ORIGINAL ARTICLE

Functional movement screen score to predict injury risk of sports students: a review of foot shape and body mass index

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Abstract

Background and Study Aim Excessive physical activity poses a risk of injury, particularly when coupled with high exercise intensity. Factors such as Body Mass Index (BMI) and foot morphology may contribute to this risk. This study seeks to evaluate the relationship between BMI, foot shape, and the likelihood of injury among sports students.

Material and Methods A total of 119 sports students, comprising 33 females and 86 males, participated in this study. Purposive sampling was employed to select participants. BMI was determined using height and weight measurements, while foot shape was assessed through footprint measurements. The Functional Movement Screening (FMS) instrument, encompassing 7 movements: Deep Squats, Hurdle Steps, Inline Lunges, Shoulder Mobility, Active Straight Leg Raises, Trunk Stability Push-ups, and Rotary Stability, was utilized to assess injury risk. Data analysis was conducted using Microsoft Excel and IBM SPSS v.25.0, employing descriptive statistics.

Results Based on data analysis, the FMS value in females shows a mean of 18.7 and a standard deviation of 1.21. At the same time, the FMS value in males shows 18.5 and a standard deviation of 1.41. BMI values in females showed a mean of 21.6 and a standard deviation of 3.03. At the same time, BMI values in males showed a mean of 22.9 and a standard deviation of 4.62. The results were that all FMS scores were ⩾14. While of BMI measurements, some samples obtained <18 kg/m² and >30kg/m². BMI measurements according to gender were mainly in the normal weight category. However, those who fall into the obesity category are primarily males. With the results of measuring the foot's shape, the percentage of flat feet is only 0.84% in females and 7.59 in males, while the rest of the sample has a normal foot shape.

Conclusions Individuals with a BMI in the overweight to obese category are more susceptible to high-category injuries, likely due to limited motion range. However, the study did not find evidence linking flat foot shape to high-category injury risk. This inability to establish a correlation may be attributed to the predominantly normal foot shape observed in the sample, resulting in a prediction of low-category injury risk.

Keywords: sport injury, FMS, foot shape, BMI

Introduction

The foot is part of the body most often in contact with the ground, which is needed to exert energy when walking, running and jumping. Foot shape consists of several types, such as normal, flat, and high. Flat and high foot shape can be one of the intrinsic factors for the risk of lower extremity injuries [1]. It was revealed that those with a flat foot shape are more susceptible to injuries from abnormal joint rotation. On the other hand, someone who has a high foot shape has less foot mobility, making them more susceptible to injury. An abnormal foot shape leads to abnormal compensatory movements, thus increasing the risk of musculoskeletal injuries [2]. In addition to this, foot arch geometry and arch mechanics are also associated with the occurrence of injuries [3]. Factors such as age and anatomical features can affect the dynamic shape of the foot. The shape of the foot can also change with the footwear worn, as the heel height of the footwear changes the width of the foot and the arch length of the foot in a nonlinear manner [4]. In addition, Body Mass Index (BMI) also has a significant influence on arch height in foot shape [5].

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The fact that BMI can change the shape of the foot has also been revealed in studies that have been conducted, revealing that individuals with more weight can increase the risk of lower extremity injuries [6, 7]. Lower extremity injuries, such as Anterior Cruciate Ligament (ACL) injuries, while ACL injuries require a lengthy healing time so that they can interfere with activities in individual careers [8]. A BMI below normal can also affect balance because it will be difficult to maintain body balance. After all, the body cannot resist external forces [9]. These statements argue that injuries can occur in every individual with fairly dense physical activity. Since sports students must master all sports, each student must have an excellent physical condition to achieve lecture targets.

Physical activity, especially in sports, whether in education or training, will face injury risk [10]. Sports in education have a level of physical activity that exceeds normal activities. Mastering almost all sports is one of the demands of a sports student. So sports students have quite a lot of physical activity, considering that almost every day they do sports activities that are not enough with one sport. When individuals are injured, it can have a significant impact on their daily routine activities and participation [11]. A sports injury is any physical complaint resulting from training or education that can limit an individual's participation [12]. Injury can lead to a lack of confidence when performing sports activities [13]. Individuals who have a history of injury will incur considerable treatment costs, which have an impact on their long-term quality of life. The history of injury experienced by each individual can hinder the improvement of one's abilities, even the achievements one wants. Even though the individual has entered the recovery phase of the injury, the physical activity performed cannot be as optimal as that of someone who has never experienced an injury. Based on the many losses that will occur if an individual is injured, prevention efforts are needed to minimize the occurrence of injuries.

One way to prevent injury is to know the potential risk of injury that is likely to occur in each individual. Functional Movement Screening (FMS) can evaluate the quality of 7 fundamental movement patterns to identify individual movement limitations and asymmetries. The FMS used to identify these limitations and asymmetries can be used to determine the risk of future musculoskeletal injuries [14, 15]. Therefore, it is necessary to conduct research that measures FMS in sports students to identify the risk of injury in each individual. So far, researchers have never found a study that measured FMS in a sample of sports students with a review of foot shape and BMI. Previous studies used FMS measurements with a sample of athletes or only took measurements on one variable.

This study aims to identify the risk of injury that sports students may experience in a review of BMI and the shape of the feet owned by sports students.

Materials and Methods

Participants

This study involved 119 sports student participants consisting of 33 females and 86 males. This study used a purposive sampling technique. The inclusion criteria for sample selection include a) active sports students, b) not currently experiencing injury or injury recovery, c) sports students with an age range of 17 to 20 years, and d) willingness to be a sample from the beginning to the end of the study. At the same time, the exclusion criteria are not sports students who have injuries or are recovering from injuries and are not willing to be research samples from the beginning to the end of the study.

Research Design

This research is a type of quantitative descriptive research. This study aims to determine the risk of injury to sports students by reviewing foot shape and BMI. Researchers use height tests and weight tests to determine BMI. While measuring the shape of the soles of the feet, researchers use *footprint measurement* [16]. FMS is used to obtain potential injury risk data. FMS consists of 7 movements: Deep Squat, Hurdle Step, Inline Lunge, Shoulder Mobility, Active Straight Leg-Raise, Trunk Stability Push-up and Rotary Stability [17, 18].

The data obtained from measurements using the FMS instrument were analyzed and categorized using the assessment norm guidelines applied in previous studies [18, 19, 20] (Table 1).

Table 1. FMS Scoring Norms

Points	Injury Risk Category
⩽14	High Risk
15-18	Medium Risk
19-21	Low Risk

The BMI measurement results of each sample will be adjusted to the BMI category. Table 2 shows the BMI categories [21].

Table 2. Categories of BMI

Scores	Categories
15-19.9	Underweight
20-24.9	Normal weight
25-29.9	Overweight
⩾30	Obesity

The height and weight measurements were analyzed to calculate the BMI score using the formula: body weight (in kilograms) divided by height squared (in meters). Subsequently, the BMI score was categorized according to the BMI categories outlined in Table 2. Regarding the foot shape measurements, the data analysis method differs from that used for analyzing the results of FMS and BMI measurements. The results are adjusted based on the shape of each individual's feet and their corresponding foot arch type [22], as illustrated in the following figure.

Figure 1 clearly shows three types of foot arch shapes: flat foot (low arch), normal foot (medium arch), and hollow foot (high arch). The measurement results of the foot shape will be adjusted to Figure 1 above to find out how the foot shape of the research sample.

Statistical Analysis

The data was analyzed using both a computerized Microsoft Excel program and IBM SPSS v.25.0 statistics. Descriptive statistics were employed to analyze the research data.

Results

The results of data analysis are illustrated in Table 3, differentiating between genders: female (n=33) and male (n=86). It presents descriptive statistics of research data (n=119), showcasing height, weight, BMI score, and FMS score, thereby providing a comprehensive overview of the physical attributes and functional movement capacities of the study participants.

Furthermore, the frequency and percentage of samples analyzed according to the categorization of BMI scores, FMS scores, and foot shapes are presented (Table 4).

Table 4 provides a breakdown of BMI scores for females and males. In females, the majority fell within the Normal weight category, while in males, Normal weight was also prevalent, followed by the Overweight category. Regarding FMS scores, both genders predominantly showed a Low-Risk category. Additionally, the analysis of foot shape revealed that the majority of females and males had a Normal foot shape, with a small percentage exhibiting a Flat foot shape. High foot shape was not observed in any of the samples.

The analysis of foot shape and BMI score was used to review the prediction of injury risk through the FMS score. Table 5 will present the study samples with predicted injury risk levels across different foot shapes and BMI categories.

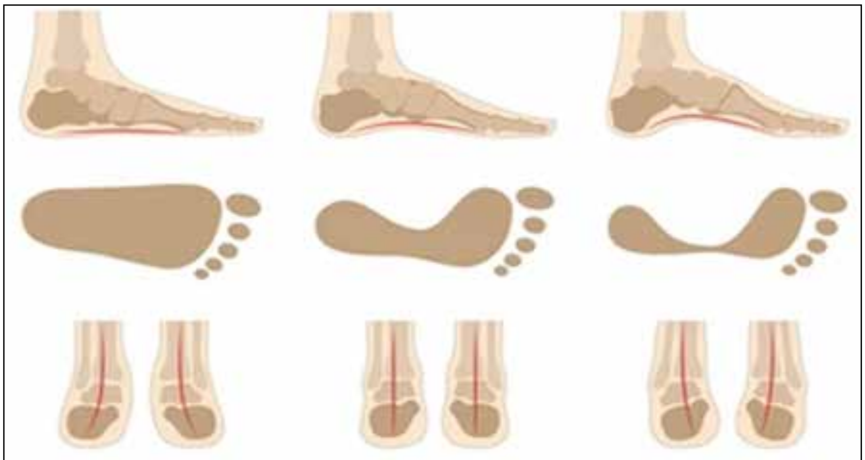

Figure 1. Three types of human foot arches.

Table 3. Descriptive statistics of research data (n=119)

Gender	Number (n)	Variable	Mean ± SD	Min.	Max.
Female	n = 33	Height (cm)	156.9 ± 5.89	148	169
		Weight (kg)	53.6 ± 8.03	41.5	70.5
		BMI (kg/m²)	21.6 ± 3.03	15.1	29
		FMS (points/21)	18.7 ± 1.21	16	21
Male	n = 86	Height (cm)	167.9 ± 5.38	156.6	179.5
		Weight (kg)	64.0 ± 10.81	47.2	94.8
		BMI (kg/m²)	22.9 ± 4.62	16.7	50.2
		FMS (points/21)	18.5 ± 1.41	16	21

Note. n = Sample Number, SD = Standard Deviation, Min. = Minimum Value, Max. = Maximum Value

Table 4. Percentage category results of BMI, FMS and foot shape data (n=119)

BMI			
Gender	**BMI Categories**	**Frequency**	**Percentage (%)**
Female (n=33)	Underweight	5	4.20
	Normal weight	24	20.17
	Overweight	4	3.36
	Obesity	0	0.00
Male (n=86)	Underweight	9	7.56
	Normal weight	57	47.90
	overweight	14	11.76
	obesity	6	5.04
FMS			
Gender	**FMS Categories**	**Frequency**	**Percentage (%)**
Female (n=33)	Low Risk	22	18.49
	Medium Risk	11	9.24
	High Risk	0	0.00
Male (n=86)	Low Risk	43	36.13
	Medium Risk	43	36.13
	High Risk	0	0.00
Foot Shape			
Gender	**Foot Shape Categories**	**Frequency**	**Percentage (%)**
Female (n=33)	Normal	32	26.89
	Flat	1	0.84
	High	0	0.00
Male (n=86)	Normal	77	64.71
	Flat	9	7.56
	High	0	0.00

Note. n = Sample Number

Table 5. A review of foot shape and BMI in injury risk prediction (n=119)

FMS Categories			
	High Risk (n)	**Low Risk (n)**	**Medium Risk (n)**
Foot Shape			
Flat	0	7	3
Normal	0	58	51
High	0	0	0
BMI Categories			
Underweight	0	7	7
Normal	0	52	29
Overweight	0	4	14
Obesity	0	2	4

Note. n = Sample Number

Table 5 above indicates that samples without gender distinction and low risk of injury consist of 7 individuals with flat feet and 58 individuals with normal foot shapes. Furthermore, individuals with low risk of injury are distributed as follows: 7 in the underweight BMI category, 52 in the normal weight category, 4 in the overweight category, and 2 in the obesity category.

Additionally, Table 5 demonstrates that samples with a medium risk of injury include 3 individuals with flat foot shape and 51 individuals with normal foot shape. Moreover, individuals with a medium risk of injury are categorized as follows: 7 in the underweight BMI category, 29 in the normal weight category, 14 in the overweight category, and 4 in the obesity category.

Discussion

This study found that the FMS scores obtained were related to the sample's BMI and foot shape measurements. The average combined FMS score was 18.2 ± 1.36 points. These results indicate that samples with high FMS scores tend to have normal body weight and foot shape. The results of the FMS measurements in this study predicted that the samples had a moderate risk of injury, and there were no samples that had a high predicted risk of injury. Samples who have a moderate risk of injury by having excessive body weight to obesity amounted to 15.12%. At the same time, samples that have a flat foot shape are partly predicted to have a moderate risk of injury and partly have a low risk of injury. The BMI of the sample influences this.

The results above illustrate that samples with BMI >24.9 kg/m² tend to have FMS scores <19 points. Samples with optimal FMS scores have lower injury rates than non-optimal ones [23]. These results align with the results of a study which revealed that people with BMI >30 kg/m² had an average combined FMS score that was 2 points lower than people with BMI <30 kg/m² [24]. A higher BMI was found to be more common in those with limitations in performing daily activities [25]. It was revealed that a dynamic and reciprocal relationship exists between body weight, motor skill competence, and physical fitness [26, 27]. Our results showed that samples with BMI results > normal showed lower FMS movement quality. Research also reveals that samples with higher body weight will produce lower FMS total scores [28]. This opinion also aligns with the results that revealed samples that obtained a total FMS score ≤14 points were significantly greater in overweight samples [14]. Individuals with excess BMI will experience limitations in performing movement activities, so individuals with excess BMI will also have difficulty performing a series of FMS movements [29]. Therefore, the FMS score will decrease as BMI increases.

Additionally, the analysis encompassed reviewing the FMS value against the BMI of the sample, along with assessing the shape of the sample's feet. The results of this study show that only a few samples have a flat foot shape, and none even have a high foot shape. The dominant sample has a normal foot shape. The findings of this study, FMS measurements in terms of foot shape, did not show a prominent difference. Samples with a normal foot shape have more predicted levels of low injury risk, but there is not much difference in samples with a moderate risk of injury. Likewise, samples with flat feet had more low injury risk than those with moderate injury risk. Our results show that the shape of the foot in the sample does not affect the prediction of the risk of injury that the sample has. This can happen if the sample has a level of physical condition and other supporting factors that make the sample have a low risk of injury. According to research that has been conducted, many researchers have revealed that foot arch correlates with lower extremity injuries [30]. Most commonly, flat feet show significant changes in the talocalcaneal joint and talonavicular joint, resulting in an increased risk of injury [31].

According to research [30], it has been shown that flat feet are associated with improper static force distribution, causing the forefoot to have lower pronation in walking than normal feet. Some studies have also found an association between excessive foot pronation and an increased risk of acute injury [32]. Excessive pronation transmitted to internal rotation of the tibia may cause overloading of the knee joint or other changes in the proximal part of the lower extremity. Individuals with low foot arches are thought to have disproportionate foot flexibility, allowing the foot to pronate excessively during the standing phase, such as when running [33]. In addition, it has been found that stress fractures of the metatarsals are more common in feet with flat arches [34]. These phenomena will have consequences such as dysfunction or weakness of the active support of the medial longitudinal arch (MLA), which can lead to injury. Although the results of this study did not find a significant difference between foot shape and injury risk prediction, our study may suggest intrinsic factors, such as the influence of BMI on injury prediction outcomes.

Conclusions

The total FMS score obtained in the review of the foot's shape shows that the dominant sample has a normal foot shape with a low predicted risk of injury. However, those who have a flat foot shape have yet to be proven they will be at risk of high-category injuries. While the results obtained in the review of BMI, it is proven that individuals who have normal BMI have a lower risk of injury compared to individuals who have a BMI in the overweight to obese category. These results may be due to the limitation of movement that results from having a BMI above normal

According to the research results, individuals can improve their lifestyle, especially by maintaining their BMI. The risk of moderate to high-category injuries is mainly experienced by individuals who have a BMI above normal. Meanwhile, individuals with a foot shape other than normal can strive to improve their physical condition and other supporting factors. This is because, despite having an abnormal foot shape, it does not rule out the possibility that individuals are included in a group with a low predicted risk of injury.

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