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The Influence of Major Ergonomic Factors on the Demand for Underwear in the Highly Educated Male Group

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Abstract: At present, it is unclear how ergonomic factors of underwear affect men's work, lifestyle, physiology and psychology, and whether the demand factors of some special groups will affect the development of underwear. This study analyzed the underwear preferences of male groups working in Chinese and European universities from the perspective of ergonomics. The survey results confirm that ergonomic factors significantly affect men's preference for underwear, including subjective style preference and objective comfort. These problems come from style structure, materials, functional design and size standards. In general, this typical male group needs underwear with good support in standing posture and good comfort in sitting state. This study also provides important information and evidence for the analysis and prediction of group characteristics and demand-oriented product development. Designing underwear products according to consumer needs and avoiding waste of resources from inefficient development has a positive impact on the green development and recycling of textiles.

Keywords: ergonomic factors; men's underwear; comfort and function; psychological preferences

Citation: Cheng, Z.; Wu, X.; Kuzmichev, V.; Adolphe, D. The Influence of Major Ergonomic Factors on the Demand for Underwear in the Highly Educated Male Group. *Sustainability* **2022**, *14*, 12464. https://doi.org/10.3390/su141912464

Academic Editors: Marc A. Rosen, Chengyi Hou, Yun Su and Rui Li

Received: 18 August 2022
Accepted: 28 September 2022
Published: 30 September 2022

1. Introduction

During the past decade, consumer demands for underwear have been growing on a global scale [1]. In 2020, the size of China's underwear market (retail sales) reached 490 billion (yuan). In this market, men's underwear occupies one-sixth of the women. The development scale o men's underwear is growing rapidly, growing to 208.3 billion (yuan) in 2020. According to the national census of China, there are about 600 million males over 16 years old, and Chinese men's underwear is mainly purchased by young people, which is a huge potential market [2].

Nowadays, there are a large number of waste textiles in the world every year. From a certain point of view, it is particularly important to increase their life cycle and acceptability, which directly affects the service life and reduces the possibility of their being discarded in the short term [3]. It has a direct impact on the green development and circular development of textiles. The global public is increasingly aware of personal hygiene, the improvement of people's living standards and the growing consumer health consciousness, the comfort demands and customization of underwear have expanded beyond the traditional requirements [4]. In contrast with outerwear, underwear is intimate and unsuitable underwear cannot be returned or exchanged. Moreover, the ordinary underwear is not expensive, if it is not suitable, the uncomfortable intimate underwear is not tolerated and is often permanently unused or simply discarded, nor can it be donated or reprocessed. However, this is not the end, consumers must continue to try to buy new products until they are satisfied. A new product that has not reached its life cycle will be wasted, which undoubtedly increases the unnecessary waste of resources and the burden of recycling. Therefore, to avoid the frequent occurrence of this situation, it is more important to develop

good comfort and functional underwear that can increase the life cycle than to create useless products that are ostensibly "environmentally friendly" but not accepted by people.

Today, male consumers are also very concerned about the functionality and practicality of textiles, consumer expectations and purchasing behavior have changed greatly [5]. In the environment of higher education, men's consumption of underwear has also become more rational. Due to occupational characteristics, their work in long-time sitting or static standing positions as well as the impact of home isolation and online teaching caused by COVID-19 make this group have special ergonomic needs for intimate underwear [6–9]. According to the statistics of the Ministry of National Education, the number of higher education groups in 2021: 291 million students and 18,443,700 full-time teachers, among which the total number of male groups occupies at least 200 million people and is dominated by young people. In this research group (at least the Chinese group), they are at least aware of and concerned about sustainable development issues (currently or have been), and in Chinese higher education, most issues are often accompanied by ideas related to sustainability development [10]. Therefore, the demands of the male group in higher education environment for underwear needs to be focused, and to researching these needs can help with target market analysis and the creation of effective marketing and research strategies [11].

The wrong material and ergonomic design of men's underwear will cause great male health problems for this group [12]. It can cause vascular disease or discomfort not only in the lower back, but also in the male private parts, groin and buttocks [13,14]. For example, in a long-time sitting state, the scrotum is hot, wet and squeezed, which seriously affect the temperature of the testicles or fertility [15]; on the other hand, in a long-time standing state, the problem of genital support causes uncomfortable falling feelings or varicocele, etc. [16]. This male group has more obvious needs for underwear, such as newer shapes, more comfortable sitting and standing functions, moisture absorption and quick drying function, etc.

At present, the men's underwear market is open to the world, with various styles of products for consumers to choose. However, there are few studies on the needs and preferences of male consumers, especially the functional underwear analysis for male groups in colleges and universities. Many men's underwear patterns are designed empirically, without taking into account the scientific findings of ergonomics and scientific research [17]. This leads to poor feedback from male consumers about the product, resulting in difficult to sell goods, inventory backlog, and a great waste of textile resources. It has a negative impact on companies, consumers and even the human environment. For all these reasons, it needs to be investigated specifically for male consumption habits, needs and expectations of underwear [18,19]. On this basis, enterprises can develop new products that meet consumers' demands and avoid wasting a lot of resources due to consumers' disapproval or dissatisfaction with products.

2. Materials and Methods

2.1. Objects and Investigations

This investigation has used the literature survey and several ways to question consumers such as interviews, online questionnaires, and physical questionnaires, to study necessary consumer information, related physiological and psychological expectations. The content of the questionnaire has been designed based on the evaluation of comfort and functional requirements. The questionnaire design was simple and clear, making it easy to understand and to answer.

The study conducted a sample survey on male target groups in higher education institutions. The target group consists of divided into two groups: students and teachers, and each group included a sufficient number of participants for statistical analysis. The group are mainly undergraduate, graduate, and doctoral students, (aged 16–29, 61.3%) as well as young faculty members of their professional courses (aged 26–39, 38.8%), who spent more than 6 h per day studying, researching or teaching with long-time sitting

and standing. The questionnaire investigates the male group in four countries, mainly youth-oriented 700 Chinese (from the central region). In addition, 100 European young males were included as additional data references (70 French and 30 Russians). Informed consent was obtained from all subjects participating in the study. All data is anonymous and personal names and addresses are not recorded. Before sending out the questionnaire, the participants have been informed orally or online of the purpose of the survey and the publication of the research results. All research data was analyzed and processed, and no personal information was published.

The experiment is divided into two stages. In the first stage, the PCA of 12 explanatory variables is performed to determine the characteristic values among the explanatory variables grouping the sample categories. In the second stage, the weighting coefficient of the variables is calculated by the PCA to reflect which principal components the variable contributes to. Then the samples' preferences are evaluated and sorted out, and the results are analyzed by SPSS software. Questionnaires were surveyed by rank evaluation of 5 levels, such as: "1 (Very dislike), 2 (Dislike), 3 (General), 4 (Like), 5 (Very like). The reliability of questionnaires was statistically analyzed by SPSS software. The underwear was presented in 7 mainly styles (Figure 1). To create a good uniformity effect, the underwear was presented by redrawing. Real photos of the underwear were included in the questionnaire, as well as Chinese expressions without ambiguity, so that respondents could better distinguish the different styles.

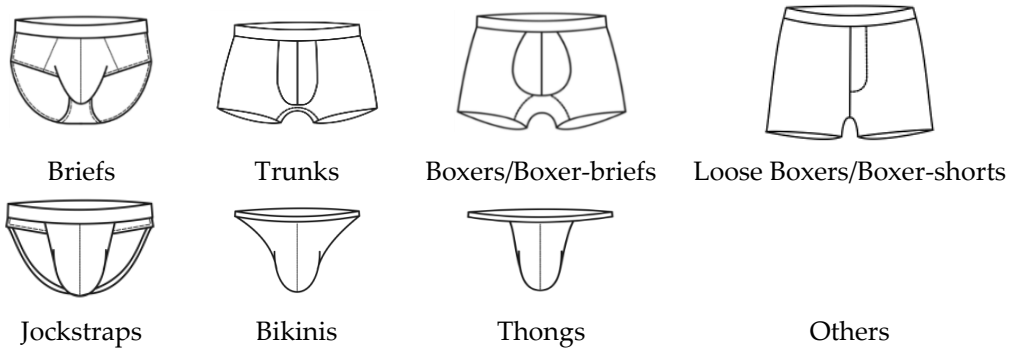


Figure 1. Main styles of men's underwear.

There are special options in the questionnaire for the real underwear sizes, main materials, colors and brands. Respondents were not asked to perform try on evaluations and give feedback on specific experimental samples, and they only answered questions based on their own "experience".

To analyze the preference mode, their personalized variables should be preliminary classified. 12 variables were selected from psychological (preferences) variables, behavioral (purchase) variables and physiological (feelings) variables, as follows: preferences of underwear style (X_1), preferences of functional (structural line) design (X_2), preferences of style (waist height) design (X_3), preferences of the tightness (X_4), purchase underwear style (X_5), purchase size (X_6), purchase focus (X_7), purchase frequency (X_8), purchase brand (X_9), feeling (uncomfortable) of wearing (X_{10}), dressing (way) habit (X_{11}) and dressing (functional) demand (X_{12}).

2.2. Principal Component Variable Analysis and Grouping

The validity of the questionnaire was analyzed by SPSS. The KMO test is 0.89, Bartlett's test value is 0.00 ($p < 0.05$). The KMO value is closer to 1, the stronger the correlation between variables, the better the effect of factor analysis. Table 1 shows the total variance explained.

Table 1. Total variance explained.

No.	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	Variance, %	Cumulative, %	Total	Variance, %	Cumulative, %
1	5.08	42.29	42.29	5.08	42.29	42.29
2	1.32	10.99	53.28	1.32	10.99	53.28
3	1.02	8.47	61.75	1.02	8.47	61.75
4	0.76	6.31	68.05	0.76	6.31	68.05
5	0.67	5.61	73.67	0.67	5.61	73.67
6	0.59	4.87	78.54	0.59	4.87	78.54
7	0.57	4.71	83.24	0.57	4.71	83.24
8	0.51	4.27	87.51			
9	0.46	3.81	91.32			
10	0.42	3.46	94.78			
11	0.36	3.03	97.81			
12	0.26	2.19	100.00			

Through the extraction method of PCA, the eigenvalues, variance rate and cumulative contribution rate are obtained according to the calculation of the correlation coefficient matrix. From the perspective of variance contribution rate, the contribution rate of the first seven factors can reach 83.24%, and the first three components are 42.29%, 10.99% and 8.47% respectively. The principal component factor method was used to calculate the load variables of seven factors, and the maximum variance orthogonal rotation was carried out (Table 2). These seven factors are further categorized and can well describe men's needs for underwear (Table 3).

Table 2. Rotated Component Matrix *.

	Component						
	1	2	3	4	5	6	7
X_5	0.87	0.14	0.09	0.12	0.11	0.05	0.17
X_1	0.84	0.14	0.13	0.26	0.09	0.05	0.07
X_4	0.59	0.13	0.13	0.18	0.36	0.31	0.20
X_3	0.43	0.08	0.28	0.58	0.26	−0.07	0.17
X_2	0.31	0.79	0.08	0.01	0.19	0.16	0.07
X_{10}	0.25	0.12	0.14	0.20	0.11	0.04	0.92
X_{11}	0.24	0.22	0.07	0.83	0.14	0.16	0.16
X_9	0.22	0.24	0.67	0.32	0.09	0.20	0.15
X_6	0.22	0.08	0.18	0.19	0.90	0.02	0.09
X_7	0.11	0.22	0.23	0.09	0.02	0.91	0.03
X_8	0.09	0.07	0.91	0.01	0.14	0.13	0.06
X_{12}	0.03	0.84	0.14	0.24	−0.05	0.11	0.07

Rotation Method: Varimax with Kaiser Normalization. * Rotation converged in 6 iterations.

Table 3. Grouping of seven factors.

No.	Describes	Variables
1	Underwear style factor	X_5, X_1, X_4
2	Underwear function factor	X_{12}, X_2
3	Purchase (frequency and brand) factor	X_8, X_9
4	Underwear wearing (waist position) factor	X_{11}, X_3
5	Underwear size factor	X_6
6	Underwear focused factor	X_7
7	Underwear (uncomfortable) feeling factor	X_{10}

According to the component matrix in Table 2, the factors with high scores (>0.5) are recalculated.

3. Results

3.1. Style and Function Factors

According to the survey results of style factors (X_5, X_1, X_4), we take the two popular underwear-boxer-briefs and trunks—as examples, and use SPSS software to make cross statistics for different groups and convert them into percentages, as shown in Table 4.

Table 4. Cross-tabulation of boxer style preferences (boxer-briefs/trunks), %.

	Very Dislike	Dislike	General	Like	Very Like
Students	1.96	11.28	24.02	18.63	5.39
16–29	0.98	7.84	15.69	30.88	5.88
Teachers	0.98	8.33	12.25	14.22	2.94
26–39	0.00	1.96	10.78	21.08	4.90
Total	2.94	19.61	36.27	32.85	8.33
	0.98	9.80	26.47	51.96	10.78

The underline data are the results for trunks.

More than half of the people in each group prefer the trunks style, a simple, compact, and basic style. However, this is likely to be the "fixed impression" of the respondents on these two kinds of underwear. They "trust" this most conservative underwear and make their choices accordingly. Such trunk styles usually do not have any additional function; therefore, it is necessary to analyze whether this preference result has hidden meaning.

Further findings revealed that most respondents are more interested in the comfort and function of their underwear, with a higher demand for overall comfort (34.2%) (X_{12}, X_2). For example, almost a quarter of Chinese respondents were interested in the corrective/shaping effect of the front part (genitalia). Table 5 shows the functional position design preferences for underwear.

Table 5. The analysis of variance and post-hoc test.

Dependent Variable	Multiple Comparisons (Scheffe)					
	(I) Many Seams	(J) Many Seams	Mean Difference (I−J)	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Correction effect in front (genitalia)	Dislike	Very like	−0.89	0.03	−1.72	−0.07
	Like	General	0.46	0.04	0.01	0.90
	Very like	General	0.86	0.00	0.28	1.44
Correction effect in back (buttocks)	Very like	Dislike	0.89	0.03	0.07	1.72
Correction effects in both	Very like	Dislike	1.08	0.00	0.28	1.89

Through our analysis of variance and post-hoc test of Scheffe's method, the three dependent variables of the F values of the overall test are 6.81, 3.14 and 4.97, all sig. < 0.05, both of them reached a significant level. By comparing two pairs, the location of the underwear correction effect (front, back and both) showed significant differences in the results of consumer preference for "Many seams".

- Correction effect in front—respondents "Very like" underwear with many seams more than "Dislike" and "General", no major fluctuations, means they prefer underwear with many seam lines and front correction;
- Correction effect in back—they "Very like" underwear designed many seam lines to correct buttocks;
- Correction effect in both—mean difference (I−J) is 1.08, means they "Very like" underwear designed many seam lines to correct front and hips, and there are significant differences with "Dislike".

It can be seen that this group prefers very close-fitting underwear with many seams and pays attention to the correction effects, and prefers the "push-up" (is the correction effect on soft tissues) feeling in the back (buttocks) and the front (genitalia). This can explain the results in the previous section that this group had a "hidden" preference for functional underwear—boxer-briefs. It means that this younger group will have a greater demand for the "functionality" of underwear, but the clear function needs to be further explored.

We can observe the "functionality" through an objective comparison of our designed underwear. The models were obtained with the help of the VITUS Smart XXL 3D non-contact body scanner, with dimensional standards conforming to ISO 7250. Figure 2 shows that the No. 1 model of a man wears ordinary trunks; the No. 2 and 3 models of the same man wear the boxer-briefs of multi-construction lines and corrective effect with two materials.

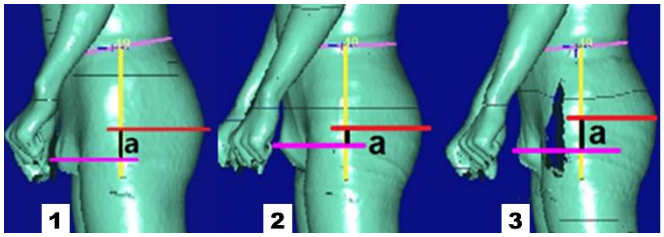


Figure 2. Correction effects for the male torso in front and back.

The value "a" is: the vertical distance between the horizontal lines of the genital protrusion and the buttocks. When the same man wears different underwear, the effect of soft tissue modification (lifting) is completely different. Compared with the traditional trunks style, it has obvious supporting effect on the genitalia and buttocks, and also has good tightness, which solves the problem of falling male genitalia without good support when long-time standing.

3.2. Size and Material

For the design and function of underwear products, their sizes/shapes need to be considered (X_{11}, X_3, X_6), because the respondents (44.4%) will consider the shape of trousers when choosing underwear. For example, tight-fitting underwear is always matched with slim trousers, so that the underwear waistband is exposed. In addition, they most prefer underwear waistband below 5–7 cm than the natural waistline. Since this is neither similar to the old-fashioned high-waist underwear, nor the trendy low-waist underwear, such a position is what they want to be comfortable.

Underwear size identification is also an issue that confuses this group. Different underwear brands have different sizes, shapes and crafts. Even though most products are labeled with the approximate body size range, the labeling is often wrong or not easy to understand, such as a smaller size underwear being defined by some brands with L or M labels. Furthermore, most Chinese men's underwear brands define L as the smallest size. L and XL underwear usually represent a man's weight 50–75 kg and waist girth 65–80 cm, which is clearly a male characteristic belonging to the S and M sizes. After investigation, half of Chinese consumers buy sizes L and XL, but actually they do not consider their size to be in those sizes. Nearly 80% of French respondents and half of Russian respondents buy M and L underwear in their respective countries, and this size represents a man of weight 50–70 kg and waist girth 70–82 cm in European men's underwear, which seems more reasonable.

As shown in Table 6, we only collected underwear sizes with good fit (ranking $\geq$3) for different age groups, the evaluation rating is 1–5 (very misfit, misfit, general, fit, very fit).

Table 6. Rating of size fit.

Size	S	M	L	XL	XXL
Rating	3.15	3.74	3.76	4.06	3.79
Std. Dev., ±	0.77	0.18	0.18	0.44	0.31

The results show the respondents did not give high comments on the fit of underwear, S and XL underwear are rated "general" and "fit". As can be seen, the evaluations of S and XL sizes fluctuate greatly, which shows that men who buy them have mixed comments. Therefore, for S and XL underwear, the size fit needs to be optimized, and the new classification of the male lower body and the structural design of underwear are also necessary.

In addition to the size factor, the style, color and material of the underwear are also major factors in determining the purchase of underwear (X7). Underwear materials almost contain 2–15% elastic spandex fibers, usually mixed with cotton, modal, and viscose fibers, etc. This does not change the material appearance but can greatly improve its elastic properties. Nowadays, although some emerging materials are also popular, "100% cotton" or viscose fiber underwear is still the first choice, because it is affordable and has a large variety of products, and people do not have to bear the risk of trying new products.

3.3. Feeling of Wearing Underwear

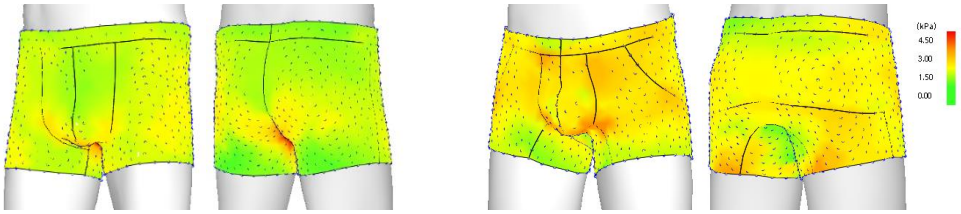
Wearing comfort (X_{10}) is one of the most important factors that men tend to overlook. For underwear, the main influencing factor comes from the lack of structural design, resulting in structural defects in key areas, which leads to poor actual wearing experiences. Half of the respondents feel that the main uncomfortable feelings come from the front crotch part (28.5%) and the bottom of crotch (21.8%).

At the level of probability 99.9%, two-tailed analyzed by SPSS, we can see the correlation coefficient between underwear tightness and discomfort parts/factors in Table 7.

Table 7. Bivariate analysis (Pearson's correlation *r*).

Factors		Very Tight-Fitting	Tight-Fitting	General	Loose-Fitting	Very Loose-Fitting
Material	*r*	0.28	0.05	0.27	0.11	0.06
	sig.	0.00	0.51	0.00	0.13	0.02
Construction (front)	*r*	0.02	0.18	0.23	0.11	0.03
	sig.	0.79	0.01	0.00	0.12	0.66
Construction (crotch)	*r*	0.11	0.01	0.21	0.09	0.12
	sig.	0.11	0.92	0.00	0.23	0.09
Construction (waistband)	*r*	0.25	0.11	0.16	0.04	0.21
	sig.	0.00	0.12	0.02	0.57	0.01

From the respondents' feedback, the most uncomfortable feeling and the "general" style of underwear have higher correlation coefficients with a significant 0.001 level. However, for very tight-fitting and very loose-fitting styles of underwear, there was an uncomfortable feeling in the waistband. For the uncomfortable feeling of being tightly supported in the front area, it is found that respondents have good acceptance from general to very tight-fitting. Furthermore, some uncomfortable situations are caused by the front and crotch which we can evaluate as a defect of structural design. Therefore, it is necessary to optimize this part. We can further explain this uncomfortable problem through the models with the same material properties and design ease, the trunks (Figure 3a) and the self-designed men's boxer-briefs with multiple construction lines and corrective function (Figure 3b).



(**a**) (**b**)

Figure 3. Pressure map of underwear models: (**a**) model of the trunk; (**b**) model of the boxer-briefs.

After ergonomic studies, the structural shape of the front crotch was optimized, and a separate crotch bottom piece was added. The boxer-briefs in the pressure map have large compression pressure values and a very even and reasonable pressure distribution, without excessive differences in pressure values on the trunks, looseness at front crotch and back thigh parts, and fabric pulling at the bottom of the crotch part.

3.4. Purchase Factors

The developed products need to be recognized by the target group, so it is very important to investigate their purchasing willingness (X_8, X_9). Respondents in China (62%), France (90%) and Russia (83%) own more than 5 pairs of underwear. Most respondents buy new underwear in half a year (29%) or irregularly (38%), without a relatively fixed purchase cycle or plan, and they usually buy when they find the right one. Moreover, 56.3% of the respondents have doubts about the products during the purchasing process, but they do not ask for help or advice. It can be seen that there are many reasons why the underwear they own is not being used, these reasons also discourage their willingness to buy.

According to the survey, the number of large and small brands operating in the Chinese underwear market exceeds 3000, and about 400 brands (enterprises) have a certain scale [20], but the consumers well know about 10 or fewer professional men's underwear brands. It means that most underwear brands currently lack insufficient interpretation for consumers so that consumers' awareness of product functions and features is insufficient, or that the products themselves are not attractive enough. This situation needs to be improved with scientific explanations and reasonable promotion. Many Chinese consumers prefer products with brand Logos or symbols [21], for example, CK and Boss waistband designs can be accepted by most youth [22]. It is important to note that this study targeted a special group rather than a broad social group, and therefore there were no significant class differences. Furthermore, the reason why the respondents only prefer CK and Boss brands is that they may prefer one of their design features, which does not mean that these underwear are comfortable or the best products.

4. Discussion and Conclusions

This study analyzes the ergonomic design needs of a highly educated male group for underwear, and studies the feedback on their purchasing and wearing experiences. Due to the particularity of this group, they need underwear with good support and comfort in long standing and sitting positions. The findings indicate that style, functional (structural line) design, and wearing feelings are the primary concerns in the development of men's underwear. In general, the group prefers underwear with "many seams" and correction effects in the front and back. Therefore, the design and optimization of its structure in front and crotch areas are particularly important for its wearing comfort.

However, most underwear products are not developed in combination with ergonomic theory. As a result, one quarter of the respondents did not know which underwear design or structure they preferred, and one third could not determine their underwear size. This indicates that contemporary men's underwear does not provide scientific and rational explanations of its structural features and functions for consumers. Moreover, most of the respondents felt more uncomfortable in the front and crotch area with extra ease values and

wrinkles due to their long-time sitting and standing posture. The structure of the underwear does not conform to human morphology, causing problems such as inappropriate size (too loose or too tight) and high pressure, etc. It can be seen that the quality of men's underwear products in the current market needs to be optimized and improved.

Now and in the future, comfortable underwear is the mainstream direction, Individualized and fashionable underwear is also becoming more and more popular due to the fixed university environment and single occupational environment of the male group. However, this group generally believes that the most important factors in purchasing new underwear are not fashion style but what type of new underwear suits them and how the new underwear experience is (if it is not a repeat purchase of the same underwear). This means that scientific analysis of men's underwear pattern characteristics, size matching, material performance and function is the focus, which can provide comfortable wearing pressure and "push-up" effect based on human structural characteristics to meet the main needs of consumers, followed by additional fashion factors will be taken into account.

In summary, only by solving these problems raised by consumers about underwear can the number of inappropriate and low-quality products be effectively reduced. Developing high-quality, precise underwear products suitable for the consumer target group market, improving the functionality and applicability to achieve maximum recognition and wearing comfort can further extend the life cycle of products and reduce the number of recycled products instead of discarding them prematurely. In a sense, accurately responding to certain needs of the market and developing corresponding products is undoubtedly conducive to healthy environment development, and is also one of the paths of sustainable development and green production in underwear enterprises. According to the development trend of today's society, for each clothing enterprise, developing products from the perspective of sustainable development is no longer an option, but a necessary path and basis for competition with other enterprises in the same field, as well as a responsibility for environmental protection.

Author Contributions: Conceptualization, Z.C. and V.K.; methodology, Z.C. and V.K.; software, Z.C. and X.W.; validation, Z.C. and X.W.; investigation, Z.C. and V.K. and D.A.; data curation, Z.C. and X.W.; writing—original draft preparation, Z.C.; writing—review and editing, X.W. and V.K.; project administration, Z.C and X.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Hubei Provincial Department of Education-Philosophy and Social Sciences Research Project (21Q104), WTU's Nurturing Project (223075), and Wuhan Textile and Clothing Digital Engineering Technology Research Center.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: Thank the participants who took part in the survey. The authors also thank the anonymous reviewers for their valuable comments.

Conflicts of Interest: The authors declare no conflict of interest.

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