

Modelling equation of soccer shoes design among Malaysia soccer players

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Published online: November 30, 2022

(Accepted for publication November 15, 2022)

DOI:10.7752/jpes.2022.11343

Abstract:

Sports knowledge contribution that focuses on product design and performance enhancement is still limited, particularly in Malaysia as compared to other countries. This includes mechanical features of footwear based on biomechanics, morphological features based on anatomy and anthropometry, physical features based on environmental factors, which determined foot and body disorders. Soccer shoes, an important component of soccer equipment, may play a role in over exposure to injury. Soccer shoes evolution is all the more challenging, because the design and mechanical structure differ in various aspects compared to other modern shoes developed for sport. The objective of this study is to identify the factors affecting soccer shoes design of Malaysian soccer players. A total of 398 Malaysian male soccer players from various ages and game categories were selected for this study. This study used the quantitative method, whereby questionnaires were applied to obtain information from respondents. The three selected independent variables, namely anatomy, anthropometry and biomechanics have been chosen to identify the significant contribution to the design of soccer shoes. Statistical analysis was carried out using the Statistical Package for the Social Sciences (SPSS) software version 26.0. The related equation for each variable was obtained through the analysis of variance (ANOVA) and regression model. The value of R squared ($R^2 = 0.633$) showed the overall contribution of the three variables in the design of soccer shoes amongst Malaysian soccer players. Based on the findings, the multiple linear regression equation was $Y = 0.697 + 0.417X_1 + 0.007X_2 + 0.375X_3$. This study revealed that the dominant variables contribution was anatomy followed by biomechanics and anthropometry in the soccer shoes design.

Key Words: - Soccer shoes, Anatomy, Anthropometry, Biomechanics, Design

Introduction

Soccer is the most popular and widely practiced sport in the world, however, limited research has been published in the field of soccer biomechanics, particularly on the significance of soccer shoes in the game (Kunz, 2007; Blanchard et al., 2018). Its popularity has converted it into a business, whereby the sports scores and goals scored are everything (Unlucan, 2014). Soccer shoes have long been regarded as the most vital tool, with a significant impact on athletes' performance (Sterzing, 2016; McPoil, 2000). The design and arrangement of soccer shoes are crucial shoe qualities that allow for quick accelerations and stops as well as quick cuts and turns. Soccer shoes design has an impact on shooting speed and more importantly, kicking accuracy in the game. A soccer player's performance can be enhanced and injuries can be prevented with proper shoes design (Daack & Senchina, 2014). Shoe features, such as cushioning, sole stiffness, frictional properties and other modifiable parameters, influence biomechanics and as a result, may affect both performance and injury risks (Frederick, 1986).

Malaysia is one of the Asian countries with a small population. In comparison to Australians, Southeast Asians and Africans have smaller feet (Kouchi, 1998). Foreign sizes, such as the US and UK standard sizes, are used in the Malaysian shoe market. Unfortunately, these resized sizes do not fit the foot form and size of Malaysians very well (Naimah et al., 2007). In the Asian market, there are various shoe styles that do not adhere to the standard or true foot anthropometric criteria. According to Chaiwanichsiri (2008), several of the elderly generation could not find shoes that fit their feet well. As a result, consumer products, particularly footwear, should be designed to fit varied human body forms to provide consumers' comfort and satisfaction. Footwear designers typically create shoes based on foot length, width, height and ankle circumference (Waterson & Sell, 2006). The shape of the human feet varies according to demographic characteristics (e.g., geographical, age, gender, ethnicity) and foot size varies with age, weight and other factors. The human foot is an intricate structure of 26-bone, 33 joints, multiple muscles, tendons, ligaments, blood vessels, nerves and lymphatics that makes up

the entire body. The plantar ligament, which extends from the heel bone to the metatarsal, keeps the bones in place by connecting them with tough bands of tissues, known as ligaments (Logan et al., 2017).

The foot anatomy is a study of the human body's structures, which is significant in shoes design since it provides mechanical harmony for human biomechanics, which can be improved through design and engineering solutions (Hafizoglu, 2005). This requires a thorough understanding of bone structure and musculature (Vass & Molnar, 1999). Understanding the foot anatomy and how individual bones and joints, ligaments and tendons, muscles, nerves and blood vessels operate in human biomechanics is the first step in the footwear design analysis process. According to a study conducted by Rossi (2002), almost 95% or more of these physically deprived adults' feet begin during childhood with the use of defective designed and manufactured footwear. The foot variant should be detected for appropriate function. A flat foot or a high arch foot is the most common foot types. The shoe should suit the foot regardless of the variation (Hafizoglu, 2005).

The study of normal mechanics (kinetics and kinematics) in the musculoskeletal system by studying the forces and their effects on anatomical structures, is known as biomechanics. Through human factors and biomechanical criteria, shoes design entails the difficult process of determining the most versatile characteristics for human performance (Watkins, 2014). Anthropometric measurements are a series of quantitative measurements of the muscle, bone and adipose tissue used to assess the composition of the body (Sebo et al., 2017). It deals with the measurement and examination of the human body as well as the relationship between the dimensions of its various sections (Ujevic et al., 2006). Furthermore, anthropometric measurement is required to produce standardised sizes. Anthropometric measurements are used in the construction and modelling procedures in the manufacturing of attractive apparel and footwear.

Shoes have a significant impact on the health of humans' feet. The health and vitality of the feet will be maintained if the right shoes sizes and forms are chosen. Improper shoe size is one of the reasons of strain in the foot muscles and tendons (Luximon et al., 2005). Incorrect shoe size selection, on the other hand, is a common cause of foot and ankle disorders (Chaiwanichsiri et al., 2008). Furthermore, incorrect shoe size is another source of foot injury, pain and deformity. For individuals involved in the design and production of shoes, a thorough understanding of foot shape and structure is essential (Mauch et al., 2008). Foot form varies due to a variety of causes. Genetics, the environment, socioeconomic status, lifestyle and varied shoe styles all contribute to this variation (Razeghi & Batt, 2002). Anatomy, anthropometry, biomechanics, physical factors and ergonomic concerns are all taken into account when designing shoes (Hafizoglu, 2005). Based on the survey results and biomechanical studies, a shoe was designed to complement a human's foot. The shortcomings of soccer shoes ergonomics have been linked to a decreased sense of comfort as well as an increased risk of injury (Kinchington & Naughton, 2010; 2012; Lees & Nolan 1998; O'Connor, A. M., & James, I. T., 2013). According to Freychat and Bouche (1999), a shoe should be comfortable and fit.

In recent years, soccer shoes have evolved significantly. The modern soccer shoe causes a reduction in movement efficiency and acts as a barrier to both performance and injury prevention. Based on historical trends, it is clear that players expect their shoes to provide strong traction and to be lightweight. The lack of protection provided by soccer shoes against high peak pressures had been noted since the 1990s (Lees & Kewley, 1993). The amount of literature published in the field of soccer shoes research is astounding. The study's goal is to determine the aspects that influence the design of soccer shoes for Malaysian soccer players and to develop a modelling equation. Moreover, quantitative analysis was used for this study.

Material & methods

Population and Sample

The sampling selection for this study was referred to the scheduling method that was proposed by Cohen et al. (2001). For a population of 250,000 or more, 384 samples were required. Larger sample sizes will be more dependable and compelling (Cohen et al., 2001; Best & Kahn, 2006; Sekaran & Bougie, 2002). Sampling was accomplished by selecting a significance level (α) of 0.05 with a 95% degree of confidence. The intermediate individuals were selected from the sample frame using a basic random sample. Researchers can utilise simple random selection to identify the optimum sample size for participants, which can subsequently be extrapolated to a broader population (Trochim, 2006). This study surveyed 398 individuals and the target population was male Malaysian soccer players. Individuals that opted for the online survey formed the sampling frame. The population comprised of individuals who were 19 years of age or older, had one or more years of experience and represented a variety of different categories or levels of play and roles. The poll was administered through an intermediary. The intermediary communicated with the respondents; the researcher had no direct interaction with them.

Instruments

The questionnaire for this study was distributed via Google Forms. An Internet survey is a popular data collection method due to speed, efficiency and cost. Data collection via online surveys have the potential to collect large amount of data efficiently (i.e., with less errors due to minimal transfer of written data to a computer), economically (as it requires little human resource effort while collecting or managing data) and in a relatively short time frame (Regmi et al., 2016). However, such surveys also carry validity risks as to the accuracy and reliability of responses. The survey consisted of four sections (54 questions), each of which provided demographic

data, such as age, weight, height, race, occupation and income as well as state of birth. The second section contains information on the player's experience, highest level of play, playing position, foot size and foot use domain. The third section contains information on soccer shoes, such as pricing, brand used, preferred brand, purchasing method and purchasing factors. The fourth section contains information on the perception level of players based on anatomical, anthropometric and biomechanical aspects of soccer shoes design. The subjects were requested to rank their questionnaire responses using a nominal scale and a 5-point Likert ordinal scale.

Data Collection and Analysis

The Statistical Package for the Social Sciences (SPSS) programme version 26.0 was used to analyse the data. The mean, standard deviation, and the maximum and minimum values were calculated using descriptive statistics. Relationship between the three variables, which included anatomy, biomechanics and anthropometry in the design of soccer shoes was evaluated using a one-way analysis of variance (ANOVA). For each parameter, the F-test was used to get the mean square value. To determine the association between anatomy, anthropometry and biomechanics with soccer shoe design, the Pearson correlation coefficient was used. Furthermore, a regression modelling equation was identified to determine the contribution of these three variables in the design of soccer shoes.

Validity and Reliability. The instrument was published and its validity and reliability were established using Cronbach's alpha. The Cronbach's alpha value for this study was 0.985. Cronbach's alpha coefficient approaching 1.00 indicated that the item had a high reliability interpretation (Bond & Fox, 2016).

Results and Discussion

Analysis of Variance (ANOVA).

In this study, ANOVA was used to examine the relationship between the three variables in the design of soccer shoes. The F-value was used to find the mean squares (MS) value for each parameter. MS is equal to the sum of the square root deviations divided by the parameter's degree of freedom.

Table 1. One way-ANOVA of anatomy to soccer shoes design

Group		Sum of Square	df	Mean Square	F	Sig.
Soccer Shoes Design	Between Groups	158.519	30	5.661	20.136	0
Anatomy	Within Groups	103.464	368	0.281		
	Total	261.983	398			

Table 1 summarises the findings to demonstrate the association between soccer shoes design and anatomy characteristics of Malaysian soccer players. ANOVA was used to determine the link between anatomical characteristics that influence the soccer shoes design. The one-way ANOVA test revealed a significant difference in the architecture of shoes design in terms of value ($F = 20.136$, $\text{sig} = 0.00 < 0.05$). The greater the F-value, the greater the influence on shoes design. If the p value is less than the alpha value of 0.05, then the results of this test will indicate that there is a statistically significant difference in the group's achievement of the mean value.

Table 2. One way-ANOVA of anthropometry to soccer shoes design

Group		Sum of Square	df	Mean Square	F	Sig.
Soccer Shoes Design	Between Groups	137.542	39	3.717	10.724	0
Anthropometry	Within Groups	124.441	359	0.347		
	Total	261.983	398			

Table 2 demonstrates the ANOVA association between the design of soccer shoes for Malaysian soccer players based on anthropometric factors. According to a one-way ANOVA test, there was a significant difference in anthropometry on shoes design in terms of value ($F = 10.724$, $\text{sig} = 0.00 < 0.05$). As a result, this test revealed that there was a statistically significant difference in the group's tested achievement of mean values. This indicated that anthropometry and the design of soccer shoes for Malaysian soccer players differ significantly.

Table 3. One way-ANOVA of biomechanics to soccer shoes design

Group		Sum of Square	df	Mean Square	F	Sig.
Soccer Shoes Design	Between Groups	162.737	32	5.086	18.652	0
Biomechanics	Within Groups	99.246	364	0.273		
	Total	261.983	396			

Table 3 summarises the findings on the differences in biomechanics and design of soccer shoes for Malaysian soccer players. A one-way ANOVA test revealed a significant difference in values between biomechanics and shoe design ($F = 18.652$, $\text{sig} = 0.00 < 0.05$). The p value was 0.00, which was less than the alpha

value of 0.05. The results of this test revealed that there was no statistically significant difference in the group's tested achievement of mean values. As a result, there were substantial variances in biomechanics and even soccer shoes design. The anatomical aspect had the largest significant difference ($F = 20.136$), followed by biomechanics ($F = 18.652$) and anthropometry ($F = 10.724$) on the design of soccer shoes for Malaysian soccer players, according to the findings of a one-way ANOVA test for all three criteria. Footwear mechanically works together with the foot according to foot anatomy and biomechanics (Hafizoglu, 2005).

Correlation.

Table 4. Correlation of anatomy, anthropometry, and biomechanics to soccer shoes design

		Anatomy	Anthropometry	Biomechanics	Soccer Shoes Design
Anatomy	Pearson Correlation	1	.735**	.746**	.749**
	Sig (2-tailed)		0	0	0
	N	398	398	398	398
Anthropometry	Pearson Correlation	.735**	1	.788**	0.65**
	Sig (2-tailed)	0		0	0
	N	398	398	398	398
Biomechanics	Pearson Correlation	.746**	.788**	1	0.739**
	Sig (2-tailed)	0	0		0
	N	398	398	398	398

Table 4 illustrates the findings of the correlation study, which revealed that the three factors (anatomy, anthropometry and biomechanics) have a significant and positive link with the design of soccer shoes ($r = 0.749$, $p < 0.05$), ($r = 0.65$, $p < 0.05$) and ($r = 0.739$, $p < 0.05$). The result of the (r) value, the interpretation of the strength between the three parameters of anatomy, anthropometry and biomechanics with the design of soccer shoes indicated a positive and high correlation, according to the Guildford's rule of thumb; high correlation (0.71 – 0.90). This means that the design of soccer shoes for Malaysian soccer players was influenced by anatomy, anthropometry and biomechanics.

Table 5. Regression of anatomy, anthropometry and biomechanics to soccer shoes design

Model	Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig	R ²
Anatomy	0.417	0.046	0.443	9.007	0	0.56
Anthropometry	0.007	0.053	0.007	0.141	0	0.422
Biomechanics	0.375	0.051	0.402	7.428	0	0.546
Cons	0.697	0.125		5.594	0	

The regression of contributions in soccer shoes design for anatomical, anthropometric and biomechanical characteristics is shown in Table 5. The R² (0.633) was a predictor with a significant correlation and contribution of 63.3% ($p < 0.05$) for the design of soccer shoes when all three factors were combined. In this scenario, it was possible that additional aspects in the design of these shoes led to the remaining 37%.

Anatomy ($\beta = 0.443$, $t = 9.007$ and $p = 0.000$) was the most important and strongest predictor of soccer shoes design. This situation demonstrated that while the score on anatomy rises by one unit, the design of soccer shoes amongst soccer players rose by 0.417 units. Biomechanics ($\beta = 0.402$, $t = 7.428$ and $p = 0.000$) was the second-best predictor of soccer shoes design. This situation demonstrated that as the biomechanics score rises or rises by one unit, the design of soccer shoes amongst soccer players rose by 0.375 units. Anthropometry ($\beta = 0.007$, $t = 0.141$ and $p = 0.000$) was the third best predictor of soccer shoes design. This situation demonstrated that as the anthropometry score rises or rises by one unit, the design of soccer shoes amongst soccer players rose by 0.007 units.

Table 6. Results of analysis of variance

	Sum of Squares	df	Mean Square	F	Sig.
Regression	165.941	3	55.314	226.343	0
Residual	96.042	393	0.244		
Total	261.983	396			

The results The ANOVA results are shown in Table 6, with a value of $F = 226.343$ ($Df = 3$) and a significance level of $p = 0.000$. The R² (0.633) indicated the overall impact of the three variables to the design of

soccer shoes amongst Malaysian soccer players. Generally, the following regression equation could be used to determine the contribution of these three key variables in the design of soccer shoes.

Human anatomy knowledge is essential for excellent product design and for human engineering to work for human-footwear interfaces. The human foot, biomechanics and human body in motion are the most important components in understanding the design and manufacturing of good shoes. Designers and developers of shoes should focus on interface design and strive to produce better design solutions based on a thorough understanding of human engineering (Hafizoglu, 2005). The most significant qualities that soccer players look for in their footwear are fit and comfort (Hennig & Sterzing, 2010). Specific design, physical properties and construction of footwear are known as important factors for footwear comfort (Nigg et al., 1999). Because comfort is linked to muscle activation, therefore, fatigue and performance, specific design, physical properties and construction of footwear are known to be important factors for footwear comfort. From a human engineering standpoint, footwear design could be enhanced by investigating the comfort component in human performance development. Many factors affect footwear comfort, including size, shape, flexibility, style, weight, inner shoe climate (temperature, humidity), materials, tread and cushioning.

Conclusions

This study found that anatomy was an important factor for soccer shoes design amongst Malaysian soccer players. The study also concluded that all the factors had a strong relationship with soccer shoes design. Foot anatomy, anthropometry and biomechanics data are vital components to be considered while designing soccer shoes that fit Malaysian feet. These factors are important in designing footwear products, especially soccer shoes. Problems with foot comfort and health could be solved by designing suitable shoe sizes. Malaysian soccer players and shoe producers should have a basic understanding of anatomy, biomechanics and anthropometry to create soccer shoes that meet the needs of Malaysian soccer players. In general, the regression equation could be used to calculate the contribution of these three key variables in soccer shoes design. As a result, data will aid in the development of ergonomic soccer shoes for Malaysian soccer players in the future.

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