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Research Article

Anthropometric Measurements of Workers with Elementary Occupations in Eastern Region of Nepal- An Ergonomic Approach

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Abstract

Introduction: Variation in the anthropometric measurements of the different occupational groups can be correlated with the variation in ergonomic design for the betterment of the individual involved in works, which eventually affects the productivity of the work. To correlate the occupation, gender and race of the Nepalese individuals with the anthropometric measurements was the aim of this study.

Materials and Methods: This is a comparative cross-sectional study conducted among the workers associated with elementary occupation in the Sunsari district of eastern region of Nepal. Subjects (N=600) were chosen from the three major subgroups of elementary occupation (cleaners and helpers, industrial workers and agricultural workers or farmers) having age between 25 to 50 year.

Results: Mean standing height of farmers (157.22±4.34 for male and 147.01±4.31 for female) was less than that of industrial workers (163.65±5.43 for male and 149.44±6.40 for females) for male and more than industrial workers for female. Weight was more in farmers (63.66±5.67 for male and 56.68±5.44 for female) than that of industrial workers (59.72±9.29 for males and 52.19±8.53 for female). Wrist breadth was also more in farmers (5.93±0.40 for male and 5.33±0.26 for female) than that of industrial workers (5.92±0.36 for male and 5.30±0.23 for female).

Summary and Conclusion: Physical anthropometry cleaners and helpers and industrial workers were more similar in size as compared with the farmers and this could be useful for designing the equipment according to occupations to improve working conditions and to minimize work related trauma and illness.

Keywords: Elementary occupation; Physical anthropometry; Standing height; Ergonomic

Abbreviations

CTDs: Cumulative Trauma Disorders; BMI: Body Mass Index; ISCO: International Standard Classification of Occupations; VDCs: Village Developmental Committee; IERB: Institutional Ethical Review Board; ANOVA: Analysis of Variance; BPKIHS: BP Koirala Institute of Health Sciences; MSDs: Musculoskeletal Disorders; CTS: Carpel Tunnel Syndrome; WRULD: Work-Related Neck and Upper Limb Disorders

Introduction

The word 'anthropometry' means measurement of the human body. It is derived from the Greek words 'anthropos' (man) and 'metron' (measure). Anthropometric data are used in ergonomics (a science that deals with designing and arranging things so that people can use them easily and safely [1]) to specify the physical dimensions of work spaces, allowable space equipments, furniture and clothing to ensure that physical mismatches between the dimensions of equipment and products and the corresponding user dimensions are avoided [2,3]. This matching is used for occupational injury prevention when the tools and equipment, machinery and spaces are appropriate to the body measures. Otherwise, work efficiency decreases and inappropriate work difficult utility conditions arises. This in turn leads to a physical and mental stress [4]. The work difficult utility conditions are serious such as health impairment and diminished quality of life which finally affects their independence [5]. Musculoskeletal injuries caused by occupation are common. Cumulative Trauma Disorders (CTDs) and Repetitive motion injury are terms used to refer certain musculoskeletal injuries caused by defective coordination between machines and workers [3,6]. Almost 50% of workers in the industrial world are thought to suffer from back problem, originated from improper sitting positions [3]. World today is undergoing tremendous socio-economic and political change, resulting in increasing migration of people. Migration occurs both between the countries and internally within country. National population cannot therefore regard as homogenous. Industrial, service and other workplace now have mixed population, not only in gender but also in ethnic groupings. Population heterogeneity is of great importance to anthropometric consideration in the design of workplaces and consumer products. For example, body proportions of people with different ethnic origins are found to be different. Black Africans have proportionally longer limb length than the

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European white population. People belonging to Chinese, Japanese, Indonesians and Vietnamese population have proportionally shorter limb than Europeans. Therefore workplace and facilities cannot be used easily and efficiently by all the members of the population due to these variations [7]. Nepal, also known as 'agriculture dominant country' had population of 26.49 million with a growth rate of 1.35% per year. Agriculture contributes 36%, service 52%, industry 9.6% to GDP [8]. Agriculture provides an employment opportunity to 73.9 percent of the total population but with very low productivity due to several factors including low adoption of improved technology [9]. Sunsari is one of the six district located in eastern region of Nepal which is divided into three region- Himalayan, hill and Tarai (plane) region from north to south. Total population is 795096 (50.39% male). This district is occupied by multiethnic variety of People with more than 90 types of caste (*Jat*). By occupation 61.75% of economically active (above 10 yr) population (51.39% of total population) is involved in agricultural, industrial and health sectors which was the reason behind choosing the subjects from those sectors. According to a survey, proportion of male and female in economically active population is nearly equal (50.28% male) [10].

Anthropometry permits us to develop standard and specific requirements against which a product, machine, tolls or piece of equipments can be evaluated to ensure their suitability for the user population [7]. Designs that are incompatible with normal anthropometric measurements of a workforce could result in undesired events. For example the misfit of a heavy equipment cabin to a worker could produce operator blind spots that expose workers on foot to strike by injuries. Inadequate length or configuration of seatbelts could lead to non use of seatbelts, which will affect post-crash survivability. Inadequate fit of personal protective equipment cannot provide workers with sufficient protection from health and injury exposures. The workplace should be designed according to the body size of the user. Engineering anthropometry applies these data to tools, equipment, workplaces, chairs and other consumer products, including clothing design [3].

For using anthropometry in ergonomics, Selection of the user population (gender, age, occupation, ethnicity, and cultural aspect of population) and determination of body dimensions are needed. Beside these, determining the design criteria is utmost important. For the vertical reach, workplace design should be set by shortest individual and if criteria is for passing every individual without bending his/her body the it should be set by tallest individual of that particular population. This approach is called as 'designing for extreme' [11]. It is some time desirable to set a range of values as design limit. In this case design should incorporate an adjustment in required dimensions. For example office chairs can be designed to provide adjusted seat height [7]. Existing data on the size and shape of workers is sparse. Because of the lack of anthropometric data for the general worker population, safety researchers have generally had to rely on data drawn from studies of military personnel, most of which was collected during the 1950s through the 1970s. However, substantial anthropometric variability exists among the various U.S. workforce populations, and they are quite different from the average military population. Industrial workers, such as the agriculture, truck driver, and firefighter workforces, are even anthropometrically very different from the average civilian population [12].

The skilled movements needed to use occupational tools are critical to carrying out many daily activities. When performing skilled movements, a person learns how to use muscles, joints, and limbs in a series of coordinated steps that lead to the desired goal. First the person learns how to reach for those tools, to hold the tools, and then to move the tools to get a job done [13].

Work-Related Neck and Upper Limb Disorders (WRULD) are the most common form of occupational disease, accounting for more than 45% of all occupational diseases. These disorders emerge mainly from work performing and the conditions in which work is carried out. Any region of the neck, shoulders, arms, forearms, wrists and hand can be affected. Many of the musculoskeletal conditions are non-specific indicating that a specific diagnosis or pathology cannot be determined by physical examination but pain and/or discomfort, numbness, tingling in the affected areas are reported. Other symptoms which can be exacerbated by cold or use of vibrating tools include swelling in the joints, decreased mobility or grip strength, changes in skin colour of the hands or fingers. These complaints can lead to physical impairment and even disability. The most common occupational MSDs are tenosynovitis of the hand or wrist, and epicondylitis of the elbow. MSDs including CTS accounted for 59% of all recognized diseases in 2005. The incidence rate for musculoskeletal disorders is higher for men than women, but MSDs make up a much higher proportion of all occupational diseases for women: MSDs including CTS represent 85% of all occupational diseases among women [14].

The causes of Work-Related Neck and Upper Limb Disorders (WRULD) are usually multifactorial. The acknowledged risk factors related to various types of MSDs include biomechanical, organisational, psychosocial and individual factors [15]. Important biomechanical factors are listed below.

Hand force exertion– Sustained or excessive force results in heavy mechanical loads on the neck, shoulders and upper limbs: handling objects, using tools, fast movements or excessive force generated by the muscles of the body. Different manipulating actions on a tool are examples of activities that require exerting force or muscle effort (e.g. digital griping is more demanding than palm griping). Not only is the intensity of effort harmful but also its duration.

Repetitive movements- Work involving repetitive movements is very tiring because the worker cannot fully recover in the short periods of time between movements. If the work activity continues in spite of the fatigue, injuries can occur. The cycle duration is significant if less than 30 seconds or if the repetitive movements account for 50% of work time (e.g. repetitive tasks: making folds during packaging, screwing drywall, and tying rebar).

Working posture- This represents unnatural positions, deviated from "neutral positions", in which joints are held or moved away from the body's natural position. The closer the joint is to its end of range of motion, the greater the stress placed on the soft tissues of that joint, such as muscles, nerves, and tendons. When muscles are contracted, the body is subjected to a greater mechanical effort. Joint positions of the upper limb, when working outside comfort angle; increase the possibility of WRULD, regardless of effort intensity or degree of repetition.

Table 1: Operational definitions of body dimensions measured.

Parameters	Operational Definition
Weight	It is total weight of subject in kilogram standing upright over platform of weighing scale.
Standing height	The vertical distance from the floor to the vertex (i.e. the crown of the head) in upright posture.
Sitting height	It is the vertical distance from the sitting surface to the vertex (i.e. the crown of the head). It reflects trunk height without considering the limb length.
Upper arm length	It is distance from the most upper edge of the posterior border of the acromion process of the scapula to the tip of the olecranon process.
Hand breadth	It is the distance across the palm of the hand at the metacarpal-phalangeal joints of digits 2 to 5.
Biacromial breadth	Horizontal distance across the shoulders measured between the acromian processes
Sitting elbow height	It is the vertical distance from the seat surface to the underside of the 90 degree flexed elbow.
Wrist breadth	It is the distance between most prominent aspect of the ulnar styloid process to the most prominent aspect of the radial styloid process
Facial height	It is the distance between roots of the nose (Nasion) to the lowest point in the lower border of the mandible.

Contact pressure- Any external pressure that is applied to soft tissues (e.g. holding tools where handles press into parts of the hand or arm; sharp edges of tools, machines or furniture that press into the fleshy tissues) can cause distortion and injury.

Few studies were done to compare anthropometric measurements on the basis of races, gender, climate and duration of retirement after work among Nepalese people. According to those study physical anthropometric parameters like weight, standing height, and BMI (Body Mass Index) were found to vary between different groups of population [16-19]. Few studies were available comparing the anthropometric data of Nepalese people with other countries which showed that most of parameters are lesser than that of other countries [6,20,21]. Variation in the anthropometric measurements of the different occupational groups could be correlated with the variation in the measurements of the work places and occupational tools they used for the betterment of the individual involved in works, which eventually affects the productivity of the work. To correlate the occupation and gender of the individual with the anthropometric measurements is key factor to achieve this distant goal. And this was the stimulus for this study. To match the dimensions of occupational tools with the body dimension it is necessary to have the anthropometric data of the workers associated with various occupations to be considered for designing the tools and equipments. This necessitates the separate data bank for Nepalese people for designing tools and also for forensic anthropometry. But in our country there was no study found regarding comparison of the body dimensions of different groups of workers so far, so this study was expected to aid information in anthropometric data bank of Nepal and will open the door for further research in this subject.

Materials and Methods

Sampling population

This was a comparative cross-sectional study conducted among the workers associated with elementary occupation in the Sunsari district of Nepal. Subjects were chosen from the three major subgroups of elementary occupation (cleaners and helpers, industrial workers and agricultural workers) as defined by ISCO (International Standard Classification of Occupations) which is a tool for organizing jobs into a clearly defined set of groups according to the tasks and duties undertaken in the job [22]. Total sample size was 600, 200 (100 male and 100 females) from each subgroup having age between 25 to 50 years (to obtain the maximum dimension due to completion of growth). All the subjects were Nepalese in birth and ancestry. The subjects were also migrated from various other districts of Nepal. Purposive sampling technique was chosen for selecting the VDCs, Industries, Institutes, Clinics, Hotels and restaurants. After that, simple random sampling was chosen to take a total sample unit of 600 among those areas. Individuals having chronic systematic illness, injuries like fractures and having major surgeries in past one year were not included in research.

Ethical clearance

Research protocol was approved by the IERB (Institutional Ethical Review Board) of the BPKIHS (BP Koirala Institute of Health Sciences) and a consent form was signed by the each sample subject before making the observation.

Data collection

A brief semi-structured questionnaire on demographic profile was circulated among participants of the study which included questions about nutritional habit, personal habits of the individual and most worrying occupational hazard related with the occupation. The questionnaire was pretested among 20 subjects before using for research. Nine body dimensions (important for designing the tools and workplace) were measured along with Body Mass Index (BMI) (Table 1). Upper arm length, Hand breadth, Sitting elbow height and Wrist breadth were measured on right side of the individual. Weight was measured in kilogram (Kg) and all other measurements except for BMI were measured in centimeter (cm). BMI was calculated as {weight in kg/ square of height in meter} and international reference was taken to describe BMI (18.5 to 24.9 as normal, 25 to 29.5 as overweight, above 30 as obese and below 18.5 as thinness) [23].

The methodology for the measurements was according to the literature from, NASA (1978) [24]. Weight, standing height and upper arm length were measured when subject was in standing posture with head in frankfort horizontal plane and arms by the side of body. Standing height was measured by martin's anthropometer from floor to the vertex. Upper arm length was measured as distance from the posterior margin of acromian process and tip of olecranon process and was measured by using plastic tape. Other measurements were measured in sitting posture. Sitting height was measured from the sitting surface to the vertex to reflect the trunk height by anthropometer. To measure the sitting elbow height subject was asked to flex the elbow 90 degree and at the same time distance from the sitting surface to the underside of elbow was measured by using

Table 2: Mean values of socio-economical parameters among 3 occupational groups.

Parameters	Occupational groups	Mean ± SD
Salary in NPR	Farmers	6520.00 ± 1582.60
	Industrial workers	7322.35 ± 1989.74
	Cleaners and Helpers	7481.85 ± 2210.13
	Total	7108.07 ± 1986.86
Number of family members	Farmers	5.18 ± 1.47
	Industrial workers	4.94 ± 1.49
	Cleaners and Helpers	5.03 ± 1.47
	Total	5.05 ± 1.48
Number of earning members	Farmers	2.36 ± 0.92
	Industrial workers	1.92 ± 0.80
	Cleaners and Helpers	2.18 ± 0.94
	Total	2.15 ± 0.91
Working hour per day	Farmers	8.26 ± 1.51
	Industrial workers	8.10 ± 0.47
	Cleaners and Helpers	8.18 ± 1.18
	Total	8.18 ± 1.14
Number of year in occupation	Farmers	15.28 ± 7.73
	Industrial workers	9.69 ± 7.31
	Cleaners and Helpers	10.41 ± 7.03
	Total	11.79 ± 7.76
Age of subjects in year	Farmers	35.44 ± 8.04
	Industrial workers	36.90 ± 8.28
	Cleaners and Helpers	34.77 ± 8.13
	Total	35.70 ± 8.19

anthropometer. Hand breadth was measured by using sliding caliper as a distace from 2nd to 5th metacarpophalangeal joint in volar aspect of hand. Biacromial breadth was measured by plastic tape as the distance between two acromian processes when subject was sitting in flat surface with straight posture with arms hanging by the side of body. Wrist breadth was measured by using sliding caliper by finding radial and ulnar styloid processes when subject was asked to flex the arm at elbow joint. Facial height was measured by using sliding caliper from root of nose to the lower border of mandible when head lies in frankfort horizontal plane.

Two surveyors were involved in data collection and were well trained to identify body landmarks and to measure body dimension accurately. Instruments used to measure the body dimensions were Martin's stadiometer, Sliding Caliper and plastic tape (manufactured by Siber Hegner India Pvt Ltd).Weighing scale was also accurate and reliable and this was pretested by putting a known weight on the scale. The instrument was manufactured by Momert Company, Hungary. All the instruments were properly calibrated before use. Nearest dimension considered to be valid was 0.5 kg for weight and 1mm for other body dimensions.

Data analysis

Collected data were first entered in Microsoft Excel and then for statistical analysis were transferred to the SPSS (Statistical Package for Social Science) version 11.5. At first all the socio-economical variable were summarized. Since all the data were assumed to have normal distribution for applying the statistical tests, so to find the differences of mean value between the genders and races Unpaired Student T -test was applied and to compare the differences among three occupational groups One Way ANOVA (Analysis of Variance) was applied. P value less than 0.05 was taken as significant for statistical analysis.

Table 3: Descriptive statistics of workers by gender and race with score of significance for mean difference.

Measurements	Sex	Mean ± SD	P value	Race	Mean ± SD	P value
Weight	Male	60.82 ± 7.81	<0.001	Indo-Aryan	57.56 ± 8.16	0.370
	Female	54.75 ± 7.16		Mongoloid	58.18 ± 7.93	
Standing height	Male	160.05 ± 6.69	<0.001	Indo-Aryan	155.85 ± 8.36	< 0.001
	Female	149.23 ± 6.12		Mongoloid	152.53 ± 8.03	
Sitting height	Male	80.60 ± 4.37	<0.001	Indo-Aryan	78.31 ± 4.89	< 0.001
	Female	74.57 ± 3.95		Mongoloid	76.31 ± 5.33	
Upper arm length	Male	34.85 ± 2.06	<0.001	Indo-Aryan	33.97 ± 2.19	0.001
	Female	32.64 ± 1.52		Mongoloid	33.36 ± 1.94	
Hand breadth	Male	7.76 ± 0.44	<0.001	Indo-Aryan	7.49 ± 0.52	0.005
	Female	7.13 ± 0.37		Mongoloid	7.37 ± 0.49	
Biacromial breadth	Male	38.27 ± 2.63	<0.001	Indo-Aryan	36.99 ± 2.81	0.648
	Female	35.64 ± 2.07		Mongoloid	36.89 ± 2.50	
Sitting elbow height	Male	22.71 ± 3.04	<0.001	Indo-Aryan	21.68 ± 3.05	< 0.001
	Female	19.58 ± 2.60		Mongoloid	20.21 ± 3.33	
Wrist breadth	Male	5.95 ± 0.41	<0.001	Indo-Aryan	5.70 ± 0.48	< 0.001
	Female	5.36 ± 0.28		Mongoloid	5.56 ± 0.41	
Facial height	Male	10.96 ± 0.55	<0.001	Indo-Aryan	10.85 ± 0.63	< 0.001
	Female	10.38 ± 0.60		Mongoloid	10.36 ± 0.55	
BMI	Male	23.77 ± 2.89	0.001	Indo-Aryan	23.73 ± 2.97	< 0.001
	Female	24.64 ± 3.24		Mongoloid	25.04 ± 3.15	

Results

Total sample size of the study was 600, in which numbers of workers from Indo-Aryans were 382 and from Mongoloids were 218. By religion 450 were Hindu, 138 were Buddhists and 12 were from other religions. Maximum numbers of workers (319) were educated between grade five to ten, 150 were between grade one to five, 88 of them had no grade and small numbers of workers (43) were educated above grade ten. Some other socio-economical parameters of each group are presented in Table 2.

Anthropometric measurements of all the workers by gender and race were presented in Table 3. When compared between genders, all the measurements were higher in males except for BMI. The differences in mean value for all the measurements were statistically significant (*P* value≤0.001). When compared between races, except for weight and BMI all the dimensions were higher in Indo-Aryans than that of Mongoloids. Except for Weight and biacromial breadth all other dimensions were significantly difference between two races (*P* value <0.005). Anthropometric measurements of three occupational groups were calculated. Data were presented as mean and standard deviation for male and female by using. Score of significance of difference between two genders (p value) was also found by using independent T-test (Table 4). Comparison of mean values of anthropometric measurements showed that except for BMI all other parameters were higher in males. Among the farmers the different was statistically highly significant (*P* value <0.001)

Table 4: Comparison of parameters between male and female of three occupational groups.

		Farmers		Industrial workers		Cleaners and helpers	
Parameters	Sex	Mean±SD	*P* value	Mean±SD	*P* value	Mean±SD	*P* value
Weight	Male	63.66±5.67	< 0.001	59.72±9.29	< 0.001	59.09±7.30	< 0.001
	Females	56.68±5.44		52.19±8.53		55.41±6.45	
Standing height	Male	157.22±4.34	< 0.001	163.65±5.43	< 0.001	159.30±8.07	< 0.001
	Females	147.01±4.31		149.44±6.40		151.24±6.66	
Sitting height	Male	78.70±2.59	< 0.001	83.38±3.31	< 0.001	79.73±5.28	< 0.001
	Females	72.24±3.26		75.90±2.74		75.57±4.54	
UAL	Male	34.05±1.50	< 0.001	35.89±2.06	< 0.001	34.63±2.12	< 0.001
	Females	32.29±1.13		33.09±1.80		32.54±1.47	
Hand breadth	Male	7.91±0.45	< 0.001	7.84±0.30	< 0.001	7.54±0.46	< 0.001
	Females	7.05±0.30		7.17±0.33		7.17±0.44	
Biacromial width	Male	40.32±2.11	< 0.001	37.06±2.01	< 0.001	37.44±2.44	< 0.001
	Females	36.37±1.82		34.57±1.96		35.98±1.99	
SEH	Male	22.28±2.45	< 0.001	24.76±1.28	< 0.001	21.09±3.64	< 0.001
	Females	17.45±1.30		22.04±1.70		19.26±2.27	
Wrist breadth	Male	5.93±0.40	< 0.001	5.92±0.36	< 0.001	5.99±0.47	< 0.001
	Females	5.33±0.26		5.30±0.23		5.45±0.33	
Facial height	Male	10.91±0.47	< 0.001	11.08±0.57	< 0.001	10.90±0.59	< 0.001
	Females	10.43±0.53		10.24±0.65		10.49±0.60	
BMI	Male	25.72±1.66	0.077	22.23±2.69	0.010	23.36±2.98	0.029
	Females	26.23±2.29		23.37±3.49		24.32±3.16	

for all parameters except for BMI. Among the industrial workers all parameters except for BMI were statistically highly significant (*P* value<0.001), different in BMI was statistically significant (*P* value=0.001). Among the cleaners and helpers when compared between male and female, different in all parameters except for BMI were statistically highly significant (*P* value<0.001), different in BMI was statistically significant (*P* value=0.029).

Comparisons of measurements were done with respect to three occupations along with genders of subjects (Table 5) by finding out the score of significance (*P* value <0.05). Significant differences were seen mainly between farmers and industrial workers and between farmers and cleaners and helpers. Except for wrist breadth and hand breadth in male significant different was seen between farmers and industrial workers. When compared between farmers and cleaners and helpers more numbers of parameters were found significant except for weight, biacromial breadth and upper arm length in females, sitting height and wrist breadth in males and facial height in both sexes. When compared between industrial workers and cleaners and helpers significant differences were found except for weight, biacromial breadth, wrist breadth in males and sitting height and hand breadth in females.

Table 6 showed the two-tailed Pearson correlation test to show the correlation between various anthropometric measurements. Standing height had positive correlation with sitting height (PC=0.902), with upper arm length (PC=0.785) with hand breadth (PC=0.619), with biacromial breadth (PC=0.410), with sitting elbow height (PC=0.639), with wrist breadth (PC=0.622) and with facial height (PC=0.477) which was statistically highly significant (*P* value < 0.001). There was negative correlation between standing height and BMI (PC=-0.323) which was statistically highly significant (*P* value < 0.001).

Discussion

Human body is not a unique being; biological variability appears to result from the combined influence of human behavior and natural forces that have been at work throughout human prehistory [25]. Natural forces can be taken as gender, race and climate while human behavior meant lifestyle of person including alimentary habits and physical activity. To understand the changes in the anthropometric variables, the natural forces (gender and race) and human behavior (occupation) were correlated with the body dimensions in the form of multivariate analysis. Such analysis showed that weight was more dependent on sex (F value= 98.34) followed by sex plus occupation (F value= 58.16). Similar analysis for standing height showed highest dependency with sex (F value= 428.03) followed by sex plus occupation (F value= 235.22). Detailed analysis of all the data showed that changes in body dimensions were not due to chance but as an effect of gender and occupation followed by race of the individual.

Stature is one of the most important and widely used body dimensions which varies primarily with gender and ethnicity (16). It is used as a design parameter from building codes (making sure doors are tall enough) to airplane design (to ensure you have enough head room when walking down the aisle). The 95th percentile male is typically the tallest stature of a given anthropometric population that is designed for. While the 5th percentile female represents the shortest person in the population that is considered in most designs. For example, work should be located to suit the height of the operator. If the work is located too high, the neck and shoulders may suffer due to the shoulders frequently being raised to compensate for the incorrect height. If the work is located too low, a backache can result from required leaning and bowing the back. Anthropometric dimensions can also be used in workplace layout to optimize vertical and horizontal reaches and grasps. It is also used to compare different populations; for example, the Nordic population is much taller than the Korean population [26]. Shoulder breadth is used to determine minimum clearance needs for a body for access at shoulder height. Shoulder breadth also represents a key measurement for clearance of

Table 5: Comparison of measurements among three occupational groups with score of significance (N=600).

Measurements	Mean ± SD				P value$^{\#}$	P value*	P value**	P value***
	Occupations	Male	Female					
Weight	Farmers	63.66±5.67	56.68±5.44	M	<0.001	<0.001	<0.001	NS
	Industrial workers	59.71±9.29	52.19±8.53					
	Cleaners and helpers	59.08±7.30	55.41±6.45	F	<0.001	<0.001	NS	0.001
Standing height	Farmers	157.22±4.34	147.01±4.31	M	<0.001	<0.001	0.018	<0.001
	Industrial workers	163.65±5.42	149.44±6.40					
	Cleaners and helpers	159.30±8.07	151.24±6.66	F	<0.001	0.004	<0.001	0.032
Sitting height	Farmers	78.70±2.59	72.24±3.26	M	<0.001	<0.001	NS	<0.001
	Industrial workers	83.38±3.31	75.90±2.74					
	Cleaners and helpers	79.73±5.28	75.57±4.54	F	<0.001	<0.001	<0.001	NS
Upper arm length	Farmers	34.05±1.50	32.29±1.13	M	<0.001	<0.001	0.036	<0.001
	Industrial workers	35.89±2.06	33.09±1.80					
	Cleaners and helpers	34.62±2.12	32.54±1.47	F	<0.001	<0.001	NS	<0.001
Hand breadth	Farmers	7.91±0.45	7.05±0.30	M	<0.001	NS	<0.001	<0.001
	Industrial workers	7.84±0.30	7.17±0.33					
	Cleaners and helpers	7.54±0.46	7.17±0.44	F	0.029	0.021	0.021	NS
Biacromial breadth	Farmers	40.32±2.11	36.37±1.82	M	<0.001	<0.001	<0.001	NS
	Industrial workers	37.05±2.01	34.57±1.96					
	Cleaners and helpers	37.44±2.44	35.98±1.99	F	<0.001	<0.001	NS	<0.001
Sitting elbow height	Farmers	22.28±2.45	17.45±1.30	M	<0.001	<0.001	0.002	<0.001
	Industrial workers	24.76±1.27	22.04±1.70					
	Cleaners and helpers	21.09±3.64	19.26±2.27	F	<0.001	<0.001	<0.001	<0.001
Wrist breadth	Farmers	5.93±0.40	5.33±0.26	M	0.048	NS	NS	NS
	Industrial workers	5.92±0.36	5.30±0.23					
	Cleaners and helpers	5.99±0.47	5.45±0.33	F	<0.001	NS	0.003	<0.001
Facial Height	Farmers	10.91±0.47	10.43±0.53	M	0.037	0.032	NS	0.021
	Industrial workers	11.08±0.57	10.24±0.65					
	Cleaners and helpers	10.90±0.59	10.49±0.60	F	0.010	0.027	NS	0.003
BMI	Farmers	25.72±1.66	26.23±2.29	M	<0.001	<0.001	<0.001	0.002
	Industrial workers	22.22±2.69	23.37±3.49					
	Cleaners and helpers	23.36±2.98	24.32±3.16	F	<0.001	<0.001	<0.001	0.027

(Test applied – One way ANOVA with Post Hoc multiple comparison at significance level of 0.05)
#- between the groups, *- Between Farmers and Industrial workers, **- between farmers and Cleaners and Helpers, ***- between Industrial workers and Cleaners and Helpers, M- male, F- female, NS- not significant

access ways when the subject crawls or lays prone. Sitting height is used to determine the necessary head room and clearance between a seat and any overhead objects or obstacles [27]. The construction of the seat should be taken into consideration and the compression of the seat [28]. Sitting elbow height is a critical measurement for the design of sitting work surfaces, such as working tables. It is also used in design layouts to determine optimum armrest heights for office chairs, bucket seats in car, lounge chairs in home or any other type of seated arm rest. The construction of the seat should be taken into consideration and the compression of the seat cushion should be measured and subtracted from sitting height [29].

Most of the anthropometric parameters were found to be normally distributed, in that condition we need mean and SD for work place design. Some dimensions were found to have more variable than others; variability is expressed as Coefficient of variation. Body breadth and depth were found to have higher (5-9%) CV than body length (3-5%) [7]. In this study all the parameters were found to have normal distribution. CV of breadth measurements was ranged from 5.1 to 7 % while for body length measurements had CV ranged from 5 to 13.3%. Weight, facial height and BMI were more variable in female subjects than in males while other parameters were more variable in male subjects.

A study done by Nancy in Solukhumbu district of Nepal among the 50 males of Tibeto-Nepali origin having age of 20 to 38 year showed that their mean weight (51.1±4.85) and BMI (20.2±1.3) were less than that of this study result, and their standing height (159.3±5.0) and sitting height (84.5±2.8) were more than that of this study result. Genetic factors and climatic acclimatization might be responsible for these differences due to variation in climate of the Sherpa people (who stay in mountain region) because those factors were mentioned to be responsible for variability in body dimension and composition [30,31]. Study done by Shrestha et al among 444 healthy people (210 males) aged between 25-50 years belonging to pure race of Rai and Limbu communities of Sunsari district showed that mean height of Rai male (157.73± 5.57) was slightly lower than that of this study result (158.61±6.90) and height of female (148.65±4.04) was slightly higher than that of this study result (147.75 ± 5.09). If compared with the standing height of Limbu community (160.10±6.50 for male and 151.03±4.89 for females), this study population was slightly shorter. This variation might be due to presence of mixed type of sample in

Table 6: Pearson correlation among anthropometric measurement of total sample size of 600.

		Weight	Standing height	Sitting height	Upper arm length	Hand breadth	Biacromial breadth	Sitting elbow height	Wrist breadth	Facial height	BMI
Weight	PC										
	P value										
Standing height	PC	0.468**									
	P value	<0.001									
Sitting height	PC	0.446**	0.902**								
	P value	<0.001	<0.001								
Upper arm length	PC	0.425**	0.785**	0.736**							
	P value	<0.001	<0.001	<0.001							
Hand breadth	PC	0.515**	0.619**	0.607**	0.527**						
	P value	<0.001	<0.001	<0.001	<0.001						
Biacromial breadth	PC	0.684**	0.410**	0.364**	0.332**	0.540**					
	P value	<0.001	<0.001	<0.001	<0.001	<0.001					
Sitting elbow height	PC	0.240**	0.639**	0.722**	0.610**	0.606**	0.221**				
	P value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001				
Wrist breadth	PC	0.563**	0.622**	0.569**	0.497**	0.602**	0.511**	0.406**			
	P value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
Facial height	PC	0.322**	0.477**	0.432**	0.336**	0.388**	0.354**	0.315**	0.459**		
	P value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
BMI	PC	0.680**	-0.323**	-0.274**	-0.202**	0.025	0.388**	-0.291**	0.075	-0.058	
	P value	<0.001	<0.001	<0.001	<0.001	0.542	<0.001	<0.001	0.066	0.157	

* *.Correlation is significant at the 0.01 level, *.Correlation is significant at the 0.05 level

this study involving other ethnic people beside Rai and Limbu [16].

When compared with the similar study done by KN Agrawal among the male and female farmers of Northern India (N=1027) of 19 to 51 years of age showed that Nepali male farmers were shorter and heavier than that of farmers of north India and also found having more biacromial breadth [32]. Another study done by KN Dewangan among the female farmers showed that the female farmers of Nepal were heavier, wider and shorter than that of India [33]. When compared with the data of British population (both male and female of 19 to 65 years of age) given by Pheasant, it showed that stature, sitting height, sitting elbow height and biacromial breadth were found to be different from our study result. All the body dimensions were lesser in value in comparison with the British population (Stature: 174±7.0 For male and 161±6.1 for female, Sitting height 91±3.6 for male and 85±3.5 for female, Sitting elbow height 24.5±3.1 for male and 23.5±2.9 for female and Shoulder breadth 46.5±2.8 for male and 39.5±2.4 for female) [34]. This variation was thought to be due to differences in Biological variability appears to result from the combined influence of human behavior and natural forces that have been at work throughout human prehistory. This makes it difficult to develop a particular human body model for all of us. That is why measurements of different population are needed to make a human model [25]. A study done by M Mokdad among the 514 male farmers of Algeria showed that their weight (64.0±10.9), standing height (172.6±7.60), sitting height (87.0±3.54), shoulder breadth (40.6±2.7), hand breadth (8.2±4.0) and RSH (50.4%) were more than that of this study result , but BMI (21.0±2.0) was less than that of Nepali female farmers [35]. Comparison was done with the study done by Jinky Leianie among the 1805 Filipino workers (843 males) showed that mean values for male in this study: standing height (163.65±5.43), sitting height (83.38±3.31), hand breadth (7.84±0.30), and biacromial width (37.06±2.01) were less than that of mean standing height (167.01±8.03), sitting height (84.84±5.81), hand breadth (9.80±4.72) and biacromial breadth (44.7±7.33) of Filipino workers and mean upper arm length (35.89±2.06) and sitting elbow height (24.76±1.28) of this study results were more than that of male Filipino workers [upper arm length (25.99±4.54) and sitting elbow height (22.23±4.21)]. Comparison of same study in female showed that result of this study: standing height (149.44±6.40), sitting height (75.90±2.74), biacromial breadth (34.57±1.960, and hand breadth (7.17±0.33) were less than that of Filipino workers [standing height (153.92±8.28), sitting height (79.92±4.50), biacromial breadth (40.24±8.29) and hand breadth (9.23±6.97)] and mean upper arm length (33.09±1.80), and sitting elbow height (22.04±1.70) were more than that of Filipino workers [upper arm length (24.92±8.38) and sitting elbow height (21.89±4.09)] [36].

An analysis of third National Health and Nutrition Examination Survey (NHANES) (1988 to 1994) involving 16000 workers of different occupation was the large scale study done among different occupational groups [37]. This survey study compared measurements between farmers and industrial workers and many more, which showed that mean standing height of agricultural worker (173.3 for male and 159.2 for female) was less than that industrial worker (174.1 for male and 159.7 for female) which was similar to the result of this study for male (157.22 for farmers and 163.68 for industrial workers). But for female, this study result showed that standing height was more in industrial workers (149.44) than that of farmers (147.01). Mean weight of farmer (80.5 for male and 68.7 for female) was also less than that of industrial workers (80.5 for male and 70.4 for female) while in this study weight was more in farmers (63.66 for male and 56.68 for female) than that of industrial workers (59.71 for male and 52.18 for female). Mean biacromial breadth was more in farmers (41.0 in male and 36.2 in female) than in industrial workers (40.9 in male and 36.6 in female) which was similar to the result of this study, more in farmers (40.32 for male and 36.37 for female) than in industrial workers (37.05 for male and 34.57 for female). Mean wrist breadth was also more in farmers (6.03 in male and 5.30 in female) than in industrial workers (5.93 in male and 5.25 in female) which was similar to the finding of this study which showed more wrist breadth in farmers (5.93 in male and 5.33 in female) than in industrial workers (5.92 in male and 5.30 in female). According to the NHANES, upper arm length was found to be more in male farmers (37.8) than in male industrial workers (37.5), and equal in female workers, while in this study this body dimension was found to be more in industrial workers (35.89 in male and 33.08 in female) than in farmers (34.05 in male and 34.29 in female). BMI was more in male farmers, (similar to this study) and less in female farmers than that of industrial worker (opposite of this study). Though we could not present scientific evidence regarding the pattern of variation in anthropometric parameters, it might be due to difference in nutritional, genetic, cultural, climatic and geographical condition of different groups of population and it necessitates the need of population specific workplace and equipment design.

The difference between genders could be due to different in working style between male and female. Females were more likely selected for working by sitting which make them more obese than male. The difference in BMI between the races was accordance with the study done among different ethnic races [37,38].

Summary and Conclusion

Significant differences between the male and female could be useful for designing the equipment according to gender. Comparison among the occupational groups showed that significant differences in parameters were found more between farmers and industrial workers and between farmers and cleaners and helpers and less between industrial workers and cleaners and helpers. The increasing demands for anthropometric information for the design of machinery and personal protective equipment to prevent occupational injuries has necessitated an understanding of the anthropometric differences to be found among different occupations. It is hoped that these data will be used in the improvement of local working conditions and in order to minimize ergonomic problems and related injuries and illnesses like backache, work related stress and CTDs due to mismatch between size of equipments or work place and anthropometric parameters of workers. Providing operator training and using careful preplacement screening to identify high risk employees are also suggested to manage occupation related problems. In this study maternal and gestational history was not considered which are also responsible for variation in anthropometric parameters. There is a need to enlarge the sample size, not only in terms of age range, but also to encompass other occupational groups as their numbers are increasing day to day in the country.

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