life span and mechanically good condition were selected as the

**Table 1 – The selected operators' physical description.**

Operator	$N_1$	$N_2$	$N_3$	$N_4$
Weight, kg	72	84	83	78
Height, m	1.65	1.75	1.80	1.85
BMI, kg/m <sup>2</sup>	26.45	27.43	25.62	22.79
Thigh length, m	0.40	0.43	0.44	0.45
Thigh weight, kg	7.32	8.71	8.60	8.02
Leg length, m	0.41	0.43	0.44	0.46
Leg weight, kg	3.08	3.53	3.49	3.31
Trunk weight, kg	0.97	1.05	1.04	1.01

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