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# Pedal power for occupational activities: Effect of power output and pedalling rate on physiological responses

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ABSTRACT

Because of the socio-economical conditions of farmers in developing countries including India, human muscle power is going to contribute energy requirements for performing many farm activities for the next two decades. Pedalling is the most efficient way of utilising power from human muscles. Pedal power enables a person to drive devices at the same or higher rate as that achieved by hand cranking, but with far less effort and fatigue. However, the use of pedal power for occupational work such as stationary farm operations has got scant attention in the past. Keeping these points into consideration a study was planned to optimise power output and pedalling rate for stationary farm operations. Physiological responses of 12 male subjects were studied on a computerised bicycle ergometer at five levels of power output (30–90 W) and seven levels of pedalling rates (30–90 rev $min^{-1}$). Analysis of data indicated that physiological responses were significantly affected with power output as well as pedalling rate. Increase in physiological responses (heart rate and oxygen consumption rate) over rest (delta values) were significantly higher when pedalling frequency was 30 rev $min^{-1}$ and above 50 rev $min^{-1}$. There was no significant difference between physiological responses at 40 and 50 rev $min^{-1}$. Physiological responses increased linearly with power output and were significantly different at different power outputs. The delta values of physiological responses at 60 W power output and 50 rev $min^{-1}$ pedalling rate ($\Delta HR = 40$ beats $min^{-1}$ and $\Delta VO_2 = 0.56$ l $min^{-1}$) were within acceptable limits for continuous pedalling work. From the results of the study it was concluded that for daylong pedalling work the power output from an Indian agricultural worker should be limited to 60 W and pedalling rate should be 50 rev $min^{-1}$.
*Relevance to industry:* The optimal power output and pedalling rate may be used for the ergonomic design of a dynapod or any pedalling device for efficient utilization of human muscle power with reduced drudgery and fatigue.



## 1. Introduction

Until about two and half centuries ago, muscle power was the prime source of energy for performing all the physical activities on our earth, and much of this power had been from human muscles. Because of the socio-economic conditions of farmers in several developing countries including India, human muscle power will go on contributing energy requirements for performing many farm activities at least for next two decades. In remote villages in India, where electric power supply is not available and repair and maintenance facilities for internal combustion engines are scarce, human power is still one of the major contributors of energy for production agriculture as well as for post harvest agricultural operations.

Human energy has generally been utilised through arms, hands, and back. It was only with the invention of the bicycle, that legs also began to be considered as a means of developing power from human muscles. Maximal power produced with legs is generally limited by adaptations within the oxygen transport system. On the other hand, the capacity for arm exercise is dependent upon the amounts of muscle mass engaged (Shephard, 1967). Owing to these limitations, a person can generate more power (about four times) by pedalling than by hand cranking (Wilson, 1986). Pedal power enables a person to drive devices at the same or higher rate as that achieved by hand cranking, but with far less effort and fatigue.

The main use of pedal power in the high-power range (75 W and above) is still for bicycling during exercise training, sports and rehabilitation activities. In the low-power range the major occupational use of pedal power is for transport of people using cycle rickshaw. However, pedal power seems to be potentially

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