

Anthropometric Relation of Neck and Waist Circumference in Non-obese: Implication for the Fashion Industry

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Abstract

The measurement and relation of body proportion is an important guide in clothing fashion industry. There is an assumption in clothing fashion that the circumference of a person's waist is about twice the circumference of the neck. Whether this is true or not is still a subject of debate. Thus the aim of the study is to determine the relationship between the circumference of the neck and circumference of the waist as it relates to clothing fashion industry. A total of 915 (589 males and 326 females) non obese subjects between 18-70 years volunteered for the study. Obese and pregnant subjects as well as subjects with known pathologic conditions that affect body morphology were excluded from the study. The neck and waist circumferences of participants were taken at the upper neck circumference (UNC), middle neck circumference (MNC), lower neck circumference (LNC) and upper waist circumference (UWC), middle waist circumference (MWC) and lower waist circumference (LWC) respectively. In addition, the weight and height of subjects were taken to determine their body mass index (BMI). The data obtained were analysed using Microsoft excel statistical tool version 2010. Pearson's correlation and Coefficient of determination analysis for all correlated aspects of the waist and neck region are as follows; UNC versus UWC ($r=0.70$, $r^2=0.49$, $p<0.05$), MNC versus MWC ($r=0.48$, $r^2=0.23$, $p<0.05$), LNC versus LWC ($r=0.24$, $r^2=0.06$, $p<0.05$), UNC versus MWC ($r=0.46$, $r^2=0.23$, $p<0.05$), UNC versus LWC ($r=0.24$, $r^2=0.06$, $p<0.05$), MNC versus UWC ($r=0.69$, $r^2=0.48$, $p<0.05$), MNC versus LWC ($r=0.23$, $r^2=0.05$, $p<0.05$), LNC versus UWC ($r=0.67$, $r^2=0.44$, $p<0.05$), LNC versus MWC ($r=0.48$, $r^2=0.21$, $p<0.05$). The ratio factor of waist circumference to neck circumference was above 2.00 for all measured parameters. Regression analysis showed that various segments of the neck circumference could be derived from the waist circumference and vice-versa. The upper neck circumference and upper waist circumference showed a stronger and more significant positive correlation and the highest coefficient of determination. The implication is that determining the waist line from the neck line at this point will result in a more fitted cloth. The study showed that while the neck circumference (NC) can be used to estimate the waist circumference (WC), it is not exactly equal to half the circumference of the waist. In addition, the neck circumference can be used to predict the waist circumference better in males.

Keywords

Waist, Neck, Fashion, Anthropometry, Clothing

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1. Introduction

Beyond the provision of one of man's basic need – clothing, the fashion industry is one of the largest employers of labour in the world. These roles, underscore its importance to

mankind. In clothing fashion design, what is popularly referred to as “tailoring” in Nigeria, body measurements are an important part, because it helps to guide tailoring decisions and improve the fit of clothes. However, there seems to be some assumptions and considerable ambiguity in

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the measurements of some parts of the body. One of the assumptions is that if the waist-line of a skirt or trouser is wrapped around the neck and both ends meet, the trouser or skirt would fit the waist. On the other hand, if the ends of the waistline of the trouser or skirt don't meet at the back of the neck, they will be tight and if the waist-line overlaps, they will be oversize. This is practiced in some rural and urban settings of Nigeria when the actual measurement of the body is not possible due to the absence of measuring tools, inadequate time due to shopping rush and religious beliefs. The implication of the assumption is that the circumference of a person's waist is twice the circumference of the neck.

While it can be said that body measurement and proportions are very important to clothing fashion, it seems the anatomical landmarks used are ill-defined. This is contrary to the practice in biological anthropometry where anatomical landmarks are well defined for easy communication as well as reportage of variation in body morphology due to race/ethnicity. For instance it has been speculated that the waistline used in clothing is well below the anatomical waistline [1].

The proportions of the human body vis-à-vis its relations were brought to limelight by the works of Leonardo da Vinci – The Vitruvian man [2]. In both clinical and aesthetic anatomy and medical anthropology, there are several reports of correlation of body proportion such as neck circumference and waist circumference to health status [3] [4] [5] [6] [7] but literature of the relationship of these two parameters as applicable to fashion design are very limited. The available ones tend to platonically verify the assumption that the neck circumference is twice the waist circumference. Tong *et al.* [8], Royston *et al.* [9], Doreen *et al.* [10] and Cindy [11] have documented some reports. While James *et al.* [12] reported a positive, strong and significant relationship between a person's waist and neck, the contrary was reported by Claire *et al.* [13]. A deficiency of each of these researches is the ambiguous assumption of where the neck and waist circumference should be. Anatomically, the parts of the body referred to as the waist and neck are whole regions covering extended areas of the body. While the waist is the part of the abdomen between inferior border of the rib cage and superior border of the iliac crest of the hip bone, the neck is the transitional area between the base of the cranium and superior border of the clavicle [14]. An evaluation of the surface anatomy of these areas will show that circumferential diameter will vary along the various parts of the waist and neck regions.

In view of the limited scientific data to prove the correlation of the neck circumference to waist circumference as used in the fashion industry, as well as the paucity of reliable anthropometry data relevant for aesthetic anatomy in the fashion industry, we set out to determine the following:

Is there a relationship between neck circumference and waist circumference?

Is the neck circumference equal to half the waist circumference?

What part of the region of the neck and waist best correlate with one another?

The information arising from this investigation would be of importance to aesthetic anatomist, medical anthropologist and also provide quantitative information that will ensure a better customer service in the fashion industry.

2. Materials and Methods

2.1. Subjects

A total of 915 (589 males and 326 inclusively) subjects between the ages of 18 to 70 who were predominantly members of the University of Port Harcourt community volunteered for the study. The selection process of the volunteers was through simple random technique. Obese, pregnant as well as subjects with medical conditions that affect body morphology were excluded. The set-up and measurements were done at the Friendship Centre and Fashion home within the University campus. Before measurements were taken, a written informed consent was given by volunteers after the aim and procedure of the study was properly understood by the subjects as explained. The research was approved by the Ethics Committee of the Department of Anatomy, College of Health Sciences, University of Port Harcourt.

2.2. Procedure

To determine if volunteers were not obese or overweight, the body mass index ($BMI = \text{kg/m}^2$) of subjects were obtained using a weighing balance manufactured by Hana and a metre rule manufactured by Helix, X47 in England. The circumferences of the neck and waist were taken at three points noted as upper, middle and lower regions of the neck and waist respectively using an inelastic measuring tape.

Upper neck circumference: With the participant looking straight ahead with relaxed shoulders (not hunched), the measuring tape (levelled and parallel to the floor) was placed around the neck above the Laryngeal prominence (Adam's apple for males), at the soft tissue point of the mento-cervical angle (See figure 1).

Middle neck circumference: The measuring tape was placed at the laryngeal prominence as shown in figure 2.

Lower neck circumference: The tape measure was placed below the laryngeal prominence where the neck joins the thorax (See figure 3).

Upper waist circumference: With the participants standing relaxed and arms by the side, the measuring tape was placed around the abdomen just at the lower border of the ribcage (12th rib) superior to the umbilicus, as shown in figure 4.

Middle waist circumference: The tape measure was placed at the midline around the umbilicus as shown figure 5.

Lower waist circumference: The tape measure was placed at the upper border of the iliac crest inferior to the umbilicus as shown figure 6.



Fig. 1. Measurement of upper neck circumference.



Fig. 2. Measurement of middle neck circumference.



Fig. 3. Measurement of lower neck circumference.

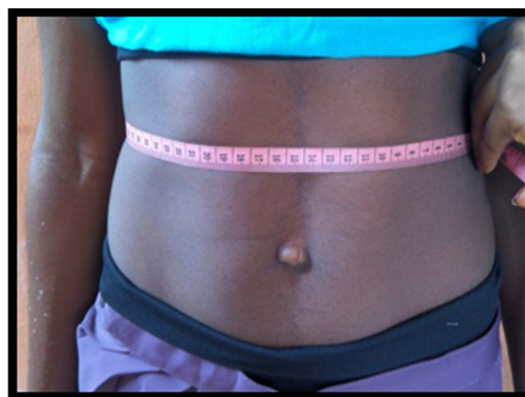


Fig. 4. Measurement of upper waist circumference.



Fig. 5. Measurement of middle waist circumference.



Fig. 6. Measurement of lower waist circumference.

The values obtained for each subject were taken thrice and the mean recorded. Measurements were taken at the end of the subjects' normal relaxed exhalation and the tape was placed horizontally as anatomically feasible i.e the tape line in front of the neck and waist were at the same height as the tape line at the back of the neck and waist.

2.3. Data Analysis

The data obtained were analysed using Excel statistical tool (version 2010). The percentages, mean, standard deviation, standard error and variance of data are presented in tables and bar chart for easy interpretation. Pearson's correlation

and the t-test of correlation at 0.05 levels of significance were done. In addition, regression analysis and ratio factor of waist to neck circumference were determined

3. Results and Discussion

The result of the study is shown in figure 7 and tables 1-10 below. Figure 7 shows the average values for measured parameters irrespective of sex. These values were 24.90±0.19 yrs, 34.81±0.10 cm, 34.81±0.09 cm, 35.60±0.09 cm, 74.19±0.17 cm, 75.84±0.17 cm, 78.54±0.16 cm, 63.70±0.25 cm, 1.69±0.003 m, 22.18±0.06 kg/m² for age, UNC, MNC, LNC, UWC, MWC, LWC, Wt, Ht and BMI respectively. Tables 1 and 2 showed the descriptive statistics for measured parameters for male and females subjects.

Pearson's correlation test for all subjects indicates that UNC versus UWC and MNC versus UWC had the highest correlation values of 0.70 and 0.69 respectively. These values were also significant ($p < 0.05$), while the weakest correlation was between MNC versus LWC with a correlation value of 0.23 (table 2). The result showed irrespective of gender, there are varying correlations between the various segments of the neck and waist circumferences. However, the correlation between the UNC and UWC is the strongest, while those among LNC versus LWC, UNC versus LWC and MNC versus LWC were very weak. The implication is that cloth fitness design based on proportional estimation using the three later segments may fit sparingly or need further adjustment.

Based on gender, UNC versus UWC and MNC versus UWC had the highest correlation value of 0.52 for males (table 3). For the females, the correlation value of UNC versus UWC was the highest (table 4). On the whole, females had lower correlation values compared to males. Dorren and associates [10] made similar observation. They reported the association between the circumference of the neck and half the waist is stronger for males compared to females. A probable reason may be the preferential deposition of fat around the hip and gluteal regions. It is common knowledge that females' hormone such as progesterone and oestrogen in particular play a major role in the fat distribution in females [15].

On the average, the ratio factor of waist to neck circumference was above 2.00 in all correlated segments of the waist and neck. The implication is no circumference of

the neck is exactly two times that of the waist. However, the ratio factor was low for UNC versus UWC, LNC versus MWC and UWC versus LNC a further indication that measurements estimated from these segments would produce better fitted clothes. Similar observations were made by Tong *et al.* [8] and James *et al.* [12]. Tong and associates [8] in their statistical illustrative work titled 'Predictor of waist length with Neck circumference' showed the waist circumference was not exactly double of the neck circumference. The waist circumference was shown to be about 2.28 times of the neck circumference. James and associates [12] also reported the relationship between waist and neck circumference was linked by a factor of 2.984. The reported proportion for these parameters were actually high compared to our study. Two reasons may be adduced for this. Firstly, the waist circumference was taken at the transumbilical plane of the abdomen, where increase in abdominal fat may lead to undue increase in the circumference. The point of transition between the waist and the hip can pose a little difficulty to individuals not trained in the anatomy of the body. Secondly, the predictability of waist to neck circumference is affected by gender.

Another serious index that may affect the predictability of neck to waist ratio in clothing fashion industry is pronounced ethnic variation in the waist to hip ratio. These variations could be attributed to genetic and environmental factors. For instance, most population indigenous to Sub-Sahara Africans tend to have a high waist to hip ratio which is more pronounced in the females.

Pearson's coefficient of determination is shown in tables 6-8. It was 49% for all subjects at UNC versus UWC, 28% for females at UNC versus UWC and 27% for males at UNC versus UWC and MNC versus UWC respectively. The positive and significant correlation or relationship between all measured parameters showed to some extent that any region of the neck could be used to predict the waist. But the predictability would be seriously reduced in correlating parameters that have a coefficient of determination of less than 0.2.

Furthermore, regression analyses provide equations for the determination of the neck circumference from the waist and vice-versa for the various segment of the waist and neck region (see tables 9-10).

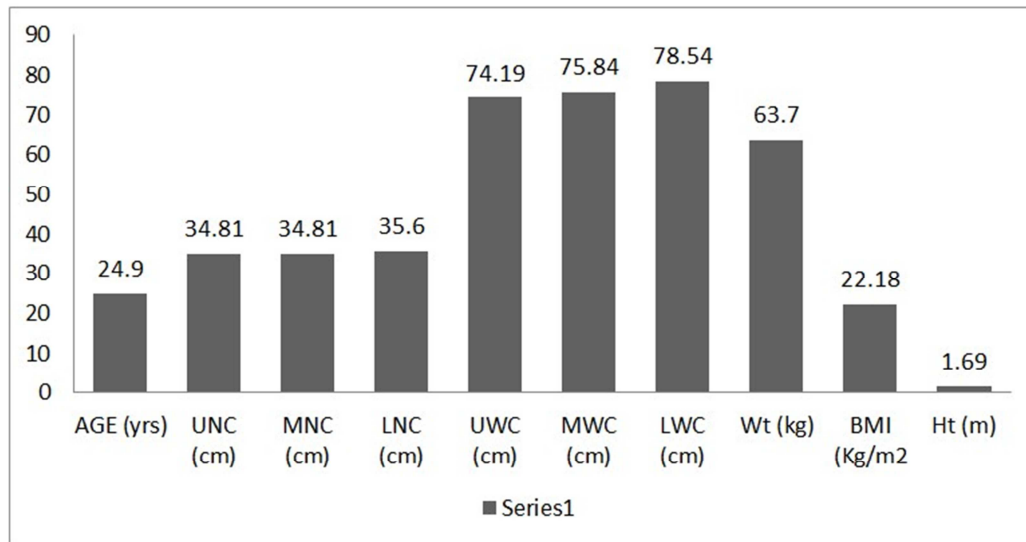


Figure 7. Mean values for measured parameters irrespective of sex.

Table 1. Descriptive statistics of measured parameters based on sex.

Parameters	Sex	N	Mean	SE	SD	Var	Minv	Maxv
AGE (yr)	M	587	25.74	0.24	5.93	35.12	18.00	70.00
	F	326	23.37	0.29	5.14	26.52	18.00	59.00
UNC (cm)	M	587	36.53	0.08	1.91	3.64	29.00	43.00
	F	326	31.71	0.10	1.75	3.07	27.50	39.00
MNC (cm)	M	587	36.41	0.07	1.81	3.26	29	42.00
	F	326	31.92	0.10	1.79	3.21	27.50	38.50
LNC (cm)	M	587	37.07	0.07	1.83	3.34	29.50	42.00
	F	328	32.95	0.10	1.85	3.43	28.00	40.00
UWC (cm)	M	587	76.29	0.18	4.42	19.50	61.50	90.00
	F	326	70.39	0.24	4.40	19.36	61.00	89.00
MWC (cm)	M	587	76.87	0.20	4.81	23.12	62.00	91.00
	F	326	73.99	0.27	4.89	23.97	61.00	92.50
LWC (cm)	M	587	78.57	0.20	4.91	24.14	64.00	93.00
	F	326	78.50	0.28	5.09	25.95	65.50	102
Wt (cm)	M	587	66.72	0.28	6.72	45.22	45.00	86.00
	F	326	58.27	0.34	6.14	37.68	44.00	76.00
Ht (m)	M	587	1.73	0.003	0.07	0.01	1.54	1.94
	F	326	1.62	0.003	0.06	0.004	1.47	1.83
BMI (kg/m ²)	M	587	22.21	0.07	1.68	2.84	17.96	24.93
	F	326	22.13	0.09	1.76	3.08	17.96	24.99

Key: F = females, M = males, N = sample size, SEM = standard error of mean, SD = standard deviation, Var = Variance, MinV = minimum value, MaxV = Maximum value, LWC = lower waist circumference (cm), MWC = middle waist circumference (cm), UWC = Upper waist circumference (cm), LNC = lower neck circumference, MNC = middle neck circumference (cm), UNC = upper neck circumference (cm), BMI = body mass index Kg/m²

Table 2. Pearson's correlation (r) and correlation test irrespective of sex.

Parameters	Pearson Correlation value (r)	Calculated t score for correlation value	Critical t score at 0.05 level	Inference
UNC vs UWC	0.70	29.41	1.98	Positive correlation is significant (p<0.05)
MNC vs MWC	0.48	16.38	1.98	Positive correlation is significant (p<0.05)
LNC vs LWC	0.24	7.40	1.98	Positive correlation is significant but weak (p<0.05)
UNC vs MWC	0.46	16.33	1.98	Positive correlation is significant (p<0.05)
UNC vs LWC	0.24	7.34	1.98	Positive correlation is significant but weak (p<0.05)
MNC vs UWC	0.69	29.07	1.98	Positive correlation is significant (p<0.05)
MNC vs LWC	0.23	7.26	1.98	Positive correlation is significant but weak (p<0.05)
LNC vs UWC	0.67	26.91	1.98	Positive correlation is significant (p<0.05)
LNC vs MWC	0.46	15.67	1.98	Positive correlation is significant (p<0.05)

Table 3. Pearson's correlation (r) and correlation test for male subjects.

Parameters	Pearson Correlation value ®	Calculated t score for correlation value	Critical t score at 0.05 level	Inference
UNC vs UWC	0.52	14.84	1.98	Positive correlation is significant (p<0.05)
MNC vs MWC	0.48	13.26	1.98	Positive correlation is significant (p<0.05)
LNC vs LWC	0.40	10.61	1.98	Positive correlation is significant (p<0.05)
UNC vs MWC	0.47	12.88	1.98	Positive correlation is significant (p<0.05)
UNC vs LWC	0.42	11.12	1.98	Positive correlation is significant (p<0.05)
MNC vs UWC	0.52	14.63	1.98	Positive correlation is significant (p<0.05)
MNC vs LWC	0.43	11.38	1.98	Positive correlation is significant (p<0.05)
LNC vs UWC	0.47	12.81	1.98	Positive correlation is significant (p<0.05)
LNC vs MWC	0.43	11.56	1.98	Positive correlation is significant (p<0.05)

Table 4. Pearson's correlation (r) and correlation test for female subjects.

Parameters	Pearson Correlation value (r)	Calculated t score for correlation value	Critical t score at 0.05 level	Inference
UNC vs UWC	0.53	11.31	1.98	Positive correlation is significant (p<0.05)
MNC vs MWC	0.34	6.64	1.98	Positive correlation is significant but weak (p<0.05)
LNC vs LWC	0.24	4.51	1.98	Positive correlation is significant but weak (p<0.05)
UNC vs MWC	0.37	7.22	1.98	Positive correlation is significant but weak (p<0.05)
UNC vs LWC	0.28	5.32	1.98	Positive correlation is significant but weak (p<0.05)
MNC vs UWC	0.52	10.91	1.98	Positive correlation is significant (p<0.05)
MNC vs LWC	0.24	4.39	1.98	Positive correlation is significant but weak (p<0.05)
LNC vs UWC	0.48	9.78	1.98	Positive correlation is significant (p<0.05)
LNC vs MWC	0.34	6.46	1.98	Positive correlation is significant but weak (p<0.05)

Table 5. Ratio factor of waist circumference to neck circumference.

Parameters	Males	Females	Both
UNC vs UWC	2.088	2.220	2.131
MNC vs MWC	2.111	2.318	2.131
LNC vs LWC	2.120	2.382	2.193
UNC vs MWC	2.104	2.333	2.131
LWC vs UNC	2.151	2.476	2.256
UWC vs MNC	2.095	2.205	2.131
LWC vs MNC	2.158	2.459	2.256
UWC vs LNC	2.058	2.136	2.072
MWC vs LNC	2.074	2.246	2.072

Table 6. Pearson's correlation for coefficient of determination (r^2) irrespective of sex.

Parameter	Coefficient of determination	Inference
UNC vs UWC	0.49	49% of the variability of UNC is due to the variance of UWC
MNC vs MWC	0.23	23% of the variability of MNC is due to the variance of MWC
LNC vs LWC	0.06	6% of the variability of LNC is due to the variance of LWC
UNC vs MWC	0.23	23% of the variability of UNC is due to the variance of MWC
UNC vs LWC	0.06	6% of the variability of UNC is due to the variance of LWC
MNC vs UWC	0.48	48% of the variability of MNC is due to the variance of UWC
MNC vs LWC	0.05	5% of the variability of MNC is due to the variance of LWC
LNC vs UWC	0.44	44% of the variability of LNC is due to the variance of UWCs
LNC vs MWC	0.48	48% of the variability of LNC is due to the variance of MWC

Table 7. Pearson's correlation for coefficient of determination (r^2) for male subjects.

Parameter	Coefficient of determination	Inference
UNC vs UWC	0.27	27% of the variability of UNC is due to the variance of UWC
MNC vs MWC	0.23	23% of the variability of MNC is due to the variance of MWC
LNC vs LWC	0.16	16% of the variability of LNC is due to the variance of LWC
UNC vs MWC	0.22	22% of the variability of UNC is due to the variance of MWC
UNC vs LWC	0.17	17% of the variability of UNC is due to the variance of LWC
MNC vs UWC	0.27	27% of the variability of MNC is due to the variance of UWC
MNC vs LWC	0.18	18% of the variability of MNC is due to the variance of LWC
LNC vs UWC	0.22	11% of the variability of LNC is due to the variance of UWC
LNC vs MWC	0.19	19% of the variability of LNC is due to the variance of MWC

Table 8. Pearson's correlation for coefficient of determination (r^2) for female subjects.

Parameter	Coefficient of determination	Inference
UNC vs UWC	0.28	28% of the variability of UNC is due to the variance of UWC
MNC vs MWC	0.12	12% of the variability of MNC is due to the variance of MWC
LNC vs LWC	0.06	6% of the variability of LNC is due to the variance of LWC
UNC vs MWC	0.14	14% of the variability of UNC is due to the variance of MWC
UNC vs LWC	0.08	8% of the variability of UNC is due to the variance of LWC
MNC vs UWC	0.27	27% of the variability of MNC is due to the variance of UWC
MNC vs LWC	0.06	6% of the variability of MNC is due to the variance of LWC
LNC vs UWC	0.23	23% of the variability of LNC is due to the variance of UWC
LNC vs MWC	0.11	11% of the variability of LNC is due to the variance of MWC

Table 9. Regression Analysis for the correlation of Neck and waist circumferences of all subjects.

Parameter	Regression Equation
UNC/UWC	$Nc = 1.2326*(wc) + 31.275$
MNC/MWC	$Nc = 0.8548*(wc) + 46.085$
LNC/LWC	$Nc = 0.4386*(wc) + 62.931$
UNC/MWC	$Nc = 0.8072*(wc) + 47.739$
UNC/LWC	$Nc = 0.3966*(wc) + 64.739$
MNC/UWC	$Nc = 1.2947*(wc) + 29.114$
MNC/LWC	$Nc = 0.4149*(wc) + 64.101$
LNC/UWC	$Nc = 1.2894*(wc) + 28.278$
LNC/MWC	$Nc = 0.8572*(wc) + 45.321$

Nc = neck circumference, wc = waist circumference

Table 10. Regression Analysis for the correlation of Neck and waist circumferences of male and female subjects.

Parameters	Regression Equation	
	Males	Females
UNC/UWC	$Nc = 1.2102*(wc) + 32.075$	$Nc = 1.3305*(wc) + 28.203$
MNC/MWC	$Nc = 1.2771*(wc) + 30.367$	$Nc = 0.9412*(wc) + 43.94$
LNC/LWC	$Nc = 1.0771*(wc) + 38.637$	$Nc = 0.6636*(wc) + 56.633$
UNC/MWC	$Nc = 1.185*(wc) + 33.572$	$Nc = 1.0349*(wc) + 41.174$
UNC/LWC	$Nc = 1.0765*(wc) + 39.241$	$Nc = 0.8194*(wc) + 52.521$
MNC/UWC	$Nc = 1.2619*(wc) + 30.344$	$Nc = 1.2678*(wc) + 29.913$
MNC/LWC	$Nc = 1.1576*(wc) + 36.42$	$Nc = 0.6699*(wc) + 57.115$
LNC/UWC	$Nc = 1.1218*(wc) + 34.701$	$Nc = 1.1286*(wc) + 33.198$
LNC/MWC	$Nc = 1.1283*(wc) + 35.036$	$Nc = 0.8878*(wc) + 44.732$

Nc = neck circumference, wc = waist circumference

4. Conclusion

The present study has evaluated the relation of the neck circumference to waist circumference with respect to its application in the fashion industry. Fashion is a major factor in socio-cultural life of a people. Beyond this, it has been noted to play a key role in the early industrialization of many countries with attendant improvement in the economy and creation of job opportunities. For instance, global textile export contributed a historical 1.2 trillion US dollars to world economy [16]. Trends and innovations in the fashion industry are mainly the handiwork of tailors and dressmakers who couple glamour and style with the fitness of clothes. Thus for

proper fitness, the understanding of body measurements and proportion is indispensable. This is much so with the large scale of production of clothes in one country for use in another country.

For the neck and waist circumference, we can conveniently conclude by answering the questions raised earlier. Is there a relationship between neck circumference and waist circumference? The obvious answer is yes. The implication is that any segment of the neck-line can be used to determine the waist-line for clothes. As to whether if the waist circumference is equal to twice the neck circumference? The answer is no. The waist circumference is slightly above two times the neck circumference. The result from the study showed that estimation of clothes dimension from the upper segment of the neck and upper segment of the waist would give a better fit.

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