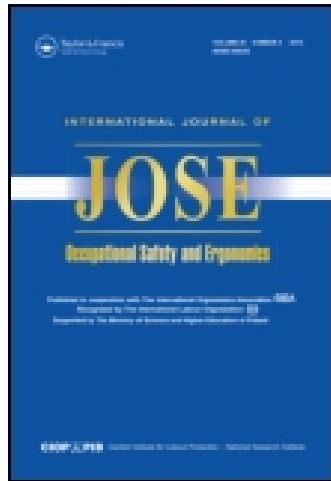


This article was downloaded by: [185.55.64.226]

On: 15 March 2015, At: 01:31

Publisher: Taylor & Francis

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



International Journal of Occupational Safety and Ergonomics

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/tose20>

Cardiovascular Load During Summer Work of Two Age Groups of Van-Rickshaw Pullers in West Bengal, India

Subhashis Sahu^a, Santi Gopal Maity^a, Subhabrata Moitra^a, Moumita Sett^a & Prasun Halder^a

^a Department of Physiology, University of Kalyani, Kalyani, India

Published online: 08 Jan 2015.

To cite this article: Subhashis Sahu, Santi Gopal Maity, Subhabrata Moitra, Moumita Sett & Prasun Halder (2013) Cardiovascular Load During Summer Work of Two Age Groups of Van-Rickshaw Pullers in West Bengal, India, *International Journal of Occupational Safety and Ergonomics*, 19:4, 657-665

To link to this article: <http://dx.doi.org/10.1080/10803548.2013.11077019>

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the "Content") contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms & Conditions of access and use can be found at <http://www.tandfonline.com/page/terms-and-conditions>

Cardiovascular Load During Summer Work of Two Age Groups of Van-Rickshaw Pullers in West Bengal, India

Subhashis Sahu
Santi Gopal Maity
Subhabrata Moitra
Moumita Sett
Prasun Haldar

Department of Physiology, University of Kalyani, Kalyani, India

Van-rickshaw is a popular mode of transport of people and merchandise in developing countries. The purpose of this study was to assess the effect of age on cardiovascular load of van-rickshaw pullers in the summer season (March–June) in real situations. In 142 participants, divided into 2 age groups (25–40 and 41–55 years), cardiovascular load was assessed on the basis of working and partial recovery heart rate (HR), predicted maximal HR, working maximal HR, average working HR, percentage of reserved HR, sum of recovery heart beats, percentage of recovery, relative and net cardiac cost, etc. Except for percentage of recovery, all parameters differed significantly between the groups and were significantly correlated with age. As this activity is very stressful, it places a heavy demand on the cardiovascular system. Therefore, age is an important factor for sustainability of the work, especially in a hot environment. Some ergonomic interventions are necessary to reduce cardiovascular load.

van-rickshaw puller age hot environment cardiovascular load cardiac cost

1. INTRODUCTION

In spite of the technological advances, a large number of people in developing countries, especially in rural areas, use rickshaws or van-rickshaws for transport; it is also a livelihood for many people. The word *rickshaw* comes from Asia, where this vehicle was mainly used as a means of transportation for the social elites. The word derives from the Japanese word *jinrikisha* (*jin* = human, *riki* = power or force, *sha* = vehicle), which literally means “human-powered vehicle”. In some streets and narrow lanes in Asian countries, where heavy vehicles are not able to pass through, rickshaws are the only option. They are perfect for short-distance travelling; many people prefer them when they want to reach their destination that is not very far.

Various types of rickshaws are found in different countries. In India, there are three main types: hand-pulled rickshaws, cycle-rickshaws and van-rickshaws. The tricycle van-rickshaw is a modified rickshaw, propelled by pedalling with both legs (Figure 1). It is a popular mode of transport for carrying passengers, luggage and merchandise in cities, suburban towns and villages in India and other Asian countries. Like the cycle-rickshaw [1], the van-rickshaw has certain overriding advantages: both are very cheap, do not require fossil fuel and do not pollute the air (unlike auto-rickshaws). Van-rickshaws can be used as emergency ambulances, as a patient can travel in them in a supine position. They can also be readily used for carrying loads (up to ~330 kg), but they are usually used for carrying passengers (up to seven). In contrast,

The authors sincerely thank all the van-rickshaw pullers who were constantly in support of this study and have given their precious time and consent to participate. The study was partly supported by DST-PURSE programme (Government of India) of University of Kalyani.

Correspondence should be sent to Subhashis Sahu, Ergonomics and Occupational Physiology Laboratory, Department of Physiology, University of Kalyani, Kalyani-741235, Nadia, West Bengal, India. E-mail: skcsahu@yahoo.co.in.



Figure 1. A van-rickshaw for carrying passengers or merchandise. Notes. Photo by Santigopal Maity.

the cycle-rickshaw does not carry heavy loads and carries two passengers only. Rickshaws provide self-employment to a large proportion of Indian rural populations. Vehicles like buses, cars, taxis, motor vans, etc., cannot travel through remote areas but van-rickshaws are suitable for transport even on unpaved roads.

Peddalling the tricycle van-rickshaw is a most stressful job; it requires extensive muscle force and is linked with heavy workload, which increases in summer because of higher temperature and humidity [2, 3]. Exposure to heat also causes dehydration of the workers working outdoors [4, 5]. In West Bengal, mean air temperature during summer ranges between 28 and 44 °C, and the hottest months are April and May.

There are some reports on the energy expenditure of pullers of hand-pulled rickshaws [6, 7] and the design of those rickshaws [8]. Other reports cover various aspects of cycle-rickshaws, such as design, brake system, mechanical efficiency [9] and the energy expenditure of the pullers [10]. Pradhan, Thakur and Mukherjee studied the anthropometric characteristics of Indian cycle-rickshaw pullers [11], but so far there has

been no published study on the physiological cost of work of van-rickshaw pullers of different age groups in a hot environment. So, this study was mainly aimed at assessing cardiovascular load and the effect of aging of van-rickshaw pullers working at a high ambient temperature.

2. MATERIALS AND METHODS

2.1. Participants

The study group consisted of 142 van-rickshaw pullers aged 25–55 years, with at least 5 years of working experience in this occupation. They were randomly selected as participants and divided into two groups depending on their age. The mean (*SD*) age of one group of participants was 31.8 (4.9) years (range: 25–40) and 48.1 (3.9) years (range: 41–55) of the other.

2.2. Study Period and Task Design

This study was done in the summer season (March–June) from 9:00 to 13:00, between the pullers' working periods. For the first 1.5 h, they were acquainted with the study and some data

were collected about the job, physical profile, resting heart rate (HR), etc. Next, the van-rickshaw pullers were asked to perform the experimental task, i.e., to pull the van-rickshaw with four passengers for 30 min.

2.3. Physical Profile

Body height and weight were measured with a standardized anthropometric rod and properly calibrated weighing machine, respectively. From those data, body mass index (BMI) and body surface area (BSA) were calculated with Weisell’s [12] and Banerjee and Sen’s [13] methods, respectively.

2.4. Physiological Parameters

2.4.1. Resting, working and partial recovery HR

HR was constantly controlled with a monitor (Polar Accurex Plus, Polar Electro Oy, S810i, Finland). Resting HR was measured before the participants performed their task. Working HR was recorded every minute up to 30 min of work, and partial recovery HR was recorded up to 20 min after cessation of work.

2.4.2. Predicted maximal HR

Predicted maximal HR of the participants was calculated from their respective ages with Londeree and Moeschberger’s equation [14]:

$$HR_{max} = 206.3 - (0.711 \times \text{age}), \quad (1)$$

where HR_{max} = predicted maximal HR.

2.4.3. Average working HR

Average working HR was derived from the value of the fourth minute of work onwards [15].

2.4.4. Percentage of reserved HR

Percentage of reserved HR for average working HR and working maximal HR was calculated from predicted maximal HR for respective ages:

$$\begin{aligned} &\% \text{ of reserved HR for } X \\ &= [(HR_{max} - X)/HR_{max}] \times 100\%, \quad (2) \end{aligned}$$

where X = average working HR or working maximal HR (HR_{max}).

2.4.5. Cardiac strain

Net and relative cardiac cost (CC) were considered as two derived indices of cardiac strain [16]; they were determined with Equations 3–4:

$$\begin{aligned} \text{net } CC &= \text{sum of working heart beats} \\ &- (\text{resting } HR) \times \text{working time}, \quad (3) \end{aligned}$$

$$\begin{aligned} \text{relative } CC &= \text{net } CC / [(\text{working } HR_{max} \\ &- \text{resting } HR) \times \text{working time}] \times 100\%, \quad (4) \end{aligned}$$

where CC = cardiac cost, HR = heart rate, HR_{max} = working maximal HR.

2.4.6. Work strain or sum of recovery heart beats (SRHB)

SRHB is a measure of work strain, which was calculated by summing the values of HR during the partial recovery period of 20 min for each participant.

2.4.7. Percentage of recovery (PREC)

PREC was calculated from Pradhan, Thakur, Mukherjee, et al.’s equation; it is expressed as the ratio of fall in HR during the recovery period as a percentage of the increment of working over resting HR [10]:

$$PREC = [(a - b)/(a - c)] \times 100\%, \quad (5)$$

where $PREC$ = percentage of recovery, a = HR of last minute of work, b = HR of last minute of recovery recorded, c = resting HR.

2.5. Thermal Environment

Dry bulb temperature, natural wet bulb temperature and globe temperature were recorded hourly during study periods with dry bulb, wet bulb and globe thermometers. Next, the wet bulb globe temperature index in outdoor conditions was calculated with Equation 6 [17]:

$$\begin{aligned} WBGT_{out} &= 0.7 nWBT + 0.2 GT \\ &+ 0.1 DBT, \quad (6) \end{aligned}$$

where $WBGT_{out}$ = wet bulb globe temperature index in outdoor conditions, $nWBT$ = natural wet

Downloaded by [185.55.64.226] at 01:31 15 March 2015

bulb temperature, GT = global temperature, DBT = dry bulb temperature; all in degrees Celsius.

2.6. Statistical Analysis

Means and standard deviations were calculated for the physical and physiological parameters. Unpaired Student's t test for unequal sample size between groups was performed to analyse the differences in the physical characteristics of the participants (age, height, weight, BMI, BSA); work experience and physiological parameters, including cardiac strain parameters. Correlation analysis was also performed among physiological parameters to find the degree of their interde-

pendence. Levels of significance were taken as $p < .001$, $p < .01$, and $p < .05$ [18].

3. RESULTS

The study was conducted in the summer season; mean (SD) $WBGT_{out}$ varied from 30.20 (1.30) to 32.29 (0.92) °C. According to Dey, Samanta and Saha [19], the World Health Organization [20] and the American Conference of Governmental Industrial Hygienists [21], $WBGT$ over 25 °C is stressful. This is bound to increase cardiovascular load and physiological stress [22].

Table 1 presents the participants' physical characteristics, work experience, daily working time

TABLE 1. Physical Characteristics, Work Experience, Daily Working Time and Daily Distance Travelled in 2 Age Groups of Van-Rickshaw Pullers ($N = 142$)

Parameter	Young Pullers ($n = 92$)		Older Pullers ($n = 50$)		t
	$M \pm SD$	Range	$M \pm SD$	Range	
Age (years)	31.75 \pm 4.90	25–40	48.07 \pm 3.94	41–55	16.38***
Height (cm)	165.95 \pm 5.44	155–176	167.00 \pm 7.30	155–181	0.52
Weight (kg)	56.65 \pm 6.52	48–72	54.40 \pm 4.52	47–63	1.30
Body surface area (m^2)	1.62 \pm 0.08	1.44–1.82	1.60 \pm 0.08	1.44–1.73	0.71
Body mass index	20.62 \pm 2.71	16.84–15.59	19.58 \pm 2.17	17.04–23.30	1.34
Work experience (years)	8.80 \pm 3.08	5–15	24.85 \pm 6.89	14–39	9.75***
Daily working time (h)	9.90 \pm 2.51	4–14	7.05 \pm 2.32	2–10	3.72***
Daily distance travelled (km)	57.20 \pm 15.47	15–80	35.70 \pm 15.83	10–60	4.34***

Notes. *** $p < .001$; two-tailed unpaired t test.

TABLE 2. Resting Heart Rate, Predicted Maximal Heart Rate and Cardiac Strain Parameters in 2 Age Groups of Van-Rickshaw Pullers ($N = 142$)

Parameter	Young Pullers ($n = 92$)		Older Pullers ($n = 50$)		t
	$M \pm SD$	Range	$M \pm SD$	Range	
Resting HR (beats/min)	80.20 \pm 6.06	68–88	81.60 \pm 14.96	58–98	0.27
Predicted HR_{max} (beats/min)	183.95 \pm 3.60	178–189	171.45 \pm 2.81	167–176	12.22***
Average working HR (beats/min)	132.92 \pm 13.92	117.88–148.40	157.85 \pm 12.55	147.51–169.22	5.69***
Working HR_{max} (beats/min)	141.50 \pm 17.73	132–174	170.90 \pm 21.76	162–186	4.85***
$SRHB$	1591.80 \pm 113.64	1443–1776	1815.30 \pm 186.41	1588–2197	3.55**
$PREC$ (%)	72.32 \pm 11.97	53.84–88.00	56.25 \pm 21.99	28.57–88.88	2.03
Relative CC (%)	70.96 \pm 4.65	63.64–77.06	76.54 \pm 3.96	72.11–85.82	-2.89**
Net CC (beats)	1485.00 \pm 260.77	1102–1734	2165.30 \pm 499.64	1536–2952	-3.82***

Notes: ** $p < .01$, *** $p < .001$; two-tailed unpaired t test; HR = heart rate, HR_{max} = working maximal heart rate, $SRHB$ = work strain, sum of recovery heart beats, $PREC$ = percentage of recovery, CC = cardiac cost. Values in parentheses indicate ranges.

and daily distance travelled. Student's *t* test was performed to compare these characteristics in the two age groups. The results show highly significant differences ($p < .001$) in age, experience, daily working time and daily distance travelled.

Predicted HR_{max} was significantly ($p < .001$) higher in the young group, while average working *HR*, working HR_{max} , *SRHB*, and relative and

net *CC* were significantly higher in the older group (Table 2). No significant difference was observed for resting *HR* or *PREC*. Percentage of reserved *HR* for average working *HR* and working HR_{max} was lower in older workers than in their younger counterparts (Table 3).

All cardiac parameters were positively correlated with one another except for relative *CC* and

TABLE 3. Percentage of Reserved Heart Rate (HR) for Average Working HR and Working Maximal HR Calculated From Predicted Maximal HR in 2 Age Groups of Van-Rickshaw Pullers (N = 142)

Pullers	HR_{max}	Average Working <i>HR</i>		Working HR_{max}	
	<i>M</i> ± <i>SD</i> (beats/min)	<i>M</i> ± <i>SD</i> (beats/min)	as % of Reserved <i>HR</i> From HR_{max}	<i>M</i> ± <i>SD</i> (beats/min)	as % of Reserved <i>HR</i> From HR_{max}
Young (<i>n</i> = 92)	183.95 ± 3.60	132.92 ± 13.92	27.17	141.5 ± 17.73	23.36
Older (<i>n</i> = 50)	171.45 ± 2.81	157.85 ± 12.55	7.60	170.9 ± 21.76	0.58

Notes. *HR* = heart rate, HR_{max} = working maximal *HR*.

TABLE 4. Coefficients of Correlation Between Parameters of Cardiovascular Load Assessment and Participants' Age (N = 142)

	HR_{max}	Average Working <i>HR</i>	Working HR_{max}	<i>SRHB</i>	<i>PREC</i>	Relative <i>CC</i>	Net <i>CC</i>
Age	.63***	.51***	.43***	.40**	.19	.33**	.34**
HR_{max}		.70***	.72***	.57***	.34**	.26*	.56***
Average Working <i>HR</i>			.93***	.53***	.27*	.49***	.63***
Working HR_{max}				.50***	.32**	.29*	.73***
<i>SRHB</i>					.45**	.25*	.41**
<i>PREC</i>						.20	.55***
Relative <i>CC</i>							.38**
Net <i>CC</i>							

Notes. * $p < .05$, ** $p < .01$, *** $p < .001$; two-tailed unpaired *t* test; *HR* = heart rate, HR_{max} = working maximal heart rate, *SRHB* = work strain, sum of recovery heart beats, *PREC* = percentage of recovery, *CC* = cardiac cost.

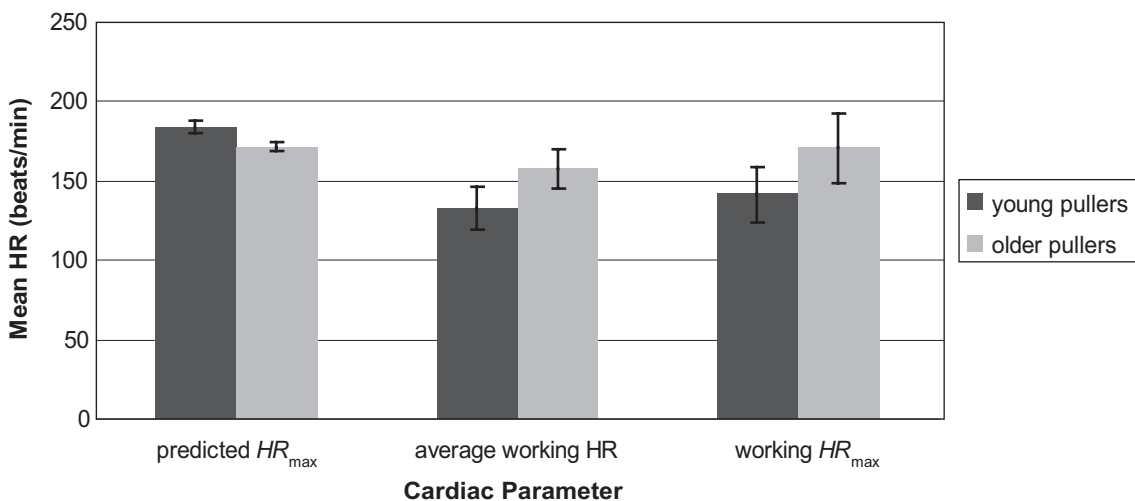


Figure 2. Predicted maximal heart rate (HR), calculated for respective age; average working *HR* and working maximal *HR* in 2 age groups of van-rickshaw pullers. Notes. *HR* = heart rate, HR_{max} = working maximal heart rate; error bars denote *SD*.

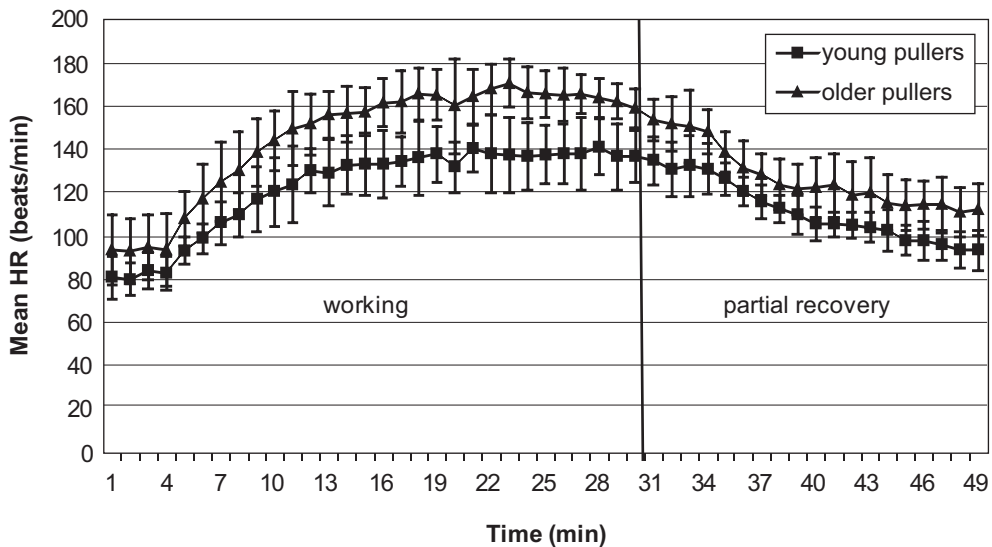


Figure 3. Comparison of mean working and partial recovery heart rate (HR) in 2 age groups of van-rickshaw pullers. Notes. Error bars denote SD.

PREC (Table 4). There were significant correlations between age and all cardiac parameters except *PREC*, too.

Mean values of predicted HR_{max} , average working *HR* and working HR_{max} did not differ significantly between the two groups (Figure 2). Figure 3 compares mean *HR* during 30 min of work and 20 min of partial recovery in the two groups.

4. DISCUSSION

In this study, van-rickshaw pullers were divided into two age groups because age is the most important factor for any type of strenuous activity [23, 24]. HR_{max} declines with increasing age [14], so assessing cardiovascular indices is crucial in evaluating physiological workload, but studies in real situations are limited.

No significant changes in BMI were observed between the age groups and the values (i.e., 20.62 ± 2.71 versus 19.58 ± 2.17) were within the normal limits [25]. This indicated that the pullers did not have any chronic energy deficiency. Duration of their daily work varied significantly ($p < .001$) between the groups. The older group failed to sustain the workload for a long period; therefore, the number of their daily trips was much lower than in their young counterparts.

An analysis of cardiac parameters shows that cardiac efficiency was much lower among the older workers for that specific and similar workload. According to Maritz, Morrison, Peter, et al., the average working *HR* standard for 8-h industrial jobs should be 105 beats/min (range: 95–115) [26]. According to Brouha, *HR* in industry should not exceed 110 beats/min, as cumulative fatigue could ensue beyond this *HR* level [27]. Later, Saha, Datta, Banerjee, et al. proposed that the acceptable workload for sustained physical activity might be estimated as 35% of the maximal aerobic power for Indian male workers, which corresponded to working *HR* of 110 beats/min [28]. Figure 2 shows that mean (*SD*) average working *HR* greatly exceeded this value: 132.92 (13.92) and 157.85 (12.55) beats/min in the young and older groups, respectively. Mean (*SD*) working HR_{max} for the two groups was 141.50 (17.73) and 170.90 (21.76) beats/min, respectively; therefore, according to Åstrand and Rodahl, their work was very heavy [29]. As this work is very stressful and very heavy [30], it requires extreme muscle force and strength, and more cardiac efficiency. With advancing age, muscle and cardiovascular strength decreases [31]; moreover, exposure to environmental heat increases stress [32, 33]. *SRHB*, used as a measure of work strain [1], was higher in the older

group (1815.30 ± 186.41 versus 1591.80 ± 113.64 beats/min among the younger pullers). This indicates that to recover from exhaustion after work, their hearts had to beat faster. The net and relative *CC* were also higher among the older workers. This indicates that there was excessive physiological load on the cardiovascular system among the older workers.

In the young group, the percentage of reserved *HR* for average working *HR* and working HR_{max} reached 27.17% and 23.56%, respectively, compared to only 7.60% and 0.58% in the older group. This indicates that the workload was much heavier for the older participants, probably due to the effect of age on the metabolic functions of the body and reduced muscle strength. The correlation coefficients, which best described the association between cardiac stress indicators and age, reflected this, too. According to Standards No. EN ISO 9886:2004 [34] and No. EN ISO 8996:2004 [35], HR_{limit} in the workplace should not exceed the maximal value for the person reduced by ~20 beats/min [36]. Figure 3 shows that mean working *HR* was much higher in the older group than in their young counterparts. So, exposure to heat increased the load experienced by the older van-rickshaw pullers because of their poorer metabolism [37, 38]. Consequently, they were unable to work for a long period. This, in turn, reduced the number of trips, which ultimately affected their earnings.

5. CONCLUSIONS

Results of this study confirm that van-rickshaw pulling is a very strenuous job, especially in hot environmental conditions. Pedalling requires extreme muscle force, which can increase cardiovascular load. Mean values of all parameters in both groups of workers showed that cardiovascular load was very high and increased with age. So, the older participants reduced the number of trips and lost some of their earnings. Global heating due to climate changes will pose an additional threat to this occupation. The workload could be minimized by implementing some ergonomic interventions, e.g., redesigning the vehicles, establishing a fixed weight carrying limit for different age groups of

pullers, maintaining the vehicles properly, establishing proper rest pauses. Besides, regular re-hydration between trips is recommended.

REFERENCES

1. Pradhan CK, Thakur S, Mukherjee AK, Roychowdhury A. Energy expenditure of cycle rickshaw pullers in different places in India. *Ergonomics*. 2008;51(9):1407–17.
2. Azer NZ, McNall PE, Leung HC. Effects of heat stress on performance. *Ergonomics*. 1972;15(6):681–91.
3. Hancock PA, Vasmatazidis I. Effects of heat stress on cognitive performance: the current state of knowledge. *Int J Hyperthermia*. 2003;19(3):355–72.
4. Pitts GC, Johnson RE, Consolazio FC. Work in the heat as affected by intake of water, salt and glucose. *Am J Physiol*. 1944;142(2):253–9. Retrieved July 24, 2013, from: <http://nrsdec.natick.army.mil/LIBRARY/36-58/R44-05.pdf>.
5. Coyle EF. Fluid and fuel intake during exercise. *J Sports Sci*. 2004;22(1):39–55.
6. Banerjee S, Acharya KN, Chattopadhyay DP. Studies on energy metabolism in rickshaw pullers. *Indian J Physiol Pharmacol*. 1959;3:147–60.
7. Datta SR, Chatterjee BB, Roy BN. The energy cost of rickshaw pulling. *Ergonomics*. 1978;21(11):879–86.
8. Sen RN, Basu S. An ergonomic design of hand-pulled rickshaws (Project Report No. 30). Kolkata, India: Ergonomics Laboratory, Department of Physiology, University of Calcutta; 1977.
9. Locating the space for innovations in Indian cycle rickshaws: a review of the efforts and the perceptions of the innovators, assemblers and pullers (Project sponsored by Department of Science and Technology). New Delhi, India: Centre for Science, Technology and Environmental Policy Studies; 1993.
10. Pradhan CK, Thakur S, Mukherjee A, Roy Choudhury A. Physiological assessment of cycle rickshaw pullers. *Indian Journal of Physiology & Allied Sciences*. 2004;58: 113–8.

11. Pradhan CK, Thakur S, Mukherjee KA. Anthropometric characteristics of Indian cycle rickshaw pullers. *J Hum Ergol (Tokyo)*. 2010;39(2):79–88.
12. Weisell RC. Body mass index as an indicator of obesity. *Asia Pac J Clin Nutr*. 2002; 11 Suppl 8:S681–4.
13. Banerjee S, Sen R. Determination of the surface area of the body of Indians. *J Appl Physiol*. 1955;7(6):585–8.
14. Londeree BR, Mosechberger ML. Effect of age and other factors on maximal heart rate. *Research Quarterly for Exercise and Sport*. 1982;53(4):297–304.
15. Nag PK, Sen RN, Ray US. Cardio-respiratory performance of porters carrying loads on a treadmill. *Ergonomics*. 1979; 22(8):897–907.
16. Costa G, Berti F, Betta A. Physiological cost of apple firming activities. *Appl Ergon*. 1989;20(4):281–6.
17. Parsons KC. Human thermal environments. The effects of hot, moderate and cold environments on human health, comfort and performance. London, UK: Taylor & Francis; 1993.
18. Das D, Das A. Statistics in biology and psychology. 4th ed. Kolkata, India: Academic; 2004.
19. Dey NC, Samanta A, Saha R. Assessment of cardiac strain amongst underground coal carriers—a case study in India. *Int J Ind Ergon*. 2007;37(6):489–95.
20. Health factors involved in working under conditions of heat stress. Report of a WHO scientific group. *World Health Organ Tech Rep Ser*. 1969;412:1–32.
21. American Conference of Governmental Industrial Hygienists (ACGIH). Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH, USA: ACGIH; 1992–1993.
22. Biswas R, Samanta A, Saha P. Cardiac strain of confectionery worker in relation to heat exposure during regular work shift. *Indian J Occup Environ Med*. 2011;15(3): 120–6. Retrieved July 24, 2013, from: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3299096/>.
23. Pugh KG, Wei JY. Clinical implications of physiological changes in the aging heart. *Drugs Aging*. 2001;18(4):263–76.
24. Lusa S, Louhevaara V, Kinnunen K. Are the job demands on physical work capacity equal for young and aging firefighters? *J Occup Med*. 1994;36(1):70–4.
25. National Institute of Nutrition. Nutritional trends in India. New Delhi, India: Indian Council of Medical Research; 1993.
26. Maritz JS, Morrison JF, Peter J, Strydom NB, Wyndham CH. A practical method of estimating an individual's maximum oxygen intake. *Ergonomics*. 1961;4(2):97–122.
27. Brouha L. Physiology in industry: evaluation of industrial stresses by the physiological reactions of the worker. Oxford, UK: Pergamon Press; 1960.
28. Saha PN, Datta SR, Banerjee PK, Narayane GG. An acceptable workload for Indian workers. *Ergonomics*. 1979;22(9): 1059–71.
29. Åstrand P, Rodahl K. Textbook of work physiology. 3rd ed. New York, NY, USA: McGraw-Hill; 1986.
30. Drust B, Rassmussen P, Mohr M, Nielsen B, Nybo L. Elevations in core and muscle temperature impairs repeated sprint performance. *Acta Physiol Scand*. 2005; 183(2):181–90.
31. Shephard RJ. Physical activity and aging. 2nd ed. London, UK: Croom Helm; 1987.
32. Ghosh AK, Abdullah TAT, Kishan B. Effect of hot environment on repetitive sprint performance and maximum accumulated O₂ deficit of cyclists. *International Journal of Sports Science and Engineering*. 2008;2(2),94–100. Retrieved July 24, 2013, from: <http://www.worldacademicunion.com/journal/SSCI/SSCIvol02no02paper05.pdf>.
33. Sahu S, Chatterjee A. Effect of heat exposure in van-rickshaw pullers: implication of climate change in future. *Asian-Pacific Newsletter on Occupational Health and Safety*. 2013;20(2):37–40. Retrieved July 24, 2013, from: http://www.ttl.fi/en/publications/electronic_journals/asian_pacific_newsletter/Documents/Asian-pacific_2_2013_nettilehti.pdf.

34. European Committee for Standardization (CEN). Ergonomics—evaluation of thermal strain by physiological measurements (Standard No. EN ISO 9886:2004). Brussels, Belgium: CEN; 2004.
35. European Committee for Standardization (CEN). Ergonomics of the thermal environment—determination of metabolic rate (Standard No. EN ISO 8996:2004). Brussels, Belgium: CEN; 2004.
36. Bugajska J, Zużewicz K, Szmauz-Dybko M, Konarska M. Cardiovascular stress, energy expenditure and subjective perceived ratings of fire fighters during typical fire suppression and rescue tasks. *International Journal of Occupational Safety and Ergonomics (JOSE)*. 2007;13(3):323–31. Retrieved July 24, 2013, from: <http://www.ciop.pl/23212>.
37. Febbraio MA, Snow RJ, Stathis CG, Hargreaves M, Carey MF. Effect of heat stress on muscle energy metabolism during exercise. *J Appl Physiol*. 1994;77(6), 2827–31.
38. Finn JP, Wood RJ, Marsden JF. Effect of 30 °C heat on the anaerobic capacity of heat acclimatised athletes. *J Sports Sci Med*. 2003;2:158–62. Retrieved July 24, 2013, from: <http://www.jssm.org/vol2/n4/6/v2n4-6pdf.pdf>.