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Effect of tractor cultivation on heart rate and electrocardiogram RR intervals

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ABSTRACT. *To assess the effect of tractor use on operator workload, we examined the effects of tractor type (large cabin tractor vs small open tractor) and operation (driving forward vs turning vs reversing) on heart rate and the coefficient of variation (CV) of electrocardiogram RR intervals. In a big cabin tractor, the mean heart rate was higher on reversing (82.1 bpm) than on turning, and higher on turning (79.5 bpm) than on driving forward (72.4 bpm). In the small open tractor also, it was higher in reversing (92.6 bpm) than in turning, and higher in turning (86.8 bpm) than in driving forward (83.1 bpm). Tractor operation had significant effect on mean heart rate, but the type of tractor had no significant effect. The mean CV was higher at rest (3.77%), followed by operation of the big cabin tractor (3.64%), followed by the small open tractor (2.93%), although the decrease was not significant. Our results suggest that a smaller area of land increases the work load by requiring more turns and reverses.*

Keywords: Ergonomics, fatigue, operator comfort, stress analysis, tractor

Introduction

In Japan, the number of fatal farm work accidents has remained above 300 a year during the past 10 years. The biggest number of fatal accidents occurred on riding-type tractors, accounting for 29.9% of all fatal accidents in 2015 (MAFF 2017). Such accidents are exacerbated by mental and physical stress, vibration, and noise, which contribute to fatigue and loss of concentration. Heart rate and electrocardiogram data have been used for measuring work load. Heart rate is increased not only by physical load, but also by mental load (Ishibashi et al. 1968) via the autonomic nervous system (Wheeler and Watkins 1973). Here, we measured the physical and mental loads of tractor operators by using heart rate and its variation from electrocardiogram data. To assess the effect of tractor use on operator workload, we examined the effects of tractor type (large cabin tractor vs small open tractor) and operation (driving forward vs turning vs driving backward) on heart rate and electrocardiogram RR intervals.

Materials and Methods

(1) Measurement apparatus

Heart rate was measured from electrocardiogram signals picked up from the operator's body by disposable electrodes (Blue Sensor SP, Ambu A/S), amplified (BA1104 signal amplifier, TEAC Corporation), and passed to a notebook computer by an analog-to-digital converter (ADA16-32/2(CB)F, Contec Co., Ltd.) and software (LaBDAQ-PRO CT, Matsuyama Advance Co., Ltd.) at a sampling frequency of 100 Hz. The apparatus sat within the large cabin tractor or behind the seat of the small open tractor (Fig. 1).

Figure 1. Small open tractor with measurement apparatus.

(2) Subjects and experiment

The subjects were seven healthy men, 30 to 55 years old, who worked as technical personnel at our institute. They each operated two types of tractor, a large Kubota KL50H cabin tractor with a 37-kW engine, and a small Iseki Piccolo open tractor with a 10-kW engine. The subjects' electrocardiogram data were measured at rest for 5 min, while they performed rotary tillage operations in a field (800 m^2), and while they rode a bicycle ergometer with loads of 25 and 50 W.

(3) Signal and data analysis

We analyzed electrocardiogram data in a program written in LabVIEW v. 8.6 software (National Instruments) to calculate heart rate and the R wave to R wave (RR) intervals (Fig. 2). The coefficient of variation (CV) of RR intervals was calculated as CV (%) = SD / M × 100, where SD is the standard deviation of 100 consecutive RR intervals and M is the mean of those intervals (Kageyama et al. 1985).

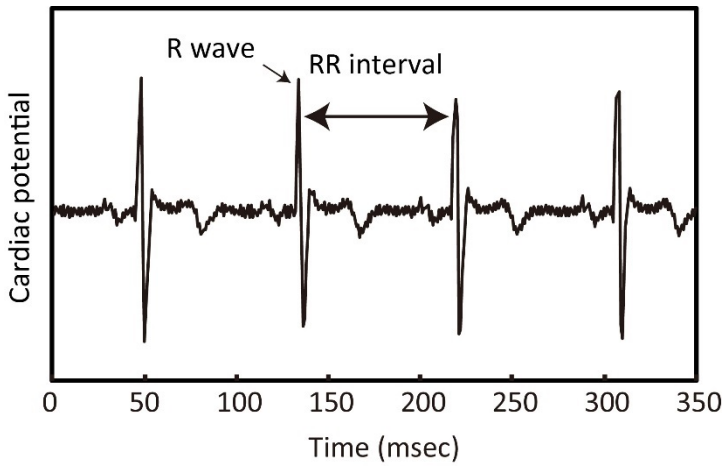

Figure 2. R wave to R wave interval of electrocardiogram data.

(4) Statistical analysis

We tested the effect of tractor type and operation (forward vs turning vs reversing) by two-way ANOVA, and compared means among CVs by one-way ANOVA in Microsoft Excel with an SAS add-in (SAS Institute).

Results and Discussion

(1) Comparison of heart rates

The mean heart rate of the seven men rose from 67.6 bpm at rest to 84.3 bpm on the bicycle ergometer at a load of 25 W to 97.5 at 50 W.

In the big cabin tractor, the mean heart rate was highest during reversing (82.1 bpm), followed by turning (79.5 bpm) and driving forward (72.4 bpm) (Table 1). In the small open tractor also, the mean heart rate was highest during reversing (92.6 bpm), followed by turning (86.8 bpm) and driving forward (83.1 bpm).

Table 1. Heart rate of subjects during tractor operations.

	Mean heart rate (bpm)			Rate of increase of mean heart rate (÷ driving forward)	
	Tractor operation				
	Driving forward	Turning	Reversing	Turning	Reversing
Big cabin tractor	72.4	79.5	82.1	1.03	1.10
Small open tractor	83.1	86.8	92.6	1.05	1.12
Rate of increase of mean heart rate (big tractor / small tractor)	1.04	1.06	1.07		
Two-way ANOVA					
Type of tractor	NS				
Operation	*				
Interaction effect	NS				

Driving forward increased mean heart rate by 17% relative to rest. Turning and reversing increased it by between 3% and 10% relative to driving forward. These increases were significant ($P < 0.05$). Driving the big cabin tractor increased mean heart rate by between 4% and 7% relative to the small open tractor, but the increase was not significant.

In relation to the work loads on the ergometer, the work loads of tractor operation during turning and reversing equate to 25 W or more, because these actions require more concentration.

(2) Comparison of CVs

The mean CV of heart rate was higher at rest (3.77%), followed by operation of the big cabin tractor (3.64%), followed by the small open tractor (2.93%), but the differences were not significant .

Although a reduced CV can indicate a disorder of the parasympathetic nervous system (Wheeler and Watkins 1973), the short duration of tractor operation (~30 min) would make this unlikely.

Conclusion

Tractor operation increased the operators' mean heart rate, notably during turning and reversing, but the type of tractor was not significant. Our results suggest that a smaller area of land increases the work load by requiring more turns and reverses. As there was no significant difference in the mean CV of operators' heart rates between rest and tractor operation, we will conduct longer experiments to clarify the effect of increased work load on operator stress.

References

Ishibashi T, Ohtani A, Miura T. (1968). Heart rate as an index of the mental load. *Jpn. J. Indust. Health 10,* 377-379. (in Japanese with English abstract)

Kageyama S, Sasoh F, Taniguchi I, Homma I, Saito H, Isogai Y. (1985). Cardiorespiratory arrest in a patient with advanced diabetic autonomic neuropathy. *Diabetes Res. Clin. Pract. 1,* 243-246.

MAFF (Ministry of Agriculture, Forestry and Fisheries) (2017). Outlook of farm work accident in 2015. MAFF, Tokyo, available from URL: http://www.maff.go.jp/j/press/seisan/sizai/170206.html (in Japanese).

Wheeler T, Watkins PJ (1973). Cardiac denervation in diabetes. *Br. Med. J. 4,* 584-586.