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Association of Soccer and Genu Varum in Adolescents

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Background: Genu varum is a physical deformity marked by bowing of the leg. One of the risk factors of this musculoskeletal alignment is stress on the knee joint such as with exercise.
Objectives: Since the evaluation of genu varum has not been widely studies, this study was conducted to examine the association between genu varum and playing soccer.
Materials and Methods: Between Septembers 2010-2012, 750 soccer players and 750 non-soccer players 10-18 years of age were included in the study. A questionnaire of data including age, height, weight, body mass index (BMI), years of soccer participation, the average time of playing soccer per week, previous trauma to the lower limbs, history of any fractures of the knee, previous hospitalizations, and the distance of joint lines between the knees was assessed for all subjects. Chi-square, student t-test, and one-way ANOVA were used for statistical analysis by SPSS v.19.0 software. In all tests, a P value of less than 0.05 was construed as statistically significant.
Results: Both soccer players and controls had genu varum. However, the incidence of genu varum was higher in the soccer players (P = 0.0001) and it was more prevalent in the 16-18 year age group (P = 0.0001). The results revealed a statistically significant association between the degree of practices and the prevalence of genu varum (P = 0.0001). Moreover, previous trauma to the knees and practicing in load-bearing sports led to an increase in the degree of genu varum (P = 0.0001).
Conclusions: There was a higher incidence of genu varum in soccer players than in control adolescents; the stress and load imposed on the knee joint led to more severe genu varum.

Keywords: Genu Varum; Soccer; Adolescent

1. Background

Genu varum is one of the angular deformities of the knee. It is one of the most common anatomic variations of musculoskeletal alignment and one of the common reasons for referral to orthopedic surgeons (1, 2). Physiologic varus is often an abnormal internal rotation of the tibia that occurs after the age of two while pathologic varus may be caused by Blount's disease, systemic disorders (such as nutritional rickets and other bone metabolic diseases), bone dysplasia, asymmetric growth from unilateral trauma, infection, or neoplasm (1-4). Although the physiologic type can improve with age, pathologic genu varum tends to develop during skeletal growth (3). Chantraine et al. hypothesized that the stress and strain on a joint caused by regular practicing of an intensive sport during adolescence may lead to a growth deformity (5).

Approximately 3-11 % of children sustain injuries while participating in various sports, especially soccer. Playing soccer regularly exposes the knee joint to load and torque stresses that contribute to genu varum in the lower limbs (6). Genu varum causes damage to the cartilage of the tibiofemoral joint; the medial compartment is located there and is more prone to injury than the lateral meniscus. This damage can lead to osteoarthritis of the knee. Additionally, the patellofemoral joint can be damaged and genu varum is a risk factor for consequent patellofemoral pain in athletes (7).

2. Objectives

Since genu varum has not been widely evaluated, this study aimed to show the association between genu varum and playing soccer.

3. Materials and Methods

Between Septembers 2010-2012, we conducted a cross sectional study on male students with 10-18 years of age from local schools in Rasht. The Ethical Committee of the Research Deputy of Guilan University of Medical Sciences provided ethical approval for the study with the protocol (No. 1593). Subjects whose questionnaires were

not filled completely were excluded from the study. All subjects and their parents signed a written informed consent and the participants' information was kept highly confidential.

A questionnaire concerning data including age, height, weight, BMI, years of soccer participation, the average time of playing soccer in a week, previous trauma to lower limbs resulting in grade III ligament damage, history of fractures of the knee, previous hospitalizations, and the distance of joint line of the knees was recorded for both soccer players and controls. We divided the soccer players into two groups; those who played longer than six hours a week were defined as professional soccer players and those who had played less than six hours a week were defined as non-professional soccer players. Any history of participating in other load-bearing sports such as track and field, martial arts, basketball, volleyball, and handball as well as some non-load bearing sports such as swimming and bicycling was recorded. The distance between the medial edges of the tibiofemoral joint line in centimeters was measured while the participants were standing straight with the feet touching and the hips and knees in maximal extension.

Based on the measured distance of separation at the tibiofemoral joint line, genu varum is classified into four grades; Grade I: less than 2.5 cm; Grade II: 2.5 to 5.0 cm; Grade III: 5.0 to 7.5 cm; and Grade IV: greater than 7.5 cm.

Descriptive-analytic methods were employed to analyze the gathered data. Chi-square, student t-test, and one-way ANOVA were used for statistical tests by SPSS 19.0 (SPSS Inc., Chicago, Illinois, USA). In all tests, a $P < 0.05$ was considered as statistically significant.

4. Results

One thousand and five hundred students 750 professional and 750 non-professional soccer players were recruited in the study. The mean (SD) age of soccer players and controls were 13.97 (2.56) and 13.99 (2.54) years old, respectively. The mean age of the participants had no statistical difference ($P > 0.05$).

There were significant differences in the weight and BMI of the two groups; soccer players had lower weight and BMI ($P = 0.0001$ and $P = 0.007$, respectively) as shown in Table 1. The difference in mean height between two groups was not statistically significant.

This study revealed a positive correlation between the distances of the tibiofemoral joint line and the height, weight, age, and BMI of the soccer players ($P = 0.0001$ for all). Increased height, weight, age, and BMI resulted in more severe genu varum. Analysis also showed a positive correlation between the tibiofemoral joint line distance and the years as well as the mean hours per week spent playing soccer ($P = 0.0001$ for both).

Statistical analysis showed significant differences in the distance of the tibiofemoral joint line between soccer players and controls as well as between participants with and without previous trauma. In the professional and non-professional soccer playing groups, any history of previous trauma to the knee and practicing load-bearing sports had a significant impact on the distance of the tibiofemoral joint line ($P = 0.0001$). There was no significant difference in the distance of the tibiofemoral joint line between soccer players with respect to participation in other load-bearing sports. This is illustrated in Table 2.

There were significant differences between soccer players and controls with regard to the different grades of genu varum ($P = 0.0001$). Of 750 soccer players, 317 (42.3 %) had grade I, 403 (53.7 %) had grade II, 29 (3.9 %) had grade III, and 1 (0.1 %) had grade IV of genu varum. Of 750 controls, 504 (67.2 %) had grade I, 232 (30.9 %) had grade II, 14 (1.9 %) had grade III, and none of them had grade IV of genu varum.

There were significant differences ($P = 0.0001$) between the mean hours of practicing per week and the years of playing soccer with the different grades of genu varum in the soccer players (Table 3).

5. Discussion

Lower limb deformities such as genu varum are prevalent in children. It is caused by numerous factors including developmental bowing, congenital bowing, tibia vara (Blount's disease), neurofibromatosis, rickets, osteogenesis imperfecta, camptomelic dysplasia, achondroplasia, and even intense exercise (1, 3). We investigated the impact of playing soccer on the knee joint because of the great public attention and interest in this sport.

Thijs et al. and Witvrouw et al. demonstrated a higher prevalence of genu varum in adolescent soccer players between 13-18 years of age (8, 9). In our study, the highest degree of genu varum was seen between 16-18 years of age. Since the age of 16 years is the end of the growth spurt in boys, 18-year-old male soccer players had significantly higher degree of genu varum in comparison

Table 1. Basic Characteristics of the Participants [a]

	Values	Demographic
Age, y		13.98 ± 2.55
Soccer players	13.97 ± 2.56	
Controls	13.99 ± 2.54	
Weight, kg		51.2 ± 12.75
Soccer players	50.31 ± 12.4	
Controls	52.09 ± 13.03	
Height, cm		158.77 ± 12.4
Soccer players	158.53 ± 12.92	
Controls	159.01 ± 11.87	
BMI, kg/m^2		19.96 ± 2.92
Soccer players	19.66 ± 2.53	
Controls	20.25 ± 3.25	

[a] Data are presented as mean ± SD.

Table 2. Comparison of the Distances of the Tibiofemoral Joint Line of the Knees [a]

	Distances of the Tibiofemoral Joint Line, cm	P value
Soccer players	3.01 ± 1.2	
Controls	2.28 ± 1.08	0.0001
Students without doing exercise	1.82 ± 0.87	
Students with doing exercise	2.81 ± 1.18	0.0001
Students without a previous trauma to the knees	2.59 ± 1.18	
Students with a previous trauma to the knees	3.64 ± 1.12	0.0001
Soccer players without practicing other sports	2.96 ± 1.17	
Soccer players with practicing other sports	3.06 ± 1.24	0.267
Soccer players without practicing other load-bearing sports	2.91 ± 1.17	
Soccer players with practicing other load-bearing sports	3.38 ± 1.26	0.0001
Soccer players without a previous trauma to the knees	2.97 ± 1.19	
Soccer players with a previous trauma to the knees	4.04 ± 1.11	0.0001

[a] Data are presented as mean ± SD.

Table 3 . The Hours of Playing in a Week and the Years of Playing in Terms of the Grades of Genu Varum [a]

	Grade I	Grade II	Grade III	Grade IV	P value
The hours of playing in a week	6.92 ± 1.68	7.77 ± 2.47	8.89 ± 3.06	8	0.0001
The years of playing	6.92 ± 1.68	6.92 ± 1.68	6.92 ± 1.68	6.92 ± 1.68	0.0001

[a] Data are presented as mean ± SD.

to the controls (10, 11). A previous study reported that boys generally tend to show varus during the last two years of the skeletal growth (12). Our study showed that the duration of a load-bearing activity imposed on the knee joint played a significant role in the presence and severity of genu varum. Intense soccer participation increased the degree of genu varum and it supported the theory of Chantraine et al. (5).

Rezende et al. demonstrated that there was a positive correlation between degree of genu varum and anthropometric variables such as weight, height, and BMI (13). The prevalence of musculoskeletal discomfort, impaired mobility, and malalignment of the lower limbs are more common in overweight adolescents than non-overweight ones. These conditions continue to deteriorate in a vicious cycle; the deformities lead to decreased physical activity and hence, increase in childhood obesity. Orthopedic difficulties may perpetuate the accumulation of excess weight in the afflicted children (14). These conditions also encourage a more sedentary lifestyle. These children may stay inside their homes and have less exposure to the sun and consequently, receive less vitamin D. Voloc et al. reported that low levels of vitamin D increased the risk of genu varum (15). Our results were consistent with previous studies; the incidence of genu varum increased with greater height, weight, and BMI in our participants.

McDermott et al. reported that runners showed significant correlations between degenerative changes and the number of years spent on training (16). Various factors are associated with malalignment of the knees including age, weight, metabolic disorders, vitamin D distribution, and environmental elements. Extensive soccer practices such as running, passes, cutting maneuvers, tackles, and kicking cause the development of genu varum in children (9, 17-19).

While no previous studies were performed concerning the association of genu varum and the hours of soccer playing, our study showed an association between soccer playing (load-bearing activity) and the degree of genu varum.

To understand the association of genu varum and playing soccer, the external load on the knee joint during this activity should be considered. Besier et al. measured the external load on the knee joint and reported that varus and valgus stresses on the knee joint were dramatically increased during cutting maneuvers when compared to normal running. Finally, they demonstrated that cutting maneuvers led to varus or valgus malalignments. However, whether these cutting tasks can solely lead to genu varum is still unclear (20). These cutting maneuvers are seen in other sports such as basketball,

volleyball, handball, and tennis. In this study, when we compared soccer players with adolescents playing other sports (basketball, volleyball, or handball) significant differences were found between the two groups. Hence, another physical activity might be accounted for this difference. Additionally, these cutting maneuvers are not just seen in football and they are seen in other sports such as basketball, volleyball, handball, and tennis.

On the other hand, kicking is unique to soccer. Several biomechanical studies demonstrated that the kicking action was a diagonal approach of the leg to the ball (21-23). This diagonal approach is emphasized instead of a straight kicking action because it results in greater peak ball velocity. The kicking action involves not only hip flexion and knee extension, but also an adduction component. As kicking is a frequent action in soccer and players might have developed strong adductor muscles as well as alteration in their normal adductor or abductor strength (21-23); the difference found between soccer players and other sports participants in our study might be due to the diagonal kicking action in soccer that led to genu varum in the soccer players.

According to existing literature, the etiology of genu varum is multifactorial and contributes to a condition characterized by biomechanical overloading of the proximal medial tibial physis (24-27). Cook et al. showed that mechanical overload played an important role in the development of genu varum. They reported that restricted and asymmetric physeal growth due to excessive asymmetric loading led to progressive deformity; hence, a vicious cycle of loading and deformity led to permanent injury (25). It is still unclear why soccer activity increases genu varum in comparison to the other loadbearing sport activities.

Our study showed the load imposed at the knee during playing soccer, regardless of cutting maneuvers, might result in genu varum. Future biomechanical studies should aim to investigate how the diagonal kicking action in soccer might contribute to the development of genu varum. In conclusion, the incidence of genu varum was higher in soccer-playing adolescents than control adolescents; the stress and load imposed on the knee joint led to greater deformity during growth period and more severe genu varum.

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Authors' Contributions

Study concept and design: Kamran Asadi; acquisition of data: Ahmadreza Mirbolook; analysis and interpretation of data: Mohsen Mardani Kivi; drafting of the manuscript: Melina Rouhi Rad; critical revision of the manuscript for important intellectual content: Kamran Asadi; statistical analysis: Abtin Heidarzadeh; administrative, technical, and material support: Ahmadreza Mirbolook; study supervision: Mohammad Kazem Emami Meybodi.

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