



An Evaluation of Leggings Selected by Athleisure Consumers

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Abstract

The purpose of this research was to identify the features of leggings that consumers of athleisure desire and the performance problems they encounter. A non-probability sample (n=133) of college students who identified as female and wore leggings for non-athletic purposes was surveyed. A questionnaire was designed based upon examination of online product reviews and current complaints with leggings products. The results of the survey were used to design a laboratory evaluation. Laboratory samples and methods were chosen to assess the performance qualities desired by the surveyed consumers when purchasing leggings and the problems encountered when wearing leggings. Three brands were identified by the survey as regularly consumed and included in the laboratory study. All laboratory samples were a nylon and spandex blend fabric. Garments were laundered and evaluated after one, five, ten, and twenty washes. All evaluations were conducted in a Textile Testing Laboratory according to AATCC and ASTM standard test methods. Survey results identified the following as desirable features: comfort fabric, which is not see-through, low pilling propensity, and fabrics which do not stretch out easily. Likewise, see-through fabric, pilling, stretched out fabric, and worn-down fabric were each identified as a frequently encountered problem. The laboratory evaluation determined that the leggings demonstrated minimal degradation after twenty laundering cycles. Statistically significant differences were found between leggings brands for fabric specifications, bursting strength, pilling, and fabric stretch.

Keywords: Leggings; Athleisure; Performance; Testing; Consumer behavior**Abbreviations:** ASTM: Society for Testing and Materials; AATCC: American Association of Textile Chemists and Colorists

Introduction

The zeitgeist of the U.S. is reflected in the way consumers dress in the workplace and their everyday activities, which tend towards casual lifestyles that demand versatility and comfort from fashion [1]. As the millennial generation's interest in living a healthy lifestyle has increased, athletic clothing has become more acceptable for everyday wear, including in the workplace [2]. In the past, casual sportswear garments became a significant part of women's wardrobes in the decades following World War II and included pants that fit so close to the leg that shoes had to be removed to pull them up [3,4]. In the 1970s, the Oxford dictionary defined leggings as tight trousers made of stretch fabric [5,6]. In the

1980s, many women wore Lycra leggings to participate in aerobic exercise [5]. The trend of wearing leggings to the gym calmed in the 90s before escalating two decades later [7]. There are noticeable differences between the leggings fashions of the 1980s and those of the 21st century; now, women often wear them as acceptable standalone leg covering [7]. Also, leggings are no longer associated with only the gym. A survey conducted by Cotton Incorporated reported that 9 out of 10 consumers wear athletic clothing (i.e., leggings) for activities that are not exercise related [8]. Athleisure is the relatively new name given to clothing items that fall into the category of athleticwear worn for everyday wear [9]. Athleisure has

changed the fashion industry and has become a vital segment. It has become so successful that in 2016 athleisure first appeared in the Merriam Webster Dictionary [10].

This research focused on perhaps one of the most prevalent garments in the athleisure category, leggings. Leggings are such a significant part of the apparel and sportswear industry that they have replaced denim as an essential garment for many women in the U.S [1]. Due to their popularity, leggings provide a staple garment for athletic and non-athletic brands to enter the athleisure market. An abundant number of retailers have included leggings under their private label brands to enter the athleisure market; discount retailers like Wal-Mart and Target have joined as well as high-end brands [2]. Even celebrities such as Beyoncé and Carrie Underwood have found a way to partner with retailers by offering their athletic lines to compete in the \$33 billion-dollar market [8,11]. In addition to numerous retail offerings, consumers are faced with a variety of performance features for leggings. The number of options available creates an extremely competitive market [11]. Lauren Blanda, City Sport's category manager of apparel, claims a quality difference in high-end \$100 workout pants and lower-end workout leggings due to factors such as the fabric's durability and ability to stretch [12]. However, in both lab testing and a wear study, Champion leggings for a price of only \$35 were considered the top-rated legging [13]. It is apparent why consumers can grow confused and frustrated by the legging market with countless options available and the desire for higher performance; however, little research exists on consumers' desires for leggings.

The relatively new athleisure market is exceptionally competitive, and many believe that athleisure is here to stay because of its associations with an esteemed lifestyle of wellness [1]. When a market is competitive, it is important to prioritize those who will purchase the final product. Lululemon and Under Armor sales declined in 2017 due to the saturated and volatile athleisure market; Nike has been less at risk because it relied on research and effective marketing [14]. The success from which Nike benefits reveals the importance of research and development. For leggings, the fabric, design, construction, performance features, and intent to wear vary; therefore, researching and understanding consumers' desires for performance will allow brands and manufacturers to select and create relevant products. Consumers may grow overwhelmed by the vast amount of options available in the market; consequently, marketers should strive to meet consumers' needs [15]. Companies cannot improve without first hearing from their consumers; it is vital for brands that wish to remain relevant in the athleisure market to place value on consumer desires before developing a superior product.

Purpose

The overall objective of this research was to better understand consumer opinion by creating a customer profile of legging preferences and complaints through a survey and to compare the

performance of three frequently purchased legging brands through laboratory evaluations. The following research objectives were established:

1. Identify and evaluate the desired characteristics of women's leggings for college-age athleisure consumers.
2. Identify and analyze the encountered problems of women's leggings for college-age athleisure consumers.
3. Compare the evaluation results of three brands of leggings selected by college-age consumers to determine if there are differences in their fabric specifications, performance, and aesthetics.

Methodology

A quantitative research design was used to create a consumer profile related to legging preference and evaluate the performance of three legging brands based on the survey data results. The first objective was addressed by collecting descriptive data through a questionnaire. In the second phase of the research, a quasi-experimental method compared the three brands of leggings identified from the survey. The comparison evaluated the fabric specifications of the samples and their aesthetic and functional performance features.

Women who are college students and wear leggings for non-athletic purposes were the target population of the study. A non-probability sampling method was used by distributing an online survey to two sororities at a public university. A social media representative from each sorority's social media page shared the survey after receiving IRB approval from the researcher's institution. The survey questions were generated from an assessment of consumer online reviews of various legging styles from different brands. Problems frequently identified by consumer reviews and consumer comments on blogs and social media posts were noted. According to Lamb & Kallal's FEA model, the identified problems were grouped, which states that consumers' desires for any apparel item include three categories of consideration: functional features, expressive features, and aesthetic features [16]. Functional features describe a garment's utility; expressive features describe the message a consumer communicates or a garment's symbolism [16,17]; aesthetic features relate to observable traits [18]. Six questions were designed to address each FEA model category; additional questions asked consumers about the style, and fabric frequently purchased. A pretest was given to a small convenience sample (n=25) of college-age women. Results were used to refine and clarify the finalized survey.

Laboratory evaluations of three brands of leggings (Brands A, B, and C) were conducted in a textile testing laboratory using standard test methods from the American Society for Testing Material and the American Association of Textile Chemists Colorists [19,20]. The evaluations included examining the leggings' aesthetic features (color change, stretch recovery, pilling/fuzzing, and dimensional

stability), functional performance (bursting strength), and fabric specifications (fabric weight, fabric count, and fabric thickness). The standard test methods for these evaluations are provided in (Table 1).

Sample

Consumers were asked, "What brand(s) of leggings do you regularly purchase?" Brand A was the most selected response of surveyed consumers. Approximately 24% (the higher response

rate) of survey respondents indicated that they wore a specific style of Brand A leggings that are 81% nylon and 19% spandex. Sample B was the second most frequently consumed brand by surveyed respondents, a style made of 78% nylon and 22% spandex. Significant in-store and online research were conducted to find a third highly consumed nylon/spandex blended legging, popular to both survey respondents and online. Brand C's popular 87% nylon and 13% spandex legging was selected. Details of the leggings identified as Brands A, B, and C, are presented in Table 2.

Table 1: Test methods used for laboratory evaluations.

Evaluation	Test Method
Fabric Weight	ASTM D3776/D3776M – 09a (2013): Standard Test Methods for Mass Per Unit Area (Weight) of Fabric
Fabric Count	ASTM D8007-15: Standard Test Method for Wale and Course Count of Weft Knitted Fabrics
Fabric Thickness	ASTM D1777-96:(2015): Standard Test Method for Thickness of Textile Materials
Bursting Strength	ASTM D3786/D3786M – 13: Bursting Strength of Textile Fabrics: Diaphragm Bursting Strength Tester Method
Color Change	AATCC Evaluation Procedure 1–2012: Gray Scale for Color Change
Stretch Recovery	Modified ASTM D2594: Standard Test Method for Stretch Properties of Knitted Fabrics
Pilling and Fuzzing	ASTM D4970/D4970M – 10: Pilling Resistance and Other Related Surface Changes of Textile Fabrics: Martindale Tester
Dimensional Stability	AATCC Test Method 150 – 2012: Dimensional Changes of Garments after Home Laundering

Table 2: Summary of material, size, and price of each brand.

Sample	Brand A	Brand B	Brand C
Fiber Content	81% Nylon/19% Spandex	78% Nylon/22% Spandex	87% Nylon/13% Spandex
Fabric	Warp Knit	Warp Knit	Warp Knit
Color	Black	Black	Black
Size Range	0-14	XS-XL	XS-XL
Samples Size	6, 12, 14	S, L, XL	S, L
Country of Origin	Vietnam	Cambodia	Vietnam
Suggested Retail Price	\$98.00	\$95.00	\$88.00
Purchase Price	\$98.00	\$66.00	\$29.00

Samples from each brand were purchased in black and ankle-length since these were the most popular among surveyed consumers. Prior to testing, the leggings were conditioned according to ASTM D1776–16 Standard Practice for Conditioning and Testing Textiles (ASTM, 2019). The samples were placed in an atmospheric chamber registering at $70^{\circ} \pm 2^{\circ}$ Fahrenheit and relative humidity of $65\% \pm 5\%$ for a minimum of four hours before each test. The care labels of each brand were evaluated to determine the wash parameters. The samples were laundered on the 'colors/normal' cycle with 'cold' water ($30^{\circ}\text{C}/86^{\circ}\text{F}$). Each cycle duration was approximately 60 minutes. For each laundry cycle, 30 grams of a national brand of liquid detergent was used. Water hardness from a municipal source averaged 12 grains per gallon. Samples were tumble dried on the 'color/normal' cycle. Three samples of each brand were combined to create an average size clothes load without the use of a dummy load. The leggings were washed for 20 wash/dry cycles and evaluated initially before washing and after washes one, five, ten, and twenty.

Data analysis

For analysis of the survey data, descriptive summary statistics were used. Percentages and frequency of responses were reported. Descriptive statistics, one-way ANOVA, and Fisher's pairwise comparison was utilized using Minitab statistical software. Statistical significance was determined using a 95% confidence interval with a significance level (α) of 0.05.

Results and Discussion

Consumers' desired legging features and encountered problems were assessed to create a consumer profile of college-aged students who wear leggings for non-athletic purposes. The fabric characteristics and the aesthetic and functional performance qualities of frequently purchased brands were identified, and evaluations were performed on three brands of legging samples after one, five, ten, and twenty laundering cycles.

Survey results

The final survey sample included 133 female participants.

Approximately 51% were aged 20-21, 30% were aged 18-19, and 19% were aged 22 or older. The survey responses are grouped according to questions related to functional, expressive, and aesthetic qualities of leggings (FEA Model).

Function: Results for survey questions relating to function are presented in Table 3. "See-through fabric" was the most frequently selected response when consumers were asked what functional and durability problems they had encountered. Another frequently encountered problem cited by 58% of respondents was "fabric becoming worn down".

Respondents were asked to rank their level of frustration with the functional performance problems encountered. The level of frustration was rated using a five-option scale, which included not frustrating, slightly frustrating, moderately frustrating, very frustrating, and extremely frustrating. The top two levels of importance (very frustrating and extremely frustrating) were combined for each category to achieve a substantive rating level. "See-through fabric" had the highest combined percentage with 57%. The second highest combined percentage was that of "holes," with 49% of responses, closely followed by "ripping seams" with 42%.

The survey then asked consumers which functional feature they found to be most desirable when selecting a new pair of leggings. Approximately 43% of respondents indicated "comfortable material." The second most frequently selected option was "material is not see-through," which was selected by 36% of respondents.

The survey also asked participants to rate the level of importance for each functional performance category when shopping for a new pair of leggings. There were five rating options, which ranged from not important to extremely important. When extremely important and very important ratings were combined, over 90% of respondents were found to have chosen "comfortable material" and "material which is not see-through."

Expressive: Results for survey questions relating to the expressive qualities are presented in Table 4. Consumers were asked what legging brand they regularly purchase and what brand they would ideally prefer to purchase. Brand A was selected as the most regularly purchased brand, and Brand B was the second most regularly purchased. Brand A was also selected as the most ideally purchased brand, with B being selected as the second most ideal brand. Survey responses for other regularly purchased brands included Brand C, but Brand C was not as frequently chosen as an ideal brand.

Table 3: Summary of problems and desired features related to functional performance of leggings.

Summary of Survey Questions	Results			
Problems encountered after wear	See-through (73.70%)	Worn down fabric (57.90%)	Holes (44.40%)	Seam ripping (40.6%)
Level of frustration with problems*	See-through (56.80%)	Holes (48.50%)	Ripping seams (42.00%)	Worn down fabric (36.50%)
Desired feature in new athleisure leggings	Comfort (43.20%)	Not-see through (35.6%)	Odor control (5.30%)	Not thick (3.00%)
Value of performance in new legging	Comfort (91.70%)	Not see-through (90.9%)	Odor control (43.2%)	Thick or restrictive (41.7%)

*Results reflect combined rating categories

Table 4: Summary of brand preferences and criteria used in selection of leggings.

Summary of Survey Question	Results		
Brand of legging regularly purchased	Brand A (56.40%)	Brand B (39.80%)	Brand C (27.10%)
Main criteria for regular purchase of selected brand	Quality (60.20%)	Price (23.30%)	Color/Design (6.80%)
Brand of legging ideally purchased	Brand A (73.70%)	Brand B (51.10%)	Brand C (15.00%)
Main criteria for ideally selected brand	Quality (67.90%)	Price (12.20%)	Color/Design (12.20%)
Situation where typically worn	Running Errands (99.2%)	Travel (97.70%)	Class (97.00%)
How legging is typically worn	As pants regardless of top length (86.50%)	As pants but only with longer style top (12.80%)	Base layer (0.80%)

When the respondents were asked why they regularly purchased a brand, approximately 60% indicated that their favorite brand offered a "quality" product. Additionally, 68% of consumers indicated that they selected an ideal brand to purchase because they believed the brand offered "quality" products. "The price is best for me" was also recurrently selected as a reason for frequently purchasing. Survey respondents were also asked, "In which of the following situations would you wear leggings?" "Running errands"

was the most selected situation, with almost all survey respondents (132 of 133) indicating they wore leggings for this activity. Wearing leggings "for travel" and "to class" were picked almost as frequently as "running errands." The final question for the expressive category was, "How do you typically wear your leggings?" Approximately 86.5% of the survey participants indicated that they wear their leggings "as pants regardless of top length."

Aesthetic: Results for survey questions regarding the aesthetic qualities of leggings are presented in Table 5. Survey respondents were asked two questions regarding preferences for features. They were first asked, "What style features do you prefer for your leggings?" A "high waistband" accumulated 41% of the responses. "Pockets" were the second most frequently mentioned style feature with 22% of responses. The second question regarding feature preferences was, "What length do you prefer for your leggings?" Most of the survey participants (approximately 84%) selected "ankle length" as their preferred legging length. "Mid-calf length" was the next most frequently selected option, with only 13% of respondents preferring this length.

When the sample was asked about aesthetic problems, "pilling" was the most often reported issue, being selected by 78% of the respondents. "Excessive lint" was reported by 65% of respondents, while "stretched out fabric" was experienced by 45%. Survey respondents were requested to rate their frustration level with aesthetic problems. To measure the level of frustration, the sample was given a five-option rating scale, ranging from not frustrating to extremely frustrating. When very frustrating and extremely

frustrating were combined, 60% of consumers found "pilling" frustrating. The next highest combined percentage was that of "stretched out fabric," which had 52% of responses, "shrinkage" had 49%, and "lint accumulation" had 43%.

Consumers were asked what aesthetic features they desired when shopping for or purchasing a new pair of leggings. "No pilling" was the most selected aesthetic performance feature by approximately 40% of the surveyed sample. "Fabric does not stretch out" was the second-highest category, selected by 28% of consumers. Consumers were also asked to rate the level of importance for aesthetic performance categories when shopping for a new pair of leggings. There were five rating options, which ranged from not important to extremely important. When combining the very important and extremely important responses, 61% of consumers valued "fabric does not stretch out easily" as important. "Low pilling" and "low lint" were described by 55% and 51% of survey respondents when the two levels of importance were combined. "Minimal shrinkage" had less than 50% of the respondents describe the category as very important or extremely important (Table 6).

Table 5: Summary of problems and desired features related to aesthetic performance of leggings.

Survey Question	Results			
Problems encountered after wear	Pilling (78.20%)	Lint (65.4%)	Stretched out (45.1%)	Color change (32.3%)
Level of frustration with problems*	Pilling (59.90%)	Stretched out fabric (52.00%)	Shrinkage (48.50%)	Lint (43.10%)
Desired feature in new athleisure leggings	No pilling (40.90%)	Does not stretch out (28.00%)	No lint (17.40%)	No shrinkage (7.60%)
Value of performance in new legging*	Does not stretch out (61.0%)	Low pilling (55.4%)	Low lint (50.8%)	Minimal shrinkage (45.0%)
Preferred style feature	High waistband (41.0%)	Pockets (21.6%)	Seamless (13.40%)	Mesh panels (13.10%)
Preferred length	Ankle (84.2%)	Mid-calf (12.8%)	Below the knee (1.5%)	Other (1.50%)

*Results reflect combined rating categories

Table 6: Summary of laboratory evaluation of textile characteristics.

Textile Evaluations	Brand	Wash 5		Wash 20	
		Mean	SD	Mean	SD
Fabric Weight (oz/yd ²)	A	6.7	0	6.8	0.1
	B	7	0	7.1	0
	C	8.9	0.2	8.7	0.1
Fabric Count	A	151*	6.0*	154	1.1
	B	147*	4.2*	148	0
	C	107*	2.5*	106	0.4
Fabric Thickness (mils)	A	29.6	0.2	29.8	0.7
	B	26.2	1.2	25.8	1
	C	30.9	0.3	30.9	0.4

*Fabric count was evaluated after Wash 1 in place of Wash 5

Laboratory evaluation results

The laboratory evaluation examined three brands of leggings with a nylon/spandex blend. For this research, the focus was on comparing the sample analyses after washes five and twenty. The product evaluation conducted after five laundering cycles reflects a garment's performance after residual or temporary fabric finishes have been removed. The product evaluation after twenty laundering cycles reflects a garment's serviceability over its lifetime. ASTM D4156-14 Standard Performance Specification for Women's and Girls' Knitted Sportswear Fabrics [19] was used to evaluate the results of the laboratory studies when applicable.

Fabric weight: According to Bubonia's classification of fabric weight [21], Brand A and Brand B had a medium fabric weight while the Brand C leggings had a medium-heavy weight. One-way ANOVA confirmed a difference in the mean weights of the fabrics after both five (p -value=0.000) and twenty (p -value=0.000) laundering cycles.

Fabric count: One-way ANOVA determined that the difference in the mean fabric count of the leggings was statistically significant after one (p -value=0.004) and twenty laundering cycles (p -value=0.000). After one wash, Brand B (147) and Brand A (151)

did not possess statistically significant differences (p -value=0.399); however, after twenty laundering cycles, all leggings had different counts, with Brand A (154) having the highest, Brand B the second (148), and Brand C (106) the lowest.

Fabric thickness: When evaluating if there was a difference in thickness of the leggings, there was statistical significance after both five (p =0.015) and twenty (p =0.003) laundering cycles. A pairwise comparison determined that the mean thickness of the Brand B leggings was statistically significant when compared to Brand A (Wash 5 p -value: 0.018 and Wash 20: 0.003) and Brand C (Wash 5 p -value: 0.007 and Wash 20: 0.002).

Bursting strength: The bursting strength of the Brand C was higher than that of either Brands A or B. One-way ANOVA determined a statistically significant difference in the bursting strength of the brands after both five (p =0.000) and twenty (p =0.001) laundering cycles. A pairwise comparison determined that the mean bursting strength of the Brand C leggings was statistically significant when compared to Brand A (Wash 5 p -value: 0.000 and Brand C Wash 20: 0.001) and Brand B (Wash 5 p -value: 0.000 and Wash 20: 0.000) (Table 7).

Table 7: Descriptive data for laboratory evaluation of performance characteristics.

Textile Evaluations	Brand	Wash 5		Wash 20	
		Mean	SD	Mean	SD
Bursting strength (psi)	A	62.6	2.8	67	3.7
	B	62.6	2.3	62.5	6.6
	C	91.5	3	94.3	5.4
Color Change	A	4.6	0.2	4.3	0
	B	4.8	0	4.5	0
	C	4.9	0.2	4.3	0
Fabric Stretch (Length)	A	98.40%	0	103.10%	0.4
	B	83.60%	0.1	89.10%	0
	C	60.90%	0.4	56.30%	0
Fabric Stretch (Width)	A	96.10%	0	89.10%	0
	B	102.30%	0	97.70%	0.1
	C	85.90%	0	93.00%	0.1
Fabric Recovery One Minute (Length)	A	10.20%	0	11.70%	0
	B	5.50%	0	7.80%	0
	C	6.30%	0	7.00%	0
Fabric Recovery One Minute (Width)	A	6.30%	0	7.00%	0
	B	7.80%	0	15.60%	0
	C	7.80%	0	13.30%	0.1
Fabric Recovery One Hour (Length)	A	3.10%	0	5.50%	0
	B	4.70%	0	5.50%	0
	C	1.60%	0	3.10%	0

Fabric Recovery One Hour (Width)	A	2.30%	1.1	3.90%	0.1
	B	3.10%	0	5.50%	0.1
	C	3.10%	0	5.50%	0
Pilling/Fuzzing	A	4.9	0.1	4.2	0.1
	B	5	0	4.9	0.1
	C	4.9	0.1	4	0
Dimensional Change (Length)	A	0.50%	0.2	0.79%	0.1
	B	0.53%	0.1	0.97%	0.3
	C	0.39%	0.3	0.73%	0.5
Dimensional Change (Width)	A	1.42%	0.4	2.04%	0.4
	B	0.68%	0.1	1.00%	0.1
	C	0.73%	0.8	0.97%	1

Table 8: Statistical significance of textile characteristics data.

Textile Evaluations	Wash 5			Wash 20		
	p-value	Pairwise	Pairwise p-value	p-value	Pairwise	Pairwise p-value
Fabric Weight (oz/yd ²)	0.000	A:B	0.064	0.000	A:B	0.053
		B:C	0.000		B:C	0.000
		C:A	0.000		C:A	0.000
Fabric Count**	0.004	A:B	0.399	0.000	A:B	0.002
		B:C	0.003		B:C	0.000
		C:A	0.002		C:A	0.000
Fabric Thickness (mils)	0.015	A:B	0.018	0.003	A:B	0.003
		B:C	0.007		B:C	0.002
		C:A	0.159		C:A	0.113

*p < 0.05 = statistically significant

**Initial fabric count was collected after Wash 1 in place of Wash 5

7.2.5. Color change: The color change was evaluated using the AATCC Gray Scale for Color Change, which includes the following scale: (1) very severe, (2) severe, (3) moderate, (4) slight, and (5) none. According to ASTM D4156-14 Standard Performance Specification for Women's and Girls' Knitted Sportswear Fabrics, a minimum grade of a 4 is required for a garment to present suitable color change results. All leggings maintained the requirement by surpassing this minimum rating. The difference in means was not statistically significant after five (p=0.354) and twenty (p=0.465) laundering cycles.

Stretch recovery: A modified version of ASTM D2594: Standard Test Method for Stretch Properties of Knitted Fabrics was used to evaluate the growth and recovery of the legging samples. Both lengthwise and widthwise specimens (4-inch x 12-inch) were cut and then stitched into loops, resulting in lengthwise loop samples and a widthwise loop samples; each sample was marked with a benchmark distance of four inches. Each specimen was elongated uniformly for two hours with a five-pound weight; the maximum

amount of stretch was measured and used to calculate the stretch ability of the leggings. In the length direction, Brand A leggings demonstrated the highest amount of stretch and Brand C the lowest amount; these differences were statistically significant after both five (p-value=0.006) and twenty (p-value=0.001) laundering cycles. In the width direction, the Brand C leggings had significantly lower stretch ability than the other brands after Wash 5 (p-value=0.008) only (Table 8).

The weight was removed, and the benchmark distance remeasured after one minute of recovery. This measurement was used to calculate growth; a higher percentage of growth indicates lower recovery abilities. There was no significant difference in the mean growth in the length direction after Wash 5 (p-value=0.192). However, after Wash 20, there was a significant difference (p-value=0.026) since Brand A leggings had more growth than Brands B or C. The width specimens' growth after one minute of recovery was significantly different after Wash 5 (p-value=0.002). This difference can be explained by the growth of the Brand A

leggings, which was lower than that of Brands B and C. After Wash 20, the difference in the mean width growth of the brands was not significant (p -value=0.177).

The specimens were measured again after one hour of recovery. The length specimens demonstrated statistical significance after Wash 5 (p -value=0,000), with the Brand C leggings demonstrating the least amount of growth and the Brand B leggings demonstrating the most. There were no significant differences after Wash 20 (p -value=0.125) in the length direction. There was no statistical significance after one hour in the width direction for Wash 5 or Wash 20.

Pilling and fuzzing: The appearance of each specimen after abrasion was evaluated compared to an ASTM photographic standard. Ratings one through five were as follows: (1) very severe pilling, (2) severe pilling, (3) moderate pilling, (4) slight pilling, and (5) no pilling. When comparing Wash 5 and Wash 20, the average pilling resistance of each brand decreased. The rating of the Brand B leggings degraded the least; however, when comparing the ratings for each brand, the difference in the mean rating was not statistically significant (p -value=0.274) after Wash 5. However, after twenty laundering cycles, the difference was found to be statistically significant (p -value=0.000). A pairwise comparison determined that all brands were significantly different from one another after twenty laundering cycles. The Brand B leggings had the least amount of pilling with an average rating of 4.9. The Brand A leggings had a lower average rating of 4.2, and Brand C had the lowest pilling rating of 4.0 after twenty laundering cycles.

Dimensional stability: According to ASTM D4156-14, the dimensions of leggings should change no more than 3% after home laundering. All legging samples met this specification in both the length and width directions. Almost all changes were below 2%, excluding Brand A's average width change after Wash 20. One-way ANOVA determined no difference in the garment's length measurements after Wash 5 (p -value=0.849) and after Wash 20 (p -value=0.753). The width measurement changes also revealed no significant differences after five (p -value=0.411) and twenty (p -value=0.263) wash cycles.

Conclusion

The overall objective of this research was to better understand consumer opinion by creating a customer profile of legging preferences and complaints through a survey and to compare the performance of three frequently purchased legging brands through laboratory evaluations. The research objectives of this study were to:

Identify and evaluate the desired characteristics of women's leggings for college-age athleisure consumers

Leggings that are comfortable and not see-through were the two most important functional features valued by consumers in this study. The athleisurewear consumer can be thought of as an athletic

performer who has functional needs for their clothing. Just as technical athleticwear is designed to enhance athletic performance [22], athleisurewear needs to be designed to satisfy the athleisure wearer's everyday needs. Consumers also expressed that a brand is considered ideal if it offers quality products; therefore, for a brand to be considered ideal, it is imperative to ensure that consumers are guaranteed comfort and non-see-through fabric. When evaluating aesthetics, no single feature was chosen as most desirable by consumers; therefore, it can be concluded that consumers have diverse desires for aesthetic performance in leggings. However, it can be noted that more than one-third of consumers did desire leggings that do not pill.

Situational occasions where consumers chose to wear leggings in this study were numerous, which further supports the statement that leggings have replaced denim as an essential garment for women in the U.S [1]. Consumers often reported wearing leggings to attend class, run errands, travel, and less frequently for business casual attire. Most consumers also indicated they chose to wear leggings as pants regardless of the type of top they wear.

Identify and analyze the encountered problems of women's leggings for college-age athleisure consumers

Brands capitalize on the trend of athleisure by mixing both functional and everyday sportswear into their product mixes, which can be confusing for consumers [23]. As discussed previously, leggings are multifunctional and multi-situational; therefore, it is crucial not to neglect their quality. Consumers can grow frustrated with leggings when encountering functional or aesthetic performance problems. In this study, consumers identified the same four functional problems as frequently encountered and frustrating: see-through fabric, worn down fabric, holes, and ripping seams. The most commonly encountered aesthetic problem was pilling, followed by excessive lint and stretched-out fabric. Therefore, a consumer may be more satisfied with leggings that do not have the problems of see-through fabric, worn down fabric, holes, ripped seams, pilling, excessive lint, and stretched-out fabric.

Compare the evaluation results of three brands of leggings selected by college age consumers to determine if there are differences in their fabric specifications, performance, and aesthetics

The leggings selected for the laboratory evaluations (Brands A, B, and C) were knit from a nylon/spandex blended fabric. Results determined that there are indeed some differences in the performance characteristics of these brands. Fabric specification evaluation revealed that Brand C had a significantly higher fabric weight than Brand A or B. While Brand C was classified as medium heavyweight, Brand A and B were both medium fabric weight. Additionally, the fabric count of Brand C was significantly lower than that of Brand A or B. Because the weight of Brand C was significantly higher, but the fabric count was lower, the size of the yarns could be larger in this garment.

Brand B was significantly less thick than the other two leggings brands; Brand A and C were similar in thickness despite their significantly different fabric weights and count. Brands A and B performed similarly when evaluated for fabric weight and count. All brands showed little variation between wash evaluations when examining the fabric specifications. This suggests little change or variation to the fabric construction of these garments after home laundering. Brand A showed the greatest difference in fabric count, which correlated with increased strength and shrinkage after washing (Table 9).

Brand C leggings had a significantly higher bursting strength than that of the other brands, while Brands A and B were similar. As mentioned above, the Brand A leggings were more resistant to bursting after washing, whereas Brand B's strength decreased, and Brand C leggings remained relatively unchanged. Aesthetic performance evaluations revealed that the brands showed little difference when comparing color change and dimensional change. The change of color gradually increased for all brands but was not significant. Also, shrinkage occurred in all brands but not significantly. Brand A shrank the most in the length direction, which correlates with its increased fabric count and resistance to bursting after laundering. However, all brands surpassed the specification required by ASTM D4156-14.

When comparing stretch recovery, there was no difference in the width direction performance for all brands. However, in the length direction, Brand C had the lowest stretch ability, while Brand A had the greatest. This may account for Brand A also demonstrating the largest growth in the length direction after one minute of recovery. None of the brands tested showed any significant difference in growth after one hour of recovery. Pilling ratings for all brands gradually declined after washing; however, each demonstrated different levels of pilling. Brand B had the highest pilling and fuzzing rating, followed by Brand A, and then Brand C having the lowest pilling rating by visual evaluation. In summary, the specific styles of leggings selected for evaluation performed well, and their performance did not decline considerably after twenty laundering cycles.

Limitations and Recommendations

The survey portion of this research was limited to a non-randomized sample of participants. Students who completed the questionnaire were predominantly from two sororities at a public university. This research chose to focus on women currently attending college; therefore, opinions of other age ranges may not be reflected in the results. The samples selected for laboratory evaluation were also limited by resource availability. Each laboratory evaluation was conducted on two to three legging samples; therefore, conclusions were based on relatively small sample sizes. Finally, the study did not account for a garment's behavior after wear. Soiling and wear from everyday activities may adversely impact garment performance.

Descriptive survey data was collected through a questionnaire. Future studies should consider other methods of collecting consumers' opinions. Qualitative approaches such as focus groups, oral interviews, or observing decision processes of consenting legging shoppers would perhaps give additional insights into consumers' purchase decisions. Future studies should also select other legging brands and fabric types for laboratory evaluation since many are made with various combinations of polyester, spandex, cotton, and nylon. Additionally, a wear study would allow for the assessment of the impact of consumer wear and laundering.

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Conflict of Interest

Authors declare no conflict of interest.

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