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Factors Affecting the Work Productivity of Oraon Agricultural Laborers of Jalpaiguri District, West Bengal

Subrata K. Roy*

Anthropology and Human Genetics Unit, Indian Statistical Institute, Calcutta 700 035, India

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ABSTRACT In developing countries like India, where the incidence of protein-calorie malnutrition is high and mechanization is at a minimum, human labor provides much of the power for physical activity. This study presents anthropometric measurements, somatotypes, food intakes, energy expenditures, and work outputs of Oraon agricultural laborers of the Jalpaiguri district, West Bengal, in an attempt to identify the factors that predict high work productivity. Specifically, this study investigates 1) the relationship between morphological variation (anthropometric measurements and somatotype) and work productivity, 2) the nature and extent of the relationship between nutritional status and work productivity, and 3) the best predictor variables of work output. Classification of groups on the basis of median values of work output show that in the aggregate, the high productive groups are significantly younger than low-productive groups in both sexes. Before age-adjustment, the high productive groups show higher mean values of a few body dimensions, though these differ by sex, and both males and females exhibit a normal range of blood pressure and pulse rate values. Mean values of grip strength and back strength are higher in high-output men and women. Mean values of both food intake and energy expenditure are also higher among men in high-output groups, with only food intake higher in high-output women. However, after eliminating the effects of age, the differences between low-productive groups and high-productive groups in most of the variables are not significant. Productivity predictors in males consist of age, food intake and chest girth (inhalation). Females, on the other hand, show age and grip strength (left) as work output predictors. Am J Phys Anthropol 117: 228–235, 2002.

Physical activity and the capacity for work are fundamental determinants of human survival (Weiner, 1978), and in any society, human power is an important factor in production and the generation of favorable living conditions (Shephard, 1978). During the 20th century, human societies diverged sharply in the importance of human labor. In developed societies, successful technology exploitation made human labor relatively unimportant, while in less developed societies, heavy physical labor (often under adverse environmental conditions) was unavoidable (Bassey and Fentem, 1981). In the absence of adequate modern technology, prolonged physical labor is often required to satisfy the basic needs for survival, e.g., food, shelter, and clothing.

In this article, the terms "productivity" and "work productivity" are used synonymously, although work is a complex entity and involves biological and psychological factors, type of work, and work setting. Productivity is an index of production efficiency, and is associated with humans engaged in labor-intensive jobs. Productivity may be defined by some quantitative measures of physical performance in actual work situations. In some types of industrial and agricultural work, payment is based on piecework, and productivity can be measured in terms of manufactured or harvested goods or pay received (Spurr, 1983). In general, however, productivity is a concept that indicates the efficiency of input as compared with output.

Intuitively, nutritional and health traits are important determinants of the human ability to perform hard work and prolonged physical activity (Brooks et al., 1979). However, such relationships have not been adequately tested with empirical data, particularly regarding specific types of jobs and health measures in the context of India.

In ideal situations, health includes three aspects: physical, mental and social (World Health Organization, 1979). In this study, health is defined in terms of specific physical traits, which are relatively easy to examine and document, e.g., adult body dimensions and somatotype, physiological variables, food intake, and energy expenditures.

A few body dimensions seem to have important relationships with productivity. Nutritional status, for example, affects body weight and, eventually, physical working capacity (Buzina et al., 1982). In Jamaica, Heywood (1974) found that weight-for-

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*Correspondence to: Dr. Subrata K. Roy, Anthropology and Human Genetics Unit, Indian Statistical Institute, 203 Barrackpore Trunk Road, Calcutta 700 035, India. E-mail: rsubrata@isical.ac.in

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height significantly affected productivity, and in rural south India, weight-for-height was important among agricultural farm laborers (Deolalikar, 1984). Such relationships, however, are not consistently observed for all traits. For example, though Wolgemuth et al. (1982) showed that productivity was related to arm circumference in Kenyan road construction workers, a decade earlier, Basta and Karyadi (1973) failed to detect any relationship between productivity and arm circumference, weight, and height, respectively, among Indonesian road construction workers. In Guatemala, height was positively related with productivity (Immink, 1978; Immink et al., 1984), and the fat-free mass of Guatemalan wage laborers was correlated with the amount of coffee beans picked per day. In India, though Satyanarayana et al. (1977) found a positive relationship between work, output, and body size, Sukhatme (1982) was unable to demonstrate any relationship between energy intake, body weight, and work output of Indian women. Among Nepalese porters, Malville (1999) was also unable to show significant correlations between load carried and body height and weight.

Because no two human bodies are exactly alike in physical characteristics, somatotypes have been employed to study human variability (reviewed in Harrison et al., 1988; Roy, 1990). The relationship between physique and the physical performance of athletes has been extensively explored (Carter, 1970; de Garay et al., 1974), and somatotypes have been used to assess the effects of environment, behavior, and physical performance (Bailey et al., 1982). Nevertheless, the relationship between physique and physiological functions remains inadequately defined.

The effect of nutritional intake on physical performance and work capacity is well-known (Kraut and Muller, 1946; Viteri, 1971; see reviews by Parizkova and Rogozkin, 1978; Spurr, 1983). Energy expenditure, on the other hand, is known to depend on several factors related to body composition, age, sex, level and duration of physical activity, temperature, and humidity, among other factors. The survival of agricultural populations depends on appropriate physical fitness, and physical fitness is dependent on cardiorespiratory fitness (Åstrand and Rodahl, 1970). Work capacity has been shown to be significantly correlated with heart rate and maximum oxygen consumption ($\dot{V}O_2$ max) (Steegmann et al., 1997), but the effects of most of the determinants of fitness are not clearly known, especially in actual work situations.

Nations which produce most of their food by human labor require a high percentage of the population to produce food to subsist. In India, about 66.8% (180 million) people are engaged in agricultural occupations (Census of India, 1991). Both males and females are engaged in agricultural work, and they form an important proportion of the total labor force

In view of this, the Oraon agricultural laborers of Shishubari Anchal of Jalpaiguri district, West Bengal, were selected to investigate 1) the relationship between morphological variation (anthropometric and physiological traits as well as somatotype) and work productivity, 2) the nature and extent of the relationship between nutritional status and work productivity, and to determine 3) the best predictor variables of work productivity.

MATERIALS AND METHODS

Population sample and measurement of work output

Oraon agricultural laborers from Rangali Bazna Anchal of Madarihat Police Station, Jalpaiguri District, West Bengal were approached to participate in this study. No statistical sampling of the Oraon population was attempted. However, individuals were included in the study without any conscious bias. The sample of 163 men and 123 women was comprised of volunteers and those who were persuaded to be involved. All were adults, aged between 20–60 years, and were engaged in rice cultivation, as described below, for the last 10 years.

The Oraons are a Dravidian-speaking tribal population, with the majority concentrated on the Chotanagpur plateau in Bihar. They are believed to have migrated to northern West Bengal from Bihar about the end of the 19th century (Choudhury, 1978). In West Bengal, Oraons practice their traditional occupation, and a sizable proportion works in the tea gardens as laborers. In Jalpaiguri District, tea planters have long preferred migrant Oraons to local workers, because the locals frequently suffer from malaria, which is endemic to the area and has a negative impact on work capacity (Grunings, 1911; Choudhury, 1978). The Oraons are the second largest group in the district, and many are settled cultivators (West Bengal District Gazetteer, 1981).

Assessment of work output

Rice (*Oryza sativa*) is the principal staple in the diet of most Indians, and two thirds of the Indian population is engaged in rice cultivation. Several activities are involved in such cultivation: tilling and leveling the soil, transplantation, weeding, and harvesting. The output of harvesting is relatively easier to measure than other activities, and was used to estimate work output.

The harvesting of rice is done manually by men and women. Differences in harvesting output occur by sex and by age; therefore, the wages per day differ by either sex and/or age. Variation in harvesting output also depends on the type of land, which was, however, not considered in this study.

Output data on harvesting were collected by counting the number of "bundles" of rice each individual harvests per hour. Although this method is not standard, there is no known method to measure

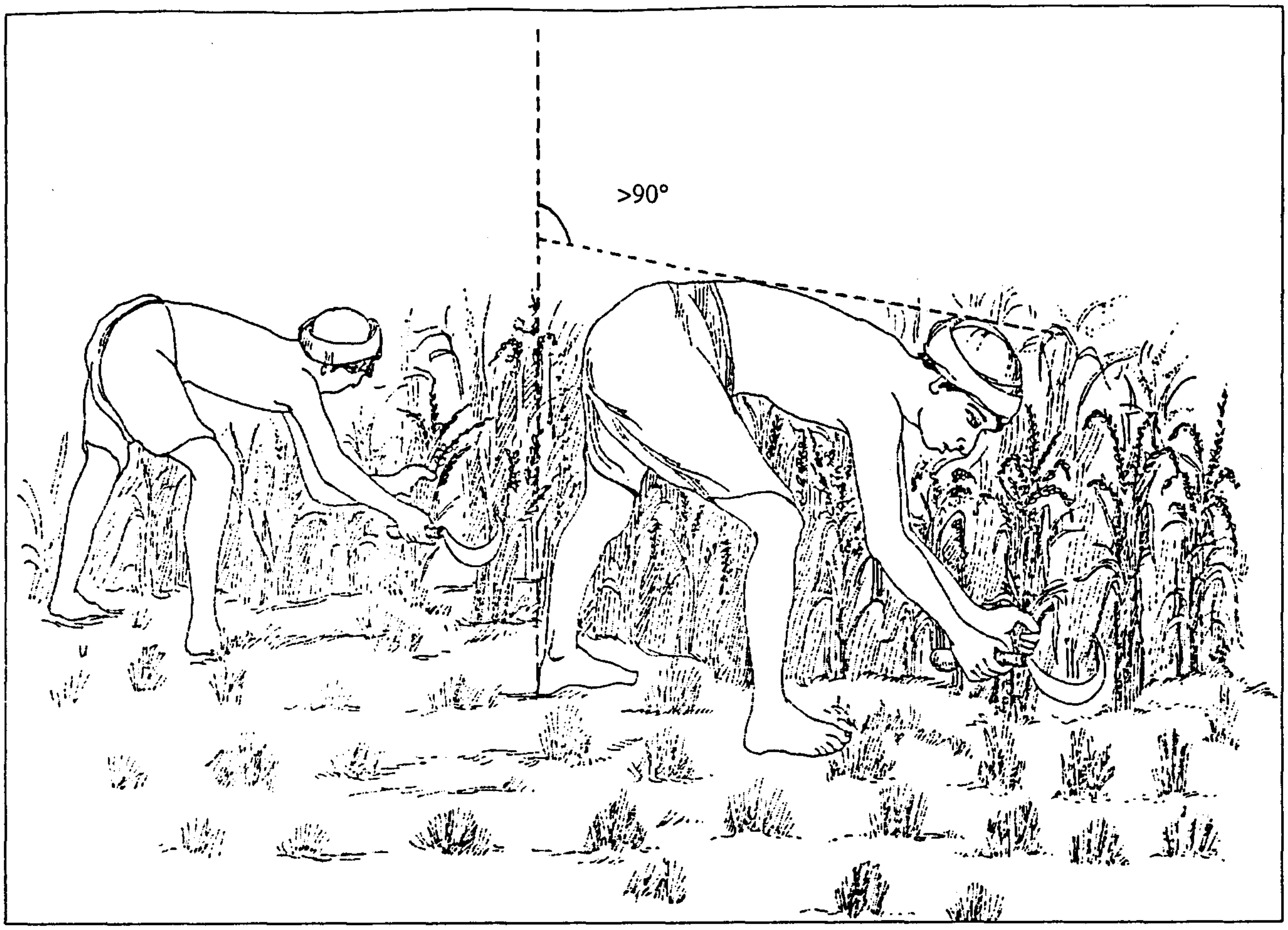

Fig. 1. Harvesting of rice in the paddy (rice) field. The harvester bends at the waist at an angle of more than 90°, with both hands extended downwards to reach the cutting position. Rice plants are 3–4 feet tall, depending on variety.

ics: the amount and rate of land cleared. The method devised in this study is straightforward, because distances between one rice "bundle" to another "bundle" are approximately 6–8 inches. The amount harvested can be calculated as easily as the rate of clearing land.

It is worth describing methods of rice harvesting because of the nonuniversality of the method of measuring harvesting output. Rice is always harvested by human labor in India. The rice crop is generally cut with a sickle, which is the traditional and perhaps the original harvesting implement. Although sickle shape varies across the country, variation is minor. Sickles usually have a serrated, self-sharpening cutting edge and a wooden handle for griping.

Rice plants are 3–4 feet tall, depending on the species. Generally the harvester bends the waist at an angle of more than 90°, with both hands extending downwards to reach the cutting position (Fig. 1). The rice crop is cut with a fairly long straw because the straw is also useful. The popular agricultural t . is "hill" for a bunch of plants grown at a single ısplant point. The harvester grips all the stems nch of stocks) on a hill with the left hand and ıraws the sickle blade, below the grip, with right hand, and this process continues. It is worth noting that when a paddy is planted, 3–4 seedlings of rice plant are thrust into the mud (single hill) with great speed and precision, maintaining uniform rows and columns. Transplanting of seedlings is primarily the job of females. At maturity, those 3–4 seedlings of rice plant make several branches with several stocks of rice, which have the appearance of a bush. This bush has been described as "bunch of stocks" and was counted in this study as the harvesting output. Generally the harvester grips 2–3 hills (bunches of stocks) every time (depending on the number of branches each hill produces and the capacity or inner diameter of the harvester's grip) every time a cut is made.

Data

In the 286 Oraon participants, several anthropometric traits, somatotypes, physical fitness, energy expenditures, food intakes, basal metabolic rates, and work productivity groups were measured directly or determined as described below.

Anthropometric measurements. Measurements were taken, using standard methodology and standard instruments (Weiner and Lourie, 1981), by the same investigator (S.K.R.). The measurements included height, sitting height, biacromial diameter, biiliac diameter, weight, calf girth, chest girth (inhaled), chest girth (exhaled), five skinfolds (biceps, triceps, subscapular, suprailiac, and calf), and total body fat. Age was obtained from individuals. Measurement error was not determined, and an unknown amount of bias may be present.

Somatotype determination. Anthropometric somatotype scoring followed the multiple regression equations of Carter and Heath (1990). Endomorphy was computed by the formula $-0.7182 + 0.1451(X) - 0.00068(X^2) + 0.0000014(X^3)$, where X is the sum of the triceps, subscapular, and suprailiac skinfold thickness, adjusted for stature (i.e., $X =$ sum of skinfold thickness $\times$ (170.18 (cm)/stature)).

Mesomorphy was determined by the equation $[(0.858 \times \text{biepicondylar}) + (0.601 \times \text{bicondylar}) + \{0.188 \times (\text{upper arm circumference} - \text{triceps skinfold})\} + \{0.161 \times (\text{calf circumference} - \text{calf skinfold})\}] - (\text{stature} \times 0.131) + 4.50$.

Ectomorphy was obtained by using the reciprocals of the Ponderal Index, and the formula HWR (height weight ratio) $\times 0.732 - 28.58$, where HWR = Stature/(Weight)$^{0.333}$. If HWR is less than 40.75 but greater than 38.25, ectomorphy is determined by using HWR $\times 0.463 - 17.63$ . . . (4). If HWR is less than 38.25, a rating of 0.1 is assigned to the ectomorphic rating (Carter and Heath, 1990). Total body fat (kg) was estimated using the formula of Sen and Banerjee (1958): Fat (kg) = Fat % $\times$ Weight (kg)/100, where Fat % = $(4.201/D - 3.813) \times 100$, and $D = 1.0890 - (0.0028 \times \text{Triceps skinfold thickness})$.

Assessment of physical fitness. Strength is basic to performance and is a measure of physical fitness. Strength tests are one of the most practical measures to evaluate fitness. Strength data for handgrip strength and back strength were collected with a battery-operated automatic handgrip dynamometer and back dynamometer, using standard test protocols (Mathews, 1973).

Systolic (SBP) and diastolic (DBP) blood pressure measurements were measured after a 15-min rest period, in a sitting position, on the upper arm by the auscultatory method, using an inflatable calf and mercury sphygmomanometer. DBP was determined at the point when the Korotkoff sound completely ceased (Rose et al., 1980), and pulse rate (PR) was also measured.

Energy expenditure. Assessment of energy expenditure began by recording the type, duration, and intensity of actual activities by means of retrospective (or recall) questionnaires. Energy expenditure data were calculated by multiplying the time spent in each activity by the energy cost of the activity (energy cost of the activity was determined following Indian Council of Medical Research, 1981). Daily energy expenditure was calculated from individual activity records taken over 7 consecutive days (Sunday through Saturday), and the mean of 7 days was used in statistical analyses. Activity records were collected using pretested questionnaires and schedules, and activities were recorded for consecutive 5-min periods for 24 hr per day. Because of possible seasonal variations in activity patterns, the peak harvesting season (end of November to middle of January) was chosen for data collection. Data obtained in this fashion may have some unavoidable limitations, e.g., lapse in recall, and/or over- and underreporting of time spent in each activity, but such is the risk with field studies. Energy expenditure in a period of 24 hr (total number of minutes spent in a particular activity) was multiplied by a factor for that activity and the weight of the given subject, as described in the report by FAO/WHO/UNU (1985). Total energy expenditure (in kcal) was then considered for further analysis. There was high variation in energy expenditure and time spent for types of activities, between subjects. Therefore, the type of activity was not compared and not considered for further analysis.

Assessment of food intake. Food intake data were collected using pretested and structured questionnaires. One-day, semiquantitative data on dietary intakes (cooked food items) were collected by the recall method for the individual within the household, and the data on the amount of raw food items used for the day were also collected for cross-verification. The findings presented here refer to calorie intakes, from cooked food items of the major sources of calories (i.e., cereals, potato, and rice beer only). Therefore, the data analyzed for the present study are an underestimation of actual food intake, but they are presented on the assumption that these food items are the major source of calories. Protein and fat intakes were not computed from cooked food items. Standard conversion tables prepared by the Indian Council of Medical Research (1981) were used to compute the calories provided by various food items.

Eimation of basal metabolic rate. Much of the energy utilized by the body is expended while sleeping or resting, and resting energy expenditure is referred to as basal metabolic rate (BMR). In this study, BMR was calculated through the regression equation (BMR for Indian males = $0.039W + 3.533$, and BMR for Indian females = $0.026W + 3.852$, where W = body weight) suggested by Hayter and Henry (1994). BMR proportions of food intake were calculated (food intake in MJ/BMR) for the validation of food intake data.

Assessment of work productivity. Classification of high- and low-productive individuals was don the basis of median points of the productive outp

TABLE 1. Descriptive statistics of anthropometric traits in high- and low-productive groups of men and women, respectively[1]

	Low-productive		High-productive			Age-corrected
	Mean	SD	Mean	SD	t-values,	t-values
Male	(n = 82)		(n = 81)			df = 161
Age (years)	38.76	14.98	30.77	10.62	3.9388*	
Height (cm)	162.08	6.44	163.47	6.07	1.4239	0.563
Sitting height (cm)	83.05	3.56	83.86	3.18	1.5333	0.401
Biacromian diameter (cm)	36.17	1.67	36.62	1.72	1.6660	0.896
Biiliac diameter (cm)	26.04	1.63	25.72	1.7	1.2410	0.781
Weight (kg)	46.94	5.33	48.65	5.12	2.0960*	1.544
Biceps girth (cm)	21.89	1.64	22.47	1.48	2.3844*	1.667
Calf girth (cm)	28.22	2.12	29.06	1.93	2.6402*	1.594
Chest girth (inhaling) (cm)	80.5	4.08	81.87	3.72	2.2337*	2.957*
Chest girth (exhaling) (cm)	78.45	3.75	79.44	3.72	1.6755	2.465*
Skinfold (sum of 5^{SF}-sites) (mm)	27.69	4.51	27.96	5.74	0.1320	0.339
Total body fat (kg)	4.71	0.93	4.55	0.94	1.1122	0.933
Female	(n = 62)		(n = 61)			df = 121
Age (years)	38.81	11.81	29.44	9.14	4.9251*	
Height (cm)	149.45	6.62	151.41	5.75	1.7508	0.006
Sitting height (cm)	76.7	3.29	77.61	2.81	1.6496	0.046
Biacromian diameter (cm)	32.39	1.58	32.77	1.45	1.4130	0.142
Biiliac diameter (cm)	25.53	1.15	25.51	1.17	0.1238	0.288
Weight (kg)	39.43	5.65	41.07	4.36	1.8112	0.326
Biceps girth (cm)	20.58	1.87	20.82	1.33	0.8069	0.015
Calf girth (cm)	26.33	2.01	27	1.48	2.1101*	0.311
Chest girth (inhaling) (cm)	73.2	4.32	74.27	3.78	1.4674	0.062
Chest girth (exhaling) (cm)	70.37	7.47	71.74	5.53	1.1536	0.142
Skinfold (sum of 5^{SF}-sites) (mm)	37.09	10.74	34.90	12.64	1.0341	0.254
Total body fat (kg)	5.46	1.57	5.18	2.37	0.7784	0.286

[1] In males, low-productive is <3,744 points of the productive output values; high-productive is ≥3,744. In females, low-productive is <2,884 points; high-productive is ≥2,884. 5^{SF}, sum of skinfold thickness of five sites (biceps, triceps, subscapular, suprailiac, and calf).

* Significant at 5% level.

values, separately by sex, since there is no standard value of harvesting output for individuals. The low-productive group in men had output values <3,744 (median), and the high-productive group had scores ≥3,744. In women, the cutoff point was <2,884 (median) for the low-productive group, and ≥2,884 for the high productive group.

Statistical analysis

The SPSS package was used to carry out statistical analyses (SPSS, release 7.5.1., 1996). t-tests were undertaken within each sex, to assess the significance of differences between the high- and low-productive groups, respectively, for age, height, sitting height, biacromial diameter, biiliac diameter, weight, biceps girth, calf girth, chest girth, sum of five skinfold sites, and total body fat. Because the high-productive groups in both sexes were younger compared to the low-productive groups, regression analysis was undertaken to eliminate the effect of age from all traits, and then t-values were calculated on the residuals of each trait.

Because of the independent nature of the relationship between body size, energy expenditure, and work output, energy expenditure values were computed adjusting body weight through regression equations. Group comparisons (low vs. high productivity) were done on the body weight-adjusted energy expenditure values. The weight-adjusted energy expenditure values were used in subsequent analyses.

Somatotype data were analyzed with MANOVA, considering all three somatotype components as a matrix. MANOVA was originally developed by Wilks in 1932 and was used in the analysis of somatotype data by Cressie et al. (1986). MANOVA results are expressed as the value of Wilks' Λ (lambda), a standard statistic (together with its P-values).

To identify which of the various variables (i.e., anthropometric measurements, somatotyping, blood pressure measurements, food intake, and energy expenditure) are significantly related to work output and are useful for predicting it, hierarchical, stepwise multiple-regression analysis was undertaken. Variables were added in a stepwise manner, to maximize the increase in R^2 at each step. The default tolerance level was 0.0001 at each step.

RESULTS AND DISCUSSION

In the present study, laborers were of the same ethnic origin and shared more or less similar socioeconomic conditions. They occupied the same habitat throughout their lives, and were engaged in agricultural work from childhood. While the test protocols for data collection were similar for all individuals, within each sex there were interindividual differences in age, as well as some anthropometric measurements when these were compared across high and low productivity groups (Table 1).

In males, age is significantly lower in highly productive males, and weight, biceps girth, calf girth, and chest girth (inhalation) are higher compared to

TABLE 2. Descriptive statistics of somatotype components in low- and high-productive groups of men and women, respectively[1]

	Low-productive		High-productive			
	Mean	SD	Mean	SD	*t*-values	F-values
Male	(n = 82)		(n = 81)		df = 161	
Endomorphy	1.88	0.55	1.84	0.45	0.4921	0.585
Mesomorphy	2.56	1.06	2.72	0.88	1.0589	0.366
Ectomorphy	4.37	0.86	4.25	1.04	0.7968	1.076
Female	(n = 62)		(n = 61)		df = 121	
Endomorphy	2.28	1.01	2.55	0.86	1.5759	0.000
Mesomorphy	2.39	0.94	2.2	0.95	1.103	1.684
Ectomorphy	3.61	1.15	3.62	0.89	0.0108	0.960

[1] Somatotype rating, which describes physique, is not a measure of size but a shorthand description of relative body shape and apparent composition. Somatotype rating is thought of as being a vector, or a point in a three-coordinate system, in which each axis carries a somatotype component scale (Carter and Heath, 1990). Univariate F-tests (ANOVA) were performed between groups, using one somatotype component at a time. MANOVA result of somatotype components between groups: male Wilks' $\Lambda = 0.990$ (F-ratio = 0.560, df = 3, 159, $P = 0.642$); female Wilks' $\Lambda = 0.967$ (F-ratio = 1.353, df = 3, 119, $P = 0.261$).

TABLE 3. Descriptive statistics of blood pressure parameters between high- and low-productive groups of men and women, respectively

	Low-productive		High-productive			Age-corrected
	Mean	SD	Mean	SD	*t*-values	*t*-values
Male	(n = 82)		(n = 81)			df = 161
Systolic blood pressure (mm/hg)	133.39	23.1	127.72	18.66	1.7263	0.368
Diastolic blood pressure (mm/hg)	85.98	12.35	84.32	8.16	0.9253	0.796
Pulse rate (beats/min)	75.78	10.4	73.83	8.9	1.2876	0.695
Female	(n = 62)		(n = 61)			df = 121
Systolic blood pressure (mm/hg)	133.1	26.51	126.62	19.54	1.5443	0.585
Diastolic blood pressure (mm/hg)	88.94	16.13	85.38	13.87	1.3113	0.214
Pulse rate (beats/min)	75.97	9.76	75.02	9.62	0.5439	0.149

less productive men. In women, age is also significantly lower in the highly productive group compared to the less productive group, but only calf girth is significantly greater among highly productive women.

The age differences across productivity groups in each sex necessitated age adjustment of the data. After correcting for age, in men significant differences across productivity groups remained in chest girths after inhalation, and age adjustment revealed significantly higher chest girths, after exhalation also, in the high productivity group. However, all other traits are nonsignificant, as they are in women.

These findings are in contrast to those of Immink (1978) and Buzina et al. (1982), who reported a positive relationship of work productivity with body weight. On the other hand, they corroborate the findings of Sukhatme (1982), who also failed to establish any relationship between body weight and work output. That biceps girth (upper arm circumference) in men, after age-adjustment, was not higher in the highly productive group contrasts with the findings of Wolgemuth et al. (1982), who had examined Kenyan laborers involved in road construction.

There are no significant differences in somatotypes (Table 2) between high and low productivity groups of either males or females, although the somatotype was sensitive in assessing the physical performance of athletes (de Garay et al., 1974).

Blood pressures do not differ among productivity groups in either sex (Table 3), in contrast with the findings of Weitz (1982) in Sherpas and Tibetan migrant groups. Pulse rates also did not differ significantly in the high-output groups compared to the low-output groups in both sexes, in contrast with the findings of Steegman et al. (1997), who found strong correlation between heart rate and work output among Chinese cycle haulers.

Grip strength in both hands and back strength (Table 4) intuitively seem important in the kind of rice-planting and rice-harvesting activity in which the Oraon people are engaged, and the raw data show significantly higher measurements in both males and females. However, in both sexes, grip and back strengths are age-associated, such that age correction rendered the differences between high- and low-productive groups nonsignificant.

Food intake (Table 5), measured as calorie intake, was computed from the major sources of calories (e.g., rice, wheat, potato, and rice beer) among the Oraon. Before age-adjustment, mean calorie intake is higher in highly productive groups of both sexes compared to those of reduced productivity, but the difference after age-adjustment persists in males only. These findings corroborate those of Kraut and Muller (1946), Johnson and Kark (1947), and Keys et al. (1950), but are in contrast to those of Belavady (1966), Satyanarayana et al. (1972), and Immink (1978).

TABLE 4. *Descriptive statistics of physical fitness parameters in low- and high-productive groups of men and women, respectively*

	Low-productive		High-productive			
	Mean	SD	Mean	SD	*t*-values	Age-corrected *t*-values
Male	(n = 82)		(n = 81)			df = 161
Wrist diameter (right) (cm)	5.17	0.64	5.32	0.63	1.5653	0.908
Wrist diameter (left) (cm)	5.06	0.64	5.22	0.73	1.5420	0.909
Grip strength (right) (cm)	29.32	7.52	33.14	6.42	3.4957*	1.448
Grip strength (left) (cm)	29.52	7.17	33.05	6.68	3.2517*	1.130
Back strength (kg)	109.45	32.26	121.97	26.97	2.6893*	0.617
Female	(n = 62)		(n = 61)			df = 121
Wrist diameter (right) (cm)	3.85	0.56	4.00	0.59	1.4306	0.758
Wrist diameter (left) (cm)	3.69	0.56	3.77	0.59	0.7303	0.164
Grip strength (right) (kg)	20.83	4.24	23.38	4.31	3.3000*	0.701
Grip strength (left) (kg)	20.11	3.73	22.53	3.44	3.7514*	1.482
Back strength (kg)	58.29	14.39	64.06	13.58	2.2850*	0.307

* Significant at 5% level.

TABLE 5. *Descriptive statistics of nutrition data in low- and high-productive groups of men and women, respectively*[1]

	Low-productive		High-productive			
	Mean	SD	Mean	SD	*t*-values	Age-corrected *t*-values
Male	(n = 82)		(n = 81)			df - 161
Food intake (kcal/day)	2,177.6	531.8	2,719	1,184	3.7477*	3.381*
Wt. adj. Ene. Exp. (kcal/day)	2,642.58	260.94	2,546.66	254.58	2.375*	3.931*
BMR	5.3581	0.2028	5.4352	0.2029	2.428*	1.544
BMR/food intake (MJ)	1.7006	0.4246	2.0900	0.8958	3.539*	3.227*
Female	(n = 62)		(n = 61)			df = 121
Food intake (kcal/day)	1,837.2	510.2	2,039.8	400.8	2.4514*	0.864
Wt. adj. Ene. Exp. (kcal/day)	2067.25	195.12	2011.71	238.23	1.416	4.878*
BMR (MJ/24 hr)	4.8793	0.1460	4.9151	0.1162	1.507	0.326
Food intake (MJ)/BMR	1.5723	0.4296	1.7352	0.3329	2.354*	0.842

[1] Wt. adj. Ene. Exp., weight-adjusted energy expenditure. Food intake and energy expenditure values have been given in kcalorie units. Conversion to SI units in joule (J) or kilojoule (kJ) can be done. One kilocalorie (kcal) is equivalent to 4.185 kilojoules (kJ). 1 megajoule (MJ) = 10^6 joules (J).

* Significant at 5% level.

The male high-productive work group, unlike the female, expends less energy (adjusted for weight) than the low-productive group before age-adjustment (Table 5). The difference persists in men, and becomes apparent in women after age-adjustment. Panter-Brick (1992) also found that energy expenditure in physically demanding activities was moderate, and explained her findings as an example of bio-behavioral adaptation.

Table 5 also shows the basal metabolic rate (BMR) and BMR adjusted for food intake. High-productivity males show higher values of BMR and BMR/food intake compared to low-productivity males, but after age correction, significant differences persist in BMR/food intake only. In women, only BMR/food intake is higher in the high-productive group, but the difference disappears with age-adjustment. It is worth noting that the female samples are a third smaller than those of males, and one wonders whether the differences would persist if sample sizes were comparable.

Stepwise regression analysis showed that in males age, food intake, and chest girth (inhalation) [illegible]e the predictors of work output (F = 21.775, P = 0[illegible]0 df = 3, 159; R^2 = 0.291). In females, on the [illegible]er [illegible]and, only age and grip strength (left) are the [illegible]di[illegible]r of work output (F = 14.424, P = 0.000, [illegible] = [illegible]120; R^2 = 0.440). Partial correlation coefficients (age held constant) show that in men, the differences persist between high and low work groups in chest girths (exhalation r = 0.1861, $P < 0.05$; inhalation r = 0.2027, $P < 0.01$), and the difference also persists in women for grip strength (left) r = 0.2436, $P < 0.01$). Age is clearly a good predictor of work productivity in both sexes, but the differences associated with the other predictors are difficult to explain. One would have expected that the grip strength of left hands, which hold the stock if cutting occurs with the instrument held in the right hand (see Fig. 1), would be equally important in both sexes. No explanation seems suitable for finding that chest girth is an important predictor of work productivity in men, also not in women. Future studies that seek to establish the relationships between anthropometric variables, body builds, food intakes, and energy expenditures could explore the utility of the variables identified as important in this study, bearing in mind that parameters of work output may be specific to particular occupations and life circumstances.

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