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博士論文

Factors Related to the Incidence of Lower Limb Sports Injuries in Adolescent Female Football Players

（思春期女子サッカー選手における下肢のスポーツ傷害発生に
関連する因子について）

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Factors Related to the Incidence of Lower Limb Sports Injuries in Adolescent Female Football Players

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【ABSTRUCT】

The purpose of this study was to investigate whether muscle flexibility, strength, and balance affect the incidence of lower limb sports injuries in adolescent female football players. The participants were 35 female football players who were high school or junior high school students at baseline. Eighteen players were available for the follow-up, one year later. At baseline, the flexibility and strength in the lower limb muscles, Star Excursion Balance Test, and postural sway with eyes open and closed during single limb stance were measured in all the participants. Football related lower limb injuries during the following year were recorded. Each variable was compared between the group that incurred injury (injured group) and the one that did not (uninjured group). Ten participants sustained lower limb injuries. There were significant differences between these groups in the flexibility of the non-dominant quadriceps and the postural sway area during non-dominant single limb stance with eyes open. A multiple logistic regression analysis revealed that only the flexibility of the non-dominant quadriceps was extracted to the incidence of injury. The flexibility of the non-dominant quadriceps was identified as a risk factor for lower limb injury related to football in adolescent female football players.

Key words: Female football player, Lower limb sport injury, Muscle flexibility

INTRODUCTION

The number of registered female players in the International Federation of Football Association (FIFA) increased from 22 million in 2000 to 26 million in 2007[1]. Similarly, the number of registered female players in the Japan Football Association Japan, increased from 19,717 in 2002 (when the FIFA World Cup games were held in Japan and Korea) to 26,978 in 2013[2]. The player population growth has been a positive for the development of female football.

Nakao, et al.[3] have reported that the incidence of sports injury in college female football players is higher than that in the male players. On the other hand, junior football players[4] and adult football players[5] have shown no significant gender differences in the incidence of sports injury. Therefore, it is unclear whether female football players have a higher risk of injuries compared with males. However, it is known that adolescent female athletes exhibit a higher incidence of injury, with a higher prevalence of severe injury[6].

In Japan, the incidence of sports injuries such as ankle sprain and anterior cruciate ligament (ACL) injury in female basketball players, is known to be significantly higher in players from the second and third grades in the junior high school[7]. In particular, female players have a higher risk of non-contact ACL injury[8-11], and it forces them to restrict their sports activities. In our previous survey[12] also, which analyzed male and female football players in high school and junior high school, the female players had been diagnosed with a high incidence of non-contact ankle sprain. We believe that the number of injuries and severe cases in adolescent female football players will increase as the population of players increases. Thus it will be a serious problem for the development of female football.

Many factors are related to the incidence of sports injury in female athletes, such as an imbalance of muscle strength and flexibility[13, 14], characteristics of the neuro-muscular control[15], psychological factors[16], genetic factors and anatomical factors (e.g., skeletal structures)[17]. However, to our knowledge, there are few studies that investigate the factors related to sports injury in the Japanese adolescent female football players. The purpose of this study was to investigate whether muscle flexibility, strength and balance affect the incidence of lower limb injury in female football players in the high school and junior high school.

SUBJECTS AND METHODS

We included 35 out of 40 female players who belonged to a regional club team at baseline. We excluded two players who had a history of injury and disease in the lower limbs restricting their football activities for the previous month. Furthermore, we excluded 2 players with knee pain and 1 player with lower back pain; the pain had affected the muscle strength measurement.

Eighteen players aged 12–17 years (8 high school students and 10 junior high school students; age, 14.17 ± 1.58 years.; height, 157.97 ± 6.17 cm; body weight, 50.56 ± 8.13 kg; mean ± SD) who continued playing football in the same team, were available for follow-up one year later.17 prior participants were missing from the follow-up investigation. 3 had entered university and were playing football in other teams, 11 were busy preparing for university and high school entrance examinations, and 3 had discontinued playing football for private reasons. The dominant limb was defined as the preferred kicking leg.

We explained the purpose and methods of this study to the participants and their guardians, assured them about the protection of personal information and obtained consent in writing. This study was approved by the Ethical Committee Board of Kobe International University, Japan (Approval No. 2012-001).

To measure the flexibility of the quadriceps muscle, the participant lay in a prone position while the examiner held the pelvis and flexed the knee until the examiner felt a moderate resistance. An inclinometer was placed along the anterior tibial crest and the angle was measured[18)]. To measure the flexibility of the hamstrings muscle (popliteal angle), the participant lay in a supine position and the tested hip was flexed at 90°. Furthermore, the tested knee was extended until a moderate resistance was detected. The incomplete extension angle of the knee was measured by placing the inclinometer along the anterior tibial crest. During the measurement, opposite hip flexion was prevented[19)]. To measure the flexibility of the gastrocnemius muscle, the participant lay in a supine position while maintaining knee extension. Furthermore, the examiner dorsiflexed the ankle joint until a moderate resistance was detected. The inclinometer was placed on the lateral side of the sole along the fifth metatarsal and the dorsiflexion angle was measured[19]. All muscle flexibility were measured bilaterally and performed by an examiner and an assistant: one determined the measurement postures and the other placed the inclinometer and measured the angle.

A hand held dynamometer (HHD: μ-Tas F-1, Anima Co., Ltd, Japan) was used to measure the hip muscle strength. The participant first lay in a supine position to measure the hip abduction[20] strength and then in a prone position to measure extension[21]. The muscle strength was measured by placing the sensor of the HHD on the distal part of the thigh. A belt was used to stabilize the HHD. The examiner stabilized the pad of the HHD so that it did not move during the measurement. After a practice attempt, a maximal hip abduction or extension was performed for 5 seconds and was repeated twice. The maximum value was recorded. The isokinetic knee flexion and extension peak torque were measured by 60°/second of angular velocity through a range of 5°–95° of knee flexion and extension by using an isokinetic dynamometer (Cybex Humatic Norm, Medica Co., Ltd., USA). After three practice attempts, 3 measurements were taken and the maximum value was recorded[22]. All the muscle strength measurements were conducted on the left side, which was the non-dominant limb, and the results were normalized to body weight.

For the modified Star Excursion Balance Test (mSEBT), the initial posture was defined as a single limb stance, with the center of the supporting sole on the point where the 3 stick measures crossed. Furthermore, the participant reached as far as possible with the non-stance limb, without lifting the heel of the stance limb, and without shifting weight to the toe of the reaching limb. We defined the maximal reach-distance as the distance at which the participant could return to the initial standing position (a double-limb stance). The sequence of the reach-direction was anterior, posteromedial and posterolateral from the reach side. Three trials were repeated and the average value was recorded. The results were normalized to the spina malleolar distance. The participant practiced for 6 attempts. After a rest period lasting a few minutes, the absence of fatigue was confirmed and the measurements were taken[23].

To measure the postural sway, the center of pressure (COP) during a single limb stance, both with eyes open and eyes closed, was measured on a pressure platform (Twin-gravicorder G-620, Anima Co., Ltd, Japan). The participant kept hands on the hips in a double-limb stance on the force platform and lifted one limb, maintaining a single limb stance in accordance with the examiner's instructions. During the measurement, the participant stared at an object placed at eye-level 2 meters away. We then repeated the measurements with their eyes closed. The height of the lifting limb was not particularly standardized. The participants were instructed that the lifting limb should not touch stance limb or the floor. Moreover, the participants were not allowed to move the stance limb. The total COP path length and COP sway area during the 20 seconds with eyes open and eyes closed, were recorded after the posture was stabilized. The measurements were conducted after 2 practice attempts each. The evaluations were on both sides, and the order of the side measured was randomized.

The follow-up was conducted one year after the initial investigation. At the follow-up, the participants filled out a questionnaire in which they were asked about lower limb injuries sustained in the past one year. Furthermore, a physiotherapist interviewed them to confirm the information. The injury was defined as any injury to the limb including the hip but not the lumbar spine or sacroliac joint. Injury was defined as an injury that occurred during playing football or caused by football, leading to the limitation of football activities completely or incompletely for more than one week[3]. We excluded the injuries which participants were sustaining at baseline but included the re-injuries. Based on the reports by Nakao, et al.[3], the body part that was injured, the diagnosis and the type of injury (traumatic injury or overuse injury) were recorded. For the traumatic injuries, it was confirmed whether these were contact or non-contact injuries.

Based on the test of normality of the distribution of each variable, a two-sample *t*-test or a Mann-Whitney test was conducted to compare each of the variables between the group that experienced more than one injury (injured group), and the group that did not (uninjured group). Injuries included both traumatic and overuse injuries. Furthermore, a multiple logistic regression analysis using the likelihood ratio test and the forward selection method was conducted to clarify the factors related to the incidence of lower limb sports injury. The SPSS PASW21 computer software program (Microsoft Inc., Chicago, Illinois) was used for statistical analyses, and the statistical significance level was set at $p < 0.05$.

RESULTS

Of the 18 participants, 10 participants who sustained more than one lower limb injury, were classified into the injured group. 8 participants who did not sustain any lower limb injuries, were classified into the uninjured group. The total number of accidents was 19 (1.06 ± 1.51 injuries/player). The total number of traumatic injuries was 7 cases in 7 participants (0.39 ± 0.50 injuries/player). Contact injuries were found in 6 cases and non-contact injuries were found in 1 case. The total number of overuse injuries was 12 cases in 5 participants (0.67 ± 1.50 injuries/player). When considering the body parts that were injured, there were ankle injuries in 9 cases, foot injuries in 2 cases, lower leg injuries in 2 cases, knee injuries in 2 cases and thigh injuries in 2 cases. The diagnoses were ligament injuries in 9 cases, muscular injuries in 3 cases, stress fractures in 2 cases, plantar fasciitis in 2 cases, Osgood-Schlatter disease in 1 case, shin splints in 1 case and bruising in 1 case.

There were significant differences between the injured and uninjured groups in the flexibility of the non-dominant quadriceps and the COP sway area during non-dominant single limb stance with eyes open (Table 1). We performed a multiple logistic regression analysis by assigning whether a participant had sustained an injury more than once in the year of follow-up to a dependent variable. Independent variables were the flexibility of non-dominant quadriceps and the COP sway area during non-dominant single limb stance with eyes open at baseline. Only the flexibility of the non-dominant quadriceps extracted to a factor which related to the incidence of injury. Although the result of Model Chi-square test was significant ($p<0.05$), the value didn't show significance ($p=0.052$) (Table 2).

Table1. Injured group vs. Uninjured group.
Mean values ± Standard Deviation for variables for players with injuries and for players without injuries.

	Injured group (n=10)			Uninjured group (n=8)			
BMI（kg/m²）	20.5	±	2.5	19.9	±	3.6	
Postural away(COP sway)							
Path length dominant stance with eyes open(cm)	77.4	±	17.7	72.7	±	15.6	
Sway area dominant stance with eyes open(cm^2)	3.6	±	1.1	4.3	±	2.4	
Path length dominant stance with eyes closed(cm)	109.5	±	47.7	120.6	±	17.9	
Sway area dominant stance with eyes closed(cm^2)	13.5	±	18.4	7.6	±	2.4	
Path length non-dominant stance with eyes open(cm)	90.0	±	28.8	72.3	±	9.5	
Sway area non-dominant stance with eyes open(cm^2)	4.6	±	1.7	3.2	±	0.7	*
Path length non-dominant stance with eyes closed(cm)	135.9	±	39.6	120.0	±	29.0	
Sway area non-dominant stance with eyes clesed(cm^2)	9.7	±	3.2	7.6	±	2.8	
Non-dominant Muscle strength (Nm/Kg)							
Hip abductor	4.9	±	1.4	4.8	±	1.0	
Hip extensor	5.2	±	1.4	4.9	±	1.4	
Knee extensor	1.8	±	0.5	1.8	±	0.4	
Knee flexor	1.1	±	0.3	1.1	±	0.3	
mSEBT (%)							
Dominant stance Anterior	102.1	±	8.5	100.6	±	6.2	
Post-lateral	102.7	±	8.7	101.2	±	7.0	
Post-medial	104.7	±	9.4	102.4	±	8.5	
Non-dominant stance Anterior	101.9	±	8.1	101.0	±	7.9	
Post-lateral	101.7	±	7.2	100.9	±	7.1	
Post-medial	105.2	±	6.9	102.9	±	8.9	
Muscle flexibility(°)							
Dominant hamstrings	-40.5	±	11.9	-34.4	±	15.5	
Non-dominant hamstrings	-37.5	±	16.5	-36.9	±	13.9	
Dominant quadriceps	127.5	±	5.4	133.8	±	8.3	
Non-dominant quadriceps	122.5	±	8.6	131.9	±	7.5	*
Dominant gastrocnemius	13.5	±	4.7	16.9	±	6.5	
Non-dominant gastrocnemius	14.5	±	2.8	16.9	±	6.5	

BMI: Body Mass Index、 COP: Center of Pressure, mSEBT: modified Star Excursiont BalanceTest

*：$p < 0.05$

Table 2. The Multiple Logistic Progression Model with exploratory variables

Variable	Coefficient(ß)	p	Odds Rates	95%CI
Muscle Flexibility of Non-dominant Quadriceps	-0.152	0.052	0.859	0.737- 1.001
Intercept	-7.787			

the Model Chi-square test, $p<0.05$,
Distinction hitting ratio 77.8%

DISCUSSION

This study prospectively investigates if the lower limb muscle flexibility, strength and balance influence the incidence of lower limb injury in adolescent female football players. The injured group showed a significantly lower flexibility of the non-dominant quadriceps, and larger COP sway area during non-dominant single limb stance with eyes open at baseline. The results of the multiple logistic regression analysis revealed that a lower flexibility of non-dominant quadriceps was identified as a factor related to the incidence of injury. However, the odds ratio showed a low influence, and the value was not statistically significant.

There are some studies on predicting the incidence of sports injury in female athletes [24-26]. It is generally hypothesized that a lower muscle flexibility can cause muscle injury. Arnason et al.[27] have shown that the incidence of anterior hip pain is associated with a lower range of motion on hip abduction in male football players. Witvrouw et al. [28] have reported that a low flexibility in the hamstrings and the rectus femoris is a risk factor in the incidence of muscle injury in male football players. On the other hand, in studies by Krivickas et al.[24] who investigated college athletes, tightness in the ligaments and a lower muscle flexibility are associated with incidence of injury in males, while this relationship is not observed in females. Furthermore, Myer, et al.[29] have reported that the incidence of ACL injury is higher in female football players who have joint laxity. However, there are only a few studies that have investigated the relationship between muscle flexibility and the incidence of injury in female athletes, and there is no consensus on the results. Landry, et al.[30] have reported that female football players have higher activity in the rectus femoris during side-cutting compared with male players. Sigward et al.[31] have shown similar characteristics during the side-step. Lyle et al.[32] have also reported a higher rigidity in the whole lower limb in female football players during the landing phase of a single limb jump compared with male players, leading to a reduction in the shock absorbing function. They have concluded that the characteristics of the neuromuscular control specific to female subjects, may lead to a higher incidence of non-contact ACL injury. The continuous contraction in the quadriceps during performance may lead to muscle tightness, causing reduced muscle flexibility. Players with lower muscle flexibility fatigue more easily, further decreasing the neural control during performance, thus leading to injury. A neuromuscular control function similar to landing after performing a jump is often required on the non-dominant limb while kicking a ball. A higher rectus femoris muscle contraction may exhibit a lower muscle flexibility, leading to a higher risk of injury. Thus, our study reveals the necessity of evaluation of the muscle flexibility of the rectus femoris and appropriate intervention for the prevention of injury in adolescent female football players.

Postural balance is an ability that can be evaluated for both the performance and the risk of injury[33)]. In general, when postural balance decreases, the incidence of lower limb injury increases[34, 35)]. There are many studies[36-39)] on the effectiveness of balance training interventions in preventing ACL injury and ankle sprains. Tropp et al.[40)] have reported that there is no relationship between the center of gravity (COG) sway and a history of ankle sprain in senior male football players, while a larger COG sway is a predictive factor of the ankle sprain incidence. Tropp et al.[40)] have focused on the investigation of ankle sprain and measured the COG, whereas our study includes all injuries of the lower limb and measures the COP. Although different assessment scales were adopted, our finding was similar to the results of Tropp et al. However, our results may have been affected by ankle injuries being the most frequent in this study. The results of this study are also consistent with those of the previous studies[34,35)], showing that participants with larger postural sway tend to have a greater risk of lower limb sports injury. Of the 19 total injuries, 12 overuse injuries and 1 non-contact traumatic injury were included in this study. It suggests that the internal factors strongly influence the incidence of injury in our participants. When postural balance decreases, the muscle contraction in the lower limb increases. It causes muscles to fatigue more easily. The joint structures (e.g., capsule, ligaments) need to compensate stability, which leads to micro-mechanical stresses in the joint and its surrounding tissues[41)]. These stresses may influence the incidence of injury.

In this study, there is no significant difference in the modified Star Excursion Balance Test (mSEBT) scores between the injured and uninjured groups. Plisky et al.[42)] have reported that when the average score of the 3 directions is ≦94%, the risk of lower limb injury is 6 times greater in female basketball players. However, Nilstad et al.[25] have also not found a relationship between mSEBT scores and the incidence of lower limb injury in female football players. The result of this study is consistent with the findings reported by Nilstad et al.[25] As mSEBT is a reliable dynamic balance assessment to predict the incidence of lower limb injury, it is an appropriate test to determine the effect of the intervention to prevent injuries[42]. Plisky et al.[43] have investigated injuries in basketball players, whereas Nilstad et al.[25] and this study have investigated the injuries in female football players. Bressel et al.[44] have reported that female basketball players have lower mSEBT scores than female football players. Few studies report that mSEBT predicts the incidence of injury in the lower limbs of female football players. It may be important to choose appropriate scales that reflect the specificities of the sports performances, as postural balance requires the interaction of various factors such as muscle strength, visual and somatosensory feedback, postural adjustment, and vestibular function.

This study has two limitations: (1) the sample size is small. The predictability of the logistic regression decreases when the number of independent variables (p) becomes greater with respect to the sample size (n). It is optimal to have $n \geq 10 \times p$. This study includes only 18 participants in the regression model[45]. We needed more than 20 participants. (2) We have not considered that the development stage may affect the incidence of sports injury. The average peak high velocity age (PHVA) in Japanese females is 10-11 years of age, and the incidence of sports injury increases dramatically immediately after the PHVA, in the second and the third grades of junior high school[46]. The body fat volume increases more in a female than in a male, especially during the ages between 10 to 17 years[47], although the body weight decreases due to rapid development of the endocrine system[48]. These significant changes in the physical characteristics of females before and after PHVA may be related to a drastic increase in sports injuries after PHVA. Because the age range of the participants in this study is between 11 and 18 years, it is possible that the stages of change in these physical components may be related to the incidence of injury.

We classified those who sustained any injuries of the whole lower limbs in the injury group and those who didn’t in the non-injury group. In addition, injuries included both traumatic and overuse injuries. Thus our prospective cohort study includes so many factors that we must admit the evidence is insufficient. We reported previously that the adolescent female players had been diagnosed with a high incidence of ankle sprain[12] as with this study. Further research should focus on risk factors related to the incidence of ankle sprain in adolescent female football players while factoring in the development stages.

EFERENCES

1) FIFA.com. Official Documents. http://www.fifa.com/mm/document/fifafacts/bcoffsurv/emaga_9384_10704.pdf (Accessed Jun. 8, 2016)

2) The Japan Football Association. Organization. Data box. The number of enrolling players. http://www.jfa.jp/about_jfa/organization/databox/player.html (Accessed Jun. 8, 2016)

3) Nakao Y, HIRANUMA K, ASHIHARA M. Characteristics of Female University Soccer Player's Injuries In Comparison with Mame Soccer player. The Japanese Society of Physical Fitness and Sport Medicine 53:493-502, 2004.

4) Ikeda H. Traumatic and Overuse Injuries Related to soccer (epidemiography). (In) Orthopaedic Sports Medicine for Return to Athletic Activities. Takeshi Muneta (Ed.) Tokyo, Medical View, pp.332-337, 2011.

5) Brynhildsen J, Ekstrand J, Jeppsson A, et al. Previous Injuries and Persisting Symptoms in Female Soccer Players. Int J Sports Med11:489-492, 1990.

6) Clausen MB, Zebis MK, Møller M, et al. High injury incidence in adolescent female soccer. Am J Sports Med42:2487-2494, 2014.

7) Suzukawa M, Takahashi S, Nagano K, et al. Epidemiological Survey on Traumatic injuries in the junior high school basketball players. Japanese Journal of Orthopaedic Sports Medicine29:44-49, 2009.

8) Arendt E, Dick R. Knee injury patterns among men and women in collegiate basketball and

soccer. NCAA data and review of literature. Am J Sports Med23: 694-701, 1995.

9) Ferretti A, Papandrea P, Conteduca F, et al. Knee ligament injuries in volleyball players. Am J Sports Med20:203-207, 1992.

10) Agel J, Arendt EA, Bershadsky B. Anterior cruciate ligament injury in national collegiate athletic association basketball and soccer: a 13-year review. Am J Sports Med33:524-530, 2005.

11) Yard EE, Schroeder MJ, Fields SK, et al. The epidemiology of United States high school soccer injuries, 2005-2007. Am J Sports Med36:2328-2335, 2008.

12) Inoue Y, Yamamoto S, Otani Y, et al. Characteristics of Injuries with Female University Soccer Players in Comparison with Male Players. Journal of Clinical Sports Medicine31:1187-1192, 2014.

13) Knapik JJ, Bauman CL, Jones BH, et al. Preseason strength and flexibility imbalances associated with athletic injuries in female collegiate athletes. Am J Sports Med19:76-81, 1991.

14) Zelisko JA, Noble HB, Porter M. A comparison of men's and women's professional basketball injuries. Am J Sports Med10:297-299, 1982.

15) Hewett TE, Myer GD, Ford KR, et al. Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: a prospective study. Am J Sports Med33:492-501, 2005.

16) Smith HC, Vacek P, Johnson RJ, et al. Risk factors for anterior cruciate ligament injury: a review of the literature-part 2: hormonal, genetic, cognitive function, previous injury, and extrinsic risk factors. Sports Health4:155-161, 2012.

17) Smith HC, Vacek P, Johnson RJ, et al. Risk factors for anterior cruciate ligament injury: a review of the literature - part 1: neuromuscular and anatomic risk. Sports Health4:69-78,

2012.

18) Murata S, Miyazoe T. The Range of Motion Test using the inclination goniometer. The Society of Physical Therapy Science18:153-157, 2003.

19) Shigeshima k, Sakanoue N. Concurrent validity and reproducibility of range of motion measurements with inclinometers. Journal of Kochi Rehabilitation Institute7:39-46, 2006.

20) Yamasaki H, Kataoka C, Ookura M, et al. Measurements of isometric hip abduction force with a hand-held dynamometer: the effect of using the belt for the fixation on the reproducibility. Journal of Kochi Rehabilitation Institute10:61-66, 2009.

21) Kato M, Yamazaki H, Nakajima K, et al. Measurements of isometric hip flexion and extension force with a hand-held dynamometer: the effect of use of the belt for fixation on the reliability. Journal of Kochi Rehabilitation Institute6:7-13, 2005.

22) Carvalho HM, Coelho E, Silva MJ, et al. Assessment of reliability in isokinetic testing among adolescent basketball players. Medicina (Kaunas)47:446-452, 2011.

23) Hertel J, Braham RA, Hale SA, et al. Simplifying the star excursion balance test: analyses of subjects with and without chronic ankle instability. J Orthop Sports Phys Ther36:131-137, 2006.

24) Krivickas LS, Feinberg JH. Lower extremity injuries in college athletes: relation between ligamentous laxity and lower extremity muscle tightness. Arch Phys Med Rehabil77:1139-1143, 1996.

25) Nilstad A, Andersen TE, Bahr R, et al. Risk factors for lower extremity injuries in elite female soccer players. Am J Sports Med42:940-948, 2014.

26) Steffen K, Myklebust G, Andersen TE, et al. Self-Reported Injury History and Lower Limb Function as Risk Factors for Injuries in Female Youth Soccer. Am J Sports Med36:700-708, 2008.

27) Arnason A, Sigurdsson SB, Gudmundsson A, et al. Risk factors for injuries in football. Am J Sports Med32:5-16, 2004.

28) Witvrouw E, Danneels L, Asselman P, et al. Muscle flexibility as a risk factor for developing muscle injuries in male professional soccer players. A prospective study. Am J Sports Med31:41-46, 2003.

29) Myer GD, Ford KR, Paterno MV, et al. The effects of generalized joint laxity on risk of anterior cruciate ligament injury in young female athletes. Am J Sports Med36:1073-1080, 2008.

30) Landry SC, McKean KA, Hubley-Kozey CL, et al. Neuromuscular and lower limb biomechanical differences exist between male and female elite adolescent soccer players during an unanticipated side-cut maneuver. Am J Sports Med35:1888-1900, 2007.

31) Sigward SM, Powers CM. The influence of gender on knee kinematics, kinetics and muscle activation patterns during side-step cutting. Clin Biomech21:41-48, 2006.

32) Lyle MA, Valero-Cuevas FJ, Gregor RJ, et al. Control of dynamic foot-ground interactions in male and female soccer athletes: females exhibit reduced dexterity and higher limb stiffness during landing. J Biomech47:512-517, 2014.

33) Chew-Bullock TS, Anderson DI, Hamel KA, et al. Kicking performance in relation to balance ability over the support leg. Hum Mov Sci31:1615-1623, 2012.

34) Payne KA, Berg K, Latin RW. Ankle injuries and ankle strength, flexibility, and proprioception in college basketball players. J Athl Train32:221-225, 1997.

35) McGuine TA, Greene JJ, Best T, et al. Balance as a predictor of ankle injuries in high school basketball players. Clin J Sport Med10:239-244, 2000.

36) Faizullin I, Faizullina E. Effects of balance training on post-sprained ankle joint instability. Int J Risk Saf Med27:99-101, 2015.

37) Mandelbaum BR, Silvers HJ, Watanabe DS, et al. Effectiveness of a neuromuscular and

proprioceptive training program in preventing anterior cruciate ligament injuries in female athletes: 2-yearfollow-up. Am J Sports Med33:1003-1010, 2005.

38) Cerulli G, Benoit DL, Caraffa A, et al. Proprioceptive training and prevention of anterior cruciate ligament injuries in soccer. J Orthop Sports Phys Ther31:655-660, 2001.

39) Rössler R, Donath L, Verhagen E, et al. Exercise-based injury prevention in child and adolescent sport: a systematic review and meta-analysis. Sports Med44:1733-1748, 2014.

40) Tropp H, Ekstrand J, Gillquist J. Stabilometry in functional instability of the ankle and its value in predicting injury. Med Sci Sports Exerc16:64-66, 1984.

41) Brukner P. Sport injuries, overuse. (In) Clinical Sport Medicine. Australia, Mac Graw-Hill Australia Pty Ltd, pp.25-40, 2012.

42) Clark RC, Saxion CE, Cameron KL, et al. Associations between three clinical assessment tools for postural stability. N Am J Sports Phys Ther5:122-130, 2010.

43) Plisky PJ, Rauh MJ, Kaminski TW, et al. Star Excursion Balance Test as a predictor of lower extremity injury in high school basketball players. J Orthop Sports Phys Ther36:911-919, 2006.

44) Bressel E, Yonker JC, Kras J, et al. Comparison of static and dynamic balance in female collegiate soccer, basketball, and gymnastics athletes. J Athl Train42:42-46, 2007.

45) Tsushima E. multiple logistic regression analysis. (in) Medical system multivariate data analysis to learn in SPSS. Tokyo, Tokyo-tosho Co. Ltd, pp.237-255, 2007.

46) Tanaka T1, Suwa S, Yokoya S, et al. Analysis of linear growth during puberty. Acta Paediatr Scand Suppl347:25-29, 1988.

47) MacMaster FP, Keshavan M, Mirza Y, et al. Development and sexual dimorphism of the pituitary gland. Life Sci80:940-944, 2007.

48) Wild CY, Steele JR, Munro BJ. Musculoskeletal and estrogen changes during the adolescent

growth spurt in girls. Med Sci Sports Exerc45:138-145, 2013.