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Journal of Agricultural Engineering

Vol. 56 (2): April-June, 2019

Optimisation of Pedal Power Output and Pedalling Rate Based on the Physiological Response of Male Agricultural Worker

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Article Info

Manuscript received: October, 2017
Revised manuscript accepted: February, 2019

Keywords: Pedalling rate, pedalling power output, physiological response, maximum aerobic capacity, optimum work load

ABSTRACT

Human power can be better utilised in rotary mode either by cranking or by pedalling. In occupational workload, pedalling is preferred over cranking as the former results less physiological cost. The present study aimed to determine the most economical pedalling rates at various power outputs as well as to arrive at the optimum power output and pedalling rate combination. Ten male subjects participated as replications with two independent parameters viz. power output (4 levels) and pedalling rate (5 levels). Three physiological parameters viz HR, OCR and ΔHR were studied. It was observed that all physiological parameters initially decreased, and then increased following a curvilinear relationship with respect to pedalling rate for all power outputs. The limiting power output for male agricultural workers was about 60 W in pedalling mode with pedalling rate 60 rpm. The HR, ΔHR and OCR at this power–pedalling rate combination were 116 beats.min^{-1}, 33 beat.min^{-1} and 0.8 l.min^{-1}, respectively.

Since ancient time, human muscle power has been utilised through arm, hand and back. The use of human power in the rotary motion was initiated in the 1870s. Hand cranking mode is better in terms of mechanical advantage over pedalling. However, due to involvement of stronger thigh muscles or quadriceps in circular pedalling motion, it has brought revolution in pedal power. In addition, it offered a compact power transmission mechanism. The desired speed ratio can be achieved by employing various sizes of sprockets with different combinations of torque and speed. Work output is more in rotary mode, achieved by simple motion transmission mechanism. Wilson (1986) concluded that a person can generate about four times more power by pedalling than by hand cranking. In agriculture and allied activities as crop threshing, winnowing, processing (chipping, peeling, etc.) are powered by pedal-operated mechanisms. Looking into the increasing prices and unreliable supplies of petroleum fuels and non-availability of repair and maintenance facilities in remote villages in India, the internal combustion engines are not so attractive power source especially for stationary farm operations; and pedal powered devices may be more suitable (Tiwari *et al*., 2011). Electricity has recently reached to most of the villages, and power-operated machines are available with the farmers. However, villages are affected with power blackouts, particularly during the summer and rainy seasons due to shortage and natural disturbances to power lines. During such occasions, the workers remain idle. Machines with pedal power system as alternative to electric power can improve the work output during non-availability of electric power.

It has been observed that sole pedal-powered machines are not popular despite better performances. The major reason is drudgery involved, which is related to efficient loading. For example, different pedal-operated machines as maize sheller, areca nut dehusker, water lifting pump, etc. have not yet received wide acceptability. The physiological cost of pedal-operated maize dehusker-sheller (Choudhari *et al*., 2018) and finger millet thresher (Paramanad *et al*., 2015) have been reported to be on higher side. If the load and frequency of pedalling are optimum, the corresponding physiological parameters will be within the limit of continuous performance. Humans are very adaptable, and may produce power in pedalling mode over a wide range of power outputs and pedalling rate. However, a person can produce more power, or the same amount of power for a longer time, if he pedals at a certain rate (Tiwari *et al*., 2011). In India, pedal powered devices are still going to be in use for some years in future. Hence, the present experiment was planned to ascertain the optimum power output and pedalling rate for male agricultural workers for efficient utilisation of human power with reduced drudgery.

MATERIALS AND METHODS

Selection of Samples

Ten subjects for conducting the experiment were selected from workers engaged in agricultural activities like working in field, agricultural machinery operation, etc. In addition to these activities, some of them were engaged in fabrication workshop and machinery maintenance activities. The subjects were free from any physical abnormalities, and were in sound health condition at the time of the experiment. The subjects were well familiar with bicycle riding, and were screened for postural abnormalities or movement restrictions. The subjects were trained to be acquainted with the experimental protocol to ensure their full cooperation. Identical clothing was preferred to the subject during each trial. Basic physical characteristics of the subjects as age, weight and stature were noted as given in Table 1. The experimental set up is shown in Fig. 1.

Fig. 1: Experimental set-up

The study was conducted in a laboratory of the Department of Farm Machinery and Power, College of Agricultural Engineering and Technology, Dapoli, Ratnagiri district, Maharashtra during the months April and June-July. The average dry bulb temperature and relative humidity during the experimental trials were 26 ^{0}C and 84 %, respectively.

Maximum Aerobic Capacity (VO_2 max) and Optimum Work Load

The VO_2 max is oxygen uptake capacity at maximum heart rate. It is the highest oxygen uptake attainable by a subject where a further increase in workload will not result in an increase in oxygen uptake (Rodahl, 1989). It was assessed through conducting sub-maximal tests using a computerized bicycle ergometer (MONARK 839E, Varberg, Sweden) as loading device. MONARK, 839 E had the option to carry out manual work test with built-in A strand, YMCA, Bruce and Naughton

Table 1. Basic physical characteristics of subjects

Subject	Age, years	Weight, kg	Stature, mm	HR max, beat.min^{-1}	VO_2 max, l.min^{-1}
I	30	65	1600	190	2.31
II	34	60	1670	186	3.26
III	40	57	1620	180	2.50
IV	40	50	1640	180	2.78
V	34	70	1750	186	2.63
VI	29	55	1620	191	2.74
VII	26	65	1630	194	3.50
VIII	30	67	1730	190	2.55
IX	39	53	1620	181	2.23
X	26	50	1620	194	3.22
Mean	32.8	59.2	1650	187.2	2.77
SD	5.5	7.3	5.1	5.5	0.42

protocols. During the manual work test, basic data of subjects as gender, age and weight were entered. Loading could be done in the form of power (W), or by other forms with incremental steps or fixed value. In increment option, the time interval(s) and step size (W) were entered. All this information could be fed though computer or its external unit. The display section provided time (s), pedalling speed (rpm), power (W) and force (N) with least counts of 1s, 1 rpm, 1 W and 0.1 N, respectively.

The saddle height of the bicycle ergometer was kept such that the subject's leg was almost straight at knee when the pedal was at its lowest position. The subject pedalled the bicycle at a pedalling rate of 50 rpm. Pedalling speed was maintained using metronome on the bicycle and continuously visible to the subject. As explained prior, manual work test was carried out with increment option and a protocol was developed in which the workload was automatically increased by 15 W at an interval of 2 min. The sub-maximal loading on a subject was carried out by increasing the load up to 75% of his maximum heart rate (HR_{max}).

HR max was calculated as (Robert and Roberto, 2002):

HR_{max} (beat.min^{-1}) = 220 – age (years) of subject…(1)

Every test was continued till 75 % of HR_{max} was achieved. If a subject was willing to continue the test beyond the HR_{max}, he was allowed to continue.

The heart rate (HR) and oxygen consumption rate (OCR) of a subject were measured using a mobile breath-by-breath metabolic system (COSMED, Rome I, Italy, model -K4b^2). It had a portable unit, receiver unit, flow meter and gas analyser as main units. Portable unit had O_2 and CO_2 analysers, sampling pump, transmitter, etc. It showed real-time OCR (VO_2) and HR data. It could store 16,000 breaths. The receiver was connected to a computer though RS 232 interface. The flow meter had digital turbine with flow measurement range of 0.03 - 20 l.s^{-1} (accuracy ± 2%). The gas analyser had O_2 and CO_2 sensors. Both sensors had response time less than 150 ms. The range and accuracy of O_2 sensor were 7-24 % of O_2, and (±) 0.02 %; while that of CO_2 were 0-8 % of CO_2 and (±) 0.01 per cent.

The instrument was mounted on a subject, and HR, OCR measured simultaneously breath-by-breath. The data was then averaged of one-minute interval. The correlations between HR and OCR for individual subject was developed, and VO_2max was accordingly predicted.

As mentioned in preceding section, the subjects were loaded with incremental protocol as 15 W at an interval of 2 min. Hence, with every 2 min interval, the workload was increased by 15 W. This workload was considered as the power output of a subject. For each workload, the physiological parameters viz, HR and OCR were measured. The data of power output (workload) v/s HR and OCR was also plotted, and the correlations between workload-heart rate and workload-OCR were developed. For continuous work, working HR was considered as 110 beat.min^{-1}, and the OCR was considered as 35 % of VO_2max (Saha *et al*., 1979; Gite, 1993). These were the basis for recommendation of workload for continuous operation.

Physiological Response at Different Power Outputs and Pedalling Rates

Large variation in pedalling rates at different load conditions have been reported by different scientists. Pedalling rate of 50-60 rpm had been reported as efficient by Seabury *et al.* (1977), Marsh and Martin (1993) and Tiwari *et al.* (2011). On the other hand, efficient pedalling rate for cross-country cycling had been reported to be 90-100 rpm by Marsh and Martin (1993).

In case of occupational work, the work is to be performed under stationary condition. Minimum energy expenditure is thus the primary criteria as the work is to be continued for long duration. The most efficient pedalling rate is dependent on work intensity and work duration. The present experiment was conducted to find the optimum pedalling rates for different power outputs based on physiological parameters. Hence, pedalling rate was varied from 40 rpm to 80 rpm with increments of 10 rpm. Wilson (1986) had observed that the reasonable workload for continuous power generation by the western population would be about 75 W for a young and healthy person,while the maximum power for intermittent uses might go up to 200 W. These values should be on lower side for Indian people because of their lower aerobic capacity (Nag *et al*.,1978; Nag,1981). Hence, the power range of this experiment was considered as 45 W to 90 W in steps of 15 W.

Protocol for Measurement of Physiological Response

Two to three subjects reported on a day in the laboratory at 9 A.M. for the measurement of physiological responses. The subjects had light breakfast about 2 hr prior to their reporting. A minimum gap of two hours was maintained between food intake and start of a test run. All experimental trials were conducted between 9.00 to 12.00 and 14.30 to 17.45 hr on a day. The average dry bulb temperature and relative humidity during the experimental trials were 26^0C and 93 %, respectively.

After arrival in the laboratory, each subject was given a warm-up exercise on a bicycle trainer. It was observed that subjects were apprehensive of performing the exercise breathing through $K4b^2$ mask and with HR chest strap. Sufficient practice, therefore, was given to eliminate error, if any. After sufficient practice, the subjects were comfortable with the exercise along with the mask and chest strap. The subjects were then given rest for half an hour by sitting in a chair. Resting HR for five minutes duration was recorded and averaged.

As mentioned earlier, a computerized bicycle ergometer (MONARK 839E, Varberg, Sweden) was used as loading device with values of load and pedalling rate set as per requirement. Also, HR and OCR for each combination of load and pedalling rate were directly recorded by $K4b^2$ for each individual subject. Each trial was conducted for about 16 minutes duration. Average HR and OCR from 6^{th} to 15^{th} minute of pedalling were calculated and noted as 'working heart rate (WHR)' and 'working oxygen consumption rate (WOCR)'. The difference in WHR and RHR was calculated (ΔHR)known as 'work pulse (ΔHR)'. The relationships between individual pedalling rate with HR, OCR and ΔHR were developed. Regression equations were computed by least squares method for curves.

Optimisation of Pedalling Rate

The regression equations of pedalling rate on HR, ΔHR and OCR at various power outputs were second-order polynomial functions with general form of $Y= aX^2+ bX+ c$, where Y was the dependent and X was the independent variable. The optimum (most efficient) pedalling rates for each power output (45 W to 90 W) was calculated by setting the first derivative of each regression equation to zero ($dY/dX = 2aX+b = 0$). Therefore, optimum pedalling rates for different power outputs and corresponding regression equations were calculated as (–) b/2a. Tiwari *et al.* (2011) used the same optimisation technique.

Experimental Design and Statistical Analyses

The experiment was planned in factorial CRD with two factors viz power output (work load) (5 levels) and pedalling rate (4 levels). The subjects were taken as replications, which were ten. Thus, there were 20 trials for each subject, and a total of 200 trials were conducted for the experiment.

The data was analysed using SAS – University Edition.

RESULTS AND DISCUSSION

Maximum Aerobic Capacities of Subjects

The mean (± SD) age, weight and stature of subjects were 32.8 ± 5.5 years, 59.2 ± 7.3 kg and 1650 ± 51 mm, respectively. The maximum HR for individual subject was in the range of 180 beat. min^{-1} to 194 beat. min^{-1}, with mean (± SD) of 187.2 ±5.5 beat.min^{-1}.

The relationships between HR and OCR for each individual subject was developed as shown in Fig. 2 and Table 2. The VO_2 max was in the range of 2.23 $l.min^{-1}$ to 3.5 $l.min^{-1}$ with mean of 2.77±0.42 $l.min^{-1}$.

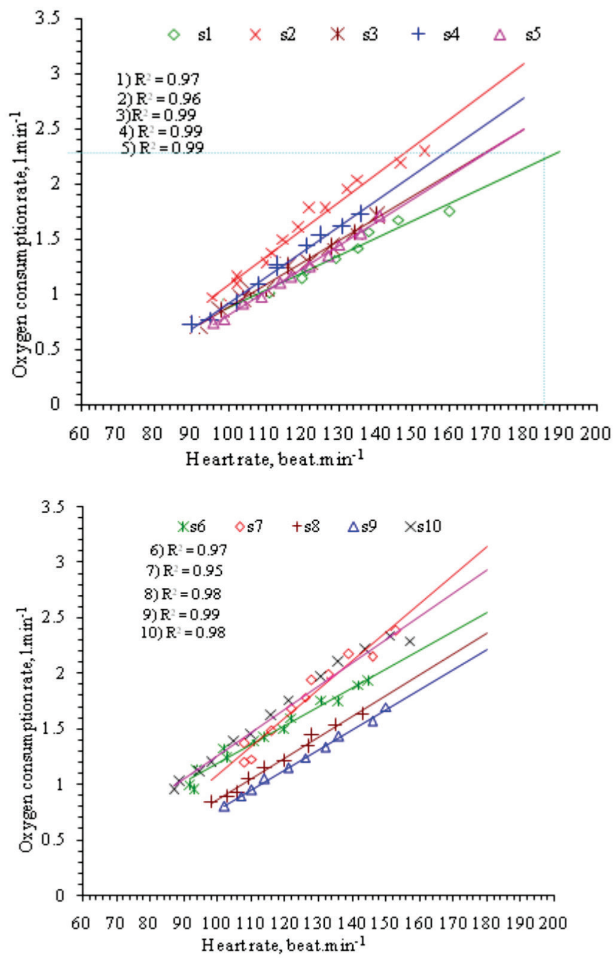


Fig. 2: Relationship between HR and OCR (Calibration Charts)

Table 2. Relationship between HR and OCR for individual subject

Sl. No.	Relationship
1.	OCR1 = 0.0158 x HR1 -0.6942; (R^2 = 0.97)
2.	OCR2 = 0.0253 x HR2 -1.4472; (R^2 = 0.96)
3.	OCR3 = 0.0202 x HR3 - 1.1323; (R^2 = 0.99)
4.	OCR4 = 0.0233 x HR 4 - 1.4126; (R^2 = 0.99)
5.	OCR5 = 0.0212 x HR5 - 1.3111; (R^2 = 0.99)
6.	OCR6 = 0.0170 x HR6 - 0.5118; (R^2 = 0.97)
7.	OCR7 = 0.0256 x HR7 - 1.4684; (R^2 = 0.95)
8.	OCR8 = 0.0188 x HR8 - 1.0197; (R^2 = 0.98)
9.	OCR9 = 0.0180 x HR9 - 1.027; (R^2 = 0.99)
10.	OCR10 = 0.0209 x HR10- 0.8311; (R^2 = 0.98)

The general equation for predicting OCR on the basis of HR-OCR responses of 10 subjects, adopting sub-maximal loading was also derived as:

$$OCR=0.0223 \times HR - 1.2983 \; (R^2=0.85) \qquad \ldots(2)$$

The relationships between workload-HR and workload-OCR are presented in Fig. 3(a,b), respectively. The respective correlations are:

$$\text{Workload (W)} = 1.6963 \text{ HR (bpm)} - 118.79 \qquad \ldots(3)$$

$$\text{Workload (W)} = 75.179 \text{ OCR} - 19.32 \qquad \ldots(4)$$

Considering the limiting HR and OCR for continuous work as 110 beat.min^{-1} (Gite, 1993) and 35 % of VO_2 max (Saha *et al*., 1979), the allowable workload was 67.8≈ 68 W and 52.9≈53 W, respectively. Hence, the ceiling sustainable workload was about 60 W. However, for short duration (about one hour), the workload could be considered on higher side. Shah (2005) reported that pedal powered electricity generator unit could generate 80 W by pedalling for an hour at the pedalling rate of 40 - 50 rpm. Wilson (1986) had reported that the reasonable workload for continuous power generation for western population would be about 75 W for a young and healthy person. He also reported that pedalling at a load of about 90 W could be sustained for around 60 min.

Considering the above facts, the power outcome of male agricultural workers could be considered as 60 W for long duration work (day long work). However, workload can be enhanced up to 75- 80 W, if work rest criteria are advocated.

The rest pause (R, min) could be calculated using the equation (Murrel, 1965):

$$R= T(K-S) /(K-1.5) \qquad \ldots(5)$$

where T is working time (min), S is average adopted as standard (generally taken as 4 kcal.min^{-1}), K is average work (kcal.min^{-1}), and the value 1.5 in the denominator was an approximation of the resting level (kcal.min^{-1}).

Physiological Responses at Different Power Outputs and Pedalling Rates

Relationship between pedalling rate and physiological parameters at different power outputs (incremental) represented in Fig. 4.

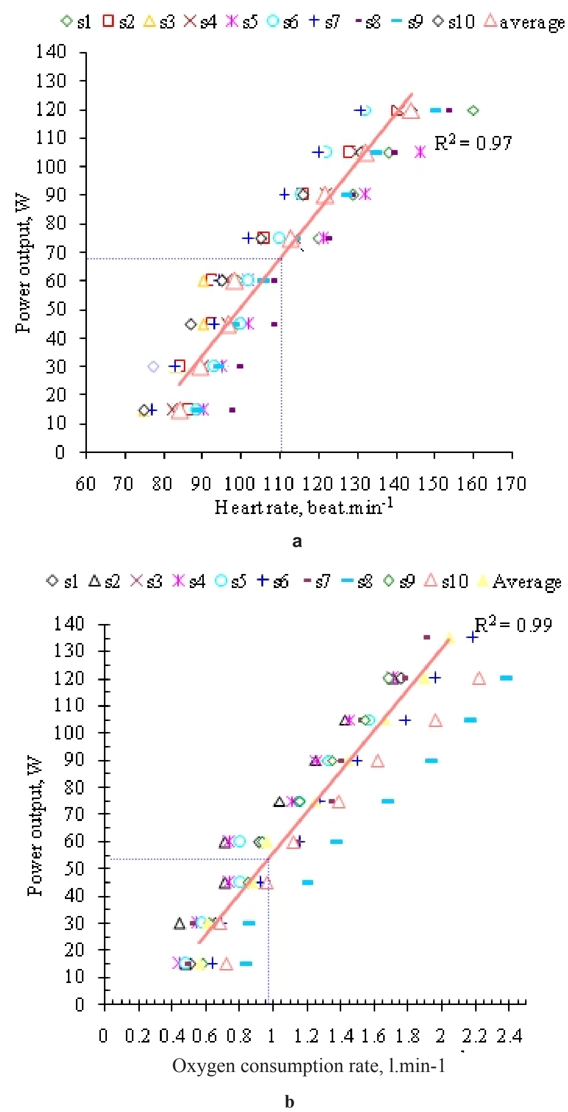
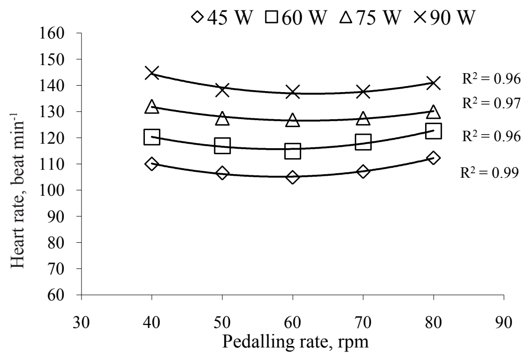
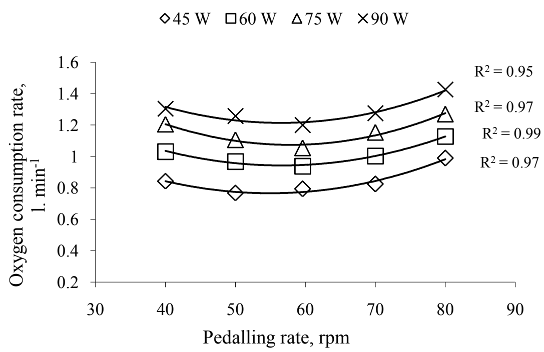


Fig. 3: Relationship between (a) power output (Workload) and HR; and (b) power output (Workload) and OCR

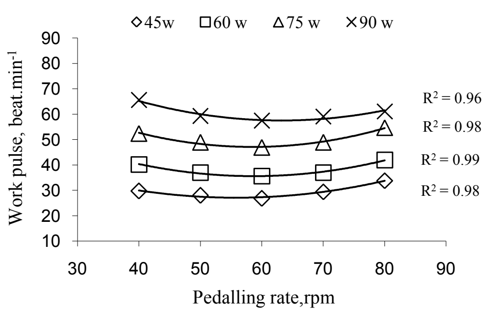
At different power outputs, physiological parameters HR, ΔHR and OCR initially decreased with increase in pedalling rate, and then increased in curvilinear fashion. At 45 W power output, the HR, ΔHR and OCR were minimum at 60 rpm; 104.9 beat.min^{-1}, 26.8 beat. min^{-1} and 0.79 l.min^{-1}, respectively. At 40 rpm and 80 rpm, these values were higher. Similarly, at 60W and 60 rpm combination, the HR, ΔHR and OCR were minimum; 114.9 beat.min^{-1}, 35.6 beat.min^{-1} and 0.94 l.min^{-1}, respectively. Similar trend was observed at 75 W and 90 W of power outputs. Within the limits of the experiment, all physiological parameters were on higher side at minimum and maximum pedalling rates for various power outputs. Similarly, it was observed that all physiological parameters showed linearly increasing trend with power outputs (from 45 W to 90 W), irrespective of pedalling rates as presented in Fig. 4.



(a) Pedalling rate verses HR



(b) Pedalling rate verses OCR



(c) Pedalling rate verses work pulse (ΔHR)

Fig. 4: Relationships between pedalling rate and physiological parameters at different power outputs (incremental)

Optimisation of Pedalling Rate on the Basis of Physiological Parameters

The regression equations of pedalling rate on HR at various power outputs are given in Table 3, which were in the form of second-order polynomial functions with general form of $Y= aX^2+ bX+ c$ with $R^2 > 0.96$ showing high degree of correlation.

The optimum pedalling rates for each power output was calculated as explained earlier. The optimum pedalling rates, both at 45 W and 60 W, was 58 rpm; and that at 75 W and 90 W was 62 rpm and 63 rpm, respectively. The ANOVA for the effect of power outputs and pedalling rates on HR is given in Table 4.

Table 4 indicates that HR was significantly affected ($p < 0.001$) by power outputs as well as pedalling rates ($p = 0.0157$). Effect of the interaction was found to be non-significant. This reflected that at 45 W and 60 W of power outputs, HR was significantly lower at pedalling rate of 58 rpm and at 75 W and 90 W of power output, HR was significantly lower at 62 rpm and 63 rpm, respectively.

Table 3. Regression equations of pedalling rate on HR of male agricultural workers

Sl.No.	Power output, W	Pedalling rate on HR					
		Regression coefficient, R^2				Optimum pedalling rate, rpm	HR at optimum pedalling rate, beat.min^{-1}
		a	b	c	R^2		
1.	45	0.015	(-)1.77	156.53	0.99	58	105
2.	60	0.015	(-)1.70	165.04	0.96	58	116
3.	75	0.01	(-)1.34	168.04	0.97	62	126
4.	90	0.01	(-)1.82	194.13	0.96	63	137

Table 4. ANOVA for the effect of power output and pedalling rate on HR

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Subject	9	10184.32	1131.59	13.37	<.0001
Power output	3	27629.49	9209.83	108.83	<.0001
Pedalling rate	4	1066.18	266.55	3.15	0.0157
Power output *Pedalling rate	12	196.19	16.35	0.19	0.9986

Regression equations of pedalling rate on ΔHR and pedalling rate on OCR were similarly developed (Table 5, 6), with $R^2 > 0.95$. The optimum pedalling rates for various power outputs based on ΔHR and OCR were arrived by equating the first derivatives to zero.

The optimum pedalling rate at 45 W and 60 W was 56 rpm with corresponding ΔHR of 27 beat.min^{-1} and 33 beat.min^{-1}, respectively. Tiwari *et al*. (2011) had reported that the acceptable limit of ΔHR for continuous work was 40 beat.min^{-1}. Hence, at 45 - 60 W work load, ΔHR was within the limit of continuous work. Similarly, at 75 W and 90 W, the optimum pedalling rates were 59 rpm and 63 rpm, respectively, with corresponding ΔHR values of 47 beat.min^{-1} and 58 beat.min^{-1}, respectively. These were higher than the limit of continuous work. The optimum pedalling rates at power output of 45 W and 60 W was 63 rpm, while that at 75 W and 90 W were 60 rpm and 53 rpm, respectively (Table 6). The corresponding OCR values were 0.6, 0.8, 1.0 and 1.3 l.min^{-1}, respectively.

The ANOVA for the effect of power outputs and pedalling rates on ΔHR is given in Table 7. ΔHR was significantly affected by power outputs ($p < 0.0001$) as well as pedalling rates ($p = 0.0122$). The effect of interaction was insignificant. This indicated that at power outputs 45 W and 60 W, ΔHR were significantly

Table 5. Regression equations of pedalling rate on ΔHR of male agricultural workers

Sl.No.	Power output, W	Pedalling rate on ΔHR					
		Regression coefficient, R^2				Optimum pedalling rate, rpm	ΔHR at optimum pedalling rate, beat.min^{-1}
		a	b	c	R^2		
1.	45	0.01	(-)1.28	62.73	0.98	56	27
2.	60	0.01	(-)1.60	82.69	0.99	56	33
3.	75	0.02	(-)1.88	102.30	0.98	59	47
4.	90	0.01	(-)1.81	114.61	0.96	63	58

Table 6. Regression equation of pedalling rate on OCR of male agricultural workers

Sl.No.	Power output, W	Pedalling rate on OCR					
		Regression coefficient, R^2				Optimum pedalling rate, rpm	OCR at optimum pedalling rate, beat.min^{-1}
		a	b	c	R^2		
1.	45	0.0003	(-)0.038	1.81	0.97	63	0.6
2.	60	0.0003	(-)0.0379	2.01	0.99	63	0.8
3.	75	0.0004	(-)0.0479	2.46	0.97	60	1.0
4.	90	0.0004	(-)0.0425	2.41	0.95	53	1.3

lower at pedalling rates of 56 rpm. Similarly, at 75 W and 90 W of power output, ΔHR was significantly lower at 59 rpm and 63 rpm, respectively.

Table 8 also indicated that OCR was significantly affected ($p < 0.0001$) by power outputs as well as pedalling rates ($p=0.0001$). However, effect of the interaction was non-significant. Hence, for 45 W and 60 W power output, OCR was significantly lower at 63 rpm. Similarly, OCR was significantly lower at 60 rpm and 53 rpm for 75 W and 90 W power output, respectively.

Based on the minimum values of HR (105 beat.min^{-1}), ΔHR (27 beat.min^{-1}) and OCR (0.6 l.min^{-1}), the optimum pedalling rates were 58, 56 and 63 rpm, respectively, at 45 W power output. For 60 W power output, the minimum values of HR, ΔHR and OCR were 116 beat.min^{-1}, 33 beat.min^{-1} and 0.8 l.min^{-1}, respectively, with pedalling rates of 58, 56 and 63 rpm, respectively. At 75 W power output, the optimum pedalling rates were 62, 59 and 60 rpm, respectively, with corresponding HR, ΔHR and OCR as 126 beat.min^{-1}, 47 beat.min^{-1} and 1 l.min^{-1}, respectively. For 90 W power output, the minimum values of HR, ΔHR and OCR were 137 beat.min^{-1}, 58 beat.min^{-1}, and 1.3 l.min^{-1}, respectively, with pedalling rates of 63, 63 and 53 rpm, respectively.

Considering the effect of pedalling rate on HR, ΔHR and OCR, the optimum pedalling rate was 59 rpm both at 45 W and 60 W work load, while it was 60.3 rpm at 75 W and 59.7 rpm at 90 W work load. The merge difference in optimum pedalling rates gave variation of power output from 45 W to 90 W. Hence, considering the average value, the overall pedalling rate could be considered as 59.5 rpm (≈60 rpm) for power output from 45 W to 90 W. As elaborated in the previous section, the limiting power output for continuous work by male agricultural workers was about 60 W in pedalling mode with pedalling rate of 60 rpm with HR, ΔHR and OCR of 116 beat.min^{-1}, 33 beat.min^{-1} and 0.8 l.min^{-1}. Nag *et al*. (1980) had reported that the work intensity with OCR of 0.8 l.min^{-1} was in 'moderate' category.

CONCLUSIONS

The power output from agricultural workers could be considered as 60 W for long duration work. At different power outputs (45 W to 90W) during pedalling with a bicycle ergometer, the physiological parameters HR, ΔHR and OCR were lowest at pedalling rate of 60 rpm. The parameters initially decreased up to pedalling rate of 60 rpm, and then increased as pedalling rate increased from 40 rpm to 80 rpm. A curvilinear relationship was observed between physiological parameters and pedalling rates. The physiological parameters exhibited linearity with increasing power outputs for all pedalling rates under study.

The physiologically economical power output and pedalling rate for male agricultural workers under pedalling mode of working were found to be 60 W and 60 rpm, respectively. The HR, ΔHR and OCR at this workload–pedalling rate combination was 116 beat.min^{-1}, 33 beat.min^{-1} and 0.8 l.min^{-1}, respectively.

Table 7. ANOVA for the effect of power output and pedalling rate on ΔHR

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Subject	9	8326.09	925.12	11.11	<.0001
Power output	3	27603.56	9201.19	110.50	<.0001
Pedalling rate	4	1100.97	275.24	3.31	0.0122
Power output x pedalling rate	12	236.27	19.69	0.24	0.9962

Table 8. ANOVA for the effect of power output and pedalling rate on OCR

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Subject	9	23.86	2.65	63.41	<.0001
Power output	3	5.54	1.85	44.19	<.0001
Pedalling rate	4	1.033	0.26	6.18	0.0001
Power output*Pedalling rate	12	0.049	0.004	0.10	1.0000

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