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Evaluation of Body Movement and Mobility of Sustainable Functional Apparel Developed for Female Fishmongers using Bernina My Label 3D Software in Aba, Nigeria.

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Abstract
The research work centred on Evaluation of Body Movement and Mobility of Sustainable Functional Apparel developed for Female Fishmongers using Bernina My Label 3D Software in Aba, Nigeria. Two research objectives, two research questions and two hypotheses guided the study. The study area was Abia State, Nigeria. The Research design employed was descriptive survey. The population was 438 fishmongers and 109 respondents that served as judges. A multi-stage technique was adopted at different stages of data collection. The sample size was 209 for fishmongers, and 85 for judges. Two sets of instruments were used for data collection. Descriptive statistics like frequency, mean and standard deviation were used to analyse research questions while Analysis Variance was used to test the hypotheses at .05 level of significance. The findings revealed that the female fishmongers and judges scored the functional apparel very good with mean above 3.00 on all the body movement and mobility attributes. There was no significant difference in the mean ratings of fishmongers and judges on small, medium and large sized based users on body movement and mobility attributes of the functional apparel. It was concluded that the engineered apparel design for female fishmongers granted the users easy body movement and mobility while carrying out their duties. It was therefore recommended among others that pattern making software should be used by lecturers and apparel designers in developing work wear that will enhance requirement of functional apparel.

Keywords: Pattern, Mobility, Attributes, Sustainable, Functional, Apparel, Design, CAD, and Fishmongers.

Introduction

Developing pattern is the technique of working with a 2D medium block which helps in making garments to drape a 3D body to achieve the desired fit with optimum utilization of resources (Anaud, 2011). The key components influencing pattern development are body shape, garment fit, fabric properties, garment assembling techniques and end use (Mazharul,

2021). Pattern development for functional apparel involves applying technical, scientific and mathematical knowledge with the objective of developing an apparel which meets the function specific requirements that is comfortable to wear and contributes to maximize the efficiency and performance of the wearer (Kibrom, 2019). Over the last twenty years, most industries have seen a transition from traditional product development that was local, face to face and sequential to one that is more global, more virtual and more concurrent (Eppinger and Chitkara, 2006). Therefore, fashion industries are faced with the challenge of product development using modern equipment and at the same time making it a sustainable fashion.

Sustainable fashion should address the emotional, expressive, and physical qualities that garments can provide for consumers, meeting needs and desires, the resulting satisfaction leads to greater use and a longer functioning cycle (Hethorn, 2009). Sustainable fashion refers to clothing that is designed, manufactured, distributed and used in ways that are environmentally friendly (Dreamer, 2019). Riyajain, (2021) sees sustainable fashion as a fashion concept that is friendly for the environment and society at large from concept through the chain of apparel production that is a part of the chain in apparel production. Apparel production that used to be a manual process from a designer producing a concept sketch to drafting the patterns by hand and then to final construction of a sample garment has now graduated to a digital process. Digital process involves the use of extensive Computer Aided Design (CAD) tools to create a standard set of patterns for different apparel design. Computer Aided Design is the use of computer technology for the process of design and design documentation (Palak, 2014). It provides the users with input tools for the purpose of streamlining design, documentation and pattern drafting (Yaw, 2013 and Bilalis, 2000).

Pattern drafting software is a computer program that enables one to input desired measurements and print out a required pattern. Bernina My Label 3D Pattern software (see Fig:1) is an example Computer Aided Design (CAD) based pattern drafting technology that also simulates (Jan,2009). The programs draft pattern to fit the inputted measurements. Specifically, reducing much fitting trial and error in the sewing room (Smith,2009). Bernina My Label 3D software simulates the body shape on the screen and puts onto the body anything that you choose from their basic drawer. Once the user inputs the desired measurements, the 3D dress forms avatar morph into body size reflection of the user. There is provision for pattern modification available for users to shorten, lengthen, widen, and narrow the existing styles. The software was used in developing the functional apparel for the female fish mongers.

Functional Apparel is defined as user-requirement specific and designed to meet the performance requirement of the user under extreme conditions while performing their duties (Gupta, 2011). Challenges associated with handling of tools, lifting up objects, bending, skin irritation, demands apparel design that does not impede movement. An understanding of the body's dynamic action and function is very essential to design and evaluate clothing that conformed to dynamic body motions (Ashdown, 2010). Functionality in apparel determines

its usability performance. Apparel, by its nature has a restrictive effect on body movement as well as on transport of heat and moisture from the body (Nzuta, 2017). Functional apparel serves as a protection and convenient workwear that will enable the user's free movement Movement starts with a change in position to anatomical position, which refers to the relaxed standing position with arms at sides and palms facing out (Thompson, 2010; Holland 2007). Therefore, from functional design perspective body movements are intrinsically necessary for wearers to perform required tasks without being impeded by the apparel. During movement the body expands and contracts and at certain joint the range of movements in more extensive in one or more direction and clothing accommodates that expansion and contraction best if it follows the same patterns.

Mobility in apparel design can also be created by shaping the cut of the apparel to the natural contour of the body and incorporated using stretch panels, adjustable further and other design details. (Anand, 2011 and Sihong, 2013). The designer of functional apparel needs to find solution on how the apparel can provide adequate level of protection required as well as the level of movement. An analysis of the movements while performing on the job tasks must be ascertained and this can be achieved in diverse ways like through observation, photographic analysis, questionnaires, survey and interviews (Boorady, 2011). Choi and Ashdown (2002) pointed out that ease of movement without stress or strain from apparels may lead to improved work efficiency. Therefore, satisfaction with designated apparel for female fishmongers may also enhance performance.

Female Fishmongers require better work clothing against environmental hazards at the same time the clothing has to meet the requirement of functional clothing which include movement and mobility. Fishmongers are people that prepare and sell fish products, iced or un-iced to members of the public. They have a deep understanding of the fish species, preparation methods and detailed product knowledge (Crown, 2016). In the context of this study, fishmongers are people that sell iced or frozen fish only. Studies carried out by Adebayo and Pitman (2017) revealed that the major marketers of frozen fish are women, therefore attention should be given to their role while discharging their duties in diversified mediums. Women have been reported to play a vital role in processing and marketing fish (Olufayo, 2012 in Cloffe and Akinrotimi, 2015). These women are trained in selecting and purchasing, handling, gutting, cutting, filleting, displaying, merchandizing and selling their product. Some operate in shops, markets and streets and engage in various movement like lifting up hands, bending, climbing etc.

It has been observed that female fishmongers in Abia state market do not wear appropriate clothing that guarantees unrestrained movement of various parts of the body when discharging their duties. Furthermore, research works like the development of functional apparel for cosmetologists in Lagos, Nigeria (Thompson, 2010) and the development of functional laboratory coat for clothing and textile students in tertiary institutions in the south-east zone of Nigeria (Ugwu, 2010) have been carried out in Nigeria on the development of prototype for functional apparel using other techniques without embracing the technological advancement of using pattern software apparel design issues.

Based on this gap, a functional apparel was developed for this target group using Bernina My Label 3D software on three size categories of small, medium and large. Therefore, this study was tailored towards the evaluation of body movement and mobility attributes of the developed sustainable functional apparel for female fishmongers using Bernina My Label 3D software in Aba, Nigeria.

Objectives of the Study: The purpose of the study was the evaluation of body movement and mobility attributes of the developed sustainable functional apparel for female fishmongers using Bernina My Label 3D software in Aba, Nigeria. Specifically, the study:

1. determined the mean ratings of female fishmongers on body movement and mobility attributes on small, medium and large size based of the developed functional apparel.
2. determined the mean ratings of judges on mobility attributes on small, medium and large size- based users of the developed functional apparel.

Research Questions:

1. What are the mean ratings of female fishmongers on body movement and mobility attributes on small, medium and large size -based user of the developed apparel?
2. What are the mean ratings of judges on the mobility attribute on small, medium and large size- based user of the developed functional apparel?

Null Hypotheses

The following hypotheses were tested at the 0.05 level of significance:

H_{O1}: There is no significant difference in the mean ratings of the nine models on small, medium and large size- based users on the body movement and mobility attributes required of functional apparel.

H_{O2}: There is no significant difference in the mean ratings of judges on small, medium and large size-based users on movement and mobility attributes required of functional apparel.

Methodology

This work was a research and development study that employed the Research and Development design by Gall, Gall and Borg (2010). In addition to the design process, descriptive survey design was adopted for the study as a technique for obtaining data from respondents through the use of questionnaire. The study was carried out in Abia State in South –Eastern Nigeria which was created on 27th August, 1991 out of the old Imo State. It occupies a land area of about 5, 243.7 square kilometers (NGEX, 2013). It has common boundaries with Ebonyi and Enugu States to the north, River state to the south and south-west Cross River and Akwa Ibom States to the east and south east respectively. Abia State has seventeen (17) Local Government Areas (LGA). The capital is in Umuahia. It has three senatorial districts. Abia state was selected for the study because the senatorial districts are

business oriented. Also, markets where women sell iced fish are located in the different Local Government Areas. This aided the researcher in having female fishmongers available for the evaluation.

The total population for the study was five hundred and forty seven (547) which was made up of four hundred and thirty eight (438) registered fishmongers, seventeen excos of fishmongers, twenty four (24) Home Economics lecturers, and sixty eight (68) functional apparel producers that served as judges. The sample size for the study was 294. Two hundred (200) were female fishmongers, nine (9) were models that fit within three sized categories of small, medium and large served as the models and was eight five (85) were judges that evaluated the fit of the developed prototype. A multi-stage technique was adopted at different stages of sample selection in order to meet the different research interests and needs of the female fishmongers' sample for the study. The sample size was determined statistically using Taro Yamane (1967) in Rafael (2014) formula.

Two different instruments were used for data collection in the study. Functional Apparel Design Assessment Instrument for Fishmonger (FADAF) and Functional Apparel Design Assessment Instrument for Judges (FADAJ). The FADAF instrument created enabling situation for the female fishmongers to express how the work apparel fits them on the attribute of movement and mobility. Functional Apparel Design Assessment Instrument for Judges (FADAJ) gave the researcher information on how the Home Economics Lecturers, Functional apparel producer and female fishmonger exco officials evaluated the fit of the work apparel on mobility attribute. The instrument of the study was subjected to face validation by five experts, three from Home Economics Department, University of Uyo, two from Department of Home Science, Michael Okpara University of Agriculture, Umudike. These experts were asked to review the items in the instrument for clarity, relevance, appropriateness of language and expressions including appropriateness of the instructions to the respondents. Modifications were made to accommodate the suggestions made by the experts. These instruments are standardized instruments adapted from Fowler (2003) and Barker (2007).

The Evaluative Instruments were pilot-tested on six models and twenty judges before conducting the main study, and reliability values were obtained for the two groups of evaluators. Three female fishmongers were chosen specifically as models from a group of fishmongers who fit into the prototype functional apparel sizes of small, medium and large designed for the preliminary testing procedures. These models and the judges rated the functional prototype apparel. Data obtained were used to determine the internal consistency of the instruments. The reliability was established using Cronbach coefficient alpha to determine the reliability coefficient. The reliability coefficients were .82 and .77.

Development Procedures of the functional apparel using Bernina My Label 3D Software.

The researcher switched **o**n the computer and plug my label software, selected the garment style, clicked on the style drawer in the studio box on the left side of the screen, a

window opens presenting a list of styles along with corresponding thumbnail illustrations and clicked on the three quarter coats (see Fig:3) which automatically brought the style pattern pieces onto the work table (see Fig:2). The researcher input the measurement of three sized based categories of small, medium and large categories. By default, the style measurements conform to the measurements that one has determined for the model. At this stage the functional ease allowance of 17cm (Boorady,2011) was added to the mean bust measurements, all measurements in centimetre. The patterns were dressed and undress on the 3D model as many times by the researcher until the desired reflection was achieved. The dressed 3D model was simulated virtually to check if it impedes body movement. When the researcher was satisfied with the virtual simulation, the patterns were saved and sent to the printer that met the specifications of the software. The printed patterns have their pattern symbols on them indicating their various size categories small, medium and large. The researcher joined and cut out all the pattern pieces front cut two, side front, cut two, back, cut two, side back, cut two, under sleeve, cut two. The pattern pieces were lay and all the pattern marks transferred to the fabric. Design specifications and criteria for selection was strictly adhered to in the prototype apparel construction. The production of the apparel was carried out by the researcher using generally acceptable sewing techniques adopted after Armstrong (2010) and Bernina My Label (2007). The unit construction method was adopted in the construction of the female fishmonger's apparel. Each garment section was handled as a unit to be completed to the greatest extent possible before being attached to other garment sections.

Fig 1: Bernina My Label Software

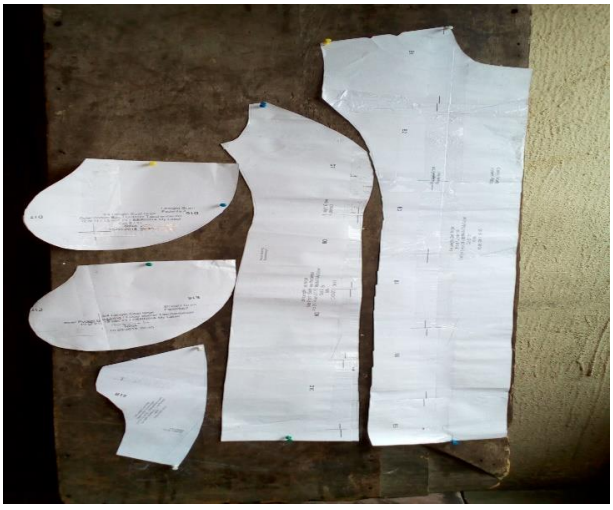

Fig 2: Drafted patterns of the Apparel

Fig 3: Three quarter coat

Fig 4: Bending movement

Fig 5: Carton lifting and walking.

Fig 6: Arm movement

Source: Development and testing of functional apparel using CAD (Nwonye,2019).

Evaluation of the Functional Apparel: The research assistants, female fishmongers, models and judges were given instructions prior to the collection of data for the study. The nine (9) models in three sets of small, medium and large were given the apparel to perform task in a field setting and to rate the prototype apparel function and performance on the parameters outlined for evaluation. The rating of the functional apparel on each of the models was also done by the female fishmongers, and judges. A set of copies of the FADAF and FADAJ instrument was given to each of the groups for scoring the mobility attribute of the apparel representing, small, medium and large size category. The copies of the questionnaire were returned at the closure of the exercise.

Method of Data Analysis: Descriptive statistics of frequencies, mean and standard deviation were used to answer the research questions. Analysis of variance (ANOVA) was used to test hypotheses at 0.05 level of significance.

Result

Research Question1: What are the mean ratings of female fishmongers on body movement and mobility attributes of the developed functional apparel**?** To answer this research question, Tables 1 and 2 was used

Table 1: Mean rating of female fishmongers on Body Movement *n = 200*

S/N	Items	x	SD	Remark
1	Kneeling	4.51	.532	Very easy
2	Body bend	4.58	.521	Very easy
3	Overhead aim extension	4.32	.689	Easy to do
4	Torso twists	4.01	.892	Easy to do
5	Cross body arm reaches	4.22	.736	Easy to do
6	Walking	4.38	.681	Easy to do
7	Carton lifting	4.02	.811	Easy to do
8	Stair climbing	3.60	.920	Easy to do
9	Sitting on chair	4.08	.781	Easy to do
10	Climb up to the fifth rung of the ladder	3.51	.961	Easy to do
	Cluster mean	**4.12**	**0.752**	**Easy to do**

Table 1 shows the mean rating of fishmongers on parameters required of functional apparel with the cluster mean of 4.12, which is above the satisfactory level. This shows that the various body movements were carried out easily by fishmongers. This clearly indicates that the functional apparels did not impede the movements of fishmongers during assessment.

Table2: Mean rating of female fishmongers on mobility of functional apparel *n = 200*

S/N	Items	x	SD	Remark
1	Free movement of arm/rest/Restricted	4.16	.589	Very good
2	Free movement of torso/Restricted	4.27	.722	,, ,,
3	Free movement of leg/Restricted	4.72	.566	Excellent
4	Ease of movement /Restricted	4.64	.578	,, ,,
	Cluster mean	**4.45**	**.61**	Very good

Table 2 showed the summary of the mean ratings of female fishmongers on (small, medium and large) mobility variables regarding the functional apparel. Each item was scored for each adjective set. All of the four adjective sets received positive mean ratings scores, it shows that female fishmongers experience appropriate ease of movement on all the body parts when they move with the prototype apparel.

Research Question 2: What are the mean ratings of judges on the mobility attribute on small, medium and large size- based user of the developed functional apparel?

Table 3: Summary of the mean rating of judges on mobility of functional apparel *n = 85*

S/N	Items	x	SD	Remark
1	Free movement of arm	4.31	.548	Very good
2	Free movement of torso	3.33	.596	Good
3	Free movement of legs	3.78	.791	Very good
4	Ease of movement	4.59	.585	Excellent
	Cluster mean	**4.00**	**.63**	**Very good**

Data contained in Table 3 indicated the overall mean ratings of three groups of judges. The judges rated the functional apparel when the models wore it to perform some movements. All the four items in the mobility rating had high positive mean ratings of above 3.00.

Null hypothesis 1: There is no significant difference in the mean ratings of the models on small, medium and large size- based users on movement and mobility attributes of the developed functional apparel. Tables 4 and 5 gave answers to null hypothesis1

Table 4: One-way analysis of variance of the models on small, medium and large size based users on movement required of functional apparel n=9

S/N	Item	Source of Variation	Sum of Squares	df	Mean Square	F	P-Sig.	Decision
1	Kneeling	Between Groups	.471	2	.236	.509	.602	NS
		Within Groups	4.830	6	.805			
		Total	5.301	8				
2	Body bend	Between Groups	.516	2	.258	.245	.783	NS
		Within Groups	47.232	6	1.205			
		Total	47.748	8				
3	Overhead aim extension	Between Groups	1.184	2	.592	1.061	.349	NS
		Within Groups	8.061	6	1.344			
		Total	9.245	8				
4	Torso twists	Between Groups	.086	2	.043	.121	.886	NS
		Within Groups	9.523	6	1.587			
		Total	9.608	8				
5	Cross body arm reaches	Between Groups	.038	2	.019	.032	.969	NS
		Within Groups	3.934	6	.656			
		Total	3.972	8				
6	Walking	Between Groups	1.007	2	.504	1.092	.338	NS
		Within Groups	4.545	6	.758			
		Total	5.552	8				
7	Carton lifting	Between Groups	.522	2	.261	.317	.490	NS
		Within Groups	.933	6	.156			
		Total	1.455	8				

8	Stair climbing	Between Groups	1.184	2	.592	1.284	.280	NS
		Within Groups	4.551	6	.759			
		Total	5.734	8				
9	Sitting on chair	Between Groups	.027	2	.013	.045	.956	NS
		Within Groups	2.043	6	.341			
		Total	2.070	8				
10	Climb up to the fifth rung of the ladder	Between Groups	.561	2	.281	.058	.345	NS
		Within Groups	6.412	6	1.068			
		Total	6.973	8				
	Cluster value					**.476**	**.600**	**NS**

The result represented in Table 4 showed the summary of one-way analysis of variance on the difference in the mean ratings of models on small, medium and large size-based users on movement required of functional apparel. The result shows no significant differences in the ten items tested On the whole, since the P-significant value of .600 was higher than the alpha at .05 level of significance, the null hypothesis which stated that there is no significant difference in the mean ratings of the models on small, medium and large size based users on parameter required of functional apparel is therefore retained.

Table 5: One-way analysis of variance of difference in the mean ratings the models on small, medium and large size-based users on mobility required of functional apparel n=9

S/N	Item	Source of Variation	Sum of Squares	df	Mean Square	F	P-Sig.	Decision
1	Free movement of arm	Between Groups	1.000	2	.500	.061	.523	NS
		Within Groups	7.010	6	1.168			
		Total	8.010	8				
2	Free movement of torso	Between Groups	.960	2	.48	.471	.636	NS
		Within Groups	5.110	6	.852			
		Total	6.070	8				
3	Free movement of legs	Between Groups	.816	2	.408	.234	.360	NS
		Within Groups	6.412	6	1.069			
		Total		8				
4	Ease of movement	Between Groups	.961	2	.481	.261	.344	NS
		Within Groups	5.601	6	.934			
		Total		8				
	Cluster value					**.257**	**.466**	**NS**

Table 5 showed that the p-value for all the variables used in the assessment of mobility in functional apparel greater than .05 Alpha. The cluster value of P=-.466 implies that the hypothesis which states, there is no significant difference in the mean ratings of the models on small, medium and large size -based users on mobility of functional apparel is therefore retained

Null Hypothesis 2: There is no significant difference in the mean ratings of judges on small, medium and large size- based users on movement and mobility attributes

of the developed functional apparel. Tables 6 and 7 gave answers to null hypothesis1

Table 6: One-way analysis of variance of difference in the mean ratings of judges on small, medium and large size- based users on movement required of functional apparel

n = 85

S/N	Item	Source of Variation	Sum of Squares	df	Mean Square	F	P-Sig.	Decision
1	Tightness of neckline	Between Groups	1.010	2	.505	.501	.711	NS
		Within Groups	87.610	82	1.068			
		Total	88.620	84				
2	Armhole pinching	Between Groups	1.000	2	.500	.020	.317	NS
		Within Groups	86.101	82	1.050			
		Total	87.101	84				
3	Fit of shoulder area	Between Groups	1.102	2	.510	.016	.314	NS
		Within Groups	88.902	82	1.084			
		Total	90.004	84				
4	Fit of bust area	Between Groups	1.111	2	.556	.117	.401	NS
		Within Groups	86.236	82	1.052			
		Total	87.347	84				
5	Fit of waist area	Between Groups	1.601	2	.801	.260	.401	NS
		Within Groups	87.911	82	1.072			
		Total	89.512	84				
6	Fit of hip area	Between Groups	1.111	2	.556	.370	.704	NS
		Within Groups	87.234	82	1.064			
		Total	88.345	84				
7	Overall length	Between Groups	.770	2	.385	1.060	.801	NS
		Within Groups	85.226	82	1.039			

		Total	85.996	84			
	Cluster value				**.335**	**.521**	**NS**

As shown in Table 6, the p significant values of all the items were greater than .05 which implies that the null hypothesis is accepted on all the variables, The cluster value of P =.521 implies that there is no significant difference in the mean ratings of judges on small, medium and large size- based users on movement of functional apparel is therefore retained.

Table 7: One-way analysis of variance of difference in the mean ratings of judges on small, medium and large size- based users on mobility required of functional apparel

S/N	Item	Source of Variation	Sum of Squares	df	Mean Square	F	P-Sig.	Decision
1	Free movement of arm	Between Groups	1.221	2	.610	.116	.340	NS
		Within Groups	93.601	82	1.141			
		Total	94.822	84				
2	Free movement of torso	Between Groups	.960	2	.480	.161	.225	NS
		Within Groups	99.924	82	1.219			
		Total	100.884	84				
3	Free movement of legs	Between Groups	1.020	2	.511	.180	.320	NS
		Within Groups	96.001	82	1.171			
		Total	97.021	84				
4	Ease of movement	Between Groups	1.312	2	.658	.190	.300	NS
		Within Groups	95.020	82	1.159			
		Total	96.332	84				
	Cluster value					**.162**	**.296**	**NS**

Table 7 showed that the p-value for all the variables used in the assessment of mobility in functional apparel were greater than .05. The cluster value P=-.296 implies that the hypothesis which states, there is no significant difference in the mean ratings of judges on small, medium and large size- based users on mobility of functional apparel is therefore accepted.

Discussion of Findings

Mean ratings of female fishmongers on movement analysis revealed that both basic body movements and task-related movements were "easy to do". This indicated that the functional apparel did not impede the movements of the female fishmongers during movement assessment. This finding is in supports the view point of Shihong, (2013), Anand, (2011) and Holland, (2007) that functional apparel should not impede the movement of any part of the body while performing required tasks. In addition to rating movements general mobility was also rated while wearing the functional apparel, female fishmongers experienced ease of acceptable mobility when they wore the prototype functional apparel.

This is in agreement with the statement that functional apparel should contribute to maximum efficiency and performance of the wearer (Kibrom,2019 and Guptaa, 2011). One-way analysis of variance on the difference in the mean ratings of models on small, medium and large size -based users on movement required of functional apparel revealed no significant differences in the ten items tested. There was no significant difference in the mean ratings of judges on small, medium and large size -based users on parameter required of functional apparel.

Conclusion

It is therefore concluded that Bernina My Label 3D software can be employed in developing functional apparel for female fishmongers. Irrespective of the design of the work wear it meet the functional requirement of the job and did not impede the movement and mobility of the user. The three quarter was able to grant the users free movement while carrying out their task. It is also paramount that the material selection has to be breathable, permeable and at same time possess the characteristics of not hindering the movement of any part of the body. Therefore, in using any software in developing functional apparel, it is very paramount to look for one that meets the design criteria in its collection or drawer. In the case of this study Bernina My Label was chosen because the design criteria accepted by female fishmongers was found in their drawer collections.

Recommendations

1. Since many of the subjects, both from the female fishmongers and judge's population, expressed satisfaction with the functional apparel attributes, there is need to make available the findings of the study to Clothing and Textiles lecturers and students in high institutions and fishmonger's organisations through seminar and workshop in order to create awareness about current research in the functional apparel workforce.
2. Home Economics lecturers and students should embrace the use of pattern software to approach design problems in Clothing, Textiles, and Interior Design/Decoration aspects of the Home Economics programme.
3. Knowledge and skills are vital to resolving issues in functional apparel research, therefore practical illustrations and awareness must be created by the lecturers for the understanding of apparel design concepts in developing occupational clothing for diverse groups.

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