How ankle joint mobility changes in young soccer players of different ages: a time series analysis.

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Abstract

Soccer practice can induce a limitation of ankle joint mobility (AJM) that is a dreaded risk factor for injury and other negative consequences over time. **Objective:** The aim of this study was to investigate the role of muscle strength (MS) in the definition of AJM of young soccer players (YSP). **Methods:** In 160 YSP, mean age 12.0 ± 2.5 yrs, body mass index (BMI) 18.8 ± 2.9 Kg/m², and in 61 subjects who practiced basketball, volleyball and martial arts matched for age, BMI and sex, the AJM in both plantar flexion and dorsiflexion and the handgrip strength (HGS) were evaluated by inclinometer and Jamar hydraulic hand dynamometer respectively. Time series analysis was applied to assess the association between muscle strength and AJM in the soccer group versus the non-soccer group, depending on the age of the members of the two groups. **Results:** The AJM value observed in YSP was significantly lower compared to that of the controls ($p < 0.001$). The HGS values found in YSP were similar to those of non-soccer players. Multivariate analysis showed that AJM resulted significantly associated with sport practiced ($p < 0.001$). In the soccer group correlation analysis showed an inverse correlation between HGS and ankle dorsiflexion ($p = 0.005$). Decomposition of time series analysis showed that in YSP after 13.3 years of age AJM decreases maintaining an inverse relationship with HGS ($p < 0.001$). **Conclusions:** In YSP the ankle joint mobility is inversely correlated to muscle strength. The trend of this inverse relationship provides an indication of the important role of muscle activity in the development of ankle stiffness as well as indications for the monitoring and prevention of the same limited AJM

Key Words: Sport practice, Footballer, Flexibility, Muscle strength, Hand grip, Injuries.

Introduction

The practice of many sports can expose the ankle joint to a high risk of acute and other long-term negative consequences (Armenis et al, 2011; Frisch et al, 2009; Golanó et al, 2014; Habelt et al, 2011) but only some sports such as soccer seem to induce evident changes in the ankle range of motion (ROM) (Moreno-Pérez et al, 2020; Rein et al, 2011; Travers&Evans, 1976). This condition is dreaded because it has been reported that it can increase the risk of injuries in soccer players (SP) and have negative effects on the integrity of the ankle, as well as on balance, posture and the biomechanics of movement (Brockett&Chapman, 2016; Fong et al, 2011; Kaufman et al, 1999; Moreno-Pérez et al, 2020; Paterno et al, 2013).

The ankle is a hinge joint formed by the medial and lateral malleolus respectively of tibia and fibula which form a mortise to receive the trochlear surface of talus. The stability of the joint, as well as being guaranteed by the same geometry of the joint, is mainly related to the action of the muscles regarding dynamic stability, however, the periarticular structures would have a major role in maintaining static stability. The movements that the ankle joint allows are mainly dorsiflexion and plantarflexion of the foot in the sagittal plane (Brockett&Chapman, 2016; Golanó et al, 2014; Houghton, 2008; Kaumeyer&Malone, 1980).

Regarding to the causes of reduced AJM in SP, an important role was assigned to the history of the players' joint injuries (de Noronha et al, 2006; Kaumeyer&Malone, 1980; Moreno-Pérez et al, 2020; Youdas et al, 2009). Such injuries can be either traumatic or resulting from repeated sports-specific microtrauma, that can induce the occurrence of an overuse condition. All ankle ligaments and joint capsule in addition to the others periarticular structures can be subjected to injuries and alterations due to sport practice (Armenis et al, 2011; Golanó et al, 2014; Paterno et al, 2013). In addition to the physical contact between players, different types of high intensity movements can be performed: jumping or running with frequent and rapid changes in speed and direction, twisting and turning, over-reaching and landing. These movements can concur to induce a condition of overuse and therefore predispose the ankle joint complex to injuries (Hattori&Ohta, 1986; Read et al., 2016; Kumar et al., 2019). The same kicking a soccer ball with power 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&Ohta, 1986; Lees et al, 2010; Sasadai et al, 2015).

Moreover, several authors have described a sport related adaptation which induces the reduction of ankle joint mobility (AJM) in soccer players (Ekstrand&Gillquist, Hattori&Ohta, 1986; 1982; Francia et al, 2021;). It has been reported that the reduction of AJM can be considered as physiological functional adaptation due to pursuing a greater joint stability aimed at protecting the ankle from the continuous micro-traumatic or traumatic events to which the joint is exposed during the usual sports practice (Ekstrand&Gillquist, 1982; Frisch et al, 2009; Golanó et al, 2014; Hattori&Ohta, 1986). In particular, the pursuit of a greater stability of the ankle could be ensured by an increased co-contraction of the agonist and antagonist muscles involved in joint movements (Blazevich et al, 2013; Corso, 2018; Golanó et al, 2014), and by the stiffness of the periarticular soft tissues and muscle-tendon structures (Ekstrand&Gillquist, 1982; Francia et al, 2021; Golanó et al, 2014; Hattori&Ohta, 1986). In young SP the development of muscle strength and tightness of the leg muscles can affect the degree of this sport related adaptation and of AJM. As result, the study of the relationship between AJM and muscle strength in child and adolescent SP appears particularly important because it could help in understanding the causes of the same limited AJM (Frisch et al, 2009; Hattori&Ohta, 1986).

Regarding the assessment of muscle strength, it is known that the hand grip strength test (HGS) provides a well-established and objective score to the point that it is considered important for following subjects throughout their growth (Hogrel, 2015; Ploegmakers et al, 2013). Moreover the HGS test is easily and quickly available even in a sports environment, it is indicative for generalized muscle strength and allows the comparison with reference values (Molenaar et al, 2010; Sousa-Santos&Amaral, 2017; Youdas et al, 2009). The aim of this study was to verify the relationship between ankle joint mobility and muscle strength in young SP.

Methods

In 160 young male Soccer players from 6.7 to 17.1 years old and 61 age, body mass index (BMI) sex-matched controls practicing Volleyball (n=33), Martial Art (n=6) and Basketball (n=22) ankle joint mobility and hand grip strength were examined. 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 and the presence of deformity, injuries and traumas such as to affect ankle joint mobility and trunk flexibility. Exclusion criteria were: age greater than 18 and less than 6 years old, 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 the 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 in male soccer and non-soccer players.

	Soccer (160)	Non-Soccer (61)	p-Value
Age (years)	12.0±2.5	11.5±1.8	0.224*
Weight (Kg)	45.9±13.0	47.1±13.7	0.487*
Height (cm)	153.9±15.5	154.8±13.8	0.565*
BMI (Kg/m^2)	18.8±2.9	19.3±3.6	0.986*
Hand Grip Strength (Kg)	23.4±9.9	23.6±7.4	0.331*
Plantar Flexion (°)	26.5±7.5	32.1±7.7	<0.001
Dorsal flexion (°)	96.7±16.4	105.0±16.7	<0.001*
Total AJM (°)	123.2±18.6	137.8±20.8	<0.001*
Δ R/L AJM (°)	5.5±4.8	5.7±5	0.941*

Values are means $\pm$ standard deviation. Comparisons were performed using T-test or Mann-Whitney test (*). Abbreviations: BMI: body mass index; HGS: Hand Grip Strength; AJM: ankle joint mobility; R/L: right/left; Kg: kilograms; m: meters; cm: centimeters; °: degrees; Δ : difference.

Determination of joint mobility

Active ROM of the ankle joint in plantar flexion (APF) and dorsiflexion (ADF) was measured by an inclinometer using a validated method (Clarkson, 2000; Francia et al, 2021; Francia et al, 2018). Players were asked to lie in the supine position on a fixed treatment table with the ankle rested in line with the edge and the feet right across 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 a dermatographic pen. 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. 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 (APF+ADF). In a previous study, concerning 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. The ankle ROM was measured by the same operator that had more than 10 years of experience (Francia et al, 2019). The dominant lower limb was identified by asking the players which was the preferred limb for kicking the soccer ball. The test operator who evaluated AJM did not know the dominant limb of the players (DeLang et al, 2017).

Determination of hand grip strength

Hand grip strength was evaluated by the Jamar hydraulic hand dynamometer (model 5030J1) 0-90 Kg. Before the test the examiner gave explanations, showed the posture to be maintained, how to hold the dynamometer and to perform the test. Only the dominant hand was tested. Dominance was determined by asking which hand was used for writing (Ploegmakers et al, 2013). The information was given respecting a sequence. Hand grip was evaluated with subjects in the standing upright position, arms by the side of the body, shoulder adducted in neutral position, elbow 90° flexed with the forearm parallel to the ground and pronated in order to maintain the display of the dynamometer on the frontal plane (De S et al, 2022).

A trial test was allowed to become familiar with the device. The young players were asked to maintain the same posture and dynamometer handle during the three tests and to squeeze with maximum strength for three seconds without moving the rest of the body.

The peak-hold needle automatically recorded the highest strength exerted. The test had to be stopped in case of pain. No verbal encouragements were offered during the test even if the examiner counted the seconds and gave the stop. The scheduled rest between repetitions was 15 seconds. Three tests were performed consecutively and the average of the values achieved was reported (Ploegmakers et al, 2013; Sousa-Santos&Amaral, 2017). The adjustable dynamometer handle was placed on the second grip position (4.76 cm), even if in younger subjects, it could be moved to the first position (3.5 cm) in order to obtain the proper device handle and handling it with adequate provision for the fingers.

In order to calibrate the device, we used a new tool and checked the “zero” position of the needle in absence of load. We then positioned the device on a rigid surface and applied a weight of 10 kg and then of 20 kg to check the accuracy of the needle indications.

In this study, the Jamar hydraulic hand dynamometer has been used since it is a well-validated device for the quantitative measurements of the maximum isometric MS of the hand with widespread use in clinical practice. Moreover, this dynamometer has a high test-retest and inter-rater reliability in addition to high reproducibility when used by children (De S et al, 2011; Hogrel, 2015; Mathiowetz et al, 1984; McQuiddy et al, 2015; Youdas et al, 2009).

Orange Data Mining Analysis

The evolution over time of the variables investigated (AJM and HGS) separately and together for the soccer and non-soccer players was also analysed by the “time series analysis” techniques interpreting the data as “historical series” while the calculation of the trend was done through a “Decomposition of time series” (Bernini et al, 2008; Cleveland et al, 1990; Dokumentov&Hyndman et al, 2015).

This was carried out by the use of the Orange (Orange Version 3.25.1; <https://orange.biolab.si/>) that is an open source code for data visualization, machine learning, data analysis and data mining that also has additional software allowing the use of techniques of time series analysis and decomposition of time series (Bernini et al, 2020; Musa et al, 2018; Štajdohar et al, 2013).

In this study, we performed a seasonal decomposition of the time series according to the “additive model”, where the original data are supposed to be a sum of four components: Level, Trend, Seasonality and Noise (Bernini et al, 2020; Dokumentov&Hyndman et al, 2015). In order to verify the effect of muscle strength on AJM, the ADF and APF increment data was analysed in response to the increase of HGS results in the soccer group versus non-SP.

Statistical analysis

All data were presented as means $\pm$ standard deviation (SD). Comparison between the two groups were analyzed by independent samples T-test or Mann-Whitney U test. Range of motion and muscle strength values were expressed in degrees and kilograms respectively. Test of normality was performed using Shapiro-Wilk tests. Multiple regression analysis was performed using AJM as dependent variables, HGS and all the others variables which appeared to be significantly correlated with AJM as confounding factors for univariate analysis in both soccer and non-SP. The strength of the association between the two variables has been evaluated by Pearson's or Spearman's correlation test. A 2-tailed P value of <0.05 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 221 young sport subjects were included in the study. The group of soccer players (160) and non-soccer players (61) were well matched for age and the other anthropometric parameters investigated: weight, height, and BMI (Table 1). Young SP showed an AJM significantly lower both in APF and ADF compared to the non-soccer ones ($p < 0.001$). The HGS values found in young SP were similar to those of non-SP (Table 1).

We performed a multivariate analysis considering ankle joint mobility APF, ADF and ATOT (APF+ADF) as dependent variables and age, HGS, BMI and sport practiced as covariates. Considering the whole cohort evaluated (221) AJM resulted significantly associated with sport practiced ($p < 0.001$; Tab. 2). Among the two groups of players considered, in the non-SP the ADF resulted significantly associated with HGS ($p = 0.034$; Tab 2).

Table 2 – Multivariate analysis considering dorsiflexion, plantar flexion and total Ankle Joint Mobility as dependent variables and age, body mass index, and muscle strength (hand grip test).

	SOCCER (n=160)			NON-SOCCER (n=61)			ALL SUBJECTS (n=221)		
	β Reg. coeff.	p-Value	p-Model	β Reg. coeff.	p-Value	p-Model	β Reg. coeff.	p-Value	p-Model
Ankle Dorsiflexion									
Intercept	120.81	<0.001	0.009	109.86	<0.001	0.092	118.15	<0.001	<0.001
HGS	-0.19	0.449		-0.93	0.034		-0.41	0.063	
Age	-0.84	0.414		2.25	0.206		0.11	0.902	
BMI	-0.46	0.336		-0.42	0.483		-0.43	0.241	
Type of sport	--	--		--	--		8.56	<0.001	
Ankle Plantar-flexion									
Intercept	27.78	<0.001	0.633	50.92	<0.001	0.205	35.85	<0.001	<0.001
HGS	0.02	0.880		0.24	0.236		0.11	0.335	
Age	0.24	0.652		-1.53	0.069		-0.28	0.529	
BMI	-0.23	0.338		-0.36	0.211		-0.29	0.114	
Type of sport	--	--		--	--		5.34	<0.001	
Total Ankle Joint Mobility									
Intercept	148.59	<0.001	0.042	160.78	<0.001	0.215	154.00	<0.001	<0.001
HGS	-0.17	0.550		-0.69	0.211		-0.30	0.239	
Age	-0.61	0.605		0.72	0.749		-0.17	0.872	
BMI	0.69	0.204		-0.78	0.309		-0.73	0.097	
Type of sport	--	--		--	--		13.89	<0.001	

Abbreviations: BMI: body mass index; HGS: Hand Grip Strength; AJM: ankle joint mobility.

Spearman's correlation analysis showed that in the group of SP the ADF values were in an inverse relationship with HGS ($p = 0.005$) while in non-SP this relationship did not reach full significance ($p = 0.072$; Table 3). In both SP and non-SP, the HGS values recorded were directly correlated to age and BMI ($p < 0.01$).

Decomposition of time series analysis was carried out; it showed that in SP there is a tendentially specular trend of the AJM and HGS (Figure 1). The results obtained showed that after 13.3 years of age AJM decreases maintaining an inverse relationship with HGS. In particular, only in SP over 13.3 years old ($n=35$) the

Spearman's correlation analysis shows an inverse relationship between HGS e ADF ($r=-0.55$; $p<0.001$) and ATOT ($r=-0.46$; $p=0.005$). This relationship was not found in subjects under the age of 13.3 years ($n=125$). The AJM of SP was significantly lower than that measured in age-matched controls in both groups of soccer subjects: those younger ($p<0.001$) and those older ($p<0.012$) than 13.3 years old.

Table 3 - Correlation matrix for Soccer group ($n=160$); Non-Soccer group ($n=61$) and All subjects ($n=221$)

	Ankle Plantar Flexion		Ankle Dorsiflexion		Total AJM	
<u>Soccer</u>	<i>r</i>	p-Value	<i>r</i>	p-Value	<i>r</i>	p-Value
HGS	0.12	0.146	-0.22	0.005**	-0.14	0.068
Age	0.08	0.296	-0.13	0.103	-0.08	0.315
BMI	-0.12	0.153	-0.23	0.005**	-0.24	0.004**
<u>Non-Soccer</u>						
HGS	-0.04	0.763	-0.23	0.072	-0.20	0.116
Age	-0.23	0.074	-0.06	0.652	-0.13	0.307
BMI	-0.16	0.215	-0.15	0.234	-0.21	0.098
<u>All</u>						
HGS	0.10	0.153	-0.20	0.002**	-0.13	0.058
Age	0.01	0.828	-0.12	0.067	-0.10	0.123
BMI	-0.13	0.062	-0.20	0.004**	-0.22	0.002**

Comparisons were performed using Spearman's rho test (*r*). Abbreviations: BMI: body mass index; HGS: Hand Grip Strength; AJM: ankle joint mobility. $p<0.05$ (*) - 0.01(**).

Discussion

Thanks to the analysis of a large sample size of young players the study allowed to confirm how young players can show an early significant reduction in AJM and furthermore it highlighted in the SP group a relationship between the limited AJM and HGS (Tab. 1,3).

The study of the relationship between AJM and HGS is important in order to better understand the causes of the limited AJM itself, a condition that paradoxically would be a preventive factor first and then a risk factor for injuries in addition to other negative consequences that SP can develop over time (i.e. ankle overuse disorders) (Basnett et al, 2013; Carlson et al, 2000; de Noronha et al, 2006; Hattori&Ohta, 1986; Kaufman et al, 1999; Moreno-Pérez et al, 2020).

Regarding the control group, young people practicing basketball, volleyball and martial art were enrolled, these sport activities according to scientific literature considered do not markedly modify the AJM (Francia et al, 2020; Francia et al; 2018; Travers&Evans, 1976). The results achieved in this study confirm that the AJM recorded in the control group was in line with the reference value for subjects at the same age reported in previous articles (Tab. 1) (Boone&Azen, 1979; Grimston et al, 1993; Kumar et al, 2011; Norkin et al, 2016; Soucie et al; 2011).

Unlike the AJM, the muscle strength was similar in the two groups investigated (Tab. 1). In particular, the data collected by the HGS test resulted to be in line with what was reported in previous literature (Hogrel, 2015; Molenaar et al, 2010; Vääntinen et al, 2011). Considering the group of SP, the analysis of the correlations highlighted a significant inverse relationship between ADF and HGS (Tab. 3). This result provides a first confirmation on the role of muscle strength in the definition of AJM in young SP.

The relationship between AJM and in particular ADF and HGS has been further studied by means of "decomposition of time series" (Bernini et al, 2020; Cleveland et al, 1990; Dokumentov&Hyndman, 2015; Štajdohar et al, 2013). The analysis carried out allowed to obtain specific age related clusters in both soccer and non-soccer groups. A first cluster concerns SP over 13.3 years of age. In these players, a negative correlation between AJM and HGS was observed. Conversely, in controls, the correlation between subjects over 13.3 years old was positive but without reaching statistical significance (Fig. 1).

Fig. 1 - Representation of decomposition in the 4 components (Level, Trend, Seasonality and Residual) of the time series of data and HGS vs ADF of 160 Soccer (1A) and 61 non-Soccer (1B) players.

1A)

1B)

The first third at the top of the figure shows the data over time of “HGS: hand grip strength and ADF: ankle Dorsiflexion”, and their value after the “Seasonal adjustment”. The middle part of the figure shows the “Trend” values extracted from the decomposition. The lower third part of the figure shows the time series of the “Residual values”.

The relationship between AJM and HGS lost significance in players under 13.3 years old. In particular, SP under 13.3 years old showed a first age related cluster referred to subjects under 11.7 years old whose MS seems to play a significant role in determining an ankle stiff condition (data not shown). A second cluster referred to subjects aged between 11.8 and 13.3 years old for whom the relationship between AJM and HGS was not found (Fig. 2). Even in controls, the trend describes a progressive but not significant reduction of ADF to the increment of the MS until 13 years old.

Fig. 2 – Ankle dorsiflexion (ADF) Vs Hand grip strength (HGS) “Trend” ratio in Soccer players.

Regarding the causes of the negative relationship between AJM and HGS found in SP under the age of 11.8 and even more evident in those over the age of 13.3, both the same practice of Soccer and the increase of MS can justify the results obtained. In this sense, it is known as children normally show a tendentially linear growth of MS while starting from 13-14 years of age this growth accelerates with an evident spurt during adolescence and which can still be evident at 18 years of age (Brown et al, 2017; De Ste Croix, 2007; Isen et al, 2014; Limony et al, 2015; Vääntinen et al, 2011; Viru et al, 1998; Wind et al, 2010).

According to these observations, the evident increase in MS in the group of SP studied is observed in subjects older than approximately 14 years (Manno, 2008; Viru et al, 1998). All this seems to confirm that on the threshold of adolescence (14 years) the role of muscle strength in determining the AJM of SP can become evident and increase in the following years (Corso, 2018; De Ste Croix et al, 2007; Radnor et al, 2018).

Regarding the identification of the causes of the loss of relationship between AJM and HGS in SP between 11.8 and 13.3 years old, while respecting the intersubjective differences related to somatic pubertal changes, it is known that the onset of pubertal growth spurt is at approximately 11-12 years for boys (Hansen et al, 1999; Limony et al, 2015; Soliman et al, 2014). In this period the skeletal growth typically occurs before musculotendinous growth, and results in a greater demand of work for the muscles that are not fully developed (Brown et al, 2017; Corso, 2017).

This condition of delay in body mass development could lead to temporary difficulties of the muscles to stabilize the ankle joint and improved AJM making less evident the same soccer related adaptation of the ankle stiffness.

As a whole, the results achieved indicate, in agreement with the hypothesis of the study, that in young SP muscle strength can concur in limiting AJM even if this effect is particularly evident in subjects older than 13.3 years old (Fig. 3). This relationship was not found in controls.

The analysis of the results carried out in this study not only allowed to describe the relationship between AJM and HGS but was also able of discriminating even the initial, less evident, phases of this relationship. This can be useful in defining appropriate training programs aimed at managing ankle stiffness and respecting the stage of development that young SP are experiencing.

Moreover, the results collected seem to suggest that in young SP it would be useful to carry out periodic measurements and check the trend of development in muscle strength in order to better understand the causes and characteristics of the limited AJM if present.

As a whole, the indications that it was possible to draw from the results obtained could help sport physicians and trainers to more fully monitor the young SP and possibly prepare preventive actions with respect to the risk of injury and other negative effects, even in the long term, associated with the limited AJM thus contributing to guaranteeing a balance between the physical potential expression and healthy growth.

Conclusion

Young male soccer players may show a significant reduction in ankle joint mobility from the first years of sports activity, underlining an early negative sports related effect. In these subjects the level and trend of muscle strength seem to affect the level and trend of ankle ROM confirming a possible role of muscle strength in the development of the limited AJM.

The progression of the AJM reduction seems to slow down in the age group which can be considered prepubertal and pubertal and then significantly increase in the immediately following years. In this regard, the relationship between AJM and muscle strength is particularly evident in young subjects over 13.3 years old. This non-uniform trend of the limited AJM could be due to the effects of the pubertal growth phase on the musculoskeletal system and especially on the articular and periarticular connective tissue as well as on muscle strength.

Knowing the particular relationship between AJM and muscle strength in young SP, as observed in this study, could be useful for monitoring such players. Furthermore, considering this relationship can be useful for defining appropriate training protocols aimed at preventing injuries and other feared consequences due to the presence of reduced AJM. Additional studies aimed at evaluating the effect of appropriate training programs to prevent the loss of AJM or its recovery in young soccer players are needed.

Competing interests.

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