

STUDY OF ANTHROPOMETRICAL DATA IN KNITTED GARMENTS

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ABSTRACT

The role of fit and sizing in promoting consumer satisfaction is increasingly recognised and this, together with an awareness of variations in garment sizing requirements in world markets is at the core of anthropometrics. Knitwear sizing is a branch of anthropometrics that has not previously been considered for academic research. However, various new techniques have become available in modern weft knitting which has enabled knitwear to be shaped three-dimensionally as not previously achievable through the sophisticated CAD software. Despite these advancements in programming software and electronic needle selection, garment development is still heavily reliant on the skill of the operator or designer to develop new shapes and manipulate this advanced technology into innovative knitwear. This advance in technology has opened up a large knowledge gap with regards to fit and styling within knitwear, and many questions have arisen; do we really understand the relationship between anthropometrical data and knitwear sizing, styling and fit, and do we utilise the knowledge effectively to enable predictions of fit to occur? This paper presents the findings of an investigation into the use and understanding of anthropometrical data in knitted garments.

1. INTRODUCTION

The study of anthropometrics has become recognised as an important contributor to the fit and sizing of clothing worldwide and thus promotes consumer satisfaction with regard to garment sizing (Pechoux and Ghosh, 2002; Bougourd, Dekker, Ross & Ward, 2000). Furthermore national and international standards and their utilisation can be derived from such data (for example, Newcomb & Istook, 2004; BSI, 2001) Scientific anthropometric studies conducted in America in the 1940s (O'Brien & Shelton, 1941; O'Brien, Girshick & Hunt, 1941) are precedent models to subsequent surveys worldwide. In the UK, the first national survey was conducted in the 1950s (Kemsley, 1957) and has influenced sizing systems in the second half of the 20th Century. Since then, data has been out of date, proprietary, of non-civilian samples and with limited samples. Although proprietary surveys have been conducted by companies, it was not until the government-sponsored SizeUK in 2001 that a state-of-the-art national survey on civilian population was conducted by scanning, bringing together academics and retailers (Bougourd et al., 2000; Stylios, 2001). The UK clothing industry contains a multiplicity of sizing systems with inter- and intra-retailer variations and coding; this has contributed to consumer dissatisfaction and confusion with sizing (Otieno, Harrow & Lea-Greenwood, 2005, Tamburrino, 1992). Following their contribution to SizeUK by co-ordinating data collection in the North West region of the UK (Webster, 2001; Taylor, 2001), Manchester Metropolitan University has continued to build a specialism in clothing anthropometrics at both undergraduate and postgraduate levels, attracting quality researchers both nationally and internationally, and thus contributing significantly to the scholarly activity and development of this subject area. It was found that previous anthropometrical studies have examined the human form in relation to the development of clothing which conforms directly to the human figure; and such data has been utilised for clothing related to woven fabrics (Pechoux and Ghosh, 2002). Citing findings from SizeUK, Derbyshire (2004) and Carvel (2002) lamented that the

average woman's body had increased by: chest, hip and height (1.5 inches), waist (6.5 inches) and weight (7 lb). A participant in this survey, the retailer Top Shop modified their sizes to accommodate what they considered a larger average body size in the UK. It can therefore be deduced that anthropometrical data on systems used in a supply chain from research and measurement, product development, purchasing and after-sales care are core to success. Also understanding the clothing environment and context in which anthropometrical data are utilised are important. Knitwear sizing is a branch of anthropometrics that has not previously been considered for academic research and it is impossible to relate the data obtained from past studies to knitted garments, since the fabric performs differently under normal wear. The fit of a knitted garment over the body contours is largely dependent on the elastic deformation of the fabric (Brackenbury, 1992) and for this reason new relationships between anthropometric data and clothing sizing are required for garments of knitted construction.

In addition to the structural differences of knitted fabrics various new techniques have become available in modern knitting machinery including microprocessor-controlled systems for needle selection and complex fabric take down systems, as well as automated loop transferring. These technologies have enabled knitwear to be shaped three-dimensionally as not previously achievable, through sophisticated CAD software that generates pattern and control during knitting. Despite this advancement in programming software and electronic needle selection, the publications relating to the usage of anthropometrical data in knitted goods, shape development and studies relating to fit are severely lacking. An evaluation of the existing technologies in order to map how anthropometric data are utilised in the knitwear industry in the UK would therefore contribute to better insight into the status quo. It is therefore reasonable to assume that knitted garment development appears to be heavily reliant on the skill of the operator or designer to devise new shapes and manipulate this advanced technology into innovative knitwear styles. Therefore, it can be stated that the advance in knitting technology has opened up a large knowledge gap with regards to fit and styling within knitwear, and many questions have arisen; do we really understand the relationship between anthropometrical data and knitwear sizing, styling and fit; and does the industry utilise the knowledge effectively to enable predictions of fit to occur? The objectives of this study were to determine available anthropometrical information in the UK knitwear industry and to classify key players or companies according to location, product type and technology.

2. BACKGROUND

It is evident that during recent years knitwear has become a key fashion item (Black, 2002), a greater percentage of a clothing range in retail outlets are knitwear based. The UK knitwear market has shown a steady increase from approx £1764 million in 1998 to £2338 million in 2003 (Euro Monitor, 2004). It has also been acknowledged that the individual knitwear manufacturers are placing much more emphasis on the development of new shapes that conform to the human form (Black, 2002). However, there appears to be an uncertainty regarding how much of this is derived from empirical development and the quantity that has a sound theoretical framework grounded in anthropometrical studies. Previous unpublished research found that many new knitwear developments are based on empirical knowledge utilising the trial and error approach to develop styles with good fit which conform to the human figure and the theoretical application is very much lacking. This suggests that there is a void caused by the lack of theoretical data

and a knowledge gap between the relationship of anthropometrics and knitwear sizing. The research project outlined in this paper is vital to assist the industry by providing a sound theoretical understanding in order to minimise time wasted utilising the trial and error approach which appears to be considered the current industry ‘norm’.

Funded by MMU this research will investigate the use and relationship of anthropometrical data within ladies knitwear. This project attempts to establish and quantify the amount of theoretical information available by conducting research into the relationship between, and the usage of anthropometrical data in knitwear sizing. Also data on the knitwear companies’ classification according to location, product focus/type and technologies available will be evaluated. For pedagogy, this work will contribute to the advancement of knowledge regarding the utilisation of anthropometric data in knitted garments and the industry. For the knitwear industry it will generate content for short courses on knitwear, raising awareness of garment fit within the commercial domain. Although data on individual company practices might be available, these are currently proprietary and disparate in nature.

Research will be conducted in two phases. Phase one will be in two stages; a thorough literature/market search to determine the key players in the UK market and primary study in the form of an investigation to determine knitwear sizing systems currently in the market. Also key market players will be identified and categorised according to nature, focus and types of products. This will establish knowledge gaps in relation to the spread of anthropometrical data within knitwear sizing. Phase two will initially devise a framework for further research in the form of scholarly activity, this will take two forms. Firstly visits and interviews with knitwear manufacturers to evaluate the current industry standards in relation to knitwear sizing and the usage of anthropometrical data. Secondly by use of laboratory-based procedures, analysis will occur by scientific evaluation into the current grading procedures utilised in knitted garments. The outcome of the research will take many forms, including a variety of publications, a database of anthropometrical information related to knitwear styles and sizing and a short course to relate the findings directly back to the commercial sector. This paper presents the initial background and justification of the research for the project.

The study of anthropometrics is not new; Roebuck (1995) links it into the study of criminology, medical practice and personnel selection and lists it as a product of physical anthropology. The use of anthropometrical data as a basis of garment size charts is an accepted reality for most woven manufacturers (Bougourd et al., 2000) and is the cornerstones of determining efficient national and international standards (BSI 2001; Kemsley 1957, Newcomb & Istook, 2004). However, the comparability of sizes between various manufacturers illustrates huge differences regarding the interpretation of anthropometrical data leading to consumer dissatisfaction and confusion worldwide (Bougourd et al., 2000; Otieno et al., 2005; Tamburrino, 1992; Newcomb & Istook, 2004). Within knitwear there is the extra complication due to a variety of different structure types; from ribs that stretch and contract, to stable interlocks with limited drape properties. In addition to the vastly different structural properties of knitted fabrics there is the concern of loop manipulation occurring within the fabric structure. Quite often this unique property of knitted fabric is utilised to the manufacturers’

advantage by producing shapes that would not fit together as a 2-D form. Figure 1 demonstrates a concept utilised in industry to shape a garment front panel with a V-neck. It can be seen from the diagram that if this style was produced from a woven material there would be severe distortion in the under arm region. However, because the knitted stitch repositions itself the distortion can be lost, within selected knitted structures, resulting in a garment shape that conforms well to the body. This approach regarding shaping in knitwear has become more common; Black (2002) acknowledged that more manufacturers are increasingly producing integral features as part of the 'norm'. With the advent of 3-D knitting in the commercial sector it is becoming increasingly important to understand the relationship between anthropometrical data and knitwear styling.

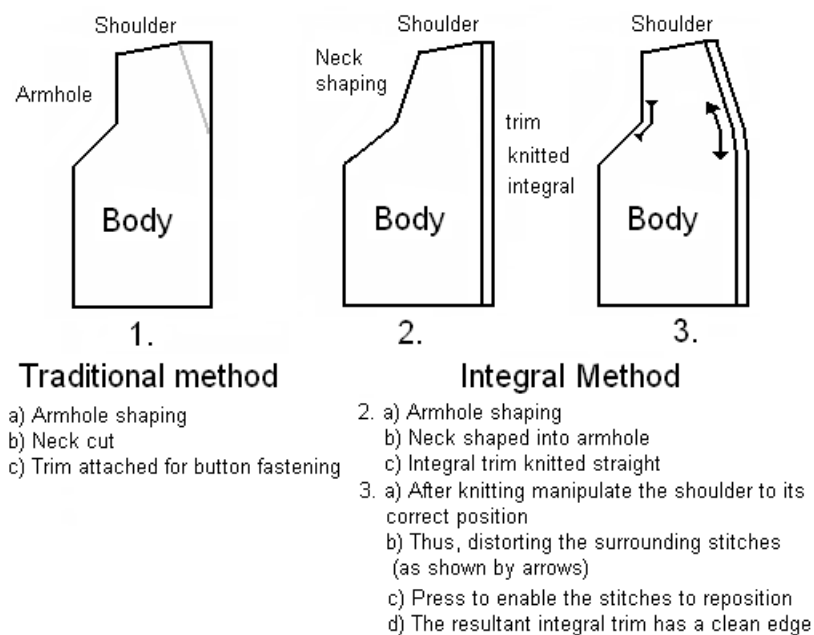


Figure 1
Integrally Shaping a V-neck

It is a well-established fact that weft knitted garments can be produced in various forms. Brackenbury (1992) identified four categories of general production methods, which can be expanded to form the definitive list as fully cut, stitch shape cut, fully fashioned, integral and three-dimensional garment. It is worth noting that the traditional boundaries no longer apply in knitwear production, brands and manufacturers are mixing shaping techniques, using a combination of high and low quality raw materials in a variety of structural combinations. The outcome is a selection of innovative knitwear styling through sophisticated pattern manipulation and quite often the sizing of the finished garment bears little relationship to traditional anthropometrical data. Currently there is no information available regarding the relationship between the various size codes and size ranges in existence; and general shaping information within the public domain is limited. It may be a common hypothesis that knitwear companies prefer to use size codes of small / medium / large to reduce the number of garment sizes produced in a range, thus, reducing overall production costs. However, it is important to investigate if this hypothesis is reflected in the market place. It was thus proposed that the initial investigation would determine the size codes in existence and examine if the size codes

relate in any form to the number of knitwear sizes in the range, the selected style line and the shaping technologies. This forms the basis of the research presented in this paper, which was investigated through observational market research.

3. METHODOLOGY

This paper presents Phase One of this ongoing study and utilises two methods: review of related literature and visits to knitwear stores in London. Initially a pilot study was devised to establish if market research was a suitable methodology for the gathering of the required data. The pilot study was conducted in spring 2006, to enable a greater understanding to be gained prior to the principle investigation occurring in the following autumn ranges, (which tend to feature more heavily on knitted styles). London was selected as the centre of the pilot investigation and data was collected focusing specifically on ladies wear in the following areas; size codes, size ranges, shaping technology and style lines. Data was collected from a total of 25 sources including 7 brands associated with knitwear, 9 designer brands and 9 high street brands. The 25 sources will be expanded upon in the principal investigation during Autumn 2006. The pilot study was conducted in London on the basis of its large and varied selection of retail outlets and its convenient location. In the first instance literature searches occurred to determine the range of retailers that were suitable for study and their locations within the city. It was found that London had the added advantage of department stores featuring traditional branded knitwear ranges side by side, enabling initial evaluation to occur regarding the knitwear sizing utilised in the commercial sector.

In order to classify knitwear industry players in the UK, the Knitwear Financial Report (Financial Survey Report, 2004) that contains a listing of all UK companies was utilised as a sampling frame. In total 346 companies were listed showing the post code, location and number of manufacturers, whether they manufactured and sold knitwear and categories of products. These data were collated and thus generated summaries of company information from which purposive techniques will be utilised to select those for further inclusion in the study.

4. RESULTS

With the exception of two brands it was found that each brand selected a single size coding system and used it throughout its knitwear collection. The two exceptions were; both classified as high street brand, one incorporated an individual specific company coding system into its ranges (which was common across its woven range), and the second brand incorporated two systems (10, 12, 14 etc and 36, 42, 44 etc) on the label of all garments. Further to this it was found that descriptive coding (eg: S, M, L) proved to be more popular (featuring in 58 % of the brands considered) than numerical coding (eg: 10, 12, 14 or 32, 34 etc) which accounted for 38 % of the 25 brands utilised in the pilot study and only one brand (4 %) opted to use a system outside the ones described above. Independent of the brand classification (knitwear, designer or high street) the percentage that used descriptive coding was always found to be slightly greater. The number of sizes that featured in each coding system did vary considerably; the knitted garments with the numerical codes had the greatest spread of sizes from 4 to a maximum of 7 with the average being 4/5 garment sizes. The descriptive size codes

appeared to favour fewer sizes; in most collections “3” was the popular choice (small, medium and large).

Regarding the shaping technologies utilised, the collections that incorporated mainly cut and sew knitwear were all classified as high street (56% of those considered for research had some cut and sew knitwear). In the designer brands 44% of all the collections considered had some cut and sew knitwear. Whilst in the tradition brands associated with knitwear only 29% had cut and sew shaping in their ranges. In addition it was found that fully fashioned knitwear shaping was evident in all brand ranges, independent of the brand classification, whilst integral shaping appeared to be evident mainly in the high street with 44% of the brands showing evidence of using it in some capacity (mainly trims). Integral shaping was less popular amongst the designers and traditionally associated knitwear brands with 33% and 29% respectively featuring it in their collections. Finally the garments that were observed which utilised 3-D shaping were most prominent in the designer classification (22 % of designers used 3-D shaping) although both the traditional knitwear and high street classifications did show some evidence of this technology being used (14% and 11% respectively).

When evaluating the styling, the 11 brands that incorporated the cut and sew method of manufacture all used the true curve armhole shape (this is the nearest to the classic woven cut shape). In addition the data revealed that all of the brands researched incorporated fully-fashioned manufacture in some form. It was established that the inset style proved the most popular (utilised in 84% of collections), the raglan and fashion curve followed next with 52% and 48% of ranges featuring this style. Finally the saddle sleeve style saw presence in a limited number of collections (8%) (probably due to its complex manufacture). The only shape that was not observed within any of the brand classification was the notch. The data relating to knitwear styling can be further sub analysed to reveal that, the most popular style amongst the designer brands was the inset sleeve 89% followed by the raglan 78%, the fashion curve 44% and the saddle at 11%. The high street brands followed a similar pattern with the inset style most popular (89%) followed by the raglan and fashion curve (both featuring in 67% of the collections) and finally the saddle at 11%. The classic knitwear brands appeared to focus on the inset sleeve (86%) followed by the fashion curve (43%) and finally the raglan (14%).

From the 51 postcodes listed in the Financial Survey Report (2004), the locations with at least 10 manufacturers were: Leicester (139), Manchester (53), Nottingham (30), Galashiels (15) and Derby (13). These 5 locations will be form a sampling frame for further proportionate sampling of companies. It is estimated that selection of 30 companies will suffice the investigation. Table 1 shows the categorisation of the knitwear manufacturers. However, none of these locations recorded the method of manufacture of the garments, nor the sale of these products.

Table 1 Locations with principal knitwear manufacturers in the UK

Location	No. of manufacturers	Sale of knitwear	Manufacture of pullovers & cardigans	Knitted & crocheted fabrics	Knitted & crocheted hosiery	Apparel products	Other
Derby	13	2	0	2	6	0	3
Galashiels	15	5	5	0	3	0	2
Leicester	139	27	7	18	65	11	11
Manchester	53	11	11	7	12	12	0
Nottingham	30	8	1	3	14	3	1

5. Discussion of findings

The data collected in the pilot study revealed some interesting information. It was found that with one exception the 25 brands considered for research all utilised a single coding system across their complete knitwear ranges. Similar to the woven sector in the UK, the knitwear manufacturers utilise a multiplicity of sizing systems including numeric, body part descriptor or key dimension and figure type estimations. Variations in size coding can be a source of consumer dissatisfaction and confusion regarding garment sizing (Otieno et al., 2005). The most popular coding system (with 58% of the brands utilising this method) proved to be descriptive coding of Small (S), Medium (M) and Large (L). In the main the manufacturers that utilised the numerical coding (which amounted to 42% of the 25 brands) preferred to use the standard ladies coding of 10, 12, and 14. However, there were two exceptions, one appeared to have an independent company system and the remaining (a traditional knitwear brand) added the chest size as an extra. It was found that the descriptive coding was most popular across all the three categories considered (designer, high street and traditional knitwear brands). The hypothesis described earlier (knitwear companies prefer to use size codes of small / medium / large to reduce the number of garments produced in a range) was also investigated. The findings revealed that where the size codes are descriptive, there does appear to be less range across the sizes, in most cases 3 sizes appears to be the standard (S, M, L). Size ranges had between four and seven sizes. The number of sizes within the numerical coding system had the greatest spread from four sizes to a maximum of seven in some styles, with between four and five proving to be most popular. Utilisation of body measurement data and its incorporation into a sizing system is usually considered proprietary information. Also size range selection is usually based on target markets with defined profiles for a retailer. This may imply that these are better fitting garments because they are utilising a greater amount of anthropometrical data hence the customer is more likely to fit one of the sizes offered in the range. It is common practice to utilise single grades for numeric sizing (e.g. 8, 10, 12 etc.) and double grades for the figure type descriptors (e.g. S, M, L).

When the results of the shaping technologies were examined it was found that 44% of all the brands considered in the data collection contained some cut and sew knitwear. However, the brands classed as high street had the greatest percentage of cut and sew followed by the designer ranges. This suggests that the traditional knitwear brands are still holding ground regarding the manufacture of what is classed as quality knitwear and fashion knitwear still recognises the requirement to produce knitwear from knitted fabric lengths which has a much shorter development time. It was interesting to note that all the brands considered independent of their category did include some fully-fashioned knitwear into their ranges for S/S 2006, and further to this it was observed that of those garments produced using the fully-fashioned shaping method the percentage that were incorporating integral features was greater in the high street brand classification – this could be the high streets strategy for offering fully-fashioned garments at a lower price. Hence, every trim that is attached using the traditional method is expensive (due to the highly skilled process); if trims are knitted integrally then the extra manufacturing cost is completely eliminated. Finally it was found that 3-D shaping was most prominent in the designer categories. This was not surprising since to some extent this technology is still in its infancy in terms of producing innovative styles and it would be expected that the designer brands would drive the experimentation forward since more investment is made in the initial development process.

The final set of data to be analysed was concerned with the style lines, since in fully-fashioned knitwear this has a significant effect on the fit of the garment to the individual's body. One important confirmation made from the data collected was that all the cut and sew shapes observed utilised a curved shaped armhole. Thus, indicating that this shape is considered the best fitting to the human form. It is worth mentioning at this point that none of the brands considered, solely featured cut and sew knitwear. Interestingly, when the fully-fashioned styles were examined it was found that the inset style proved most popular across all categories, again illustrating the desire for the material to conform to the body. The fashion curve was the next most popular style in the traditional knitwear and high street brand classification, which again reinforces the drive for good styling conforming to the body contour. Surprisingly after the inset style the raglan proved most popular for the designers followed by the fashion curve. This may be due to seasonal styling and further investigation would be required to confirm this trend. Lastly the saddle sleeve does not appear in the traditional knit brands ranges – again this could be due to the inset and fashion curve's fit superseding the saddle in regards to conforming to the body. The reason the saddle is present in the designer and high street, albeit limited, is probably relating to aesthetical reasoning, this again requires further investigation. Unsurprisingly the notch shape does not feature in any brand ranges; this is most likely due to its ill-fitting properties, which are deemed unsuitable for ladies knitwear. If men's golfing ranges had been considered in the data collection it could be assumed that the notch would be extremely popular due to its functional properties.

6. CONCLUSION

The research presented in the pilot investigation revealed interesting and vital information regarding the current sizing systems utilised in UK ladies knitwear. The descriptive sizing system was confirmed to be the most popular and it appeared from the analysed data that the hypothesis; knitwear companies prefer to use size codes of

small / medium / large to reduce the number of garment sizes produced in a range; had good grounds to be considered correct (although evidence from other sources should be considered in the subsequent investigation). This suggests that knitwear manufacturers and retailers are relying on the structural properties of the knitted fabric as apposed to considering anthropometrical data, in order to conform to a greater range of body sizes.

Four shaping technologies were considered when gathering the data, interestingly it was found that all the brands investigated contained some form of fully fashioned shaping, but not all contained cut and sew within there ranges. This suggests that perhaps it has become more cost effective to produce traditional fully-fashioned shaped knitwear utilising the available new technology. This is reinforced by many high street brands (44%) featuring integral trims within their knitted ranges. The latest shaping technique to become a commercial reality (3-D shaping) has opened up a huge area for potential garment shaping development. However, from the pilot investigation it appeared that it is the designer brands who are paving the way for innovation regarding 3-D knitting.

The final set of data revealed that ladies knitwear has become generally more fitted. This was demonstrated through all the cut and sew armhole shapes being curved, and all the fully fashioned styled garments consisting of either the inset sleeve, the raglan or the new fashioned curved shape armholes. All of which point to a more tailored silhouette. Of course it could be argued that these stylelines could be influenced by seasonal fashion, however, the general trend over this decade has pointed to knitwear conforming more to the human form. The new technologies available regarding knitwear production provide much opportunity regarding innovative styling and fit and therefore it is essential that more emphasis is placed on examining anthropometric data to enable a greater understanding to be achieved with the objective of improving how knitwear conforms to the body. It appears from the literature review that sizing data relating to knitwear is an unpublished area and thus provokes the assumption that it is company specific and related to empirical knowledge. To enable the new shaping technologies to be utilised more effectively it is important that more theoretical information relating to the relationship between knit and anthropometrics is available within the public domain. One thing for certain that can be conclude from this study is that the advancement in technology has opened up a large knowledge gap regarding fit and styling within knitwear and many questions remain unanswered. This initial study provides justification for further research as outlined in the earlier strategy.

7. FURTHER RESEARCH

This research has reinforced the requirement for further study into the use and understanding of anthropometrical data in knitwear styling. It has been previously stated that new relationships need establishing regarding the use of different knitted structures and their size specifications, since the properties of the knitted structures can greatly effect and influence garment fit. In addition to this the various shaping methods utilised in knitwear and the shaping manipulation within the knitted structure requires examining as it is suspected that the relationship between the body dimensions will change depending on the procedure selected. Finally because fully-fashioned knitwear is effectively robbing yarn, it changes the tension of the seams and therefore it is important to examine a range of stylelines during the project in an attempt to verify the relationship of anthropometrics and knitwear. If as the initial study suggests

manufacturers are using the descriptive coding to reduce the number of sizes in a range, the knitted garment must conform differently on individuals bodies and therefore it is going to have an effect on consumer satisfaction, this requires further investigation.

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