

The effect of ankle taping to restrict plantar flexion on ball and foot velocity during an instep kick in soccer.

Junpei Sasadai, Yukio Urabe, Noriaki Maeda, Hiroshi Shinohara, Eri Fujii

Graduate School of Biomedical & Health Sciences, Hiroshima University,  
Hiroshima, Japan

**Short title:** The effects of ankle taping on soccer instep kicks

**Corresponding author**

Junpei Sasadai

Post cord: 734-8553

Address: 1-2-3 Kasumi, Minami-ku, Hiroshima, Japan

TEL: +81 82-257-6337

FAX: +81 82-257-5344

E-mail: [j-sasadai@hiroshima-u.ac.jp](mailto:j-sasadai@hiroshima-u.ac.jp)

1 **Abstract**

2 **Context:** Posterior ankle impingement syndrome (PAIS) is a common disorder in soccer  
3 players and ballet dancers. In soccer players, it is caused by the repetitive stress of ankle  
4 plantar flexion due to instep kicking. Protective ankle dorsal flexion taping is recommended  
5 with the belief that it prevents posterior ankle impingement. However, the relationship  
6 between the ankle taping and ball kicking performance remains unclear.

7 **Objective:** To demonstrate the relationship between the restriction of ankle taping and  
8 performance of an instep kick in soccer.

9 **Design:** Laboratory-based repeated-measures study.

10 **Setting:** University laboratory.

11 **Participants:** Eleven male university soccer players.

12 **Intervention:** The subjects' ankle plantar flexion was limited by taping. Four angles of  
13 planter flexion (0°, 15°, 30°, and without taping) were formed by gradation limitation. The  
14 subjects performed maximal instep kicks at each angle.

15 **Main Outcome Measures:** The movements of the kicking legs and the ball were captured  
16 using 3 high-speed cameras at 200 Hz. The direct liner transformation method was used to  
17 obtain 3D coordinates using a digitizing system. Passive ankle plantar flexion angle, maximal  
18 plantar flexion angle at ball impact, ball velocity and foot velocity were measured. The data  
19 were compared among 4 conditions using repeated measures ANOVA and the correlations  
20 between ball velocity and foot velocity, and between ball velocity and toe velocity were  
21 calculated.

22 **Results:** Ankle dorsal flexion taping could gradually limit both passive plantar flexion and  
23 plantar flexion at the impact. Furthermore, limitation of 0° and 15° reduced the ball velocity  
24 generated by instep kicks.

25 **Conclusion:** Plantar flexion limiting taping at 30° has a potential to avoid posterior ankle

1 impingement without decreasing the ball velocity generated by soccer instep kicks.

## 1 **Introduction**

2 Soccer is one of the most popular sport in the world, with an estimated 300 million  
3 active players (as documented by the Fédération Internationale de Football Association:  
4 FIFA). In Japan, it is also the most famous sport; there were 953,740 registered players in the  
5 Japan Football Association in 2012.<sup>1</sup> It is important for human health and medical economy  
6 to prevent soccer related injuries because of the large number of soccer players all over the  
7 world. Posterior ankle impingement syndrome (PAIS), such as os trigonum syndrome, is a  
8 common sports injury in soccer players and ballet dancers.<sup>2,3</sup> PAIS is characterized by  
9 posterior ankle pain with forceful plantar flexion. Soft tissues, bony processes, unfused  
10 ossicles, or osseous fragments entrapped between the posterior tibial plafond and the superior  
11 calcaneus can lead to symptoms.<sup>2,4</sup> In soccer players, it is known to be caused by repetitive  
12 stress from ankle plantar flexion due to kicking (Figure 1).<sup>3,5</sup> Because surgical treatment  
13 requires a recovery period of at least 5 weeks before returning to sports activity,<sup>6,7</sup>  
14 conservative treatment is often considered initially. Protective ankle dorsal flexion taping is  
15 recommended with the belief that it prevents posterior ankle impingement.<sup>2</sup>

16 In soccer, the instep kick is one of the most typical techniques used when a faster  
17 ball speed must be generated while maintaining ankle plantar flexion. It is important to  
18 achieve a high ball velocity in soccer kicking, thus improving the chances of scoring.  
19 Because of the kinematic features of the ankle, the instep kick is believed to be a major risk  
20 factor for PAIS.<sup>3,5</sup> A powerful instep kick needs a higher foot velocity because the ball  
21 velocity is dependent upon the foot velocity just before the ball impact. It is well known that  
22 positive correlations exist between the foot velocity and the ball velocity during the ball  
23 impact phase.<sup>8,9</sup> A great foot velocity is generated by the lower limb movement during the  
24 instep kick that is expressed in the open kinetic chain. The motion pattern of kicking is  
25 generally accepted as a proximal (thigh) to distal (shank and foot) sequence of segmental

1 motions.<sup>10</sup>

2           There is no consensus as to whether or not ankle support can interfere with normal  
3 function, instead of reducing the pain and dysfunction caused by sports injury.<sup>11-13</sup> While  
4 posterior impingement at the time of impact may be reduced by protective ankle dorsal  
5 flexion taping, performance, such as the instep kick, may be reduced because sufficient ankle  
6 plantar flexion movement becomes impossible due to the restrictive ankle taping.<sup>13</sup> However,  
7 to our knowledge, the relationship between the ankle taping and ball kicking performance  
8 remains unclear.

9           Therefore, we studied the relationship between the restriction of ankle taping and the  
10 performance of an instep kick in soccer. In particular, this study aimed to investigate what  
11 kind of taping not decrease the ball velocity, establishing 4 taping conditions to control ankle  
12 plantar flexion. Our hypotheses were as follows: (1) Ankle dorsal flexion taping could  
13 gradually limit both passive plantar flexion range of motion (ROM) and the maximal plantar  
14 flexion angle at the impact. (2) Excess limitation by ankle taping would reduce the ball  
15 velocity generated by an instep kick because of the decrease of the foot velocity.

16

## 17 **Materials and methods**

### 18 **Design**

19           The study was a repeated-measures design. The taping condition, that has 4 levels,  
20 was the independent variable, and the plantar flexion ROM, the angle of ankle plantar  
21 flexion, and the velocities of the ball and foot and toe were the dependent variables.

22 Participants attended a 1-hour testing session at the university. Participants were tested on a  
23 single occasion and were tested across 4 taping conditions in a randomized order.

### 24 **Participants**

25           Eleven experienced male soccer players (Table 1), who had no history of major

1 lower limb injury or disease, volunteered to participate in this study after providing written  
2 informed consent. They were assessed for leg dominance using Chapman's test,<sup>14</sup> and all of  
3 them were determined to be right leg dominant.

4 All procedures were approved by the Ethics Committee of the Graduate School of  
5 Health Sciences, Hiroshima University (ID: 1013).

6

## 7 **Procedures**

8 **Taping technique.** Four conditions of planter flexion angle (0°, 15°, 30°, and without  
9 taping) were formed by gradation limitation with ankle taping. The tape was applied to the  
10 subject's right ankle by an experienced physical therapist to avoid variability. Three types of  
11 tape, 38mm inelastic tape, 75mm hard elastic tape, and 50mm soft elastic tape were used for  
12 the taping (Nitreat CB-38, EB-75, EBH-50; Nitto medical Inc., Tokyo, Japan). Three 38mm  
13 inelastic anchors were applied to the skin beneath the heads of the gastrocnemius. Two  
14 inferior anchors were applied over the metatarsal head. The subject's ankle plantar flexion  
15 was limited by three 75mm elastic tapes. Finally, 50mm soft elastic wrapping tape was fixed  
16 in a figure eight shape and with a heel lock (Figure 2).

17

18 **Measurement.** The measurement of passive plantar flexion ROM was recorded using  
19 manual goniometry, according to the protocol of the Japanese Orthopedic Association, before  
20 the kicking experiment under each taping condition. As shown in Figure 3, to integrate  
21 passive plantar flexion torque, the region 15 cm apart from the medial and lateral malleolus  
22 was depressed by 40N using a hand held dynamometer ( $\mu$ Tas F-1; Anima Inc., Tokyo, Japan).  
23 Based on the method of Krause et al., the magnitude of the applied force was determined  
24 through trial and error before the actual testing.<sup>15</sup> The investigators applied a "typical" force  
25 to the dorsal aspect of the foot with the dynamometer while the participant performed passive

1 plantar flexion. As a result of this process, 40N was selected as the standard force for all  
2 subjects.

3 A FIFA-approved size five soccer ball (Jabulani Lusiada; Adidas; diameter = 22cm,  
4 mass = 0.43 kg) was used, and its inflation was fixed at 900 g·cm<sup>-2</sup> throughout the  
5 experiment. The subjects performed five maximal instep kicks under each of the four taping  
6 conditions.

7 Three electrically synchronized high-speed cameras (FKN-HC200C; 4 Assist Inc.,  
8 Tokyo, Japan) were used to capture the motion of the foot, the lower leg, and the ball during  
9 instep kicking. The sampling rate was set at 200 Hz to adequately analyze the foot and the  
10 ball behavior during the impact. Reflective markers were placed on the fibular head, the  
11 lateral malleolus, the base of the fifth metatarsal bone, the head of the fifth metatarsal bone,  
12 and on the surface of the ball.

13 A digitizing system (DIPP-Motion XD; Tokyo, Japan) was used to manually digitize  
14 the aforementioned body landmarks and three of the ball surface markers in the area where  
15 the deformation was relatively small during impact. The ball surface marker intervals were  
16 approximately 10 cm.<sup>16</sup> The direct linear transformation (DLT) method was then used to  
17 obtain the three-dimensional coordinates of each marker from 10ms before ball contact to  
18 10ms after ball contact. The three-dimensional coordinates were expressed as a right-handed  
19 orthogonal reference frame, fixed on the ground, in which the X axis was horizontal and  
20 pointed to the goal, the Y axis was vertical and pointed upward, and the Z axis was  
21 perpendicular to the X and the Y axes. To calibrate the space around the ball impact area, a  
22 calibration frame (90 \* 90 \* 90 cm) with 8 control points was sampled before the trials. A 12  
23 Hz fourth order Butterworth low-pass filter was used to smooth marker displacement data.<sup>17</sup>

24 The angle between the lines formed from the fibular head to the lateral malleolus and  
25 from the base to the head of the fifth metatarsal bone was calculated and expressed in degrees

1 of ankle plantar flexion. The linear velocity of the ball during the first 10ms after the impact  
2 was calculated from the center of the ball defined by the ball surface markers. The linear  
3 velocities of the base of the fifth metatarsal marker (foot velocity) and the head of the  
4 metatarsal marker (toe velocity) during the last 10ms before the impact were calculated.

5

## 6 **Statistical analysis**

7 Data analysis for significant differences was carried out using SPSS 20.0 for  
8 Windows Statistics version 20.0 (IBM Japan Co. Ltd., Tokyo, Japan).

9 The mean values and standard deviations were calculated for each condition. One-  
10 way repeated measures analysis of variance (ANOVA) was used to test for differences in the  
11 passive ROM, maximal plantar flexion angle at ball impact, ball velocity, foot velocity and  
12 toe velocity among the four conditions. When the main effect was statistically significant,  
13 post hoc analyses were carried out with Bonferroni-adjusted paired t-tests. For each taping  
14 condition, paired t-test was used to analyze the difference between passive ROM and the  
15 maximal plantar flexion angle on impact.

16 The Pearson product-moment correlation was also used to determine the relation  
17 between ball velocity and foot velocity, and between ball velocity and toe velocity.

18 The intra-class correlation coefficient (ICC (1, 5)) was also calculated to investigate  
19 the within-subject reliability of each variable. The alpha level used for all analyses was  
20  $P < .05$ .

21

## 22 **Results**

23 Figure 4 shows the passive ROM and maximal plantar flexion angle at the ball  
24 impact. Passive ROM for the 0°, 15°, 30° taping and without taping were  $0.1 \pm 2.0^\circ$ ,  
25  $14.4 \pm 1.8^\circ$ ,  $28.8 \pm 1.5^\circ$  and  $55.3 \pm 3.2^\circ$ , respectively. There were significant differences among



1 all conditions ( $P<.05$ ). Compared with the condition without taping,  $0^\circ$ ,  $15^\circ$ ,  $30^\circ$  taping  
2 resulted in restriction of  $55.2^\circ$  (99.8%),  $40.9^\circ$  (74.0%) and  $26.5^\circ$  (47.9%)

3 The maximal plantar flexion angles at ball impact were  $19.5\pm 10.3^\circ$ ,  $27.6\pm 7.8^\circ$ ,  
4  $33.3\pm 9.9^\circ$  and  $41.6\pm 10.8^\circ$ , respectively. There were significant differences among all  
5 conditions ( $P<.05$ ). Compared with the condition without taping, the angles with the  $0^\circ$ ,  $15^\circ$ ,  
6  $30^\circ$  taping were more restricted by  $22.1^\circ$  (53.1%),  $14.0^\circ$  (33.7%) and  $8.3^\circ$  (20.0%).

7 Figure 5 shows the ball and foot and toe velocity of instep kicking for each taping  
8 condition. The ball velocities for  $0^\circ$ ,  $15^\circ$ ,  $30^\circ$  taping and without taping were  $20.4\pm 2.1$ ,  
9  $21.7\pm 2.0$ ,  $22.5\pm 1.9$  and  $23.1\pm 1.3$  m/s, respectively. There were significant differences  
10 between the two taping conditions ( $0^\circ$ ,  $15^\circ$ ) and without taping ( $P<.05$ ). Compared with the  
11 condition without taping, the ball velocities for  $0^\circ$ ,  $15^\circ$  and  $30^\circ$  taping were reduced by  
12  $2.7$  m/s (11.7%),  $1.4$  m/s (6.1%) and  $0.6$  m/s (2.6%).

13 The foot velocities for  $0^\circ$ ,  $15^\circ$ ,  $30^\circ$  taping and without taping were  $14.8\pm 1.4$ ,  
14  $15.0\pm 1.2$ ,  $15.1\pm 1.1$  and  $15.0\pm 1.3$  m/s, respectively. There were no significant differences  
15 among the taping conditions. By contrast, the toe velocities for  $0^\circ$ ,  $15^\circ$ ,  $30^\circ$  taping and  
16 without taping were  $14.4\pm 1.4$ ,  $15.2\pm 1.3$ ,  $15.5\pm 1.0$  and  $15.7\pm 1.5$  m/s, respectively. There were  
17 significant differences between the  $0^\circ$  and  $30^\circ$  taping ( $P<.05$ ).

18 Table 2 shows the correlations between the ball velocity and foot velocity, and  
19 between the ball velocity and toe velocity. There were moderate to strong correlations  
20 between the ball velocity and foot velocity and between the ball velocity and toe velocity ( $r =$   
21  $0.685$  to  $0.863$ ,  $P<.05$ ).

22 The ICC (1, 5) values of the impact angle, ball velocity, foot velocity and toe  
23 velocity were  $0.978$ ,  $0.926$ ,  $0.841$  and  $0.821$ , respectively.

24

## 25 Discussion

1 PAIS is recognized as chronic pain in athletes, such as soccer players.<sup>2,3</sup> It is known to  
2 be caused by repetitive stress from ankle plantar flexion due to kicking.<sup>3,5</sup> As a conservative  
3 treatment, protective ankle dorsal flexion taping is recommended with the belief that it  
4 prevents posterior ankle impingement. However, whether or not this taping really avoids  
5 excessive ankle plantar flexion at the ball impact and what kind of effect this has on soccer  
6 kicking performance remain unknown. Therefore, this study aimed to investigate what kind  
7 of taping could restrict excess ankle plantar flexion without decreasing the ball velocity, by  
8 using 4 precise taping conditions to control ankle plantar flexion. Based on our results, taping  
9 was able to gradually restrict the maximal plantar flexion angle at ball impact for each of the  
10 4 taping conditions, and excess restriction, such as 0° and 15° taping, decreased the ball  
11 velocity. Many independent researchers have investigated the instep kick in soccer,<sup>10, 18-20</sup> and  
12 the effect of ankle taping,<sup>11-13, 21</sup>. However, the relationship between restriction of ankle  
13 taping and ball velocity as a result of soccer kicking remains unclear. Thus, this is the first  
14 investigation to report how the kicking skills vary with the different degrees of restriction by  
15 ankle taping.

16 A previous study of amateur soccer players showed that the maximal plantar flexion  
17 angle and velocity on ball impact were 47.6° and 24.3 m/s, respectively.<sup>18</sup> Although there  
18 were some methodological differences, these results are consistent with the present  
19 findings.<sup>19, 20</sup> In addition, ICC (1, 5) values showed an almost perfect degree of reliability.<sup>22</sup>  
20 Therefore, our results of instep kicking are considered to have good validity and reliability.

21 In this study, enforced taping was used to establish a 0° taping condition in which the  
22 passive plantar flexion angle would be 0° by taping, and the 15° taping condition and the 30°  
23 taping condition were set up in a similar manner. Consequently, the taping restricted the angle  
24 near the target, i.e., 0.1±2.0° with the 0° taping condition, 14.4±1.8° with the 15° taping  
25 condition, and 28.8±1.5° with the 30° taping condition. Since taping conditions can be

1 established with an objective indicator, i.e., the passive range of motion, our method of  
2 establishing the reproducibility of the results of taping may become useful. There were  
3 significant differences in the passive ankle plantar flexion angle among all taping conditions,  
4 and it was shown that gradual restriction of the ankle plantar flexion angle by taping is  
5 possible. The three taping conditions were specified by the angle at the time of establishing  
6 the ankle plantar flexion using the same force. In previous studies of the effect of taping, the  
7 description "the same taper enforced all" is used in many cases.<sup>11,21</sup> However, to the best of  
8 our knowledge, this is the first report of a method specifying two or more taping conditions  
9 with a specific restriction angle.

10 From the result of the maximal plantar flexion on ball impact, consistent with our  
11 hypothesis, we confirmed that the maximal plantar flexion angle at ball impact could be  
12 restricted gradually. PAIS is characterized by posterior ankle pain with forceful plantar  
13 flexion. van Dijk et al. reported that dancers exhibited a normal range of motion:  
14 dorsiflexion/ plantar flexion 20°/50° on both sides.<sup>23</sup> By contrast, Calder et al. remarked that  
15 the range of motion of the ankle joint may or may not be affected.<sup>6</sup> At any rate, as long as the  
16 terminal position of ankle plantar flexion is avoided, ankle pain caused by PAIS may not  
17 occur. While it is necessary to properly assess the patients' range of ankle plantar flexion,  
18 which is defined by PAIS symptoms, our results might help the choice of moderate restriction  
19 of ankle taping that does not interfere with instep kicking performance as much as possible.

20 With respect to the ball velocity, the 0° and 15° taping conditions exhibited a degree of  
21 incongruity in the case of a kick among many of the subjects. In particular the ball velocity  
22 decreased significantly by 2.7 m/s (11.7%; 20.4±2.1 m/s vs. 23.1±1.3 m/s) for 0° and without  
23 taping, respectively. Thus, in a match situation, a drop in the velocity of 11.7% may make the  
24 difference between victory and defeat. The instep kick produces a great ball velocity by an  
25 open kinetic chain that continues from the proximal to distal segment.<sup>10</sup> Excessive restriction,

1 such as that achieved with the 0° and 15° taping conditions, inhibited this kinetic chain, and it  
2 was perceived that ball velocity decreased. Indeed, there were some correlations between ball  
3 velocity and foot velocity, and between ball velocity and toe velocity. In particular, the  
4 correlations between ball velocity and toe velocity for the 0° and 15° taping conditions were  
5 strong. However, Nunome et al. reported the foot motion was assumed to not have a  
6 substantial influence on the leg swinging motion during kicking.<sup>24</sup> In our findings, there were  
7 a few significant differences in foot velocity and toe velocity among the 4 taping conditions,  
8 with the exception of the significant toe velocity difference between 0° and 30° taping.  
9 Therefore, decreasing of the ball velocity with the 0° and 15° taping may not be explained by  
10 simply decreasing of the foot velocity and toe velocity. Asami et al. mentioned that rigidity of  
11 the foot is important for a powerful kick, and that this became impaired when the ball was  
12 struck by the forefoot.<sup>25</sup> Thus, there is the possibility that decreasing of the foot velocity and  
13 toe velocity as well as changes of the impact site are intricately interrelated in the decline of  
14 the ball speed through inhibition of the kicking kinetic chain due to excess restriction with  
15 ankle taping. While reduction of foot and toe velocity may be inevitable due to the restriction  
16 of the ankle plantar flexion, patients may be able to adjust to changes in the impact site by  
17 practicing in the taping condition.

18 In summary, restriction, such as that achieved with a 30° taping condition, will not  
19 influence ball velocity, but the contribution of the angle at the time of the impact leading to a  
20 posterior ankle impingement might be avoidable. As stated previously, PAIS in soccer players  
21 is believed to be due to repetitive excessive ankle plantar flexion at the time of impact.<sup>3, 5</sup>  
22 Therefore, we demonstrated that it is likely to reduce excess posterior ankle entrapment  
23 between the posterior tibial plafond and the superior calcaneus with ankle taping restriction  
24 on ball impact.

25 This study has some limitations. The inclusion of only healthy participants limits the

1 ability to generalize these results to soccer players with symptoms. It is necessary to confirm  
2 how instep kicking performance would change in PAIS participants when they are controlled  
3 by ankle taping. A second limitation is related to the possibility of reduced effectiveness of  
4 restriction by ankle taping when performing soccer actions that include not only kicking but  
5 also jumping, running and stopping.<sup>12, 26</sup> In a future study, we will determine whether the  
6 effect of ankle plantar flexion restricting taping persists when subjects perform repeated  
7 sports tasks, including instep kicking.

8

## 9 **Conclusion**

10 This study examined the effectiveness of protective ankle dorsal flexion taping to the  
11 dynamics of instep soccer kicking. The results suggest that excess restrictions, i.e., 0° and 15°  
12 taping, can decrease the ball velocity, because of inhibition of the kicking kinetic chain due to  
13 excess restriction with ankle taping. However appropriate restriction, i.e., 30°, could reduce  
14 excess ankle plantar flexion that is considered a cause of posterior ankle impingement with  
15 no negative effect on instep kicks in soccer.

16

## 1 **References**

- 2 **1.** Japan Football Association: Japan football association profile English edition. 2013.  
3 [http://www.jfa.or.jp/jfa/images/profile\\_eng\\_131017.pdf](http://www.jfa.or.jp/jfa/images/profile_eng_131017.pdf)
- 4 **2.** Giannini S, Buda R, Mosca M, Parma A, Di Caprio F. Posterior ankle impingement. *Foot*  
5 *Ankle Int.* 2013;34:459-465
- 6 **3.** Rathur S, Clifford PD, Chapman CB. Posterior ankle impingement: os trigonum  
7 syndrome. *Am J Orthop.* 2009;38:252-253
- 8 **4.** Robinson P, Bollen SR. Posterior ankle impingement in professional soccer players:  
9 effectiveness of sonographically guided therapy. *Am J Roentgenol.* 2006;187:W53-W58
- 10 **5.** McDougall A. The os trigonum. *J Bone Joint Surg Br.* 1955;37:257-265
- 11 **6.** Calder JD, Sexton SA, Pearce CJ. Return to training and playing after posterior ankle  
12 arthroscopy for posterior impingement in elite professional soccer. *Am J Sport Med.*  
13 2010;38:120-124
- 14 **7.** van Dijk CN, de Leeuw PA, Scholten PE. Hindfoot endoscopy for posterior ankle  
15 impingement. Surgical technique. *J Bone Joint Surg Am.* 2009;91:287-298
- 16 **8.** Rodano R, Tavana R. Three dimensional analysis of the instep kick in professional soccer  
17 players. In: Clarys J, Reilly T, Stibbe A, ed. *Science and Football II.* London: E & FN  
18 Spon; 1993:357-361.
- 19 **9.** Levanon J, Dapena J. Comparison of the kinematics of the full-instep and pass kicks in  
20 soccer. *Med Sci Sports Exerc.* 1998;30:917-927
- 21 **10.** Lees A, Nolan L. The biomechanics of soccer: a review. *J Sports Sci.* 1998;16:211-234
- 22 **11.** Wilkerson GB. Biomechanical and neuromuscular effects of ankle taping and bracing. *J*  
23 *Athl Train.* 2002;37:436-445
- 24 **12.** Metcalfe RC, Schlabach GA, Looney MA, Renehan EJ. A comparison of moleskin tape,  
25 linen tape, and lace-up brace on joint restriction and movement performance. *J Athl*

- 1        *Train.* 1997;32:136-140
- 2    **13.** Quackenbush KE, Barker PR, Stone Fury SM, Behm DG. The effects of two adhesive  
3        ankle-taping methods on strength, power, and range of motion in female athletes. *N Am J*  
4        *Sports Phys Ther.* 2008;3:25-32
- 5    **14.** Chapman JP, Chapman LJ, Allen JJ. The measurement of foot preference. *Neurophychol.*  
6        1987;25:579-584
- 7    **15.** Krause DA, Cloud BA, Forster LA, Schrank JA, Hollman JH. Measurement of ankle  
8        dorsiflexion: a comparison of active and passive techniques in multiple positions. *J Sport*  
9        *Rehabil.* 2011;20:333-344
- 10   **16.** Ishii H, Yanagiya T, Naito H, Katamoto S, Maruyama T. Numerical study of ball  
11        behavior in side-foot soccer kick based on impact dynamic theory. *J Biomech.* 2009;  
12        42:2712-2720
- 13   **17.** Lees A, Steward I, Rahnama N, Barton G. Lower limb function in the maximal instep  
14        kick in soccer. In: Reilly T, Atkinson G, ed. *Contemporary Sport, Leisure and*  
15        *Ergonomics.* New York: Taylor & Francis; 2009:149-160.
- 16   **18.** Tol JL, Slim E, van Soest AJ, van Dijk CN. The relationship of the kicking action in  
17        soccer and anterior ankle impingement syndrome. *Am J Sports Med.* 2002;30:45-50
- 18   **19.** Shinkai H, Nunome H, Isokawa M, Ikegami Y. Ball impact dynamics of instep soccer  
19        kicking. *Med Sci Sports Exerc.* 2009;41:889-897
- 20   **20.** Dörge HC, Andersen TB, Sørensen H, Simonsen EB. Biomechanical differences in  
21        soccer kicking with the preferred and the non preferred leg. *J Sports Sci.* 2002;20:293-  
22        299
- 23   **21.** Forbes H, Thrussell S, Haycock N, Lohkamp M, White M. The effect of prophylactic  
24        ankle support during simulated soccer activity. *J Sport Rehabil.* 2013;22,170-176
- 25   **22.** Landis JR, Koch GG. The measurement of observer agreement for categorical data.

- 1        *Biometrics*. 1977;33:159-174
- 2    **23.** van Dijk CN, Scholten PE, Krips R. A 2-portal endoscopic approach for diagnosis and  
3        treatment of posterior ankle pathology. *Arthroscopy*. 2000;16:871-876
- 4    **24.** Nunome H, Asai T, Ikegami Y, Sakurai S. Three-dimensional kinetic analysis of side-foot  
5        and instep soccer kicks. *Med Sci Sport Exer*. 2002;34:2028-2036
- 6    **25.** Asami T, Nolte V. Analysis of powerful ball kicking, In: Matsui H, Kobayashi K, ed.  
7        *Biomechanics VIII-B*, Champaign: Human Kinetics Publisher; 1983:695-700
- 8    **26.** Rarick GL, Bigley G, Karst R, Malina RM: The measurable support of the ankle joint by  
9        conventional methods of taping. *J Bone Joint Surg Am*. 1962;44:1183-1190



## Figures

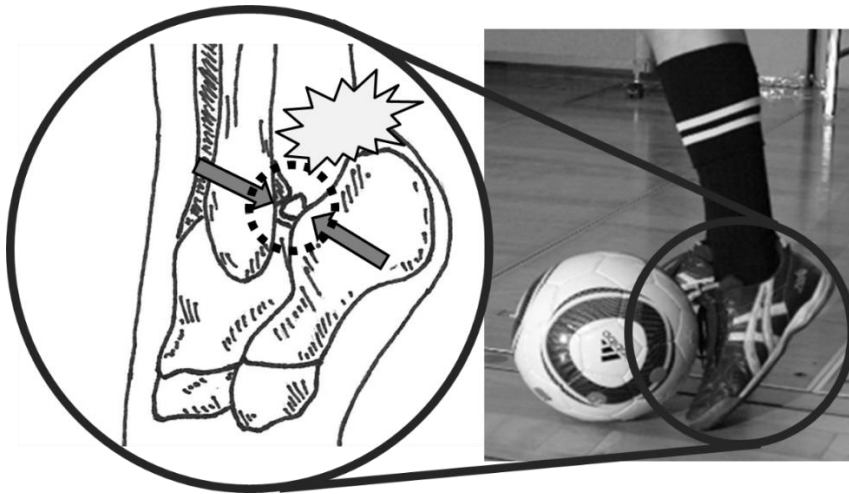


Figure 1. Mechanism of PAIS in soccer

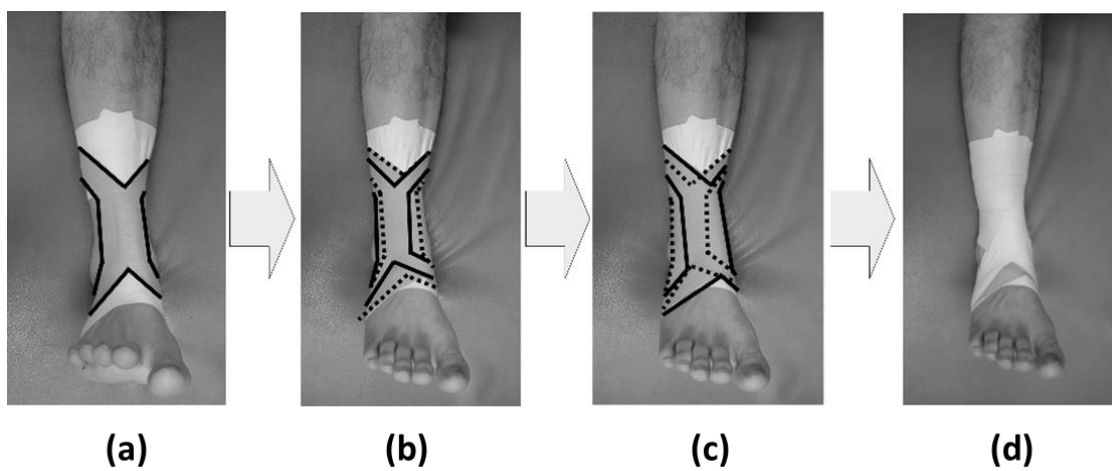
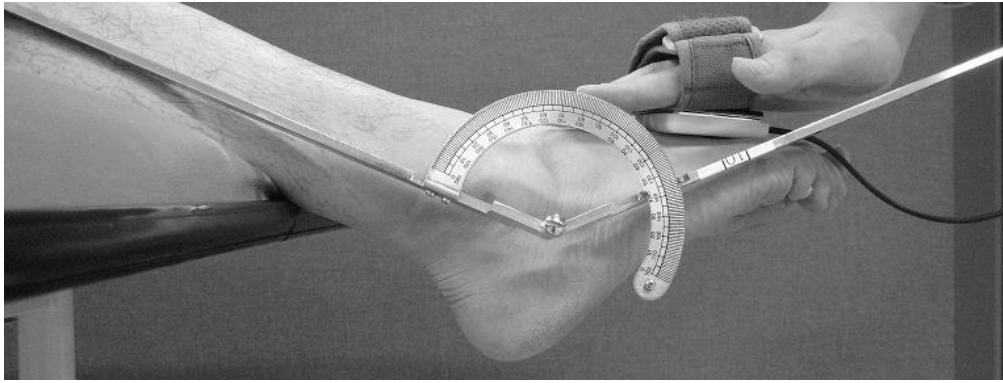
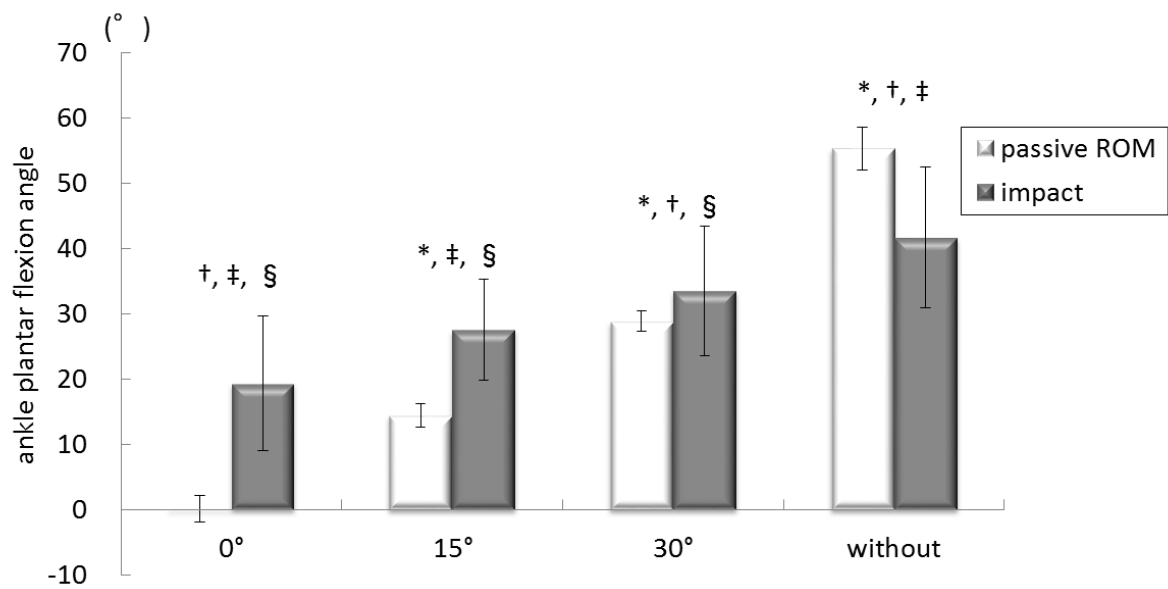


Figure 2. Ankle plantar flexion limiting taping

(a) 1<sup>st</sup> split taping; (b) 2<sup>nd</sup> split taping; (c) 3<sup>rd</sup> split taping; (d) Wrapping



**Figure 3. Measurement of the passive plantar flexion of the subject's ankle by using hand held dynamometer**

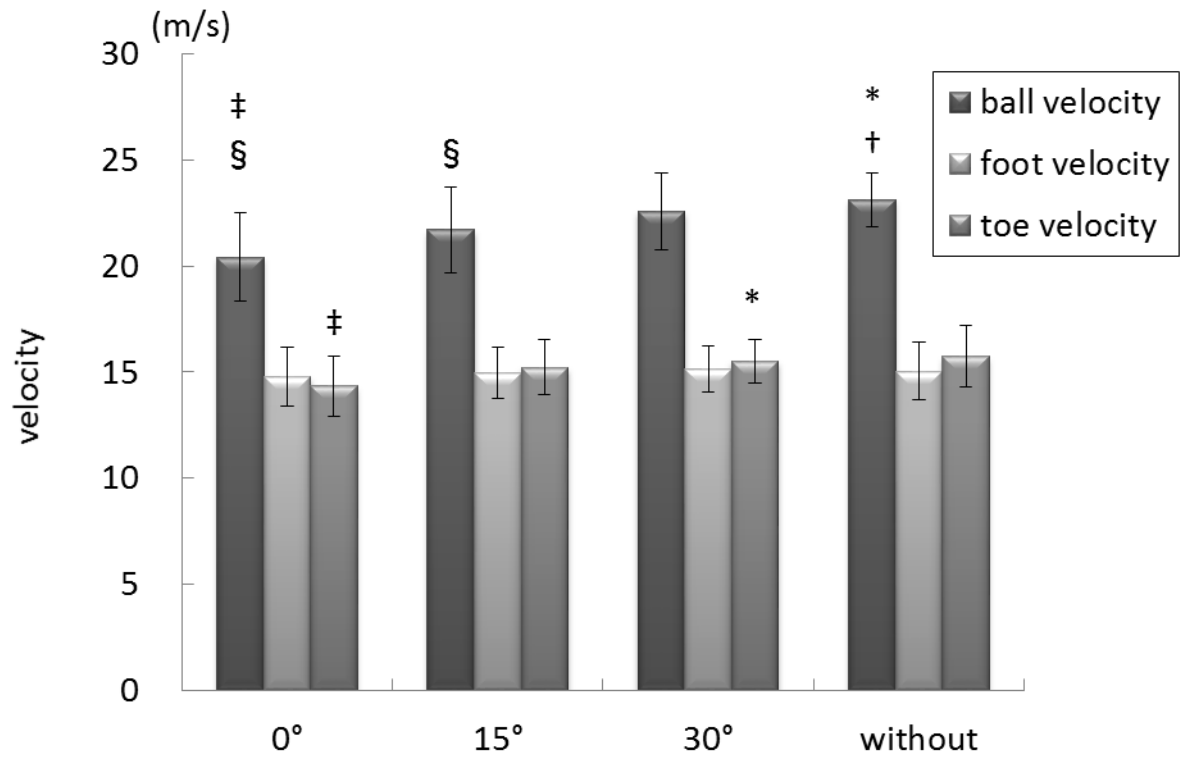


**Figure 4. The difference of angle of ankle plantar flexion among various taping conditions**

0°: 0° taping; 15°: 15° taping; 30°: 30° taping; without: without taping.

Passive ROM: passive ankle plantar flexion ROM; impact: maximal plantar flexion angle on ball impact.

\* versus 0°; † versus 15°; ‡ versus 30°; § versus without (P < .05).



**Figure 5. The difference of ball, foot and toe velocity among various taping conditions**

0°: 0° taping; 15°: 15° taping; 30°: 30° taping; without: without taping.

\* versus 0°; ‡ versus 30°; § versus without ( $P < .05$ ).

## Tables

**Table 1. Subject Characteristics, Mean  $\pm$  SD**

<b>Age (y)</b>	<b>Height (cm)</b>	<b>Weight (kg)</b>	<b>Career (y)</b>
<b>20.8<math>\pm</math>1.1</b>	<b>175.0<math>\pm</math>4.0</b>	<b>67.2<math>\pm</math>4.9</b>	<b>10.1<math>\pm</math>3.0</b>

**Table 2. Summary of correlation coefficients between ball velocity and foot velocity, ball velocity and toe velocity**

	<b>Ball - Foot</b>		<b>Ball - Toe</b>	
	<b>r</b>	<b>P value</b>	<b>r</b>	<b>P value</b>
<b>0°</b>	<b>0.705*</b>	<b>.015</b>	<b>0.863**</b>	<b>.001</b>
<b>15°</b>	<b>0.842**</b>	<b>.001</b>	<b>0.835**</b>	<b>.001</b>
<b>30°</b>	<b>0.587</b>	<b>.057</b>	<b>0.732*</b>	<b>.010</b>
<b>without</b>	<b>0.546</b>	<b>.082</b>	<b>0.685*</b>	<b>.020</b>

Ball-Foot: Correlation between ball velocity and foot velocity; Ball-Toe: Correlation between ball velocity and toe velocity. \*:  $P < .05$ ; \*\*:  $P < .01$ .