Lower limb posture and joint mobility in young Soccer players

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Abstract

Soccer practice can induce marked changes in the lower limbs with dreaded short and long term consequences. We evaluated the possible effects of sport practice on lower limb posture and their relationships with ankle joint mobility (AJM). In 61 male Soccer players mean age 11.6±1.8 years, and in 50 Volleyball and Basketball players matched for age, sex and body mass index, lower limb posture and AJM in both plantar flexion and dorsiflexion were evaluated on the sagittal plane in supine position using, respectively, images analysis and an inclinometer. A multivariate analysis of variance was carried out to assess if the practice of different sports affects the leg posture (FP: angle between foot and leg) and foot posture (LP: angle between the foot and the line perpendicular to the ground). The sport practiced showed a significant multivariate effect on the lower limb posture. Soccer players showed a greater LP angle (169.2±4.3° vs 164.9±4.5°; p<0.001) and a lesser FP angle in both Basketball and Volleyball players (298.0±12.6° vs 305.6±10.9°; p<0.002). These differences were not present between the Basketball and Volleyball players. Soccer players showed a reduced AJM (127.6±15.7° vs. 138.8±21.6°; p<0.002) compared to the other subjects evaluated. The AJM was found directly correlated to the FP angle (p<0.005). The results of this study indicate that young Soccer players could show an altered posture of the leg and foot and a reduced AJM. The alterations of these parameters seem to be a consequence of the sport practice.

Introduction

The study of the effect of sport on young players is of noteworthy importance considering the large number of subjects involved and how sport can affect the development [Strong et al., 2005; Merkel, 2013; Bergeron et al., 2015].

Soccer is the most practiced sport, especially by males, in many countries around the world. The practice of Soccer in sports settings as well as in recreational and school ones can begin from the first years of life; therefore, even young subjects can have a history of a multiple years of sports practice [FIFA Communications Division,

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2007; Study Center FIGC, 2017; Statistics Canada, 2014; Department for Digital, Culture, Media & Sport - England, 2018; National Physical Activity Plan Alliance, 2018].

Basketball and Volleyball are also two of the most practiced sports by young subjects, but they differ from Soccer where the ball is managed with the feet, a condition that can induce muscle-connective adaptations at the level of the lower limb and expose the ankle to a greater number of traumas [Faude et al., 2013; Golanò et al., 2014; Read et al., 2016].

The study of the effects of sport on ankle mobility is considered important because the ankle is a load-bearing joint of the body with fundamental biomechanical and postural functions [Basnett et al., 2013; Golanò et al., 2014; Brockett & Chapman, 2016]. The ankle is formed by a ginglymus of hinge-type synovial joint formed by the medial and lateral malleolus, which forms a mortise to receive the trochlear surface of the talus [Kaueyer & Malone, 1980; Golanò et al., 2014; Brockett & Chapman, 2016]. The anatomy of the articular surfaces of the talocrural joint together with other passive factors (e.g. capsuloligamentous structures surrounding the joint) and dynamic factors (e.g. muscle-action) determine joint mobility, by allowing and limiting it, in dorsiflexion and plantar flexion on the sagittal plane [Lin et al., 2004; Golanò et al., 2014; Brockett & Chapman, 2016].

Previous studies underlined that the practice of certain sports can significantly modify ankle mobility. In this sense, it has been reported that the practice of Soccer can induce a reduction in ankle joint mobility, while, this effect does not seem to occur in young Basketball and Volleyball players [Hattori & Ohta, 1986; Francia et al., 2021; Moreno-Perez et al., 2020]. The levels of AJM reduction detected in Soccer players were such to be able to increase the risk of ankle sprain, and affect the quality of gait as well as the balance, also due to a partial deafferentiation from the articular and periarticular structures caused by repeated injuries [Kaueyer and Malone, 1980; Kaufman et al., 1999; Carlson et al., 2000; Aronow et al., 2006; de Noronha et al., 2006; Basnett et al., 2013; Evans et al., 2018; You et al., 2009].

To date, there is no clear evidence regarding the effects that a reduced AJM can have on lower limb posture of young Soccer players [Ribeiro et al., 2003; Hoch et al., 2012]. The complexity of this condition can lead to a significant variation in ankle mobility, detectable in young Soccer players, suggesting that another parameter of great importance such as posture could be altered in these subjects [Conradsson et al., 10; Fong et al., 11; Basnett et al., 2013]. The possible detection of postural anomalies is important because they could be studied and treated in order to prevent the same joint and postural abnormalities and injuries as well as to improve sports performance [Kaueyer and Malone, 1980; Faude et al., 13; Young et al., 2013].

The main aim of this study was to evaluate the possible effects of sport practice on lower limb posture and their relationships with the AJM.

Materials and methods

A total of 111 young male athletes, 61 Soccer, 20 Basketball, and 30 Volleyball players participated in this study. Data were collected on age, height, weight, years of sports practice, other sports practiced, number of weekly training sessions, lower limb-dominance, and history of injuries. Body mass index (BMI) was calculated

Table 1. Main characteristic, ankle joint mobility and hamstring flexibility and comparison between Soccer vs controls composed of Volleyball and Basketball players.

	Soccer group	Control group	p-value	Volleyball	Basketball	p-value
Age (years)	11.6±1.9	11.9±1.6	0.60*	12.7±1.3	10.7±1.2	<0.001*
BMI (Kg/m²)	18.5±2.3	19.7±3.6	0.115*	19.0±2.9	20.8±4.4	0.178*
Years of activity	5.5±1.9	3.2±2.4	<0.001*	3.5±2.7	2.7±1.8	0.358*
Total AJM (°)	127.6±15.7	138.8±21.6	0.002	137.3±19.4	140.7±24.9	0.552
Plantar Flexion AJM (°)	24.7±7.4	31.4±7.4	<0.001*	31.2±5.7	31.7±9.6	0.843
Dorsal Flexion AJM (°)	102.9±13.0	107.5±17.0	0.113	106.4±16.1	109.0±18.6	0.231
Right AJM (°)	65.6±8.4	69.5±10.5	0.029	69.3±10.1	70.0±11.4	0.816
Left AJM (°)	62.3±8.9	69.3±12.1	<0.001	68.4±10.8	70.7±14.0	0.512
Dominant AJM (°)	65.0±8.9	69.8±10.7	0.011	69.4±10.3	70.4±11.5	0.539*
Non Dominant AJM (°)	62.3±8.6	69.1±11.9	0.002	68.3±10.6	70.2±13.9	0.586
Δ R/L AJM (°)	3.2±7.1	0.2±7.0	0.025*	0.9±7.8	0.7±5.6	0.434
S/ R test (cm)	-5.2±7.5	-8.0±8.3	0.091	-8.4±9.1	-7.5±7.0	0.627*

Values are means ± standard deviation. Comparisons were performed using T-test or Mann-Whitney test (*). Abbreviations: N.: number; AJM: ankle joint mobility; BMI: body mass index; R/L: right/left; S/R: Sit and Reach Δ: difference; °: degree; cm: centimeters.

as body weight in kilograms divided by height in meters squared (kg/m²). Detailed characteristics of study participants are shown in Table 1,2.

Before enrolment, subjects underwent a physical examination including inspection of lower limb to detect the presence of deformity, injuries, and trauma, that could affect ankle joint mobility, hamstring flexibility, or posture. Individuals with the presence of current foot and ankle problems at baseline, such as orthopaedic or surgical complications, congenital foot or leg deformity or who did not practice the same sport for at least six months continuously were not enrolled.

All young players and their parents or guardians were informed on the purpose of the study and its experimental procedures before obtaining their written informed consent and the enrolment in the study. The protocol and the consent forms were approved by the Paediatrics Ethics Committee of Meyer Children's Hospital in Florence. The study was performed according to the principles expressed in the Declaration of Helsinki.

Ankle joint mobility

Ankle joint mobility (AJM) was evaluated using a standardized protocol (Clarkson, 2013; Francia et al., 2017; Francia et al., 2018). The patient was lying supine with the feet over the edge of the outpatient examination table, and the ipsilateral knee was extended and put over a rigid support 5-cm high. The maximum range of dor-

Table 2. Soccer and Control players leg-foot inclination angles with vertex at the center of the lateral malleolus, one half-lines passing through head of the fibula and one through: head of fifth metatarsal bone (FP angle) or parallel to the ground (LP1 angle) or perpendicular to the ground (LP2 angle).

	Soccer	Control	*p-value*
FP angle			
Standing - left angle (°)	122.6±4.9	123.9±4.2	0.306*
Standing - right angle (°)	122.0±6.0	121.0±4.9	0.396
Standing Tot. angle (**°**)	244.6±8.9	244.7±6.9	0.93
Lying - left angle (°)	149.2±6.7	152.7±5.9	0.004
Lying - right angle (°)	148.8±6.7	152.9±6.0	<0.001
Lying Tot. angle (°)	298.0±12.6	305.6±10.9	0.002*
LP1 angle			
Standing - left angle (°)	87.6±3.1	86.5±3.2	0.095
Standing - right angle (°)	87.1±3.6	85.8±3.6	0.072
Standing Tot. angle (**°**)	174.7±5.8	172.2±6.3	0.049
LP2 angle			
Lying - left angle (°)	85.0±2.5	82.5±2.6	<0.001
Lying - right angle (°)	84.3±2.3	82.4±2.4	<0.001
Lying Tot angle (°)	169.2±4.3	164.9±4.5	<0.001

Values are means ± standard deviation. Comparisons were performed using T-test or Mann-Whitney U Test (*). Abbreviations: (°): degree; (Tot): right+left.

sal and plantar flexion was determined after marking the fifth metatarsal bone with the dermographic pen and positioning the inclinometer (Fabrication EnterprisesInc, White Plains, NY) along the diaphysis of the bone, with one extremity placed on the distal condyle. The subtalar joint was in a neutral position while the ankle joint was in the resting position that it naturally takes on the sagittal plane.

In a recent paper, it has been reported that the mean standard deviation of three consecutive readings of the ankle range of motion (ROM) in young subjects, as carried out 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).

Flexibility

Flexibility was evaluated using the Sit and Reach test. Participants barefooted were asked to sit on the ground with their feet approximately hip-wide against the testing box. While keeping their knees extended, putting one hand on the other, and slowly reaching forward as far as they could. Once fully extended forward, the participant could touch a metric tape and this distance was recorded (López-Miñarro et al., 2009). All measurements were performed by the same observer with more than 10 years of experience, recording the mean of 3 consecutive readings.

Angle of inclination of the foot and leg

Lower limb posture on the sagittal plane was assessed by photographic images of: a) Foot posture (FP), the angle with vertex at the center of the lateral malleolus and straight lines passing through the head of the fifth metatarsal bone and the second through the center of the head of the fibula; b) Leg posture (LP), the angle with vertex at the center of the lateral malleolus and straight lines passing through the head of the fibula and the second parallel to the ground (perpendicular in the case of subjects lying; Fig. 1).

The analysis of the images was acquired in two different postures: in the upright position and lying supine on the examination table with the patient's feet over the limit, same posture maintained during the evaluation of the ankle ROM without knee rigid support. The angles were calculated from the photographic images using Auto-CAD software.

When the results relating to the lower right and left limb were considered together, the description "tot", which stands for total, was used (i.e., right + left = tot.)
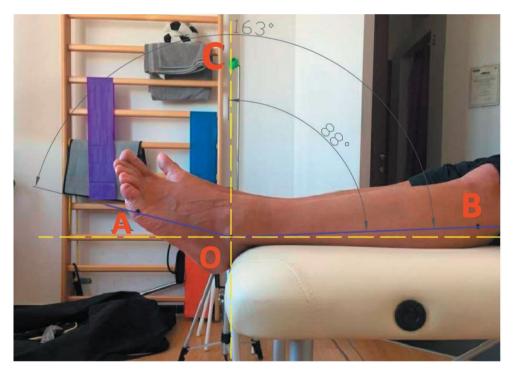

Figure 1. Lower limb posture on the sagittal plane. **Angles considered: FP angle:** vertex at the center of the lateral malleolus (O) and straight lines passing through the head of the fifth metatarsal bone (A) and the second through the center of the head of the fibula (B); **LP angle:** the angle with vertex at the center of the lateral malleolus (O) and straight lines passing through the head of the fibula (B) and the second perpendicular to the ground (C).

Table 3. Post-hoc pairwise comparison between groups of players considering leg-foot inclination angles in the lying position with vertex at the center of the lateral malleolus and half-lines passing through head of the fibula and through the FP angle (head of fifth metatarsal bone) or the LP2 angle (perpendicular to the ground).

Dependent Variable	Comparison	Mean Difference	95% CI		p-value
			CI$_{INF}$	CI$_{SUP}$	
Lying Tot. FP angle	Soccer vs Basketball	-9.68	-16.94	-2.43	0.006
Lying Tot. FP angle	Soccer vs Volleyball	-6.30	-12.58	-.02	0.049
Lying Tot. FP angle	Volleyball vs Basketball	-3.38	-11.51	4.75	0.585
Lying Tot. LP2 angle	Soccer vs Basketball	5.63	2.97	8.29	0.000
Lying Tot. LP2 angle	Soccer vs Volleyball	3.43	1.12	5.74	0.002
Lying Tot. LP2 angle	Volleyball vs Basketball	2.20	-.78	5.18	0.191

Pairwise comparisons were performed using post-hoc Tukey's HSD. CI inferior ($_{INF}$) and superior ($_{SUP}$) 95% confidence intervals of the mean difference. (Tot): right+left.

Statistical analysis

Data were reported as mean±standard deviation (SD). ROM values were expressed in degrees (°). Statistical normality test was performed using Shapiro-Wilk tests. A multivariate analysis of variance (MANOVA) was conducted to assess if the practice of different sports affects the lower limb posture (i.e., Lying tot. FP angle; and Lying tot. LP angle; dependent variables). The assumption of multivariate normality (Doornik-Hansen test: $p = 0.723$) and homogeneity of the variance (Levene's F test: Lying tot. FP angle $p = 0.332$; Lying LP tot. angle $p = 0.900$) and covariance (Box's M test: $p = 0.172$) matrices were assessed and met.

When the different sports showed a significant multivariate effect on the lower limb posture, a univariate analysis of variance (ANOVA), followed by post-hoc Tukey's HSD pairwise comparisons, was performed for each dependent variable (Tab. 3). Basketball and Volleyball players were grouped because, as demonstrated previously[16] and in the present study, they showed a similar lower limb posture and AJM, whereas they differed from Soccer players (Tab. 1,2).

The comparisons between the two groups (Soccer vs. non-Soccer players) were made using the independent T-test or the nonparametric test: Mann-Whitney.

The association between the joint mobility and posture parameter has also been evaluated separately for soccer and non-soccer players as well as considering all subjects assessed using Pearsons or Spearman's correlation coefficients. The analyses were performed using Stata (StataCorp, v.13) and SPSS Statistics (IBM, v.20) software. The α level of statistical significance was set at 0.05.

Results

According to the inclusion criteria, age and BMI were fully comparable between groups (Tab. 1). The sport practiced showed a significant multivariate effect on the

posture of the leg (Wilk's $\Lambda = 0.761$, $F_{(4, 214)} = 7.814$, $p < 0.001$). Follow up ANOVAs indicated that the sport practiced significantly affected both Lying tot. FP angle ($F_{(2, 108)} = 6.220$, $p = 0.003$, eta-squared (η^2) = 0.103) and Lying tot. LP angle ($F_{(2, 108)} = 15.013$, $p < 0.001$, $\eta^2 = 0.218$). Post-hoc pairwise comparisons showed that Lying tot. FP angle and Lying tot. LP angle were not different between the Basketball and Volleyball players. However, Soccer players showed greater Lying LP tot. angle and lesser Lying tot. FP angle than Basketball and Volleyball players (see Tab. 2).

Compared to the control group, the young Soccer players showed reduced plantar flexion AJM (p<0.001) and total AJM (p=0.002; Tab. 1). A significant difference in mobility was found in the group of young Soccer players by comparing left and right limbs (p<0.001) and non-dominant dominant limb (p=0.035). This difference was not found in the control group. Basketball and Volleyball players showed no differences in the joint mobility of the ankle and about the angle between the leg and the foot calculated in non-weight-bearing condition (Tab. 1,2).

Considering all subjects assessed the total AJM and ankle dorsiflexion was found to be directly related to the Lying tot. FP supine position angle (respectively: p <0.005 and p <0.001) and inversely correlated with the Lying LP tot. angle (respectively p = 0.015 and p = 0.009).

The sit and reach test did not show any significant differences between Soccer players and controls.

Discussion

In this study, we aim to verify whether the practice of Soccer could affect the posture of the leg and foot of young players as well as verifying the negative effect on ankle joint mobility (FIFA Communications Division, 2007; Statistics Canada, 2014; Department for Digital, Culture, Media & Sport - England, 2018; National Physical Activity Plan Alliance, 2018).

Regarding the analysis of the lower limb posture carried out, while, on one hand the evaluation of the young subjects in upright position did not show particular differences between the Soccer and non-Soccer groups, on the other hand the analysis of the images of the players in the lying position showed significant differences between the groups (Tab. 2).

The multivariate analysis showed a significant effect of the type of sport practiced on the lower limb posture. Instead Basketball and Volleyball players showed overlapping results.

In particular, the angle with the vertex at the center of the lateral malleolus and with half-lines passing through the distal extremity of the fifth metatarsal and through the head of the fibula was minor in Soccer players compared to controls (Tab. 2, FP angle). This result is evident, despite the analysis that considered the inclination of the leg in relation with the perpendicular line to the ground, which showed a lower inclination of the leg in Soccer players (Tab. 2, LP2 angle).

The results achieved suggest that, if on one hand, the modifications sport-related considered cannot prevail on postural needs in orthostatic condition, on the other hand, the foot, in young Soccer players, takes a posture in dorsal flexion if evaluated in non-weight-bearing condition (Tab. 2, LP2 angle).

Moreover, this result was only obtained in non-weight-bearing condition which suggests that the tests performed in this study may allow recognizing the early effects of Soccer practice on the posture of the lower limb in addition to those on AJM. Therefore, the posture's modifications detected could have negative consequences for young Soccer players.

One of the study results confirmed a significant reduction in AJM in young Soccer players (Tab. 1). Even if, the real causes of the limited AJM and the altered posture of the lower limb that can be shown by young Soccer players are not known, it is well known that the peculiarity of this sport is to directly manage the ball with the feet. In addition to a high risk of incurring in traumas, this activity, could involve, differently from other sports such as Basketball or Volleyball, the toning not only of the flexor muscles of the foot but more generally of the leg muscles.

In this sense, the results of this study could indicate that the main role in determining the variations of AJM could be played by the effects induced by repetitive hitting the ball with greater or lesser strength. Such activities may require high strength in both concentric (hitting) and isometric (stabilizing the joint) activity executed by the dorsal flexor muscles of the ankle involved (Kellis and Katis, 2007; Lees et al., 2010).

Moreover, the strengthening of these muscles in the anterior and lateral part of the leg would justify, at least in part, the difference between Soccer and non-Soccer groups investigated regarding the posture assumed by the foot if evaluated in a non-weight-bearing position.

This condition could also justify the apparent paradox detected in the group of young Soccer players and related to the presence of a condition of leg extension associated with a reduced total angle between leg and foot in addition to a reduced AJM in plantar flexion. The latter is often associated with rigidity of the triceps of the sura; this stiffness would hinder an extension of the leg and the dorsiflexion of the foot.

It can therefore be hypothesized that the reduced AJM and modified posture of the lower limb found in this study share the same causal factors. In fact, the results achieved on AJM and the posture evaluated in lying supine position were correlated.

According to the data reported in literature, the AJM assessed in the Volleyball and Basketball players is similar and resulted to be in line with the reference values reported for subjects matched for age (Boone and Azen 1979; Grimston et al., 1993; Lin et al., 2004; Kellis and Katis, 2007; Soucie et al., 2011). Similarly, the posture evaluated resulted similar in Volleyball players and Basketball players in both the positions examined.

Numerous studies showed that the reduced AJM is a risk factor for several dreadful adverse events and this relationship could also concern the postural anomalies detected. For this reason, it would be important not only monitoring these parameters but also verifying the effect on the performance and history of injuries in addition to study the effectiveness of exercise protocols aimed at recovering AJM (de Noronha et al., 2006; Fong et al. 2011; Hoch et al., 2012; Read et al., 2016).

Conclusions

The results of this study confirm that young Soccer players can show a reduced ankle joint mobility and an altered posture of the leg and the foot that can be seen in

non-weight-bearing position. The alterations of these parameters seem to be a consequence of the Soccer practice. While the possible negative effects induced by a limited AJM are known, the possible short and long term effects that an altered posture of the lower limb can have on young subjects are unknown. Considering the importance of the parameters investigated, further studies aimed at clarifying this relationship seem necessary.

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