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Physical Work Capacity Prediction of Agricultural Workers from Northeast India by Submaximal Treadmill Exercise

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A B S T R A C T

Maximal oxygen consumption ($VO_{2\ max}$) is an extensively recognized parameter as it is superior to quantify cardiovascular fitness, maximal aerobic power or maximum aerobic capacity, physical work capacity etc. The physical work capacity ($VO_{2\ max}$) of workers mainly depends on some important factors such as psychological, physiological, environmental, etc. Therefore, to know the physical work capacity, we conducted a study at Nerist, Nirjuli, AP on twelve local agricultural workers of the 20-30 years age group. The mean height, body weight, BMI, BSA, and LBM of selected Northeast Indian agricultural workers of 20-30 age group were 162.75±3.04 cm, 63.75±6.86 kg, 24.02±1.80 m^2, 1.69±.094 Kg/m^2 and 46.63 ± 3.27 Kg respectively. The experiment was conducted in the laboratory on a treadmill (Model: Model:900 EXL) using a fitmate pro (Made: Cosmed Italy, Range: 0-22% O_2 Measurement, Accuracy: ± 0.02%) to measure oxygen consumption (VO_2) and a heart rate monitor (Polar M200) to measure heart rate (HR). The submaximal test was continued until the HR reached 75% of the HR_{max}. The mean value of HR_{max} was 186.96±1.35 bpm. The recorded data of HR and VO_2 were plotted, and a regression equation was developed to extrapolate the VO_2 w.r.t. to the HR_{max} for getting $VO_{2\ max}$. We found the physical work capacity in the age group of 20-30 years of twelve agricultural workers of Northeast India was 50.60±2.74 ml/kg/min, which was in between the $VO_{2\ max}$ of North and South Indian people. The study on Northeast Indian agricultural workers will be helpful for the scientific community to design human-centered tools and implement and make government policy in the agricultural section. Further in a future study on the impact of heat and humidity in the form of climate change on the physical work capacity of agricultural workers can also be carried for the same sector to make the policy for workers sustainable livelihood.

***Key words*:** Physical work capacity ($VO_{2\ max}$), Heart rate, Agricultural worker, Treadmill, Submaximal test

The ability of cardiovascular and respiratory organisms to transportation of oxygen (O_2) from air to cells mitochondria and the capability of muscles to utilize the O_2 for metabolic fuel breakdown are principal measures of aerobic power. Physical fitness is reflected by aerobic power representing maximum capacity to transport and use O_2 during gradual physical exercise [1]. To identify the physiological adaptation between work and worker, the experiment on the worker's physical work capacity or aerobic power is essential. A worker's physical attempt is necessary to perform various work, which generates pressure on the respiratory system and cardiovascular and causes greater energy consumption [2]. Scientists have already discovered that a person can work without difficulty when physiological requirements for the particular work are not more than $VO_{2\ max}$ [3]. Thus, individuals with more incredible respiratory and cardiovascular stamina can survive more duration against fatigue and muscular work [2], [4]. Contraction of muscle, the metabolic process of muscle cells by oxidization, oxidizing of metabolic fuel (fat and carbohydrate), etc., plays an essential role in performing physical work by the human body. Therefore, oxygen uptake is a determinant of the rate of work and energy output [5-6].

Maximal oxygen consumption ($VO_{2\ max}$) is an extensively recognized parameter as it is superior to quantify cardiovascular fitness, maximal aerobic power or maximum aerobic capacity, physical work capacity etc. [7-8], [10]. $VO_{2\ max}$ or physical work capacity is usually defined as the maximum quantity of oxygen consumption in lit/min or ml/kg/min. $VO_{2\ max}$ is extensively used as an index of an individual's maximum physical work capacity. Physical work capacity also can measure by the maximal expenditure of energy value in an eight-hour working duration by a person without any physical fatigue or physiologic pressure [9]. The physical work capacity of workers generally depends on the consumption-ability of O_2 for the oxidation

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of food substances [5]. VO_2 max is the indicator of the range of physical work capacity, which represents the ability to work hard or for extended periods of time, a high level of tolerance, and the ability to avoid fatigue-related alterations [10]. Therefore, to know the adaptation between work and worker, $VO_{2\ max}$ and its influential factors are significantly essential [11]. Maximal aerobic capacity ($VO_{2\ max}$) mainly depends on numerous factors such as psychological factors, physiological factors, environmental factors, etc. [12].

Direct method or indirect method are usually used to determine vo2max. The generally direct method is more accurate and expensive than the indirect method and is mainly used under controlled laboratory conditions with precise measuring equipment. In natural ways, subjects generally exercise continuously until reaching a level where oxygen uptake does not increase significantly for other work rates [9] [13]. Further, in important sectors like agriculture, there is a higher need for human efforts for field operation, which completely depends on individual working capacity [14-16].

Moreover, the previous study on $VO_{2\ max}$ showed that $VO_{2\ max}$ is higher in the treadmill experiment than the ergometry experiment [17]. $VO_{2\ max}$ decreases with age and females have lower $VO_{2\ max}$ than males [18]. He also found the highest $VO_{2\ max}$ in the range 20-29 ages agricultural workers, which is about 49±2.9 ml/kg.min or 2.409± 0.144 l/min. A study on students of the passive female university to determine the $VO_{2\ max}$ by direct and indirect methods [19]. They observed that the aerobic capacity obtained by both ways is quite different. They recommended a regression equation to define the $VO_{2\ max}$. The aerobic power of the north Indian more than the south Indian people [1]. Besides, from an earlier experiment on agricultural workers, it was observed that $VO_{2\ max}$ varies with the subject's performing activity [9].

By the above consideration, we can state that the aerobic power or maximum oxygen uptake or physical work capacity is an essential representative of personal physical work capacity. Many scientists have been discovered the $VO_{2\ max}$ of different parts of agricultural workers of India. However, no significant study has been carried out on the physical work capacity of northeast Indian agricultural workers. The climatic conditions, culture, and lifestyle of agricultural workers of northeast India are quite different from the rest of India. So, it is essential to determine the physical work capacity of Northeast Indian agricultural workers for making other government policies to assist the sustainable development of agriculture of Northeast India.

MATERIALS AND METHODS

The experiment was conducted on a treadmill (3 HP, 3 Phase, AC Motor with Inverter Technology Heavy Duty treadmill, Model:900 EXL) in laboratory condition in NERIST, Nirjuli, Arunachal Pradesh. The subjects engage in the ergonomics experiments willingly and are available throughout the entire period of the investigation. The selected subjects also have a wide range of weight, stature and are completely physically fit and free from muscular and cardiovascular abnormalities. It was mentioned that workers could usually provide their peak strength level between 20 to 45 years of age [20-21], for the best working capacity is in the range of 20-29 years of age [18]. Based on the earlier study's recommended age group, we selected twelve subjects in-between the age of 20 to 30 years for the ergonomic experiments. The selected subjects were made familiar with the equipment before the ergonomic test. The anthropometric dimensions like stature (cm), age (years), weight (kg), and heart rate (bpm) were also recorded. To know the difference between body fat weight and total body weight, we determined lean body weight (LBM) with the help of Hume's formula [22]:

$$\text{LBM (Kg)} = [(\text{Body weight, kg} \times 0.29569) + \text{body height, cm} \times 0.41873) - 43.2933]$$

The body surface area (BSA) was computed from individual subject weight and height with the help of the DuBois and DuBois formula [23]:

$$\text{BSA } (m^2) = 0.007184 \times (\text{Height, cm})^{0.725} \times (\text{Weight, kg})^{0.425}$$

BMI (body mass index) was also calculated by dividing the individual subject's weight (kg) by square of height m^2. The BMI was categorized as the following category by WHO:

1. BMI<18.5 – Underweight
2. BMI=18.5 to 24.9-Average
3. BMI=25 to 29.9- Overweight

Table 1 Physical characteristic of participated agricultural workers

Particulars	Statistic of subject
Height (cm)	162.75 ± 3.04
Weight(Kg)	63.75 ± 6.86
Age	27.5 ± 1.97
BMI(m^2)	24.02 ± 1.80
BSA(Kg/m^2)	1.69 ± .094
LBM(Kg)	46.63 ± 3.27

The sub-maximal ergonomic test was conducted to determine the selected subjects' maximum aerobic capacity by following the Modified Naughton protocol (Table 2).

Table 2 Speed, grade, and predicted mets for the modified Naughton protocol [24]

Stage	Speed (KM)	Grade (%)	Time (min)	METs
Warmup	2	0	1	_
1	3	0	3	2
2	3	4	6	3
2	3	7	9	4
4	3	11	12	5
5	3	14	15	6
6	3	18	18	7
7	5	13	21	8
8	5	15	24	9
9	5	18	27	10
10	5	20	30	11
11	5	23	33	12

The total time excludes the warmup stage (1 MET=3.5ml/kg^{-1}.min^{-1})

Before performing the actual test, subjects were introduced to the instruments used in the study and gave training for walking on a treadmill. We conducted the experiment in the laboratory on a treadmill (Model: TMX425); we used a fitmate pro (Made: Cosmed Italy,

Range: 0-22% O_2 Measurement, Accuracy: ±0.02%) to measure oxygen consumption (VO_2) and a heart rate monitor (Polar M200) to measure HR. We followed the equation (*HR $_{max}$= 205.8 - 0.685 X age*) of Robergs and Landwehr for calculating the HR_{max} [25]. The submaximal test was continued until the HR reached 75% of the HR $_{max}$. The recorded data of heart rate (HR) and VO_2 were plotted, and a regression equation was developed to extrapolate the VO_2 w.r.t to the HR_{max} for getting $VO_{2\ max}$. A sample plot is shown in Fig. 1, where the red portion is extrapolated.

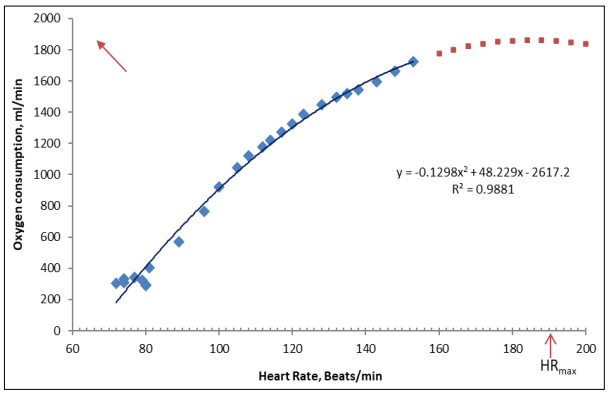

Fig 1 A sample data for HR and VO_{2max} for sub-maximum exercise

RESULTS AND DISCUSSION

From the sub-maximal test (Fig 2) of northeast Indian agricultural workers on a treadmill in the ergonomics lab of NERIST, Nirjuli, AP, we collected data of oxygen consumption and heart rate with the help of fitmate pro and Polar M200 heart rate monitor by following the Modified *Naughton protocol* [23]. The experiment continued until the heart rate reached 75% of the maximum heart rate, calculated using Robergs and Landwehr equation (*HR $_{max}$= 205.8 - 0.685 X age*) [23]. Since we were getting the highest value of 75% of HR $_{max}$ was 142 bpm, the VO_2 measure by primate pro in between 80 to 142 bpm and peak value of VO_2 varies from 30.32 to 31.56 The VO_2 of each subject varying with HR at an increment of 20 beats was plotted in (Fig 3), where the yellow dot represents the value of VO_2 of each subject. A dotted line represents the linear VO_2.

Fig 2 Measuring HR and VO_{2max} on a treadmill in laboratory condition

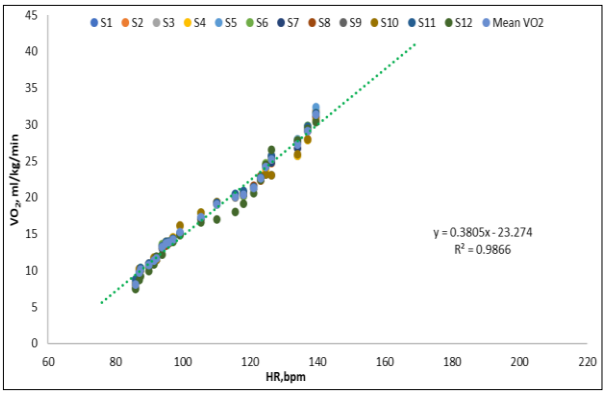

Fig 3 Representation of VO_2 of each subject of 20 to 30 years with the increment of HR on treadmill ergonomic exercise

From the data of HR and VO_2 from the sub-maximum exercise on the treadmill of each subject, we plotted a graph, and a regression equation was developed to extrapolate the VO_2 w.r.t to the HR_{max} for getting $VO_{2\ max}$. The regression equation, coefficient of correlation (R), and maximum heart rate (HR_{max}) of each subject were obtained by extrapolating the graph of VO_2 vs HR that presenting (sample graph) in material and method (Table 3). The mean value of HR_{max} of twelve subjects was found 186.96 ± 1.35 bpm. The coefficient of correlation (R) of VO_2 and HR of participated issues are varied from 0.977 to 0 .989.

Table 3 Representation of regression equation, coefficient of correlation (R) and maximum heart rate of each subject

Subject	Regression Equation	R^2 Value	Mean HR_{max} (bpm)
S_1	$y = .0002X^2 + .3322X - 20.176$	0.982	185.93
S_2	$y = 0.0007X^2 + 0.2069X - 13.268$	0.9801	185.25
S_3	$y = 0.0006X^2 + 0.2486X - 15.964$	0.9852	188.675
S_4	$y = -0.0001X^2 + 0.4042X - 24.184$	0.9806	187.305
S_5	$y = 0.0009X^2 + 0.1807X -12.803$	0.9856	189.36
S_6	$y= 0.0006X^2 + 0.2441X - 15.681$	0.9816	186.62
S_7	$y = 0.0007X^2 + 0.225X - 14.968$	0.9824	187.99
S_8	$y = 0.0004X^2 + 0.2887X - 18.151$	0.9852	185.935
S_9	$y = 0.0004X^2 + 0.2999X - 19.167$	0.9841	187.305
S_{10}	$y = -0.0002X^2 + 0.4114X - 24.475$	0.9823	185.25
S_{11}	$y = 0.0012X^2 + 0.1044X - 7.9188$	0.9898	187.99
S_{12}	$y = 0.0011X^2 + 0.1418X -10.92$	0.9776	185.935
	Mean HR_{max}		186.96 ± 1.35

The VO_2 getting from the extrapolated graph was considered as $VO_{2\ max}$ or physical work capacity or aerobic capacity of the subjects, shown in (Table 4). The mean value of $VO_{2\ max}$ of the participating subject was 50.60 ± 2.74 ml/kg/min, which was in between $VO_{2\ max}$ of north and south Indian, i.e., 51.21 ml/kg/min and 49.19 ml/kg/min

respectively [1]. The variation might be due to different climatic conditions, morphological characteristics, genetic variation, socio-economic conditions, etc. A graphical presentation of $VO_{2\ max}$ of North Indian, Northeast Indian, and south India has been exposed in (Fig 4).

Table 4 Physical work capacity of North East Indian agricultural workers

Subject	VO_{2max} (ml/kg/min)
S_1	48.49
S_2	49.08
S_3	52.30
S_4	48.01
S_5	53.68
S_6	50.76
S_7	52.06
S_8	49.35
S_9	51.03
S_{10}	44.87
S_{11}	54.11
S_{12}	53.47
Mean	50.60
SD	2.74

CONCLUSION

With the help of the sub maximum ergonomic test in laboratory condition on the treadmill, we found the physical work capacity ($VO_{2\ max}$) in the age group of 20-30 year agricultural workers of Northeast India, which is 50.60±2.74 ml/kg/min, which is in between the $VO_{2\ max}$ of North and South Indian people. In the sub maximum aerobic test, we also notice the HR of subjects varies 80 to 142 bpm, and the peak value of VO_2 of selected subjects varies from 30.32 to 31.56.ml/kg/min. The study on the aerobic capacity of Northeast Indian agricultural workers will be helpful for the scientific community to design human-centered tools and implement and making government policy in the agricultural section. Further in a future study on the impact of heat and humidity in the form of climate change on the maximum physical working capacity of agricultural workers can also be carried for the same sector to make the policy for workers sustainable livelihood.

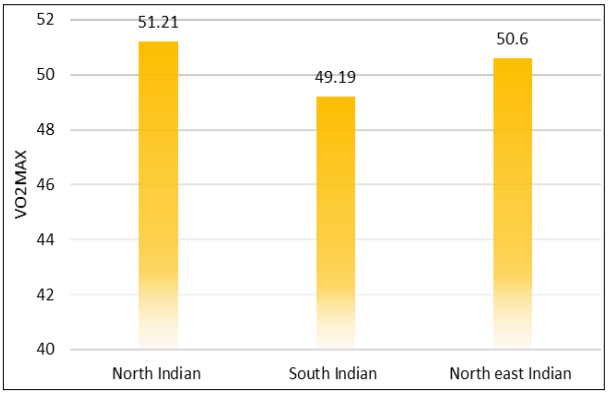

Fig 4 Comparison of $VO_{2\ max}$ of Northeast Indian with South and North Indian

LITERATURE CITED

1. Smilee JS, Vivian ST. 2010. Comparative study of aerobic power in North and South Indians. *Jr. Biomed Sci and Research* 2(3): 155-161.
2. Saffarian F, Ghaljahi M. 2018. Study of Vo 2-max in farmers of Sistan region province in 2017. *Asian Journal of Water, Environment and Pollution* 15(4): 35-40.
3. Saha PN, Datta SR, Banerjee PK, Narayane GG. 1979. An acceptable workload for Indian workers. *Ergonomics* 22(9): 1059-1071.
4. Choobineh A, Barzideh M, Gholami T, Amiri R, Tabatabaei HR, Almasi HA. 2011. Estimating aerobic capacity (Vo2-max) and studying its associated factors among male workers of industrial factories in Sepidan/Fars province. 2009: 1-12.
5. Rodahl K. 1989. *The Physiology of Work*. (Reprint). Taylor and Francis Ltd, London.
6. Singh SP, Gite LP, Majumder J, Agarwal N. 2008. Aerobic capacity of Indian farm women using sub-maximal exercise technique on a treadmill. *Agricultural Engineering International: CIGR Journal* 10: 1-10.
7. Bassett DR, Howley ET. 2000. Limiting factors for maximum oxygen uptake and determinants of endurance performance. *Medicine and Science in Sports and Exercise* 32(1): 70-84.
8. Buttar KK, SaBoo N, KaCKer S. 2020. Maximum oxygen consumption (VO 2 max) estimation using direct and indirect method in Indian population: A pilot study. *Journal of Clinical and Diagnostic Research* 14(2): 24-32.
9. Aware VV, Aware SV, Kadam VB, Wandkar SV, Shahare PU. 2018. Study of VO2max of agricultural workers for different farm operations. *Journal of Pharmacognosy and Phytochemistry* 7(5): 2585-2589.
10. Bugajska JMDT, Makowiec-Dąbrowska T, Jegier A, Marszałek A. 2005. Physical work capacity (VO2 max) and work ability (WAI) of active employees (men and women) in Poland. *International Congress Series* 1280: 156-160.
11. Khaldan A. 1990. *Exercise Physiology*. Tehran: Nashr-eTehran University, (Persian). pp 50-55.
12. Eramaki M. 1992. Ergonomy. Tehran: Nashr-eshahidbeheshti University: 6067. (Persian)
13. Maritz JS, Morrison JF, Peter J, Strydom NB, Wyndham CH. 1961. A practical method of estimating an individual's maximal oxygen intake. *Ergonomics* 4(2): 97-122.
14. F1CCI. 2015. Labour in Indian agriculture: a growing challenge. Retrieved August 23, 2020, from http://ficci.in/spdocumcnt/20550/FICCI
15. Pal G, Chattopadhyay PS. 2020. Development and testing of a power tiller operated single-row potato planter with bucket elevator type metering mechanism. *Journal of Agricultural Engineering* 57(2): 85-96.
16. Pal G, Patel T, Banik T. 2021. Effect of climate change associated hazards on agricultural workers and approaches for assessing heat stress and its mitigation strategies — Review of some research significances. *Int. Jr. Curr. Microbio. App. Sciences* 10(2): 2947-2975. doi: https://doi.org/10.20546/iicmas.2021.1002.325.

17. Varghese MA, Saha PN, Atreya N. 1995. Aerobic capacity of urban homemakers in Bombay. *Ergonomics* 38(9): 1877-1883.
18. Nag PK. 1981. Predicting maximal oxygen uptake of workers engaged in agricultural tasks. *Journal of Human Ergology* 10(1): 25-33.
19. Chatterjee S, Chatterjee P, Bandyopadhya A. 2005. Validity of queen's college step test for estimation of maximum oxygen uptake in female students. *Indian Jr. Med. Research* 121: 22-35.
20. Mc Ardle WD, Katch FI, Katch VL. 2001. *Exercise Physiology*. 5th Edition. Pennsylvania: Lippincott Williams and Wilkins Publication.
21. Ojha P, Kwatra S. 2014. Analysis of different paddy transplanting methods in northern India: Ergo-economical study. *Journal of Applied and Natural Science* 6(2): 654-658.
22. Hume R. 1966. Prediction of lean body mass from height and weight. *Journal of Clinical Pathology* 19(4): 389-391.
23. Shuter B, Aslani A. 2000. Body surface area: Du Bois and Du Bois revisited. *European Journal of Applied Physiology* 82(3): 250-254.
24. Elinoff JM, Rame JE, Forfia PR, Hall MK, Sun J, Gharib AM, Solomon MA. 2013. A pilot study of the effect of spironolactone therapy on exercise capacity and endothelial dysfunction in pulmonary arterial hypertension: Study protocol for a randomized controlled trial. *Trials* 14(1): 1-16.
25. Robergs RA, Landwehr R. 2002. The surprising history of the "Hrmax=220-age" equation. *Journal of Exercise Physiology Online* 5(2): 1-10.