


Review

Influence of Size and Fit on Malaysian Apparel Industry Sustainability: A Scoping Review

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Abstract: Mass production and global trade have fuelled apparel industry economic growth since the industrial revolution. Mass production and global trade have also contributed to sustainability issues, such as pollution and resource depletion. This scoping review explores how garment sizing and fit affect the sustainability of the Malaysian garment industry. The research objective was achieved using an in-depth analysis of the literature to identify the main sizing and fit issues and research gaps in the Malaysian apparel industry. Furthermore, the sustainability challenges resulting from sizing and fit issues were explored and the strategies to address these issues for apparel industry sustainability were proposed. Finally, the authors suggest that Malaysia should establish its own standard sizing system to contribute to the sustainable development of the local industry. This comprehensive analysis aims to provide an empirical basis and strategic guide for sustainable development by the Malaysian apparel industry.

Keywords: apparel industry; size system; fit; sustainability; Malaysia



Citation: Wang, Y.; Zakaria, N. Influence of Size and Fit on Malaysian Apparel Industry Sustainability: A Scoping Review. *Sustainability* **2024**, *16*, 2486. <https://doi.org/10.3390/su16062486>

Academic Editor: Wen-Hsien Tsai

Received: 21 February 2024

Revised: 12 March 2024

Accepted: 14 March 2024

Published: 17 March 2024

Corrected: 28 June 2024



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1. Introduction

After the 19th century, the apparel industry transitioned to mass production by relying on mechanised development [1]. In the second half of the 20th century, the apparel industry shifted production to low-cost countries, which increased efficiency while reducing costs [2]. Subsequently, the apparel industry became a global economic cornerstone. Recent statistics have estimated that the economic influence of the apparel industry is approximately USD 1.3 trillion [3]. Global apparel consumption continues to grow and is forecast to increase by 63% by 2030, from 62 million tonnes to 102 million tonnes [4]. In the 21st century, the apparel industry began to focus on using technology and digitalisation, and transitioned to Industrial Revolution (IR) 4.0. Thus, product design and development use three-dimensional (3D) printing, big data, computer-aided design (CAD), and digital twin technologies [5].

The manufacturing sector is building smart factories to optimise production [6] and the supply chain management sector is using technologies, such as the Internet of Things (IoT) and big data, to optimise inventory management and improve transparency [7]. Additionally, the COVID-19 outbreak severely affected the global market, and the resulting regional and global trade embargoes fuelled digital and virtual channel developments [8]. Some brands engage with customers by using innovative approaches, such as virtual reality (VR), augmented reality (AR), and 3D virtual simulation (VS) technologies [9], which enhances customer service flexibility.

The rapid growth of the apparel industry has contributed to economic growth and has also presented several challenges. The notable issues confronting the contemporary apparel industry are overproduction and unused inventories. Global Fashion Agenda [10] reported that the apparel industry is estimated to produce up to 114 billion garments annually. Nevertheless, approximately 30% of the inventory must be sold. The popularity of fast

fashion has significantly increased garment production recently (by ~50%). Simultaneously, garment usage has declined by 40% [11]. Catering extensively to more than one person's needs does not lead to higher product utilisation. Thus, overproduction agrees poorly with consumer demand and is environmentally detrimental.

Garment processing and textile production significantly rely on natural and non-renewable resources [12]. For example, up to 93 billion m³ of water is consumed [3]. The global textile industry generates up to 92 million tonnes of textile waste annually, of which ~60% is pre-consumer waste [13]. The widespread use of fibre dyes and chemicals in fabric production and treatment improves fabric texture and appearance but exerts significant environmental pressure [3]. Tandon et al. [14] emphasised that overproduction leads to environmental waste and resource depletion. Furthermore, the landfill or incineration methods used to for disposing discarded garments exacerbate the negative environmental effect of the industry.

The aforementioned studies demonstrate that the global apparel industry generally faces sustainable development issues. Nonetheless, the priorities and strategies to address these issues vary between countries. The apparel industry is an essential driver of Malaysian economic development and employment and a notable expression of national multiculturalism. The Federation of Malaysian Manufacturers reported that the national textile and apparel industry consists of 25% large, 44% medium, 30% small, and 1% micro-enterprises. This diverse composition corresponds to different market demands and challenges [15].

The Malaysian multi-ethnic and multi-religious backgrounds result in a complex apparel consumer market, which renders sizing and fit key considerations. Inappropriate garment sizing and fit lead to higher consumer return rates, which exacerbates inventory backlogs and negatively affects organisational economic performance and resource utilisation efficiency. As the Malaysian apparel industry faces overproduction and an idle inventory in the context of globalisation, this study focuses national apparel industry sustainability.

Therefore, this study mainly aims to provide insights into how sizing and fit affect Malaysian apparel industry sustainability. The literature was analysed, and the main sizing and fit issues and research gaps were identified. Additionally, the study systematically explored specific sustainability challenges due to sizing and fit issues and proposed the according strategies to address them. This study aims to provide empirical support and strategically guide Malaysian apparel industry sustainability using comprehensive analyses. The findings will aid the sustainable progression of the Malaysian apparel industry.

2. Method

In this scoping review, a pre-search conducted using the keywords "Malaysia" and "apparel" yielded few results, which demonstrated the initial stages of research on the relevant aspects of Malaysian apparel production. Furthermore, the academic field has not published relatively comprehensive reviews. Therefore, there is a need to establish a meticulous keyword search programme and expand the literature using snowballing.

This scoping review used the Web of Science (WoS) and Scopus (S) as the central databases as they are well-known in the academic world and cover a wide range of scientific literature. The two databases combine journal and conference papers from a wide subject range and provide a rich research resource. This database comprehensiveness ensures access to as much relevant research as possible for scoping reviews. Additionally, both platforms offer advanced search tools that enable in-depth and precise literature searches.

The scoping review methodology is illustrated in Figure 1. The keywords were extracted by analysing the study purpose and title, and were "apparel", "Malaysia", "size", "fit", and "sustainability". As there are more synonyms for "apparel", the search rules also considered the synonyms. The first search retrieved 12, 7, and 17 articles from the WoS and 43, 13, and 45 articles from Scopus for "size" (S), "fit" (F), and "sustainable" (Sust), respectively. The search results after duplicates were removed were as follows: N

(WoS-S): 3 articles, N (WoS-F): 3 articles, N (WoS-Sust): 9 articles, N (S-S): 16 articles, N (S-F): 3 articles, and N (S-Sust): 18 articles.

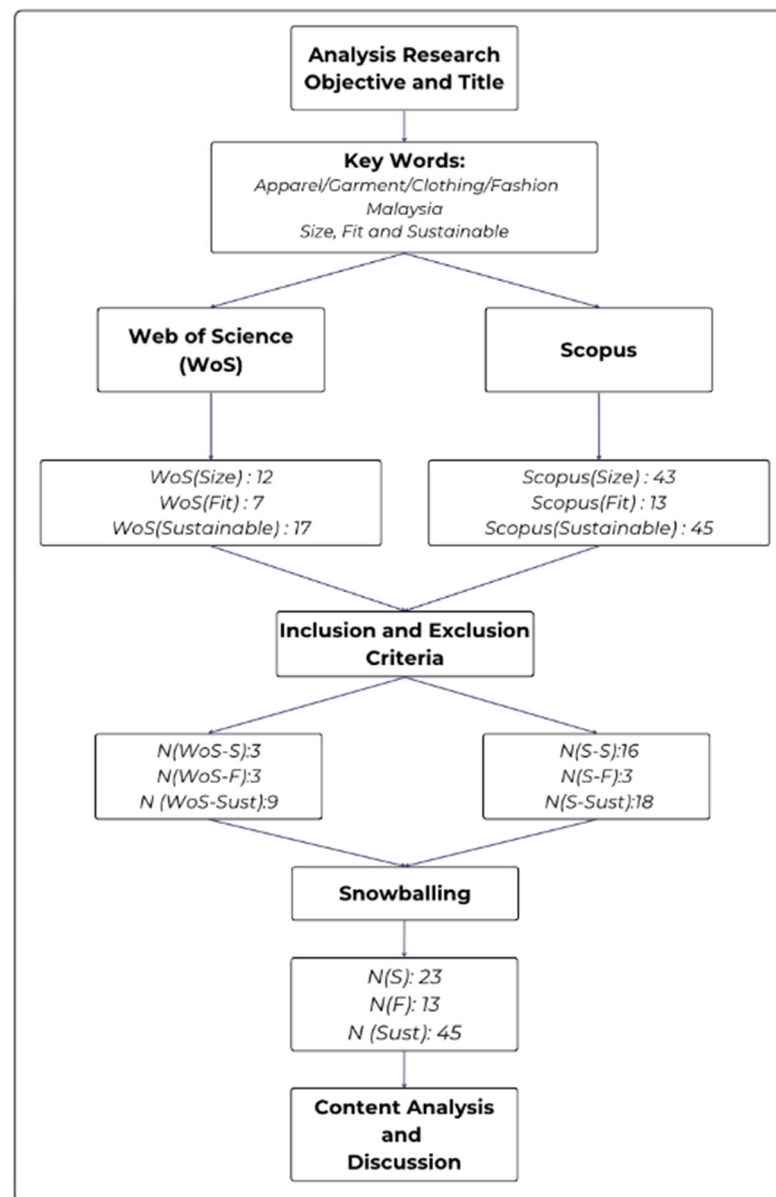


Figure 1. The research methodology.

Considering the nascent stage of academic research in this area within Malaysia, we employed a citation chasing method. This involved reviewing the reference lists of articles identified as highly relevant in the initial screening phase, which allowed us to discover additional studies not captured through database searches alone. This method is particularly effective in capturing grey literature and reports that are critical for comprehensive scoping reviews but may not be indexed in the major databases. The subsequent phase of article selection involved a more detailed review, where we applied specific inclusion criteria. Articles were included if they (1) explicitly discussed garment sizing and fit within the context of the Malaysian apparel industry, (2) addressed sustainability aspects related to garment production or consumption, and (3) provided insights into the implications of sizing and fit on sustainability. Eventually, the removal of duplicates yielded the following results: N (S-S): 23 articles, N (S-F): 6 articles, and N (S-Sust): 45 articles.

3. Results

3.1. Sustainability and Apparel Industry in Malaysia

In Malaysia, although the direct economic contribution of the textile and clothing industry is relatively small, accounting for only about 1.2% of the GDP [16], its impact in terms of environmental pollution is severe. This industry generates more than 6 billion square metres of textile waste annually due to inefficiencies in the production process [17], and this volume of waste is vast enough to cause widespread concern. Furthermore, the apparel industry is not only a significant source of environmental pollution in terms of energy consumption, waste generation, water use, gas emissions, and wastewater discharges [18], but the scale and impact of this pollution are increasing.

In recent years, the garment waste problem has worsened dramatically due to the lack of environmental management practices and public awareness, resulting in unprecedented negative environmental impacts [19]. More critically, the Malaysian textile and garment industry is highly damaging to the environment as a significant source of plastic pollution, primarily through plastic leakage triggered by the production of synthetic-fibre clothing [20]. This pollution not only affects land and water sources but also threatens biodiversity and human health, and action is urgently needed to mitigate these impacts.

In the face of the unsustainable challenge, the Malaysian government has begun to recognise the potential of implementing a circular economy for waste minimisation. It moves from the traditional linear waste management model to a circular economy model. This shift aims to reduce dependence on raw materials and extend the life of products in the economy by promoting product repair, recycling, and reuse [17].

In the contemporary economic environment, the sustainability of the Malaysian apparel industry has become a pressing issue. A study by Nestler et al., [21] highlights that the apparel industry is expected to have a high rate of return of 30 to 40 percent, and ill-fitting garments have become the main reason for returns, which not only affects consumer satisfaction, but also exacerbates the problem of waste in the apparel industry. Guo and Istook [22] further state that consumers often need help finding garments that fit well, which has led to many ill-fitting garments in the market. In addition, Hinčica et al. [23] state that the lack of a standardised sizing system and ill-fitting garments seriously affect consumers' perceptions of product quality and overall satisfaction.

Moreover, the increasing willingness to purchase sustainable garments as consumer awareness rises shows Malaysia is gradually integrating with global trends in sustainable fashion. The Malaysian Foreign Trade Development Authority (MFDA) sustainability programmes and the collaboration with the ASEAN Council of Fashion Designers (ACFD) have contributed to a better alignment of the country's apparel industry with global sustainability trends. The rise of eco-conscious start-ups, such as KANOE and Nukleus Wear, is also evident despite the unfavourable economic climate [24]. Furthermore, the Malaysian government's commitment to developing a green economy is highlighted by its support for international green product standards and its commitment to reducing carbon emissions by 10 percent [25]. These developments suggest that the Malaysian government and consumers are working together to promote environmental responsibility and the sustainable development of the apparel industry.

3.2. Garment Size and Fit in Malaysia

There are few studies on garment sizing and fit in the Malaysian fashion industry, but they reveal unique local needs and conditions. Otieno and Fairhurst have identified that sizing and fit issues, which is especially prevalent in online shopping where trying on clothes is not possible, can cause consumer dissatisfaction. This results in higher returns and costs for such businesses [26]. Saaludin et al. [27] and Qian and Zhao [28] have reported that the absence of a standardised sizing system has also led to consumer dissatisfaction and marketplace confusion. Halwani [29] and Sidorchuk [30] observed that sizing system differences between brands complicate consumer choice. The Malaysian Size Survey (MySIZE) addressed these issues by measuring Malaysians accurately using

3D body scanning technology [31]. These studies highlighted the importance of apparel industry standardisation to improve consumer satisfaction and garment fit. Tables 1 and 2 summarises garment sizing and fit research in the Malaysian fashion industry.

Table 1. Summary of key findings from the Web of Science (WoS).

| Citation | Summary of Key Findings |
|--|---|
| Hasbullah et al. [24] | Malaysia is in the initial development stages in sustainable fashion but has adopted several initiatives. The initiatives include the Malaysian Foreign Trade Development Corporation sustainability programme, the Fashion Revolution campaign, the World Wildlife Fund (WWF) project, and the ASEAN ACFD collaboration. In 2015, Malaysia joined 193 United Nations Member States in committing to 17 Sustainable Development Goals (SDGs) to collectively advance sustainable, resilient, and inclusive development globally, which charted a more sustainable future for the country and its people. The Malaysian government strongly supported the International Green Product Standard. Despite slow Malaysian economic growth, an increasing number of apparel companies are venturing into sustainable fashion. Start-ups (KANOE, Nukleus Wear, Zibossa, and Real-M) have demonstrated this trend. These fashion companies actively pursue and practise sustainable values. Up to 53.6% of the extended model of the motivation–opportunity–ability (MOA) theory and self-determination theory (SDT) explains Malaysian millennials’ willingness to buy sustainable clothing. |
| Malaysia External Trade Development Corporation [32] | The Malaysian External Trade Development Corporation (MATRADE) emphasised the promotion of national businesses to participate in sustainable development initiatives in its 2017 press release and demonstrated the importance it placed on sustainable development. |
| Yang et al. [33] | Considering the novelty of sustainable fashion in Malaysia, there are extremely few options and products. |
| Augustine et al. [34] | Kuala Lumpur millennials positively influence sustainable fashion purchases. |
| Rosli [35] | In 2018, the Malaysian fashion industry recognised sustainable fashion issues, with various global brands implementing pragmatic steps to address their environmental effect. Malaysian fashion consumers must improve their awareness of sustainable fashion consumption and its environmental effect. |
| Ali et al. [36] | Research on Malaysian sustainable fashion focussed on sustainable fashion consumption and environmental involvement. The Malaysian government-led Green Technology Corporation (MGTC) initiative is expected to promote sustainable development by establishing quotas for green product production and in various industries. |
| Hasan and Ali [37] | Research on Malaysian sustainable fashion typically focused on green business performance, consumer perceptions of eco-friendly apparel, and individual self-efficacy. |
| KeTTHA [25] | The Malaysian Green Technology Master Plan (2017–2030) core objective of reducing carbon emissions by 10% represented the national commitment to the strategic development of green technology and a low-carbon economy. |
| Hassan et al. [38] | Personal norms, social norms, and environmental awareness significantly and positively influence sustainable fashion consumption. This consumption behaviour influences charitable clothing disposal and Malaysian youths’ clothing disposal behaviour, where economic factors are key. |

Table 2. Summary of key findings from Scopus.

| Citation | Summary of Key Findings |
|--------------------------------------|--|
| R.B. Otieno and Fairhurst, 2000 [26] | Otieno and Fairhurst noted that consumer dissatisfaction often stems from sizing and fit issues, particularly in online shopping, where trying on clothes is not an option. This leads to increased returns and costs for companies. |
| Saaludin et al. 2019 [27] | Shoppers at physical stores also encounter sizing and fit challenges, frequently trying on numerous items for the best fit, a burdensome and time-intensive process. Quality products must meet consumer needs to boost satisfaction. Dissatisfaction can result in complaints, returns, and negative feedback. |

Table 2. Cont.

| Citation | Summary of Key Findings |
|-----------------------|---|
| Qian and Zhao [28] | Malaysian clothing brands have differing sizing standards. |
| Bong et al. [39] | Local retailers and manufacturers use US or UK sizing standards, which are based on anthropometric data that are notably different from that of the Malaysians. Each Malaysian brand has its own size labelling, and sizing system differences between brands can lead to consumer confusion. |
| Sidorchuk et al. [30] | Malaysian consumers' daily experience of size selection is not applicable to all brands. |
| Hasbullah et al. [31] | The MySIZE nationwide study combined 3D body scanning and traditional measurement techniques to accurately measure Malaysians' body sizes and shapes. Globalisation, consumer body size, and cultural preferences influence Malaysian clothing sizes. Increasing trade globalisation could result in international sizing standards affecting Malaysian clothing sizes. |
| Chun [40] | Specialised sizing is required to meet the needs of specific Malaysian body types. This change is reflected in Malaysian clothing sizing to accommodate different body types and preferences. International standards have led to the government developing unique sizing standards that challenge the garment manufacturers and retailers targeting international consumers. These changes highlight the potential effect of these standards on Malaysian garment sizing. Clothing fit is influenced by consumer preference, functionality, and brand image, and reflects the effect of size variation on consumer satisfaction, which emphasises the importance of standardisation. The author's perspectives on clothing labelling and consumer dissatisfaction with sizing provide insights into the challenges of sourcing well-fitting clothing. The study emphasised the importance of accurate sizing and the effect of size discrepancies on consumer frustration, which highlights retailers' challenges when catering for different body shapes and sizes. |
| Karmegam et al. [41] | There is an urgent need for a Malaysian database of anthropometric measurements. Information on the relationship between anthropometrics and socio-economic status differences in Malaysia is lacking. |

4. Discussion

4.1. The Malaysian Apparel Industry Research Gap

Chun [40] extensively compared standard garment sizing systems, which included United States, European Union, German, Chinese, Japanese, and South Korean sizing systems. The findings revealed diverse sizing systems established by different countries internationally. For example, the European Committee for Standardisation (CEN) released the revised European standard EN 13402-3:2013 [42] for body measurements and intervals [43]; the ISO/TC 133 [44] Technical Committee of the International Organisation for Standardisation (ISO) proposed the updated ISO 8559 [45–47] clothing size designation standard. Lastly, the China National Institute of Standardisation issued clothing sizing standards for men, women, and children: [48–50], respectively.

Body sizes in Malaysia tend to vary by ethnicity, contributing to challenges in establishing a standardized clothing size system. This situation can lead to some market confusion and may impact consumer satisfaction to a certain extent [28]. The lack of a standardised Malaysian clothing sizing system has led to the reliance on anthropometric data from other Asian countries (Japan and South Korea) to predict youths' body sizes [41]. Reliance is attributed to the high cost and time-consuming nature of conducting anthropometric measurements and the assumption that other Asian data can be substituted [51]. Consequently, there is a pressing need for more detailed Malaysian anthropometric data. The absence of a standardised Malaysian size system represents a significant knowledge gap, particularly in the apparel industry [41]. Given the dearth of research on anthropometric measurements for the apparel industry, there is an urgent need for sizing system research to enhance sizing standardisation and uniformity in the Malaysian garment industry.

While standard garment sizing systems are widely utilised to define body shape and guide sizing, they are primarily based on broad anthropometric data and may not

adequately consider consumers' individual sizing preferences. This critical shortcoming has led to inter-individual variability and specific needs being neglected despite national sizing systems aiming to standardise clothing sizes and labels for the public [52]. As the demand for individualised fit increases, consumers are increasingly inclined to evaluate garment fit based on personal preferences [53].

In summary, despite the increasing sophistication of global sizing system development technology, the absence of sizing systems for adult apparel in Malaysia remains a significant research gap. This gap affects consumer satisfaction and market efficiency and highlights the need to develop localised and personalised clothing sizing systems. Given Malaysia's ethnic and cultural diversity, it is essential to develop an integrated and localised adult clothing sizing system that will help to improve standardisation.

4.2. Unsustainable Malaysian Apparel Industry Issues Caused by Size and Fit

The absence of a standardised garment sizing system presents multifaceted sustainability challenges to the Malaysian apparel industry. The lack of standardisation resulted in varying sizing standards across different Malaysian garment brands. Local retailers and manufacturers frequently use US or UK sizing standards, which are based on anthropometric measurements from a population that differs significantly from that of Malaysian population [39]; each Malaysian brand uses its own size labelling, which results in consumer confusion due to sizing system discrepancies between brands [39]. These inconsistent sizing standards render the consumer's daily experience of size selection uninformative [30] and also contribute to customers purchasing ill-fitting products, thereby diminishing customer satisfaction [54].

The consequences of ill-fitting garments extend beyond customer dissatisfaction, where they increase the risk of returns and idle inventory. The increased risk diminishes retailers' operational efficiency [55,56]. Furthermore, sizing standard uncertainty can lead to overproduction, as apparel manufacturers might overproduce to meet consumer expectations [57]. The accumulated returned and unused inventories necessitate substantial warehouse management and preservation resources and also impede apparel business cash flow, which financially burdens their development [58]. Moreover, the prevalence of outdated, unused inventories result in resource wastage, while overproduction contributes to environmental pollution [59,60].

As more clothing consumers demand personalised fits, personalised sizing preferences have become pivotal in evaluating clothing product fit [53]. Consequently, the non-standardised Malaysian sizing system engenders numerous sustainability challenges for the local apparel industry [41,61,62]. The issues stemming from the primary research problem ultimately culminate in the unsustainable difficulties faced by the industry, as illustrated in Figure 2.

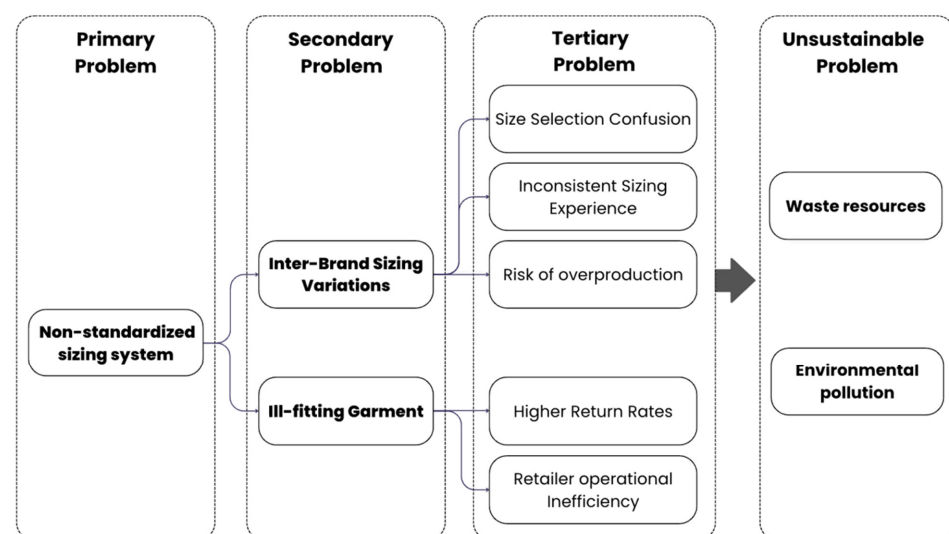


Figure 2. The research problem.

4.3. The Effect of Apparel Sizing Systems on Size and Fit

The earliest documented garment pattern dates back to 1580 in Juan de Alcega's *Libro de Geometria Pratica* and signifies early garment production systematisation attempts [63]. In 1747, *A General Description of All Trades* emphasised the significance of pattern design and cutting skills for achieving a proper fit, which reflected the increased awareness of the relationship between garment construction and fit [64]. Throughout the 18th century, tailors were challenged to create more flattering clothing as men's fashion evolved, which underscored the importance of garment fit [65]. Towards the end of the 19th century, professional tailors notably shifted towards direct measurements of the human body, which represented a more scientific approach to garment production [66]. This shift was accompanied by the commercial availability of full-size garment paper samples, which contributed to sizing system standardisation and well-fitting garments [63,67].

Apparel sizing systems significantly affect the garment size and fit relationship. In the early garment production stages, tailors crafted custom garments by relying on individual anthropometric measurements. Nevertheless, the increased demand for ready-made clothing resulted in a gradual shift towards proportional sizing systems to enhance efficiency and productivity [65]. This transition was pivotal in garment production history, as it laid the foundation for standardised sizing systems.

Achieving well-fitting garments in the made-to-measure stage of the clothing industry lies in the scientific precision of the tailor's garment paper pattern. The pattern should be based on accurate anthropometric measurements and establish a crucial relationship between anthropometric measurements and individual garment fit. The early-17th century demand for army and navy clothing was pivotal in the development of mass-produced garments, which influenced the ready-to-wear industry [68]. This historical progression laid the groundwork a standardised clothing sizing system in the late 19th and early 20th centuries based on anthropometric measurements [69].

The ASCC [70] emphasised the importance of anthropometric data in garment design, as the data provide designers with the client's critical physical, functional, and proportional characteristics. Accurate paper pattern design and sizing data are fundamental for achieving a good fit in ready-to-wear garment mass production. Sizing systems are critical for achieving garment fit for diverse groups in mass production.

The Malaysian apparel manufacturing industry mainly relies on standardised sizing systems from Europe (the UK and the USA) or Asia (China and Taiwan) for garment sizing [71]. Nonetheless, a Malaysian sizing system for adult clothing remains in the initial stages, with limited literature available on the subject. Conversely, children's clothing sizing system research has progressed significantly. Zakaria's research resulted in eight sizing systems comprising 200 sizes to accommodate the wide body-size differences in children aged between 7 and 17 years old [61]. Dr. Zakaria's study represented the first comprehensive anthropometric survey of Malaysian school-aged children and aimed to develop a new anthropometric data-based standard sizing system. The study methodology involved analysing anthropometric data, identifying critical variables, classifying children into homogeneous groups, and developing appropriate sizes for these groups.

To summarise, the historical evolution of garment production and sizing systems significantly shaped the relationship between apparel size and fit. From individual tailoring to the development of standardised sizing systems, the pursuit of well-fitting garments has been a consistent historical theme. As the apparel industry continues to evolve, establishing standardised sizing systems tailored to diverse populations remains a critical research and development area.

5. Future Research Strategy

5.1. Necessity and Challenge of Establishing a Standardised Garment Sizing System in the Malaysian Garment Industry

For Malaysia, the development of a standardised clothing size framework is critical. Evidence suggests that transitioning to standardised garment sizes in Malaysia will sig-

nificantly reduce waste. Standardised sizing achieves this by increasing the efficiency of the production process, reducing the need for excess inventory, and reducing fabric waste during the production process [72]. Implementing industrial standardised sizing based on accurate body measurements can lead to a smoother garment production process [73]. The development of new body measurement standards will increase the efficiency of sizing systems, create better-fitting garments, and potentially reduce the number of garments discarded due to poor fit. Although there may be initial challenges to moving to standardised sizing, such as the cost of system conversion [74], the benefits of reduced waste and increased productivity are apparent in the long term. A study by Mallak et al. [75] suggests that waste reduction measures, including implementing standardised sizing, play a key role in maximising the reduction in waste sent to landfills. A standardised clothing sizing system is expected to simplify choosing the right clothing for consumers, reduce the rate of returns due to size mismatches, and enhance the overall shopping experience. In addition, establishing a uniform sizing standard will help streamline the production process, reduce the pressure of excess inventory, and facilitate communication between domestic and international markets. These factors are crucial for a strong apparel industry. Therefore, the implementation of standardised sizing in the Malaysian apparel industry will be an essential step in the effort to reduce waste.

The localised standard sizing system aims to improve garment fit, reduce returns, and increase consumer satisfaction. However, the challenges of this move include aligning with the standards and preferences of international manufacturers and suppliers. Foreign manufacturers' decision to adopt Malaysian standard sizing relies on the alignment of industry standards, market demand, and manufacturers' readiness to meet new specifications.

Firstly, the transition to a standardised sizing system involves significant changes in manufacturing processes, size charts, labelling, and marketing materials, and the initial cost of change may lead to hesitation or resistance on the part of some manufacturers with lower operating margins. However, in the face of strong consumer demand for standardised sizing, manufacturers may be more inclined to adopt the new system locally and internationally, as consumer preference plays a decisive role in a manufacturer's willingness to adjust to the new standard. Secondly, if the Malaysian government or international trade agreements mandate adherence to specific sizing standards, manufacturers will likely comply unconditionally to maintain compliance and market access rights. Adopting a standardised sizing system may also provide manufacturers a competitive advantage by making it easier for customers to find the right size, potentially increasing sales. Manufacturers who recognise this opportunity may be more open to change. Ultimately, the apparel industry's complex supply chain, including fabric suppliers, manufacturers, and retailers, will need to coordinate on a standardised sizing system, which can be challenging but beneficial for efficiency and consistency.

Collectively, the Malaysian apparel manufacturers' response to establishing a standardised garment sizing system is not only a multifaceted and positively driven process, but also reflects a deep understanding and support for the direction of the industry's progress. These attitudes are not just based on cost considerations, market demand, regulatory requirements, competitive advantage, and supply chain coordination, but also on a deep understanding of the importance of standardised sizing for improving consumer satisfaction, reducing returns, and minimising waste. Although a standardised sizing system can increase the investment cost of research and standardisation in the short term, it is a worthwhile investment for the Malaysian apparel industry to consider in the long term by contributing to the sustainability of the apparel industry by reducing waste and improving consumer satisfaction. In other words, the internal attitude of Malaysian apparel manufacturers towards the push for the establishment of a standard garment sizing system and their views on the future development of the industry are positive, recognising that this direction of advancement will not only enhance productivity and consumer trust, but also contribute to the healthy and sustainable development of the industry as a whole.

5.2. Protocol of Establishing Standardised Garment Sizes

In light of a comprehensive situational analysis of the Malaysian apparel industry, this study strongly advocated prioritising a standardised national apparel sizing system. Due to the large volume of human body data, the data must be cleaned and preprocessed. This step removes outliers, deals with missing values, and standardises measurements to ensure that subsequent analyses are based on high-quality, reliable data.

The Kaiser–Meyer–Olkin (KMO) test and Bartlett’s sphericity test were utilised to assess the dataset’s suitability for Principal Component Analysis (PCA). Moreover, it assesses whether the correlation pattern between variables is sufficient to allow a meaningful reduction in dimensions without losing significant information. Subsequently, the Principal Component Analysis (PCA) was used to simplify the complexity of the data by reducing the number of variables. Identifying the principal components that explain the most variation in the dataset is critical to understanding the main factors that distinguish body size and shape. This step helps distil the vast amount of data into manageable components of information.

After that, SOM and K-means clustering were used to visualise complex data relationships and classify data points into well-defined clusters. SOM helps understand the patterns and structures in the data by creating a two-dimensional representation of the multidimensional data. K-means clustering further groups the data based on the similarities and is then used to define different size classes. Figure 3 depicts the flowchart of the size system (SS) development methodology. These methods ensure that the developed sizing system is based on comprehensive and accurate data and considers the complexity and diversity of body shapes and sizes.

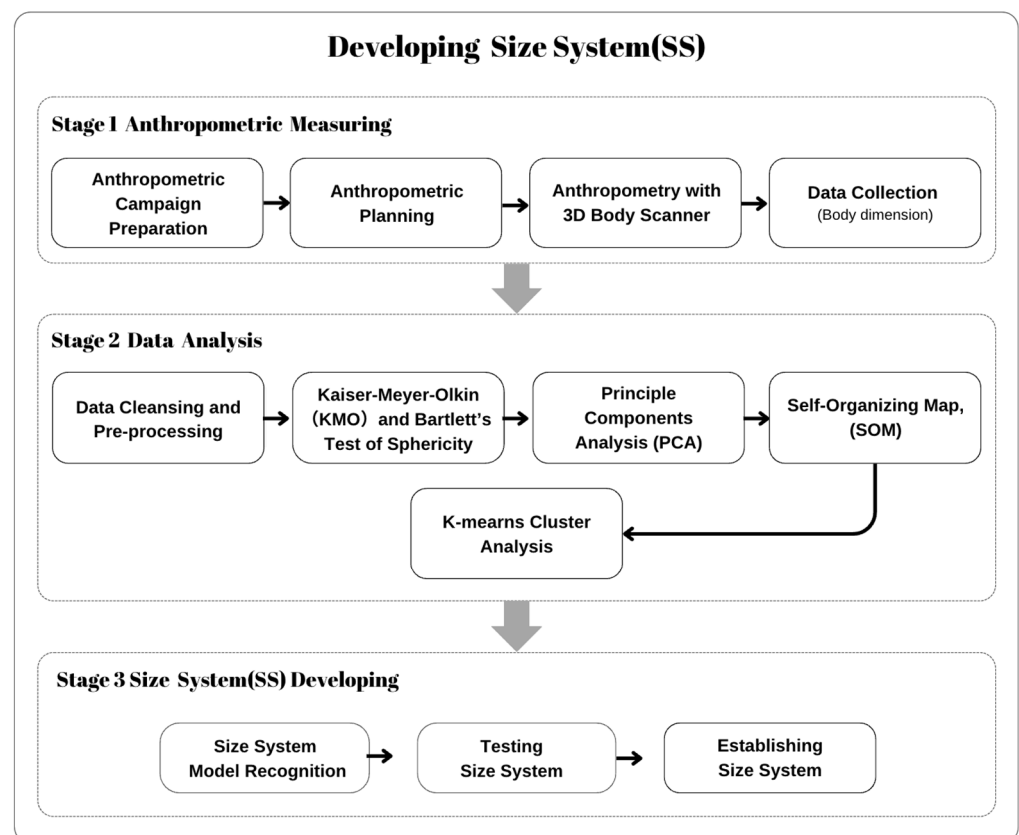


Figure 3. Planning and development of size system.

6. Conclusions

This study is crucial to enhance Malaysian apparel industry sustainability by focusing on sizing and fit. The study critically evaluated the literature and identified the urgent

need for a standardised sizing system to alleviate consumer dissatisfaction and market chaos. The study aligned the industry with global sustainability trends and emphasised the significance of garment size and fit. The proposed tailored sizing regime aims to improve sustainability, enhance garment fit, and reduce environmental effects.

Establishing a proprietary sizing system in the Malaysian apparel industry is crucial for enhancing sustainability and addressing the gaps in standardised apparel sizing. This strategic initiative is anticipated to streamline the user experience, mitigate uncertainty stemming from inconsistent sizing standards, and significantly reduce environmental and operational inefficiencies. Tailoring sizing systems to align with Malaysian population anthropometric data would enable the industry to enhance customer satisfaction, minimise waste and returns, and foster a more sustainable and economically viable ecosystem.

The comprehensive approach strategically guides sustainable development, highlighting the importance of a national sizing policy aligned with Malaysians' anthropometric diversity. This study contributes significantly to the Malaysian apparel industry by proposing a sizing system that maximises customer satisfaction and minimises waste, which would foster a more sustainable and economically viable ecosystem. The advanced statistical analysis and data visualisation techniques constructed a robust framework for a practical and effective grading system, positioning the study as a cornerstone for a comprehensive national sizing policy and catalysing a positive transformation in the Malaysian apparel sector.

Author Contributions: Conceptualization, Y.W. and N.Z.; methodology, Y.W.; software, not applicable; validation, Y.W. and N.Z.; formal analysis, Y.W.; investigation, Y.W.; resources, N.Z.; data curation, Y.W.; writing—original draft preparation, Y.W.; writing—review and editing, Y.W. and N.Z.; visualization, Y.W.; supervision, N.Z.; project administration, N.Z.; funding acquisition, not applicable. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Changzhou Vocational Institute of Textile and Garment for providing financial support during the PhD period.

Data Availability Statement: Data is contained within the article.

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

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