Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2017, 9(3):245-251

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Assessment of Physiological Health Status in Relations to Different Anthropometric and Cardio-respiratory Measures of Head-Supported Load Carrying Male Porters of Sikkim, India

Mahuya Patra Purkait[1] and Koushik Bhattacharya[2*]

[1]Department of Zoology, Sonarpur Mahavidyalaya, Kolkata, West Bengal, India
[2]Department of Physiology, Sonarpur Mahavidyalaya, Kolkata, West Bengal, India

ABSTRACT

Background: Carrying heavy loads in the hilly region, porters face extreme ranges in terrain condition, sloped path that is very steep and lack of oxygen due to altitude. The porters in Sikkim, India, routinely carry head-supported loads, which often exceed their body weight, over long distances up and down the steep mountain footpaths which prompted us to assess occupational health status of these head supported load carrying porters. Objective: We aimed our study to evaluate physical and physiological status of male porters of Gangtok, Sikkim. Methods: Seventeen male porters and twenty one healthy as well as age matched (Age: 37 – 52 years) control subjects were selected for the study. Different physical, anthropometric and physiological parameters were studied. Students "t" test was performed to find out the significant difference (P<0.05), if any, between the selected variables. Results: Results of this study on male porters suggest that they are physically healthy but having spinal shrinkage along with lower hand grip strength and PEFR. Conclusion: This study supports the hypothesis that the male porters are associated with decreased lung function and increased spinal shrinkage. To develop an effective intervention strategy, the treatment seeking behavior of individuals would also need to be improved through awareness program.

Key words: Head-supported load carrying; Peak expiratory flow rate; Spinal shrinkage; Anthropometry; Hand grip

INTRODUCTION

Human-powered load carrying (fig 1) in geographical areas where wheel-based tools are precluded by economical, technological or environmental limitations has always been a challenge. The necessity to transport relatively heavy loads remains an important occupational task for many people, including school students and the military. Consequently much attention has been paid to load carriage with a number of different approaches evident in the literature [1-5]. By far the most prevalent approach, however, has been an examination of the physiological consequences of carrying loads [6].

In the developing world heavy loads are regularly carried over long distances as a necessary part of daily routine. In order to circumvent the low carrying effectiveness of upper limbs, different strategies to walk with heavy loads evolved. Particularly famous are the women of the Luo and Kikuyu tribes in East Africa for carrying loads equivalent to 70% of their body mass balanced on their heads or using forehead supporting straps [7], similar to Nepalese porters. In addition, porters from the Himalayan region simultaneously cope with unusually heavy loads (about 80–90% of their body mass, up to 200%), rough terrain, steep paths (up to 50% gradient) and extreme altitude hypoxia. The feats of these ethnic groups have been studied, in terms of economy of transport, in the past. During loaded walking on a flat terrain, both Nepalese porters [6] and East African women [7] use remarkably less metabolic energy than Caucasian control subjects. Nepalese porters routinely carry head supported loads exceeding their body weight for many kilometers up and down steep mountain footpaths at high altitudes. It has been argued that both of these methods represent particularly economical solutions to the problem of carrying loads in these environments [7, 8, 9]. The head strap method has received some recent attention (Figure 1). Minetti *et al* (2006) [10] concluded that the remarkable capabilities of the Himalayan porters could only partially be explained by metabolic efficiency whilst Malville *et al* (2001) [11] argued that a combination of pacing strategy and metabolic efficiency contribute to the load carrying abilities of the commercial porters in Eastern Nepal. Both studies seem to support the early findings of Nag *et al* (1979) [12] who reported this method as being particularly economical when heavy loads are carried at relatively slow speeds.

Figure 1: A male Porter is carrying heavy loads in the hilly region through Head strap method

One particular area that has been explored in some detail is that of the effect of load placement and load carrying method on energy expenditure. Taylor *et al* (1980) [13] demonstrated, across a range of species, that, for loads carried on the back, the increase in energy expenditure associated with a given load was directly proportional to the relative increase in mass i.e. an additional load of 10% body mass evokes a 10% increase in energy expenditure. This result has been replicated in numerous human studies [14,15]. Load carriage systems are used as tools for a variety of industrial, military, and recreational situations. One of the most common types of load carriage systems used is head supported loads in porters of Gangtok, Sikkim. It is a well recognized and acclaimed fact that manual heavy load handling entails enormous physical labor and associated discomfort feeling, which invariably culminate into musculoskeletal disorders (MSD). Moved by the interest in load carrying when multiple burdens limit the locomotor performance we aimed our study to evaluate physical and physiological status of male porters of Gangtok, and to assess changes, if any, in peak expiratory flow rate, hand grip strength and spinal shrinkage in the same population.

METHODS AND MATERIALS

Participants

This study was conducted in Gangtok, Sikkim. 17 male porters [Age: 37 – 52 years] were recruited for the study. 21 healthy male control subjects [Age: 33 – 51 years] were chosen from the same locality mostly working in hotels and shops. Both the individuals (worker and control), had no earlier report of systemic diseases.

Measurement of height

The height (cm) of each subject was measured by an anthropometric rod [16] by allowing the subject to stand straight on a plane surface. They were instructed to look forward during the measurement.

Measurement of weight

The weight (kg) of each subject was measured by conventional weighing pan [16]. They were instructed to stand upon it and to look forward. Weighing pan was reset to zero before each measurement.

Calculation of Body Surface Area (B.S.A.) and Body Mass Index (B.M.I.)

Calculation of body surface area of each individual was measured by height – weight nomogram. [17]. The body mass index (or Quetelet Index) is the statistical measure which compares a person's weight and height by the following formula [18]: $BMI = mass\ (kg)/(Height\ in\ m)^2$. The WHO [18,19] regard a BMI of less than 18.5 as underweight and may indicate malnutrition, an eating disorder, or other health problems, while a BMI greater than 25 is considered overweight and above 30 is considered obese.

Measurement of heart rate

The heart rate (beats/min) of each subject was measured in seating condition after 15mins of rest by a stop watch from the radial artery [20].

Measurement of systolic and diastolic blood pressure

Systolic and diastolic blood pressures (mm-Hg) of the subjects were measured with the help of sphygmomanometer [20]. Both the pressures were measured by allowing the subject in seating position after 15mins of rest.

Measurement of waist and hip circumference and calculation of waist/hip ratio

Waist circumference (cm) was measured with a flexible tape midway between the inferior angle of the ribs and the supra-iliac crest, whereas hip circumference (cm) was measured at the outermost points of the greater trochanters [21]. From this data waist/ratio was calculated.

Measurement of mid upper arm circumference

Mid upper arm circumference (cm) was measured midway between the tip of the shoulder and the elbow of the left arm with the arm hanging freely by the side using a flexible tape [22].

Measurement of head circumference, head length and head breadth

Circumference of head was measured with a tape just above the supraorbital ridges [23]. Maximum length and Maximum horizontal breadth of the head as measured with spreading caliper in the midsagittal place [23] and with a spreading caliper above the level of the ears on gonion (right and left) respectively [23].

Determination of hand grip strength

Hand grip strength was determined by using a hand grip dynamometer (Inco, Ambala, India) to test the maximum voluntary contraction [24]. The best of three trials was accepted with three minutes rest in-between. All the hand grip measurements were taken with the arm straight, i.e., at 0° elbow-angle. (Figure 2)

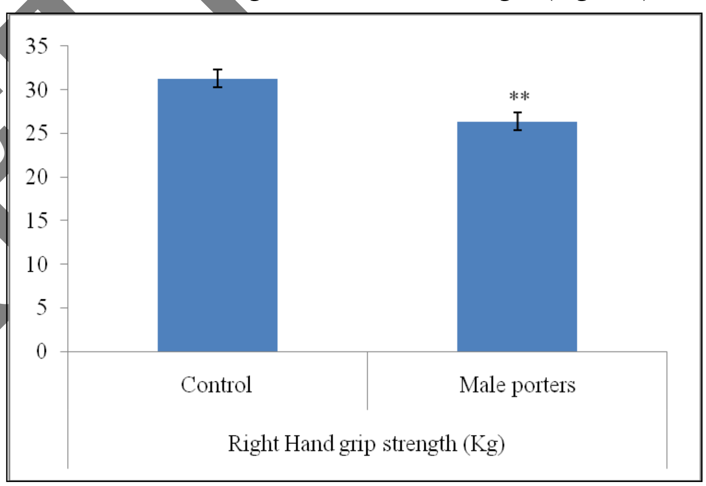

Figure 3: Right hand grip strength (Kg) of control and male porters of Gangtok, India (n=21). Significant difference is based on two tail Student 't' test. ** P<0.01

Measurement of Peak Expiratory Flow Rate (PEFR)

Peak expiratory flow rate was examined [18] with an Airmed peak-flow meter. The test was performed in standing position holding the peak flow meter horizontally. A tight fitting disposable cardboard mouthpiece was inserted in the inlet nozzle. After proper rest, subject was requested to take a deep breath and exhale as forcefully as possible in one single blow into the instrument. The procedure was repeated three times and best of the three was recorded (Figure 3).

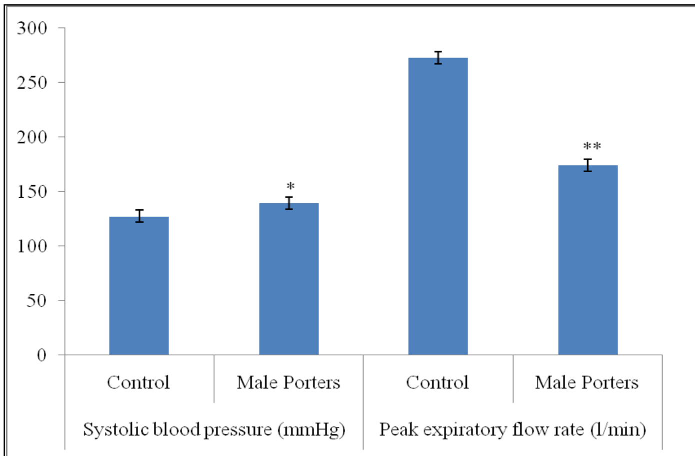

Figure 3: Sysstolic blood pressure (mmHg) and Peak expiratory flow rate (l/min) of control and male porters of Gangtok, India (n=21). Significant difference is based on two tail Student 't' test. * P<0.05; **P<0.01

Measurement of spinal shrinkage

Recumbent length was measured on a wooden desk fixed to the wall after a uniform settling down periods of 2 minutes fixed arbitrarily [25]. Measurement was taken with the help of anthropometric rod. Spinal shrinkage was measured as the difference between the recumbent length and the standing height. Percentage spinal shrinkage was calculated as: [(Recumbent length – standing height) X 100] / recumbent length. (Figure 4)

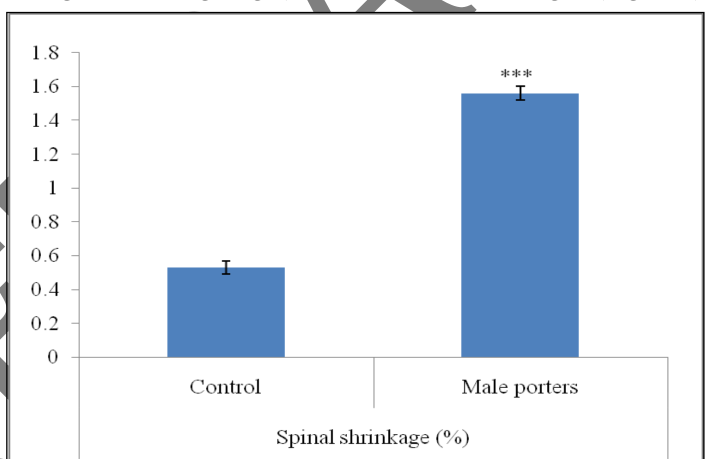

Figure 4: Spinal shrinkage (%) of control and male porters of Gangtok, India (n=21). Significant difference is based on two tail Student t test. ***P<0.001

Statistics

All the data were represented as Mean ± SD. Two tail unpaired 't' test was done to find the inter-group significance difference between the different study variables of processing unit workers [26]. P<0.05 was chosen as the level of significance.

RESULTS

Data of Height, weight, BMI (kg/m^2), BSA(m^2), heart rate (beats/min), systolic and diastolic blood pressure (mm-Hg), waist & hip circumference (cm) and waist/hip ratio, mid upper arm circumference and different head anthropometry variables of male porters and their control counterparts were presented in Table 1. Resting heart rate, systolic and diastolic blood pressure were found to higher which were statistically insignificant except systolic blood pressure ($P<0.05$). Similarly waist and hip circumference and waist to hip ratio were also higher but insignificant in male porters than their control. But we did not observe any significant difference in mid upper arm circumference (MUAC) compared to the control porters. Head circumference, head breadth and head length all are found to be insignificantly higher in porters, as compared to respective control subjects.

Results of peak expiratory flow rate (PEFR), hand grip strength and spinal shrinkage of male porters and their control counterparts were presented in table 2. PEFR of male porters in our study was found to be significantly ($P<0.01$) lower compared to control subjects. Results revealed that handgrip strength in both right and left hand of the porters were lower than their respective control subjects. Decrease in hand grip strength in right and left hands were found. Highly significant increases in percentage of spinal shrinkage were also observed when compared with their respective control subjects.

Table 1: Different physical, physiological and anthropometric variables of male porters and control subjects

Parameters	Control Subjects		Male Porters		Significance Level*
	Mean	SD	Mean	SD	
Height (cm)	164.08	7.62	160.41	5.53	NS
Weight (Kg)	56.5	11.13	53.82	5.78	NS
BSA (m^2)	1.61	0.18	1.55	0.1	NS
BMI (Kg/m^2)	20.88	2.67	20.83	1.59	NS
Resting Heart Rate (beats/min)	74.53	9.26	79.53	9.26	NS
Systolic blood pressure (mmHg)	127.33	12.89	139.47	16.91	P<0.05
Diastolic blood pressure (mmHg)	73.83	10.72	81.64	10.64	NS
Waist circumference (cm)	76.66	10.29	79.64	1.35	NS
Hip circumference (cm)	88.5	6.09	90.23	5.32	NS
Waist/Hip Ratio	0.87	0.08	0.88	0.03	NS
Mid upper arm circumference (cm)	25.33	1.86	24.35	1.89	NS
Head Circumferance (cm)	54.5	2.34	54.76	1.25	NS
Head breadth (cm)	14.71	0.35	15.69	1.12	NS
Head length (cm)	19.63	0.74	20.75	2.55	NS

Table 2: Peak expiratory flow rate (PEFR), hand grip strength and spinal shrinkage of male porters and control subjects

Parameters	Control Subjects		Male Porters		Significance Level*
	Mean	SD	Mean	SD	
Peak expiratory flow rate (l/min)	272.7	55.52	174.11	40.32	P<0.01
Right Hand grip strength (Kg)	31.3	3.14	26.35	5.46	P<0.01
Left Hand grip strength (Kg)	27.8	5.42	24.59	7.06	NS
Spinal shrinkage (%)	0.53	0.29	1.56	0.72	P<0.001

DISCUSSION

Carrying heavy loads in the hilly region is a real challenge. Porters face extreme ranges in terrain condition, path steepness and altitude hypoxia [27]. The porters in Gangtok routinely carry head-supported loads, which often exceed their body weight, over long distances up and down the steep mountain foot paths.

In this study it is evident that porters and control group of subjects had no significant association in terms of weight, height, BSA and BMI. So, in this study both groups of subjects were standardized in terms of weight, height, BSA and BMI. Further on analyzing the physical characteristics of the subjects, it was observed that the mean BMI value of the porters were within the normal range of BMI (Normal BMI: 18-25 kg/m^2), as per classification. The mean value of 0.87 of waist-hip ratio suggests that there was hardly any development of central obesity among the subjects as per classification.

People's occupations have varying impact on their blood pressure. In our study heart rate, systolic and diastolic blood pressure were found to higher in male porter but within the criteria for hypertension (Hypertension was defined as systolic blood pressure more than 139 mmHg and/or diastolic blood pressure 90 mmHg or above) [28]. So the results of blood pressure in this study suggested that there is no prevalence of hypertension in male porters.

MUAC is a good indicator of muscle mass and can be used as a proxy of wasting [29, 30]. But in our study we did not observe any significant change in MUAC among the porters with their respective control group of subjects. Also head anthropometry variables were found to insignificantly higher in porters than control subjects.

Handgrip strength is the most common assessment method for upper extremity muscle strength [31]. A decline in handgrip strength is also associated with other measures of decreased functional ability. In this study we observed decreased handgrip strength both in right and left hand of male porters as compared to control subjects. We can hypothesized from these observation that physical activity may diminish the loss of function which is well in line with the earlier studies of Bassey & Harries (1993) [32] and Sharp et al (1997) [33].

Use of load carriage systems on the trunk may oppose breathing in a manner similar to elastic loads. The pressure produced by an elastic load is directly related to the volume inspired [34]. It is likely that while wearing a backpack, greater forces must be generated by the respiratory muscles during inspiration in order to overcome the forces produced by the load carriage system. In our study we found significant decrease in peak expiratory flow rate in porters which may be due to heavy load carrying using head strap for prolonged period and it indicates prevalence decreased lung function among male porters.

Spinal shrinkage recognized as an index of the compressive forces acting on the spine. This shrinkage is caused by the visco-elastic creep from the compression of vertebral discs. When discs are unloaded as in reclining position this process is reversed leading to an increase in length of spine [35]. The spine represents approximately 40% of the total body length and the intervertebral discs occupy approximately one third of the total spinal column length. Thus the changes in the spinal length may be quantified by measuring the total body length and these changes in stature can give an index of the load imposed on the spine [36]. Percentage of spinal shrinkage was found to be significantly lower in the male porters as compared to control subjects in our study, which indicates that loading history in these porters weaken discs to such extent that structural failures occurs leading to spinal shrinkage.

CONCLUSION

This study supports the hypothesis that carrying head-supported loads is associated with decreased lung function and increased spinal shrinkage in male porters of Gangtok. The underlying reasons need to be explored to design a rational intervention strategy on larger population along with the sexual variation. To develop an effective intervention strategy, the treatment seeking behavior of individuals would also need to be improved through awareness programmed.

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