

Joint mobility in young male soccer players

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Published online: February 28, 2022

(Accepted for publication February 15, 2022)

DOI:10.7752/jpes.2022.02058

Abstract

Problem Statement: It is known that the practice of soccer can negatively affect the anatomy and mobility of the ankle even in the case of young subjects. This condition is worthy of attention because it can have serious consequences for the movement and health of athletes. **Purpose:** The aim of this study was to investigate how the ankle joint mobility (AJM) trend of young male soccer players (SP) changes during their growth. **Material and Methods:** In 173 young male SP (7-17 years) and in 67 non-soccer controls practicing volleyball-basketball, who were matched for sex, body mass index (BMI), and age, AJM in plantar flexion (APF) and dorsiflexion (ADF) was evaluated using an inclinometer. Flexibility was evaluated by the Sit and Reach test. Moreover, data were collected for sports practiced, years of activity, history of injuries, dominant kicking leg. **Results:** Young SP showed an AJM significantly lower in both plantar and dorsiflexion compared to the non-SP ($124.8 \pm 19.5^\circ$ vs $138.7 \pm 20.6^\circ$ $p < 0.001$). Multivariate analysis showed that the age significantly influences the Total AJM ($p = 0.004$) and ankle dorsiflexion ($p = 0.002$) but not the plantar flexion. This relationship was not found in controls. Regarding the SP, Spearman's correlation analysis showed that dorsiflexion and Total AJM were inversely correlated with Age ($p < 0.011$; $p < 0.013$ respectively) and BMI ($p < 0.001$). The progression of limited AJM that was significant already in the younger subjects (7-10 years) slowed in SP of 11-13 years and then increased significantly in subjects of 14-17 years. No difference between the dominant and non-dominant leg AJM was observed in the SP group. **Conclusions:** Young SP can show a sport related reduction of the AJM. This joint deficit was inversely correlated with age and BMI. These results can be useful for future studies aimed at preventing and managing the reduction of AJM in SP.

Keywords: Footballer, Ankle, Sport practice, Injuries prevention, Flexibility, Pubertal development, Muscle strength.

Introduction

Soccer practice is a significant source of physical activity for youth and it can have many positive health benefits which are considered important for growth. However, the practice of soccer over the years can have some negative consequences that should be known, monitored, avoided or managed (Merkel 2013; Bergeron et al, 2015; Matzkin&Garvey, 2019). In this regard, it is known that soccer practice can negatively affect the ankle anatomy and mobility (Travers et al, 1976; Armenis et al, 2011; Rein et al, 2011; Golanó et al, 2014; Read et al, 2016; Francia et al, 2018). This condition is worthy of attention because it can have serious consequences with possible negative long-term effects on a large number of subjects (Hattori&Ohta, 1986; de Noronha et al, 2006; Fong et al, 2011). In fact, even if practiced differently according to country, soccer is a very popular sport that is often preferred by males and can involve more than 50% of young sportsmen (FIFA Big count, 2006; Report, 2017; Taking Part, 2017; National physical activity plan, 2018).

The ankle joint or talocrural is a load-bearing joint formed by the distal articular surfaces of the tibia and fibula that form a mortise to accommodate the proximal articular surface of talus. The anatomy of the ankle joint allows us to define how a ginglymus or hinge-type synovial joint with an axis of movement (bimalleolar) mainly enables foot dorsiflexion and plantarflexion in the sagittal plane. The same morphology of the articular surfaces in addition to capsuloligamentous and musculotendinous structures provide static and dynamic joint stability (Golanó et al, 2014; Brockett&Chapman, 2016; Classen et al, 2019). Regarding ankle joint mobility (AJM), large cohort studies reported that plantar and dorsiflexion range of motion (ROM) is stable in subjects at school age. It was shown how the total AJM (flexion-extension) in young subjects is about 70° and it can result higher in females (Boone and Azen, 1979; Grimston et al, 1993; Kumar et al, 2011; Soucie et al, 2011; Norkin and White, 2016). Numerous studies have shown how AJM is significantly reduced in soccer players (Hattori&Oha, 1986; Moreno-Pérez et al, 2020; Francia et al, 2021). This condition of ankle stiffness appears to be a paradox. In fact, in theory, for the players a higher AJM could favor the management of the ball and the

sporting performance. On the other hand, a reduced Ankle ROM can limit the large movements of the lower limbs and affect static-dynamic balance and then the quality of gait in addition to increasing the risk of injuries and musculoskeletal overuse (Kaufman et al, 1999; Aronow et al, 2006; Brockett&Chapman, 2016; Paterno et al, 2013; Basnett et al, 2013).

The cause or the causes of reduced ankle range of motion (ROM) in young soccer players (SP) are still partially unknown. However, it has been suggested that an important role can be attributed to repeated injuries (Basnett et al, 2013; Paterno et al, 2013; Terada et al, 2013; Golanó et al, 2014). Such injuries can be either traumatic or resulting from repeated sports-specific microtrauma. All ankle ligaments and joint capsule in addition to other periarticular structures can be subjected to injuries and alterations due to sport practice (Armenis et al, 2011; Golanó et al, 2014; Faude et al, 2013; Paterno et al, 2013). In addition to physical contact between the players, during sports practice, different types of high intensity movements such as jumping or running with frequent and rapid changes of speed and direction, twisting and turning, overtaking and landing, can cause joint microtrauma and concur to induce a condition of overuse (Hattori&Oha, 1986; Read et al, 2016). *In particular, it is known that injuries caused by tissue overuse can be the result of a gradual process during which the sporting activity is continued with recovery times that are not sufficient to allow healing compared to previous traumas or microtraumas.* The same kicking a soccer ball with force can induce (micro) direct trauma on the ankle joint in addition to muscle and periarticular connective tissues adaptations which, over time, could affect AJM (Ekstrand&Gillquist, 1982; Hattori&Oha, 1986; Lees et al, 2010; Faude et al, 2013; Sasadai et al, 2015). Since such harmful stresses are often associated with typical sport situations (soccer handling, high-speed movements and crushes between players) it was suggested that for soccer players a number of injuries (i.e. strains of muscle and tendon, sprains of joint – ligament) are inevitable (Hattori&Oha, 1986; Lees et al, 2010; Faude et al, 2013; Read et al, 2016).

In addition to the history of injuries suffered, and their incidence that has been reported to increase with the age of young soccer players (Rössler et al, 2015), other potential risk factors for limited AJM were suggested. In particular, the reduction in ankle ROM has been attributed both to the progressive development of tightness of the leg muscles and to the stiffness of periarticular soft tissues. In this regard, it is important to consider that these tissue changes were considered as a physiological adaptive response to the considerable and repeated stresses they have undergone (Ekstrand&Gillquist, 1982; Hattori&Oha, 1986; Sasadai et al, 2015). Hence, the adaptive response of tissues to soccer practice can be considered as a second apparent paradox in the relationship between AJM and soccer. While, on one hand, the increased stiffness of the ankle improves the stability of the joint on the other hand, it increases the risk of muscle-skeletal overuse or injuries, such as when the ankle joint is forced beyond the limits of the available ROM (You et al, 2009; Sasadai et al, 2015; Kaufman et al, 1999; Bradly&Portas, 2007; Lees et al, 2010). *Consequently, the increased stiffness of the ankle that soccer players develop from the first years of activity is a physiological protection of the joint against the strong sport-specific traumas that can occur during sporting activity. At the same time, the presence of a limited AJM should be known and properly managed to avoid negative consequences for players over time.* In this sense, considering that most young people play soccer, knowing how AJM decreases during their growth it can be important in order to be able to monitor and possibly decide how and when to intervene through preventive activities on this modifiable risk factor for injuries (Armenis et al, 2011; Paterno et al, 2013; Pomares-Noguera et al, 2018; Francia et al, 2020). The aim of this study was to describe how ankle mobility changes in young SP at different ages.

Methods

A total of 173 young male soccer players and 67 age, sex-matched controls practicing volleyball (n=44) and basketball (n=23), from 7 to 17 years old, were examined for ankle joint mobility. The basketball and volleyball players were included in the control group because there was no evidence that the practice of these sports does significantly modify the AJM (Francia et al, 2018; Francia et al, 2021). Data were collected on age, weight, height, dominant kicking leg, sport practiced, number of weekly training sessions and years of practice of different sports. Body mass index (BMI) was calculated as body weight in kilograms divided by height in meters squared (kg/m^2). Detailed characteristics of the study participants are shown in Table 1. The physical examination included foot inspection for the presence of any deformity, injuries and traumas such as to affect ankle joint mobility and trunk flexibility. Exclusion criteria were: age less than 7 years and greater than 18, presence of current foot and ankle problems at baseline as well as orthopedic and/or surgical complications, in addition to a history of practice of the same sport for less than 6 months continuously. All participants and parents were informed on the purpose of the study and its experimental procedures before obtaining their written informed consent and enrolment in the study. The study protocol and the consent forms were approved by the Paediatrics Ethics Committee of Meyer Children's Hospital in Florence (protocol numbers: 161/2016 on September 29, 2016). The study was performed according to the principles expressed in the Declaration of Helsinki.

Table 1 - Main characteristics and ankle joint mobility (expressed as degrees) in male Soccer and non-Soccer players and in Basketball – Volleyball players.

	Soccer (173)	Non-soccer (67)	P-value	Volleyball (44)	Basketball (23)	P-value
Age (years)	11.7±2.5	11.9±1.7	0.309*	12.6±1.6	10.8±1.1	<0.001*
BMI (Kg/m ²)	18.7±2.4	19.5±3.5	0.161*	19.1±3.0	20.4±4.3	0.688'
Plantar Flexion (°)	27.4±8.2	31.6±7.8	<0,001	31.7±6.8	31.4±9.7	0.883'
Dorsal flexion (°)	97.4±16.4	106.8±15.9	<0,001*	106.0±15.1	108.4±17.6	0.562'
Total AJM (°)	124.8±19.5	138.7±20.6	<0,001*	138.2±19.1	139.8±23.5	0.758'
Δ R/L AJM (°)	5.7±4.8	5.3±4.7	0.554*	5.4±5.3	5.2±3.6	0.630*
Years of sport practice	6.2±3.0	3.0±2.2	<0,001*	3.2±2.5	2.7±1.6	0.615*
S/R test (cm)	-3.1±7.5	-7.8±7.9	<0,001'	-7.8±8.7	-7.9±6.6	0.950'

Values are means ± standard deviation. Comparisons were performed using T-test (') or Mann-Whitney test (*). Abbreviations: AJM: ankle joint mobility; BMI: body mass index; R/L: right/left; S/R: Sit and Reach Δ: difference; °: degree; cm: centimeters.

Determination of joint mobility

Active ROM of ankle joint in plantar flexion (APF) and dorsiflexion (ADF) was measured by an inclinometer using a validated method (Clarkson JM, 2013; Francia et al, 2018; Francia et al, 2019). In brief, players were asked to lie in supine position on a fixed treatment table with the ankle rested in line with the edge and the feet hanging over the border of the table, the ipsilateral knee was extended and put over a rigid support 5-cm high. The inclinometer (Fabrication Enterprises Inc., White Plains, New York, USA) was positioned along the diaphysis of the bone, with one extremity on the distal condyle, after marking the fifth metatarsal bone with the dermatographic pen. The subtalar joint was in the neutral position while the ankle joint was in the resting position that it naturally takes on the sagittal plane. The greater angle of the active APF and ADF was measured and the mean of three consecutive readings was reported, while the Total ankle mobility (ATOT) was the sum of the two values. In a previous study, on the use of this method, it was reported that the mean standard deviation of three consecutive readings of the ankle ROM in young subjects, just as reported in this study, was very limited: 1.1±0.9 degrees of plantar flexion and 1.4±1.1 degrees of dorsiflexion (Francia et al, 2019).

Trunk flexibility was evaluated by the Sit and Reach test. Young athletes barefooted were asked to sit on the ground with their feet approximately hip- wide against the testing box keeping their knees extended, putting one hand on the other, and slowly reaching forward as far as they could. All measurements were performed by the same observer with more than 10 years of experience, recording the mean of 3 consecutive readings.

The test operator who evaluated ankle joint mobility did not know the dominant lower limb of the players. The dominant lower limb was identified by asking the players which was the preferred limb for hitting the ball while they were playing (López-Miñarro et al, 2009).

Statistical analysis

All data were presented as means ± standard deviation (SD). Test of normality was performed using Shapiro-Wilk tests. Comparison between the two groups were analyzed by independent samples T-test or Mann-Whitney U test. The strength of the association between the two variables has been evaluated by Pearson's or Spearman's correlation test. Simple Linear regression analysis was used to examine the effect of Age on AJM. Multiple regression analysis was performed using Total AJM, plantar flexion and dorsiflexion as dependent variables and age, BMI and sport practiced as independent variables. A 2-tailed P value of <.05 was regarded as statistically significant. All calculations were performed using the SPSS system for Windows Version 25.0 (SPSS Inc., Chicago, Illinois).

Results

A total of 240 young sportsmen were included in the study. The group of soccer players (173) and non-soccer players (67) were well matched for age, sex, and BMI (Table 1).

Young soccer players showed an AJM significantly lower both in APF and ADF compared to the non-soccer players group (p<0.001; Table 1). In the control group, the mobility of young basketball players was not different from that of volleyball players, these measures being in agreement with the values reported in literature for subjects at the same age (Boone and Azen, 1979; Grimston et al, 1993; Kumar et al, 2011; Soucie et al, 2011; Norkin and White, 2016).

The group of young soccer players didn't show any difference between the mobility of right and left or dominant and non-dominant ankle. Such difference of ankle joint mobility was detected in plantar flexion of non-soccer group ($p < 0.01$; Table 2). We performed a multivariate analysis with AJM as the dependent variable while age and BMI as independent variables. From this analysis, in the soccer group Total ankle mobility resulted significantly associated with both age ($p = 0.003$), and BMI ($p = 0.045$). While ADF was found to be significantly associated to age ($p = 0.001$) and APF was associated with BMI ($p = 0.046$). In the group of non-soccer players both ADF and PDF were not significantly associated with either age or BMI (Table 3). Correlation analysis showed that dorsiflexion and ATOT were inversely correlated with age ($p < 0.011$; $p < 0.013$ respectively) and BMI ($p < 0.001$) in soccer group, while they weren't in the non-soccer group (Table 4). Soccer players showed higher trunk flexibility than controls ($p < 0.001$).

Table 2 - Ankle joint mobility (expressed as degrees) comparison right vs left and Dominant vs non-Dominant in Soccer and non-Soccer players

	SOCCER GROUP			NON-SOCCER GROUP		
	RIGHT	LEFT	p-Value	RIGHT	LEFT	p-Value
Plant Flex R vs L (°)	14.0±4.5	13.4±4.7	0.038	17.2±4.3	15.0±4.1	<0.001*
Dors Flex R vs L (°)	49.0±8.9	48.4±8.8	0.356*	52.8±8.4	54.3±9.1	0.044*
AJM R vs L (°)	63.0±10.1	61.8±10.7	0.063*	69.7±10.0	69.1±11.7	0.881*
	DOMINANT	NON-DOMINANT		DOMINANT	NON-DOMINANT	
Plant Flex Dom vs Non-Dom (°)	13.7±4.4	13.6±4.9	0.654	17.2±4.3	15.0±4.1	<0.001*
Dors Flex Dom vs Non-Dom (°)	49.1±9.1	48.5±8.9	0.406*	52.9±8.2	54.2±9.3	0.036*
AJM Dom vs Non-Dom (°)	62.8±10.6	62.0±10.5	0.364*	70.0±10.1	69.2±11.7	0.715*

Values are means ± standard deviation. Comparisons were performed using T-test (*) or Mann-Whitney test (*). Abbreviations: AJM: ankle joint mobility; °: degree; Dom: Dominant; R-L: right-left; Plant Flex: plantar flexion; Dors Flex: dorsiflexion.

Table 3 - Multivariate analysis considering Dorsiflexion, Plantar flexion and Total AJM (expressed as degrees) as dependent variables and Age, BMI as independent variables in Soccer (A) and non-Soccer (B) players.

	β-Regression coefficient (A)	p-Value (A)	p-Model (A)	β-Regression coefficient (B)	p-Value (B)	p-Model (B)
Ankle dorsal flexion			<0,001			0.048
Intercept	134,81	<0,001		147.60	<0,001	
Age	-2,00	0,001		-2.059	0,067	
BMI	-0,82	0,193		-0.871	0,119	
Ankle plantar flexion			0,038			0.357
Intercept	43,47	<0,001		42.60	<0,001	
Age	-0,18	0,588		-0.371	0,496	
BMI	-0,70	0,046		-0.332	0,224	
Total AJM			<0,001			0.039
Intercept	178,28	<0,001		193.20	<0,001	
Age	-2,17	0,003		-2.689	0,062	
BMI	-1,52	0,045		-1.189	0,098	

Abbreviations: AJM: ankle joint mobility; BMI: body mass index.

Table 4 – Correlation matrix for Soccer group (A) and non-Soccer group (B)

	Ankle Plantar Flexion (APF)		Ankle Dorsiflexion (ADF)		Total AJM (ATOT)	
	r	P-value	r	P-value	r	P-value
A						
Age	-0.05	0.549	-0.19	0.011^	-0.19	0.013^
BMI	-0.25	0.002^^	-0.27	<0.001^^	-0.31	<0.001^^
B						
Age	-0.12	0.326	-0.21	0.090	-0.23	0.061
BMI	-0.17	0.177	-0.21	0.091	-0.025	0.047^

Test of normality was performed using Shapiro-Wilk tests. Comparisons were performed using Spearman's rho test (r). Abbreviations: AJM: ankle joint mobility; BMI: body mass index; FL: flexion. $p < 0.05$ (^). $p < 0.01$ (^^).

Discussion

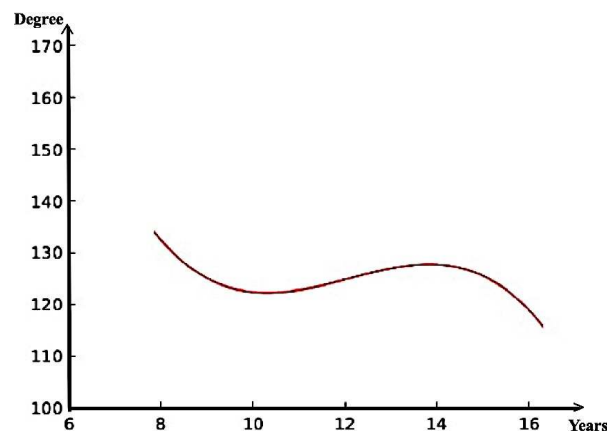
This study addressed a topic of great interest in the sports field by comparing ankle joint mobility of a wide group of young soccer players with that of young basketball and volleyball players.

The results of this study showed that the AJM of soccer players resulted significantly reduced compared to controls confirming the presence in soccer players of a sport-practiced effect on AJM (Travers and Evans, 1976; Hattori and Oha, 1986; Rein et al, 2011; Francia et al, 2021).

The main aim of the study was to investigate how AJM changes during growth in young male soccer players between 7 and 17 years old. In the soccer group an inverse relationship between AJM and age was noted (Table 3,4). In particular, a significant inverse relationship was detected for ADF. The absence of a relationship between ankle plantar flexion and age seems to indicate the presence of an early negative effect of soccer on this movement. These relationships in the control group did not reach significance even if the collected results show how the AJM decreases progressively during growth (Table 4). The inverse relationship found between AJM in both APF and ADF and BMI was also significant (Tab 4). The relevance of this result suggests the importance of studying this relationship in order to better understand the causes of the limited AJM itself.

Already in 7-10 years old SP an early negative effect on AJM was observed (Fig. 1). While in subjects aged between 11 and 13 years the ankle mobility was similar, the reduction of the AJM measured in young SP aged 14-17 years was very significant (110.7 °; Fig. 1) and in line with what was reported in previous articles (De Land et al, 2017; Francia et al, 2020). This AJM value makes it comparable or worse to that showed by elderly people or subjects with chronic diseases such as diabetes (Francia et al, 2019) and it is so noteworthy as to make one wonder if the biomechanics and posture of walking or running can be affected (Ribeiro et al, 2003; You et al, 2009; Kunugi et al, 2018).

Fig. 1 Trend of the relationship between age (years) and AJM (degrees) in Soccer players.



As suggested in previous studies, compared to these results, a first apparent paradox is that the practice of soccer seems to require a wide ankle ROM for the execution of specific sport movements including both gross and fine motor movements (Alesi et al, 2015) but an adaptation in protection of the joint from injuries and in particular ankle sprains prevails through a limitation of the ankle ROM itself (Hattori&Oha, 1986; Armenis et al, 2011; Basnett et al, 2013; Golanó et al, 2014).

Considering the individual movements analyzed, both the ADF but also the APF were significantly reduced in the young SP (Table 1). In these players, the sports related movements such as hitting the ball (i.e. kicks with force or soccer juggling) could lead to an evident muscle tightness also of the muscles involved in the ADF and therefore hinder the plantar flexion movement (Bradley&Portas, 2007; Brophy et al, 2007; Kellis&Katies, 2007; Lees et al, 2010; Francia et al, 2021).

The prevalent role of muscle tightness in limiting the ankle ROM could justify the particular trend of the AJM observed. In particular, muscle development could have a prevalent role in the decrease of ankle ROM detected in a large sample-size (14-17 years). At the same time, the decrease in the rate of reduction of the AJM showed by subjects aged 11-13 years has been an unexpected result with unknown causes. For this, we can hypothesize an effect on AJM correlated to the connective muscle actions at the early stages of pubertal development (Brown et al, 2017; Corso, 2018).

In SP, the comparison between joint mobility of the right and left ankle or dominant and non-dominant, showed no difference in line with what was reported in previous studies (DeLang et al, 2017). However, in the control group the plantar flexion between the two limbs resulted significantly different (Table 4). The lack of the effect of soccer practice on the mean difference the mobility of the two ankles may seem a further abnormality

whereas the practice of this sport seems to facilitate the prevalent use of the dominant limb in managing the ball (Brophy et al., 2007; Read et al., 2016; Delang et al., 2017). For this, it has been hypothesized that activities such as walking or running, in addition to the same limited AJM may play a key role and support the body symmetry (Delang et al., 2017; Francia et al., 2021).

Considering the amount of reduction in AJM that soccer practice can induce and the possible negative effects associated with a reduced AJM, an accurate study of the causes and characteristics of this alteration seems necessary (Faude et al., 2013; Terada et al., 2013; Read et al., 2016; Francia et al., 2020). Hence, defining whether and how adapted training programs aimed at increasing AJM are useful for young soccer players considering sports performance, injury prevention and quality of somatic growth or, if they are paradoxically a risk factor for injuries, is an important issue to be addressed without delay (Hattori&Oha, 1986).

This study has limitations to consider. Firstly, even if the BMI was assessed the study did not consider the level of development of the subjects investigated. Considering factors such as growth spurt, peak height velocity, peak growth velocity or other development-related parameters could facilitate the understanding of the evolution of joint mobility of the ankle in young players. Furthermore, the study was carried out only on a sample of male subjects and did not consider the role of the players in the team. These limits do not allow to use the findings obtained in the case of female footballers or players with a particular role such as goalkeepers.

Conclusion

Soccer is one of the most popular sports in the world especially among young males. Given the large number of young players, the study of the effects of soccer practice is very important. Increased ankle stiffness is one of the negative effects associated with soccer practice. The limited mobility of the ankle is a condition that deserves a lot of attention because it can lead to short and long-term consequences such as higher risk of injury as well as alterations in the quality of movement and posture. With this study, it was demonstrated that AJM can be significantly reduced in young soccer players from the first years of sports activity, underlining an early negative sports-specific effect. The progression of the reduction of AJM seems to slow down in the age group which can be considered pre-pubertal in males and then continues to decrease in the immediately following years. Moreover, the results collected with this study also indicate that this trend of ankle ROM does not induce asymmetry in the mobility of the two ankles. All this indicates that studies aimed at the prevention or recovery of limited AJM, while respecting the sporting dimension of the subjects investigated, are necessary. In this sense, it will be important to verify how appropriate interventions aimed at avoiding or recovering limited AJM in young players affect the risk of injury and sports performance. The pursuit of this result would allow us to resolve the paradox relating to the double role of ankle stiffness (i.e. protective factor and risk factor for injuries). The non-linear trend of the AJM during growth represents a further obstacle in the management of young players and in promoting their well-being and health.

Competing interests.

No external financial support to be declared.

Acknowledgements.

The authors thank Mary Colonnelli (BA, Dip Ed) for revising the English content.

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