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Impact of work performance on body proportions in Blacksmiths: A somatometric analysis

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Abstract

'Traditional Occupation' is the one, which a person acquires or inherits from his parents and passes it on to the next generation. Gross body size and other morphological characteristics of a person involved in such type of occupations provide clues regarding the developmental adaptations these people have undergone in response to variety of work factors or stresses. Present study has been conducted on one of the traditional occupational group of Punjab, the Blacksmiths. A total of 200 adult males ranging in age from 30 to 40 years were measured for various anthropometric measurements of upper limb, lower limb and trunk region on both right as well as left sides of the body with a view to assess their proportionality profiles and body asymmetry. Findings of the study indicate that Blacksmiths have balanced endomorph type (4.55-3.39-2.99) of body physique and shows maximum bilateral asymmetry in the upper region of the body and direction of asymmetry is towards right side.

Key Words: *Bilateral, Asymmetry, Blacksmiths, Body Proportionality, Traditional Occupation, Anthropometry, Somatotyping*

INTRODUCTION

Habitual physical activity shows its impact on body morphology of a person involved in it. As heavy physical work makes the body muscular whereas light and sedentary type of activities make the body fatter. Variable movements of different body parts results in more or less development of that region and give rise to bilateral asymmetry of the body. Thus habitual physical activity contributes maximum in the appearance of a person. Due to increase in mechanization manual work is decreasing and mental labor is increasing which keep checks on habitual physical activity. Further adaptability to the working environmental conditions and genetic factors also brings out differences in the body proportions, body compositions and body morphology and highlight the importance of specific advantage of typical physical characters in any occupation. Physical efficiency, body movement and performance in many daily activities and in sport can be determined through the study of human body morphology, body proportions, body composition and physique. These are also increasingly used as primary indicators of healthy growth and development **(Tanner et al., 1960; Bubulian, 1984; Slaughter and Lohman, 1976; Dupertius et al., 1951; Bolonchuk et al., 1989 and Bogin, 1999)**.

The present study has been conducted with a view to highlight the impact of physical work performance on the body proportions with special reference to find out the level and range of bilateral asymmetry in the body morphology of blacksmiths.

MATERIAL AND METHODS

The present cross-sectional study has been conducted on traditional occupational group of Punjab, Blacksmiths . These are called '*Lohaar*' in Punjab region. Blacksmiths expertise in making knives, grills, iron gates, agricultural equipments, blades, spare parts of various machines etc. People involved in this type of occupation perform very hard and strenuous work in comparison to Tailors, Farmers and Carpenters. Upper region i.e. thoracic part of the body is more involved during their work. One hand carry heavy iron hammer and used to hit the hard iron rod holding the other hand forcibly required very strong muscular strength. So this habitual physical activity affects the musculature of upper body parts. During the melting process of iron rods etc.they move their one hand continuously to burn the furnace and have to sit in warm and hot environments for a long duration in summers even. Working hours of this occupation also decided by the demand and load of work.

A total of 200 adult males ranging in age from 30 to 40 years were measured for anthropometric measurements with a view to assessing their proportionality profiles and body asymmetry. Data collection was done during April 2002 to January 2004 from various urban and rural areas of Punjab state including Amritsar, Bathinda, Kapurthala, Ludhiana, Moga, Muktsar and Patiala Districts. Subjects were measured in their free hours of work. They were contacted personally and appointment for their investigation has been taken accordingly. No specific method of sampling has been used for the data collection as most of the subjects refused to become the part of the study.

The anthropometric measurements were taken on each subject following the techniques given by **Lohman et al. (1988)** on both right and left sides of the body.

Proportionality assessment is done by adjusting anthropometric measurement to a standard height or size and comparing them with the specified values and standard deviation values while using the equations given by **Ross and Wilson, (1974)**.

$$Z = (1/s)\ [v\ (170.18/h)^{d} - p]$$

Z – proportionality value of z – score
s – phantom standard deviation for the given variable
v – any variable
170.18 – constant height of Phantom (cm)
h – subject's height in cm
d – dimensional constant
d = 1 for height,widths,lengths , girths and skinfolds
d = 2 for all areas
d = 3 for all masses and volume
p – is the phantom value of the variable.
Gross phantom specifications are used as given by **Ross and Ward (1982).**

Percentage distribution of asymmetry in the different parts of the body has been calculated using the formula of Relative Index of Asymmetry (RIA) given by **Wolanski (1965).**

Relative Index of Asymmetry (RIA): (2 D / X1+ X2) x 100

Where D is mean of individual differences between right and left side body measurement. Individual differences are calculated as higher value minus lower value.X1 is the mean for the right side measurement of the body X2 is the mean for the left side measurement of the body.

All the three primary components of physique have been calculated using equations given by **Carter (1980).** Classification of body mass index has been done using the criteria given by **WHO (2002).** Grading of WHR given by Willet et al. (1999) has been used to find out the prevalence of risk of developing cardiovascular diseases in Blacksmiths.

RESULTS

Table 1 depicts the mean and standard deviation (SD) values of various anthropometric measurements of Blacksmiths.

Table 1 : Mean and SD values of Anthropometric Measurements of Blacksmiths.

Sr.No.	Parameter	Mean	Standard Deviation (SD)
1.	Body Weight (kg)	64.0	7.71
2.	Height (cms)	169.6	5.25
3.	Triceps Skf.(mm)	12.71	4.86
4.	Biceps Skf.(mm)	8.12	3.78
5.	Forearm Skf.(mm)	5.90	2.14
6.	Subscapular Skf.(mm)	17.04	5.02
7.	Suprailiac Skf.(mm)	15.60	4.68
8.	Abdominal Skf.(mm)	18.83	5.44
9.	Thigh Skf.(mm)	14.51	5.19
10.	Calf Skf.(mm)	11.56	4.93
11.	Upper Arm Circumference (cm)	27.65	3.10
12.	Forearm Circumference (cm)	26.50	2.10
13.	Wrist Circumference (cm)	17.01	1.04
14.	Chest Circumference (cm)	91.48	7.55
15.	Waist Circumference (cm)	85.54	9.84
16.	Hip Circumference (cm)	94.44	8.00
17.	Thigh Circumference(cm)	47.99	4.91
18.	Calf Circumferences(cm)	32.69	3.26
19.	Upper Arm Length (cm)	35.72	2.76
20.	Forearm Length (cm)	29.14	2.45
21.	Hand Length (cm)	18.09	1.12
22.	Humerus Bicondylar Breadth (cm)	6.78	0.50
23.	Femur Bicondylar Breadth (cm)	8.76	0.63
24.	Hand Breadth (cm)	9.27	0.96
25.	Bi-acromial Breadth (cm)	41.81	3.04
26.	Bi-iliac Breadth (cm)	32.08	2.34
27.	Antero-Posterior Chest Depth (cm)	21.96	3.21
28.	Transverse Chest (cm)	29.94	3.07
29.	Body Mass Index (BMI)		
30.	Waist Hip Ratio (WHR)		

Proportional development **(Table 2)** of these anthropometric parameters indicates that out of all the skinfold thicknesses biceps are found to be more developed (mean z-score value 0.07) whereas least development has been observed in thigh skinfold thickness having z-score mean value is -1.49 .In case of body circumferences maximum proportional development has been observed in waist circumference (mean z-score value 3.13) whereas minimum proportional development is observed in case of thigh circumference (mean z-score vale -1.81). Mean z score value of segmental lengths and body breadths indicates that proportional development is maximum in forearm length (3.41) and antero-posterior chest depth (3.28) whereas hand length (-0.81) and femur-bicondylar breadth (-1.50) are proportionally least developed in comparison to the other segmental lengths and body breadths.

Table 2: Mean z-score values of gross body measurement, skinfolds, body circumferences, body breadths, segmental lengths in Blacksmiths.

Sr.No.	Parameter	Mean	Standard Deviation (SD)
1.	Body Weight (kg)	0.01	0.94
2.	Triceps Skf.(mm)	-0.58	1.11
3.	Biceps Skf.(mm)	0.07	1.91
4.	Subscapular Skf.(mm)	-0.01	0.98
5.	Suprailiac Skf.(mm)	0.05	1.03
6.	Abdominal Skf.(mm)	-0.83	0.69
7.	Thigh Skf.(mm)	-1.49	0.62
8.	Calf Skf.(mm)	-0.93	1.07
9.	Upper Arm Circumference (cm)	0.37	1.38
10.	Forearm Circumference (cm)	1.04	1.51
11.	Wrist Circumference (cm)	0.95	1.54
12.	Chest Circumference (cm)	0.76	1.44
13.	Waist Circumference (cm)	3.13	2.24
14.	Hip Circumference (cm)	0.01	1.42
15.	Thigh Circumference(cm)	-1.81	1.19
16.	Calf Circumferences(cm)	-1.05	1.46
17.	Upper Arm Length (cm)	1.87	1.52
18.	Forearm Length (cm)	3.41	1.75
19.	Hand Length (cm)	-0.81	1.34
20.	Humerus Bicondylar Breadth (cm)	0.93	1.45
21.	Femur Bicondylar Breadth (cm)	-1.50	1.42
22.	Hand Breadth (cm)	2.05	1.99
23.	Bi-acromial Breadth (cm)	2.03	1.50
24.	Bi-iliac Breadth (cm)	1.91	1.30
25.	Antero-Posterior Chest Depth (cm)	3.28	2.28
26.	Transverse Chest (cm)	1.21	1.70

Table 3 shows the mean values of individual bilateral differences (D) and trends in relative index of asymmetry (RIA) in the skinfolds, body circumferences, segmental lengths and body breadths.

Maximum bilateral differences (D) between right and left side of skinfold thicknesses has been found in triceps skinfold (1.22mm) and minimum in forearm skinfold (0.83mm).Maximum value for relative index of asymmetry (RIA) has been found in biceps (14.08%) and minimum in suprailiac skinfold thickness (5.97%).In case of body circumferences maximum and minimum bilateral differences in right and left sides has been observed in thigh circumference (1.51cm) and wrist circumference (0.38cm) respectively, and percentage distribution of asymmetry is maximum in thigh circumference (3.16%) and minimum in calf circumference (1.83%). Trends in bilateral differences and percentage distribution of asymmetry in segmental lengths indicates maximum value in upper arm length for bilateral differences (0.87cm) and for relative index of asymmetry (RIA) in hand length (3.04%). (In case of body breadths maximum bilateral differences (0.76cm) in the right and left side and relative index of asymmetry (RIA) (8.76%) are found in femur bicondylar breadth.

Table 3: Mean values of individual bilateral differences (D) and Relative Index of Asymmetry (RIA) in skinfolds, body circumferences, segmental lengths & body breadths of Blacksmiths.

Sr.No.	Parameter	Bilateral Difference (D)	Relative Index of Asymmetry (RIA)
1.	Triceps Skf.(mm)	1.22	9.61
2.	Biceps Skf.(mm)	1.16	14.08
3.	Forearm Skf.(mm)	0.83	13.65
4.	Subscapular Skf.(mm)	1.15	6.75
5.	Suprailiac Skf.(mm)	0.94	5.97
6.	Thigh Skf.(mm)	0.93	6.41
7.	Calf Skf.(mm)	1.07	9.40
8.	Upper Arm Circumference (cm)	0.79	2.88
9.	Forearm Circumference (cm)	0.73	2.78
10.	Wrist Circumference (cm)	0.38	2.24
11.	Thigh Circumference(cm)	1.51	3.16
12.	Calf Circumferences(cm)	0.60	1.83
13.	Upper Arm Length (cm)	0.87	2.44
14.	Forearm Length (cm)	0.77	2.64
15.	Hand Length (cm)	0.55	3.04
16.	Humerus Bicondylar Breadth (cm)	0.12	1.76
17.	Femur Bicondylar Breadth (cm)	0.76	8.76
18.	Hand Breadth (cm)	0.61	6.47

Further using the WHO (2002) criteria of BMI classification cases from the present study has been categorized into different grades of body mass index (**Table 4**).It has been observed that only 49% of the individuals lie in the normal range of the BMI and about 42.5% of the individuals lie in the grade-1-overweight and 5.51% suffer from grade -1-thinness.

Grading or classification of WHR given by Willet et al.,(1999) has been used to find out the prevalence of risk of developing cardiovascular (CVD) and coronary heart (CHD) diseases in Blacksmiths **(Table 5).**Results indicates that only 7% of the Blacksmiths are under the risk of developing CVD and CHD.

Table 4: Body Mass Index (BMI) classification of Blacksmiths using WHO (2002) criteria.

Body Mass Index (BMI)	Grade	Blacksmiths (n=200)
< 16	Grade-3-Thinness	-
16- 16.99	Grade-2-Thinness	6(3%)
17- 18.49	Grade-1-Thinness	11(5.5%)
18.5-22.99	**NORMAL**	**98(49%)**
23-29.99	Grade-1-Overweight	85(42.5%)
30-39.99	Grade-2-Overweight	-
≥ 40	Grade-3-Overweight	-

Digits in parenthesis indicate percentage prevalence

Table 5: WHR classification (Willet et al., 1999) in Blacksmiths

Waist Hip Ratio WHR	Blacksmiths N=200
≤ 0.95	156 (78%)
0.96 -0.99	30(15%)
≥1	14(7%)

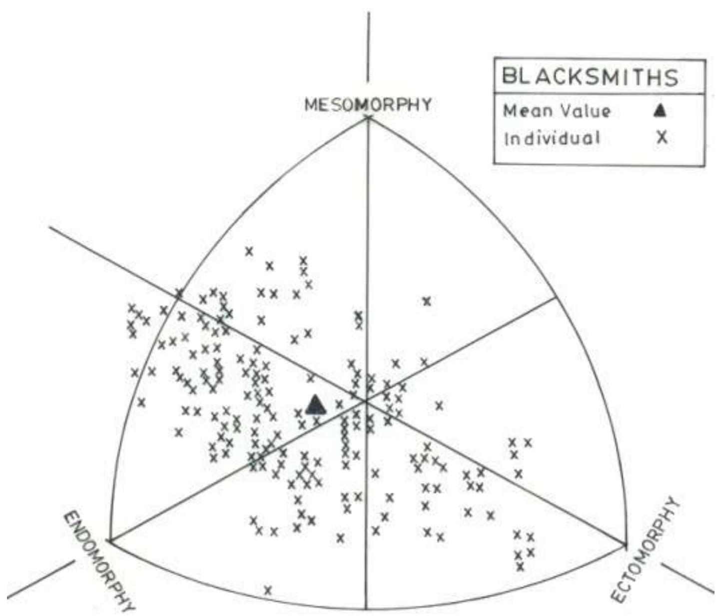
Digits in parenthesis indicate percentage prevalence

Table 6 and Fig.1 shows the somatotype components and its dispersion rates in the Blacksmiths and indicates that blacksmiths are found to be more endomorphic followed by mesomorphy and ectomorphy.

Table 6 : Mean and Standard Deviation of Somatotype components and Somatotype Dispersion Mean (SDM) and Somatotype Attitudinal Mean (SAM)

Endomorphy		Mesomorphy		Ectomorphy		SDM		SAM	
Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
4.50	1.22	3.39	1.31	2.99	1.36	4.40	2.32	2.04	0.93

Figure 1 : Somatoplots in Blackmsiths



DISCUSSION

Blacksmiths are involved in such a type of occupation which requires hard physical labor. Results of the study highlight the balanced endomorph type of body physique and showed more development of mesomorphic component alongwith endomorphy (Table 6 and Fig.1).Impact of physical activity shows good relationship with proportional development of various parameters in Blacksmiths. Higher proportional values for biceps and suprailiac skinfold thickness indicates that they have the greatest subcutaneous fat as compare to the skinfold thickness at other sites. Pattern of regional subcutaneous fat distribution is also influenced by age,sex,nutritional status,habitual physical activity patterns and possibly ethnic background (Garn et al.,1998 and Norgan,1991).According to Cronk et al.,(1982) reduction in the subcutaneous fat over the extremities happens, concurrent with the fat deposition over the trunk region of the body in older subjects. Blacksmiths have most developed upper extremity circumferences thus indicated more development of muscle mass in that region of the body.(Table 2)

Body breadths provide useful indication of fat free mass and are considered to be an independent estimate of relative fatness. Moreover it is the better measure of frame size (Katch and Freedson,1982; Frisancho,1983,1984;Fehily et al.,1990 and Facchini et al.,2003). Maximum values of transverse chest and antero-posterior chest breadths in Blacksmiths (Table 1 & 2) indicate that trunk region of the body is more influenced by their work. Vigorous training might change bone dimensions if this was undertaken before closure of the epiphysis has been completed (Tittle and Wutscherk, 1988 and Haapasalo et al., 2000).

BMI classification **(WHO, 2002)** indicates that 42.5 % the of subjects have BMI values higher than normal values. Generally very low and very high values of BMI indicate an increased mortality risk almost among all the cultures (Waaler, 1984;Bray,1987;Campbell and Ulijaszek,1994 and Kennedy and Garcia,1994).Lower limits of BMI depend not only on the fat mass and fat free mass but also on the level of habitual physical activity of a person especially if the energy balance tends to be negative (James et al.,1988).More strenuous work tends to lower the value of BMI and will probably imply an effect on work capacity.

Waist –hip ratio (WHR) is one of the important predictor of cardiovascular diseases (CVD) and coronary heart diseases (CHD) with universal application in individuals with different body builds. Only 7% of the Blackmsiths are under the risk of developing CVDs or CHDs (Table

5).WHR may also proved to be a more appropriate and universal indicator of risk of ethnically diverse populations such that small framed Asian and Indian groups and large framed Polynesians (Larsson et al., 1984, Lapidus et al., 1984 and Welborn et al.,2003). Waist-hip ratio also provides the information regarding degree of android distribution of adipose tissue. Thus more value of WHR are reflecting greater risk of non-insulin dependent diabetes mellitus and are also associated with impaired glucose tolerance (IGT) in both males and females after controlling for age (Hartz et al.,1983,Krotkiewski et al.,1983 and Sekikawa et al.,1999).

Findings of the present study indicate that Blacksmiths possess bilateral differences for all the skinfolds except for suprailiac and thigh skinfolds but maximum bilateral differences have been observed between triceps skinfold and direction of asymmetry is towards right side (57%).This might be due to the fact that right hand in Blacksmiths does the maximum work as compared to the left hand whereas left hand is used for holding the iron. Direction of asymmetry for thigh (68%) circumferences is also towards right side. Most asymmetric trait of human body is hand muscular strength, which further depends on the mass of working muscles, degree of their development and the conditional reflexes which regulate and co-ordinate the movements (Gusieva, 1964), The maximum bilateral differences in hand occurred in mechanics, metal workers and weavers (Malinowski, 1975). Asymmetry of muscular strength is related to type of work and mode of life as in cites, the skilled work is performed mostly with one hand whereas in villages or agricultural type of unskilled work, the loading of both extremities are similar which decrease the asymmetry (Wolanski, 1972).

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