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Designing 3D-Printed Smart-Sole Shoes for the Elderly: Examining Appearance Acceptance in Hong Kong

Jenny L. Cheung[1], Simon K. H. Chow[2], Roger K. P. Ng[3], Jim T. C. Luk[4], and Rainbow C. S. Lee[1]

[1]Department of Design, Faculty of Design and Environment, Technological and Higher Education Institute of Hong Kong, Hong Kong
[2]Orthopaedics and Traumatology, The Chinese University of Hong Kong, Hong Kong
[3]School of Fashion and Textiles, The Hong Kong Polytechnic University, Hong Kong
[4]Department of Sports and Recreation, Faculty of Management and Hospitality, Technological and Higher Education Institute of Hong Kong, Hong Kong

ABSTRACT

This research seeks to investigate the footwear appearance preferences of elderly individuals in Hong Kong to develop comfortable 3D-printed midsole smart sole shoes. By analyzing the participants' design requirements on shoe aesthetics, the findings will aid footwear manufacturers in developing shoes that meet the design preferences of elderly individuals, thereby improving their comfort and style. This study highlights the significance of considering shoe aesthetics as a crucial parameter in footwear design for the elderly population. Ultimately, the successful development of comfortable and stylish shoes can promote increased mobility and enhance the quality of life for this demographic group.

Keywords: 3D-printing, Older people footwear, Appearance acceptance, Comfort, Hong Kong, Footwear design

INTRODUCTION

Integrating 3-Dimensional (3D) printing and smart functions into footwear is a lead to step up the development of comfortable and functional footwear. Opening new opportunities for technology integration, such solutions should be adapted to designing footwear to meet the expectations of older people. In fact, comfortability has been identified as a crucial factor in creating shoe soles. In addition to the comfort of use, the appearance of footwear is a top consideration for older women. Their preferences revolve around the combination of shoe colours, fabric materials, patterns, shapes, heel height, and functional design features.

Functional footwear used to minimize risk of injury could be obtained from the comparison of ground reaction force in walking or running among different sole material components. The lower the ground reaction force, the more effective it is in minimizing the risk of injury. Indeed, technology is featured as an add-on function to provide more protective impact to human

foot health. The use of higher quality materials and construction could offer major support to footwear. Further investigation reveals that older women considered practical intervention not only for comfort but also for aesthetics. The appearance of footwear was the most commonly reported concern in the findings. The research stated that the prototype was designed primarily with function and should give attention to aesthetics. (Menz et al., 2017)

By adjusting materials, structures, and shapes of the midsoles, the 3D-printed midsoles could adjust the hardness and thickness by 3D-printing technologies to increase comfortability in terms of cushioning properties. Additionally, the aesthetics perspective should be investigated in the design and developed by a customization approach. To advance the application of smart insoles, the research further analyzed and investigated 3D-printed midsoles with innovative pressure sensors. It was regarded to be innovative, versatile, and will provide comfort to older people (Baena Graciá, V., & Winkelhues, K.., 2016).

Investigating the footwear appearance preferences of elderly individuals in Hong Kong lays the foundation for designing and developing comfortable 3D-printed midsole smart sole shoes. The research therefore aimed to reveal the footwear appearance preferences of elderly individuals in Hong Kong, highlighting their design requirements. The participants' expressions of design requirements on shoe aesthetics indicate the need for further development in footwear design to meet the needs of elderly individuals in terms of both aesthetics and comfort. The successful development of comfortable and stylish shoes is implying the increase in mobility and the enhancement in the quality of life for this demographic group.

The current 3D-printing materials and construction development can eliminate the production progress and build up the comfortability through different printing structures and materials. The sustained direction of 3D-printed midsole technology in comfort and functional footwear for the older people's market saves time and reduces materials in the manufacturing process, while meeting market demands and promoting environmentally-friendly products in the future.

METHODOLOGY

A quantitative method, distributing questionnaires, is used in this research. A set of 50 questions is set to create a five parts questionnaire in six pages.

A sample of 51 Hong Kong elderly volunteered to complete the questionnaires and a convenience sampling method was used to collect the data. The collected data were analyzed by the statistical software, IBM SPSS. By using IBM SPSS Statistics, there were two quantitative analysis methods, cluster analysis and t-test analysis.

51 Hong Kong elderly (females and males aged between 50 and 80) who are volunteers invited. The subjects include 36 females and 15 males. The subjects may have different education levels, occupations and income as all samples are collected from social communities.

Average Elderly Shoe Size in Hong Kong

Cluster analysis (Table 1 & 2) divides the data into groups (clustering). 'Size 37' and 'Size 42', are divided. In the cluster analysis, there were 36 samples which fell into the first cluster, 'Size 37', and 15 samples which fell into the second cluster, 'Size 42'.

On average, the shoe sizes are size 37 and size 42 among the subjects, females and males respectively.

Table 1&2. Mean of Elderly Shoe Size for Males and Females.

	Cluster	
	1	2
Size	42	37

Number of cases in each Cluster		
Cluster	1	15.000
	2	36.000
Valid		51.000
Missing		.000

The Most Important Consideration: Comfort

Five fundamental considerations, function, form, material, comfort and colour, are developed for footwear design.

Obviously, almost all of the subjects chose 'Comfort', which is 80% of subjects, as the most important consideration for footwear design. 'Comfort' is significantly considered for foot care, especially in an aging population.

1-Year Durability for Footwear Performance

A pair of shoes with higher durability is one of the key criteria for better footwear performance. Elderly wear everyday shoes on a regular basis. To maintain good foot health, replacing everyday shoes regularly, every 6 to 12 months, is usual foot protection.

According to the shopping habits of the elderly in Hong Kong, most of the subjects, which is 70.6% of them, purchase a pair of new everyday shoes every 12 months or more. Indeed, in 1-year intervals, shoes are worn out quickly.

Proper Footwear Fitting for Daily Routine

A majority of subjects have a hobby of strolling which is 35.29%. Most subjects have a hiking hobby, that is 27.45%. Coincidentally, most subjects have a traveling hobby of 27.45%. Their hobbies mostly require walking such that the exercise intensity is low.

Comparatively, the plantar pressure force is lower, resulting in lower foot pressure. Hobbies such as running and playing ball games require higher exercise intensity, which implies greater foot movements and higher foot pressure. The data showed that just 5.26%, subjects chose hobbies, most likely sports activities, which bring greater pressure to the foot.

As a result, in Hong Kong, the elderly prefer to do some light exercise and participate in casual activities, which see the foot care for better foot

health. The importance of getting proper fitting footwear is crucial for elderly person's daily routine.

Popular Colour: Darker Shades

According to the conceptual metaphor theory, different colours may concretize different meanings of abstract concepts, for example, dark blue gives people calm and relaxation.

In this survey (Figure 1), the group of colours 'Black, Grey, White' was rated in the highest mean mark, which is 4.14 out of 5 marks (Table 3). Followed by 'Brown', 'Blue' and 'Indigo', the mean marks were 3.57, 3.22 and 3.16 respectively. For further support with colour associations, elderly favored darker colours for shoes evoking internal sensations in fashion.

Figure 1: 'Black, Grey, White' colour group.

Table 3. Rate high in darker shades of colour.

	Descriptive Statistics					
	N	**Range**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Red	51	4	1	5	2.08	1.339
Pink	51	4	1	5	2.25	1.495
Purple	51	4	1	5	2.49	1.405
Indigo	51	4	1	5	3.16	1.347
Blue	51	4	1	5	3.22	1.419
Cyan	51	4	1	5	2.59	1.417
Green	51	4	1	5	2.22	1.433
Yellow	51	4	1	5	2.10	1.221
Orange	51	4	1	5	2.47	1.347
Brown	51	4	1	5	3.57	1.269
Black, Grey, White	51	3	2	5	4.14	1.059
Valid N (listwise)	51					

Popular Colour: Reddish Colour for Female

T-test Analysis is applied to analyze the 2 groups of means at this stage (Figure 2). 2 groups of subjects, Female and Male, are divided.

To find the p-value for the test, the p-value of 'Pink' is .001, implying that (Table 4) the difference in means is statistically significant. In the survey, more females chose 'Pink' colour for shoes.

At the same time, the p-value of 'Purple' is .000, showing that the result is statistically significant in which 'Purple' is said to be more attractive for female subjects in this survey. These data indicated that reddish colour expressed much more attractive in footwear design for females.

Figure 2: 'Pink' & 'Purple' colour group.

Table 4. Rate high in reddish colour for female.

		Sig. (2-tailed)	Mean Difference	Std. Error Difference
Pink	Equal variances assumed	.007	1.211	.431
	Equal variances not assumed	.001	1.211	.350
Purple	Equal variances assumed	.000	1.639	.368
	Equal variances not assumed	.000	1.639	.291

Popular Materials: Flyknit

Material selection is one of the important stages in the footwear design such that the material determines the aesthetic of shoes and the comfort of use. 'Flyknit' is a material made up of strong yet lightweight strands of yarn.

In this survey, subjects rated the highest marks for 'Flyknit' material in both aspects, i.e., Aesthetic which scored 3.98 mean marks and Comfort which scored 4.29 mean marks. On the other hand, 'Mesh' scored second highest marks in Comfort aspect which is 4.27 mean marks.

Popular Materials: Breathable in Stretch

Apparently, both of the two materials 'Flyknit' and 'Mesh' are carrying out the same characteristics, which are soft in texture, lightweight, high permeability and good stretchability, for comfort. In fact, 'Flyknit' consists of another remarkable characteristic that is the one-piece woven upper for aesthetic design of the footwear in the market.

CONCLUSION

In conclusion, a pair of shoes that offers both comfort of use and aesthetic design was welcomed by Hong Kong elderly in the market. Overall, the most important consideration of choosing footwear is 'Comfort' in Hong Kong's aging population.

The majority of the Hong Kong elderly have habits of engaging in low-intensity exercise with less likelihood of injuries. This survey showed that most of the subjects have the hobbies of strolling, hiking and traveling. As a general rule, the foot plantar pressure acting between the foot and the support surface is lower during low-impact workout. In Hong Kong, the elderly

would rather have light exercise and casual activities as part of their everyday locomotor activities. Thus, proper fitting of shoes for the foot care is a primary focus to maintain better foot health in the elderly person's daily routine. Footwear designed with support, strengthening and flexibility is highly recommended to keep healthy feet.

Footwear appearance acceptance in Hong Kong's aging population demands darker colored stretchy material with high breathability. Darker colors, such as black and brown, are commonly associated with formality, giving a conventional impression. These neutral colors work well with different statement colors, allowing for stylish mix-and-match possibilities. To a great extent, darker colored footwear is a classic option for the elderly to effortlessly dress up their daily shoe choices.

In addition to the female collection, elderly preferred reddish colours for footwear design. This sex difference in color preference due to the evolution of color vision (Hurlbert and Ling, 2007), reddish colour evolved as a natural preference among females. Ideally, two distinct tones of colours could be developed to accommodate for sex difference, in two footwear collections of male and female.

The flyknit upper offers higher flexibility for foot movements by virtue of its high-strength fibers. This lightweight design in footwear production utilizes flyknit technology to provide support and breathability in each pair of shoes. Among all the elderly subjects surveyed, the 'Flyknit' fabric received the highest ratings in both the aspects of 'Aesthetic' and 'Comfort'. This implies that the flyknit material is not only functional but also aesthetically pleasing, owing to the implementation of CNC knitting machines. Flyknit fabric could be the first choice of body material for producing footwear in the fashion market.

In the future research, the development of walking gait memory could be explored to provide additional cushioning or heel support that aligns with the low-intensity exercise habits of the aging population. This would promote natural foot movement and protect their feet for better health. Footwear intervention has the capacity to enhance balance, alleviate foot pain and improve gait tasks. Potential roles for gait memory in cushion could be introduced for elderly 3D-printing footwear, yet reducing the risk of falls in elderly by improving the posture, coordination and balance.

The development of 3D-printing materials has been rapidly evolving in this decade. The current development of 3D-printing materials and construction enable the enhancement of comfort through a wide range of materials available for 3D-printing. To adapt to the sustained direction of 3D-printed midsole technology, different materials are constantly working on developing new structures with improved properties and compatibility with different 3D-printing techniques. Additionally, in order to improve comfort and aesthetics in functional footwear for the older people's market, the application of 3D-printing technology in footwear could probably make a breakthrough, for example, 3D-printing flyknit material applying to a functional upper, to reduce materials used in the manufacturing process, while expanding customization possibilities to meet market demands and promoting environmentally-friendly products in the fashion industry.

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