Varusna deformacija kolen nogometašev najstnikov

Varus knee deformity in adolescent soccer players

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Ključne besede:
Nogomet, rastna cona, varusna deformacija kolena, šport, najstnik

Key words:
soccer, growth plate, varus knee, bowlegs, sports-related, adolescent

Članek prispel / Received
9. 7. 2018
Članek sprejet / Accepted
4. 10. 2018

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Izvleček

Osi spodnje okončine se dinamično razvijajo in oblikujejo v prvih dveh desetletjih življenja. V zadnjih letih opažamo znatno povečano intenzivnost vadbe med treningi in tekmovanji (čas, frekvenca, moč) in posledično povečano število akutnih in kroničnih poškodb med mladimi športniki. Med športe z večjo incidenco poškodb uvrščamo tudi nogomet. Pregled literature zadnjih 15 let, ki preučuje deformacijo kolenskih sklepov mladih nogometašev, nakazuje pogostejši pojav varusne deformacije spodnjih okončin med nogometaši v primerjavi s splošno populacijo in športniki drugih športnih panog, najverjetneje zaradi specifičnih obremenitev nogometne igre. Varusna deformacija vpliva na spremenjeno biomehaniko kolenskega sklepa s povečano obremenitvijo medialne sklepne špranje in posledično zgodnejšim pojavom obrabnih sprememb kolenskega sklepa. Varusna deformacija kolenskih sklepov dodatno

Abstract

The lower limb axis develops dynamically throughout the first and second decades of life. In recent years, with respect to youth athletes, we have been facing a progressive increase in the intensity of exercise during training and competition (involving increased time, frequency, and power), and, as a result, there has been an increase in the number of acute and chronic overuse injuries. There are some sports with a higher incidence of injuries, one of which is soccer. A review of literature for the past 15 years with a focus on varus knee deformities in adolescent soccer players showed that varus axial deformities of the lower limbs occur more frequently in soccer players than in the general population and in athletes from other sport, probably due to the specific loading pattern in soccer training. Varus deformities alter knee biomechanics, which results in medial joint space overloading, and consequently an early onset of degenerative joint *vpliva na pogostejši pojav sindroma patelo-femoralne bolečine in poškodb meniskusov med športniki. Etiologija varusne deformacije spodnjih udov med nogometaši je posledica kombinacije različnih dejavnikov: od naravne selekcije nogometašev z genetsko predispozicijo za varusno deformacijo spodnjih okončin do mehanske preobremenitve medialnega dela rastne cone proksimalne golenice, ki je posledica igranja nogometa. Klinične študije in raziskave na živalih nakazujejo, da lahko intenzivna športna vadba negativno vpliva na normalen razvoj rastne cone kolenskih sklepov in posledično na pojav nepravilnosti v rasti.*

disease. In addition, bowlegs predisposes athletes to patellofemoral pain syndrome and meniscal lesions. The etiology of genu varum in soccer is thought to be multifactorial, ranging from the natural selection of players to mechanical overload of the proximal medial tibial growth plate. A growing number of clinical reports and animal studies have indicated that intensive sport training may precipitate pathologic changes of the knee joint growth plate, and even produce a growth disturbance.

INTRODUCTION

More and more people (both children and adults) worldwide are participating in sport on a daily basis (1,2). Sports provide fun and satisfaction; however, sports also pose an increased risk of musculoskeletal injuries (3,4).

Physical activities and involvement in sports significantly influence the wellbeing, health, and personal development of children (5). Over recent years, these beneficial effects resulting from sports activities have been accompanied by a progressive increase in the intensity of training, competitiveness at an increasingly early age, and a premature focus on single-sport activities. As a result of increased overload, a number of sports-related adverse consequences manifest as injuries. Such injuries are attributed to incorrect preparation of athletes for intensive sport activities, as well as overload in training and competition (1,6). Several authors have indicated that 0.5-35 injuries occur per 1000 hours of exposure to sports activities (7,8). The incidence of injuries varies and depends on the age, gender, and type of sport. Hockey, American football, and soccer have the highest incidence of injuries in boys, while soccer, basketball, and gymnastics account for the highest incidence in girls (7,8).

Soccer is the most popular sport worldwide with respect to registered players and fans. According to the Fédération Internationale de Football Association (FIFA), a total of 270 million people are registered soccer players, of which 200,000 are professional soccer players (9–11). More than 50% of registered soccer players are < 18 years of age (12). Soccer has specific rules and regulations, and a unique method of play (10). Soccer combines walking, jogging, and sprinting. Soccer is characterized by frequent contact among players, high speed, quick and sudden changes in direction, and tackling maneuvers (10–12). Unlike other sports, soccer is mainly characterized by kicking the ball (12,13). During a soccer game, players and their musculoskeletal system are frequently exposed to major loading. Therefore, soccer has the greatest risk of injuries among all sports (3). Many authors agree that the majority of injuries that occur in adult and adolescent soccer players are limited to the lower extremities, with knee and ankle injuries accounting for most of the injuries (9,12). According to the literature, the incidence of injuries in football players increases with age and is significantly higher during games and lower during training (9,12).

Varus knee deformities in soccer players

During the first decade of life, the axes of the lower limb undergo dynamic changes; however, changes in the shape of the bone and the lower limb axis can occur due to physiologic bone remodeling and under the influence of external and internal factors throughout the entire life. It is well known that lower limb varus deformities (so called bowlegs) are more frequent in soccer players compared to their peers. Chantraine

(14,15) reported that > 80% knees of retired soccer players have lower limb varus deformities, which is significantly higher than the 33% of the normal male population with constitutional varus knees (> 3° of varus). An increased incidence of varus knees among adolescent soccer players has also been reported when compared to peers who did not play soccer (13,16,17) [Figure 1].

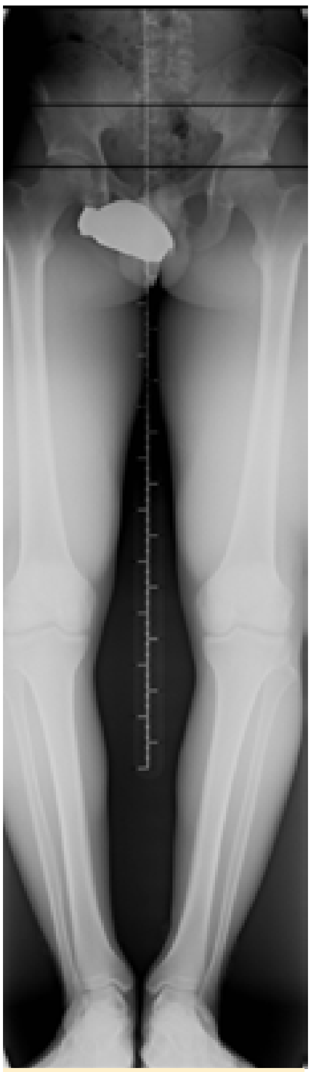

Figure 1. Bow legs of 18-year old professional soccer player, varus deformation of both knees

A review of the literature for the past 15 years involving varus knee deformities in adolescent soccer players revealed only a few relevant studies, and showed that varus axial deformities of the lower limbs occur more frequently in soccer players than in the general population and other athletes, probably due to a specific loading pattern in soccer training (13,16–19). Thijs et al. (17) compared varus development in male adolescents 13–15 years of age who did or did not participate in sports, and established that varus occurred in both groups. This is in agreement with the physiologic development of the lower limb axis described by Cahuzac et al. (20), who observed physiologic varus in boys at the end of the growth spurt period. Thijs et al. (17) also reported that varus was more common in the group of boys 13- to 15- years-old who were engaged in sports. Yaniv et al. (13), Witvrouw et al. (16), and Asadi et al. (18) compared groups of adolescent soccer players and other athletes and established that soccer players between 13 and 16 years of age have a significantly higher degree of knee varus deformities compared to non-soccer players who were engaged in other sports involving increased impact on knee joints, such as tennis, volleyball, basketball, and handball (4,13,16). Athletes engaged in these sports are exposed to similar loads characterized by slow and fast running, quick and sudden changes in the direction of movement, and jumping. The only differences between soccer players and athletes in other sports is tackling and kicking the ball, which might have a significant influence on the frequent lower limb varus deformities in soccer players (13,16,17). In a growth plate study using diffusion-weighted imaging (DWI), Krajnc et al. (19) concluded that the growth plates in adolescent soccer players (the medial proximal tibia in particular) are greatly affected by playing soccer, which might result in more frequent knee varus deformities in soccer players.

Due to the specific nature of soccer, the knee joints of soccer players are exposed to impact forces and torsional loading (13,15). In a growing and developing skeleton, these forces are further transferred onto growth plates, which are excessively and asymmetrically loaded. This feature may lead to disturbed growth plate functioning and deformation of growing bones and joints.

Reasons for varus knee deformities in adolescent soccer players

It has been established that the increased intensity of sport activities during the growth spurt period has an effect on the incidence of increased varus in a specific group of adolescent boys, especially among soccer players, who are exposed to specific training on a daily basis (13,16–18). Repeated loading in soccer players during the growth spurt phase is believed to affect lower limb varus angulation. A possible explanation for varus deformation in soccer players might be provided by the Hueter-Volkmann Law, which states that increased pressure parallel to the axis of the epiphysis inhibits growth, while decreased pressure promotes growth and changes in compressive forces causing asymmetric growth of bone, or by Frost's theory of chondral remodeling which suggests that physiologic loading stimulates growth, whereas loads outside this range (lower or higher) inhibit growth (21–23). When analyzing specific activities that might give rise to varus in soccer players, many authors agree that it is the kicking of the ball that is unique to soccer in comparison to other sports (12,13,16). Witvrouw et al. (13,24) showed knee adduction moment during ball kicking, which is the primary determinant of medial-lateral load distribution on the knee joint during gait, is enhanced. The adduction moment is related to the magnitude of the compressive load on the medial knee compartment, which is additionally increased during intensive training (17,24). The varus and valgus loading to individual knee joint parts during sudden cutting maneuvers are considerably larger than those measured during normal running activities; however, the applied loads are believed to be medial-lateral symmetric, and thus do not affect the development of varus deformities (25). Sudden changes in direction are typical for other sport activities as well and are not unique to soccer; however, kicking the ball is a unique characteristic specific to soccer compared with other sports. Authors have also suggested a theory of natural selection for soccer players with a genetic predisposition to varus, which plays an important role in infant balance and stability during the first steps and possibly when playing football (16).

According to the Hueter-Volkmann Law of remodeling, this enhanced adduction moment, resulting from repeated loads to knee joints that mostly occur during kicking actions, might have a negative impact on growth plates in the medial knee compartment. Eventually, this effect might have a negative impact on the growth and development of knees in adolescent soccer players (17).

Growth plate disturbance: A reason for varus deformation?

The growth plates around the knee joints (distal femur and proximal tibia) contribute 55%–70% of the growth of the lower limb. Even minimal growth disturbances in this area, therefore,can have a significant impact on the occurrence of possible deformations (26,27). Studies conducted to date indicate a correlation between increased sport intensity and pathologic changes in growth plates that lead to growth disturbance in affected bones and limbs (1,2,5,7,28). The susceptibility of the growth plate and the resulting increased risk of injuries is believed to be highest during the growth spurt in adolescents (1,27,29). This finding is consistent with an animal study that showed reduced growth plate resistance during the rapid growth phase (30). A thorough understanding of the pathophysiologic processes at the cellular level in growth plate overloads requires a histologic evaluation of tissue. Radiologic imaging remains the basic tool used to study the changes occurring in growth plates in humans. The results may be compared with the findings from animal studies that allow the omparison of radiologic changes in growth plates under the impact of different loads with the histologic samples of the same tissue. When evaluating growth plate injuries in humans, diagnostics are limited to conventional radiography, computer tomography (CT), and magnetic resonance imaging (MRI), but typical radiologic changes become radiologically-visible only after an interval of symptomatic pain not observed in asymptomatic athletes (1,27,31,32). It is known that increased compression loads cause changes in the growth plate width, which can be identified on an MRI scan and later, on X-ray images; however, only after a long-lasting increased load or short period of significant overload of growth plates (acute injuries), which has been confirmed with animal studies. Increased loads within physiologic limits are supposed to cause a transitional width of growth plates. If these limits are exceeded and irreparable damage has already occurred, the growth plate narrows and gradually closes (1,2,27,32–34).

Krajnc et al. (19) have used a more recent radiologic tool (Diffusion Weighted Imaging - DWI) to introduce a new method of evaluating subtle changes in growth plates resulting from repeated loads that have not yet caused clinical symptoms and/or detectable changes in growth plates that are visible using standard radiologic methods. During the study, adolescent soccer players (14 years-of-age) underwent two months of intensive football training; however, a difference in growth plate width compared to baseline measurements was not demonstrated, but only changes at the cellular level obtained by calculating the apparent diffusion coefficient (ADC), especially in the medial proximal tibial growth plate, which is supposed to reflect greatertissue cellularity in this area (Figure 2). The results of this research are consistent with the histologic findings in animal growth plates exposed to different external loads. The authors of histologic animal studies established that increased compression load on growth plates causes the expansion of hypertrophic layers in growth plates due to an increased number of chondrocytes (increased cellularity) and simultaneous gradual disorganization of the layers and columns (33,35–37).

It can be concluded that the more frequent varus deformation of knee joints among athletes, in particular soccer players, is the result of changes occurring in the growth plate as a response to repeated rotation and compression forces affecting the growth plates of knee joints.

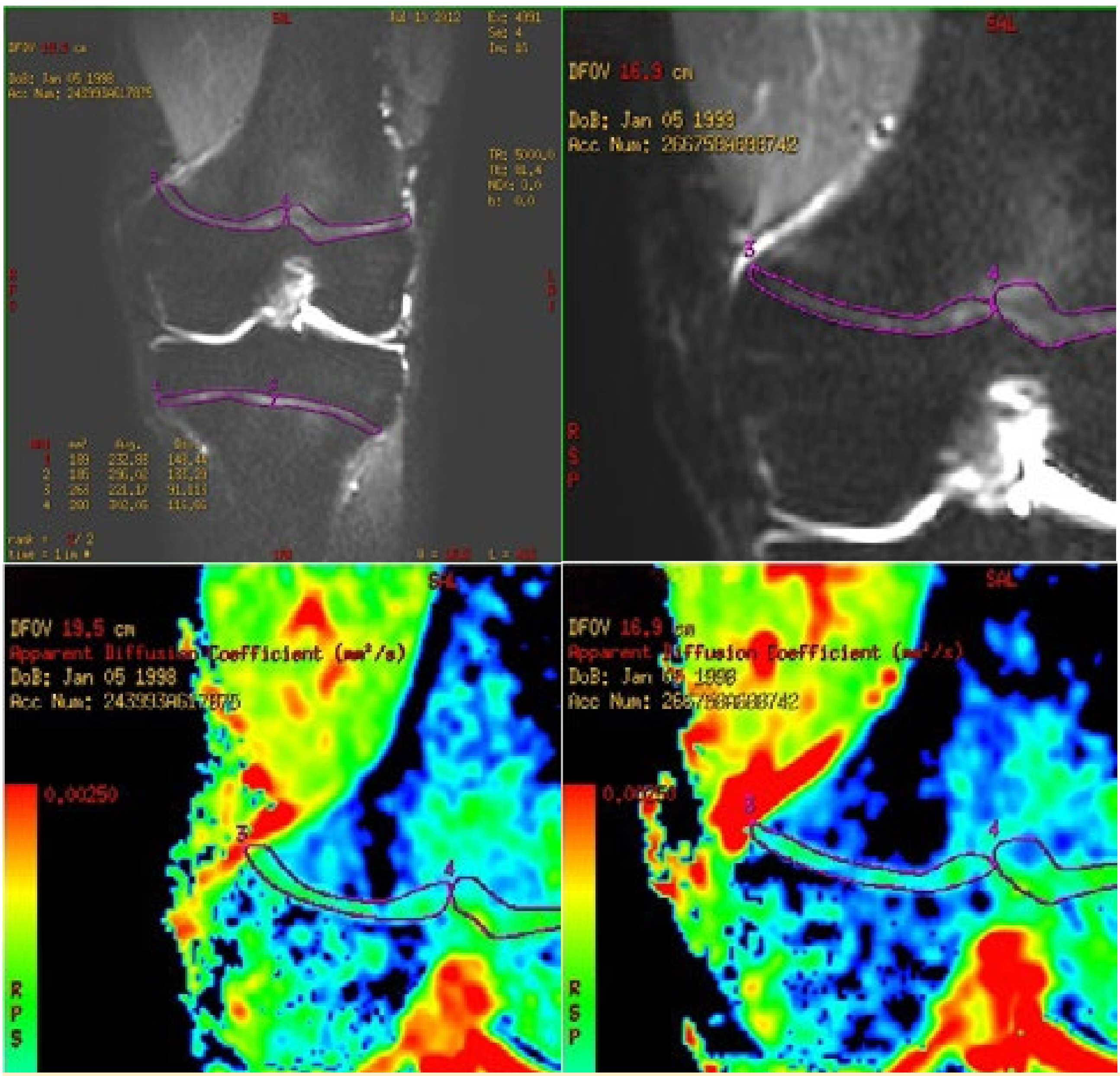

Figure 2. *A sample of DWI analysis of growth plate in an adolescent soccer player before (A, A1) and two months after (B, B1) sport activity. There were no significant differences in growth plate surface area measured in MR images (A, B). Calculated ADC values after 2 months were decreased and may reflect an increased cellularity of the growth plate (A1, B1) (reproduced with permission) (19).*

CONCLUSION

Higher incidence of varus deformations in the lower extremities of soccer players is related to several causes; specifically, several biological and mechanical factors, affecting the overloaded medial part of the growth plate in knee joints, are the most likely cause. Varus deformation changes the mechanical load placed on the knee joint. The center of mechanical axes is medialized and the medial compartment load is consequently increased several times compared to the lateral compartment (38–40). Genu varum predisposes athletes to degenerative, overuse, and traumatic lesions of the knee joints, patellofemoral pain syndrome, and meniscal lesions (13,17,41). The probability of developing a degenerative knee joint in a varus knee deformation is two-fold compared to neutral and valgus knees. The probability and progression of knee cartilage degeneration increases with the extent of varus deformation, and thus negatively affects the quality of life in athletes, even after the sporting career ends (41).

Despite the efforts of numerous researchers, the exact mechanism underlying an increased incidence of varus in soccer players remains unknown. Further research is required to gain more insight into the causes of varus deformation of the knee in order to enable millions of young soccer players to play soccer safely without negative consequences for their health and life.

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