THE INFLUENCE OF ANKLE SPRAINS ON PROPRIOCEPTION

Ya-Wen Liu[1], Shiow-Chyn Jeng[2], Alex J. Y. Lee[3]

[1]*Yu-Da College of Business, Miaoli, TAIWAN*

[2] *Vanung University, Tao-Yuan, TAIWAN*

[3] *National Taipei College of Nursing, Taipei, TAIWAN*

Ankle sprain is the most common and frequent injury in sports. The current study used the BIODEX System III isokinetic dynamometer to assess if ankle injury would impair proprioception. The ankles of 16 college-aged male subjects were tested: eight subjects with unilateral functional instability ankle sprain symptoms (FI), and eight with bilateral non-injury healthy ankle (NH). The BIODEX System III dynamometer was used to assess ankle proprioception function in both active and passive reposition sense. Results showed that the passive and active ankle reposition senses in the FI group were lower than those in the NH group. Such findings suggest that rehabilitation programs for sprained ankles should include proprioception training, especially in restoring passive reposition sense.

Keywords: rehabilitation, sports injury, static balance

Introduction

Injuries to the lateral ligament complex ankle through sprains are most frequent from sport and exercise, especially from basketball, soccer, badminton, and volleyball (Payne et al. 1997). Among all the basketball related sports injuries, almost 35% were injuries sustained around the ankle and foot. Furthermore, Arnason et al. (1996) reported that 34.8 injury cases happened for every 1,000 hours of soccer. That study also showed that the most frequent injury was joint sprain, and that almost 68.4% of sprain injuries were ankle sprains. Morbidity associated with these injuries accounts for the greatest loss of time to training programs and competition.

Corresponding Author
Alex, J. Y. Lee, Department of Exercise and Health Science, National Taipei College of Nursing, 11257, No.365, Min Te Rd., Taipei, Taiwan
Email: jylee@ydu.edu.tw

Proprioception can be defined as the conscious awareness of limb position and movement, and is a specialized variation of the sensory modality that encompasses the sensation of joint movement (kinesthesia) and joint position (joint position sense) (Lephart et al. 1992). Proprioception is generally defined as the ability to assess a respective limb's position without the assistance of vision. Proprioception is governed by central and peripheral mechanisms that come mainly from muscular receptors, but also includes tendinous, articular and cutaneous receptors. The respective roles of these various sources of afferent information have been debated, but it is now recognized that muscular receptors have the most important part in the elaboration of limb proprioception (Bouet & Gahery 2000). This role for muscular receptors indicated that modifying the functional state of the muscles could affect the precision of position sense.

Ankle instability is estimated to affect up to 50% of those who sustain an acute injury to the lateral collateral ligaments, and might persist as a chronic condition long after the signs and symptoms of the original injury have subsided (Wilkerson & Nitz 1994; Freeman 1965). Impaired proprioception (Robbins & Waked 1998; Ryan 1994), muscle weakness, subtalar instability (Tropp 1986), and ligamentous laxity (Wilkerson & Nitz 1994) have been identified as contributing factors to chronic instability, but the primary mechanism underlying post-sprain dysfunction remains obscure.

To assess the effects of injury on proprioception, most studies examined the difference between pre- and post-operation on anterior cruciate ligament deficient knee, reconstructed knee, and on the shoulder joint, but few studies have tested the effects on the ankle joint. According to limited tests on ankle proprioception, investigators have placed subjects' ankles in various predetermined angles and asked them to reproduce their remembered perception of the angles, mostly in passive movement. This study purposefully examined total active and passive reposition sense, for a detailed understanding of ankle proprioception. Furthermore, ankle injury is common for college students who participate in exercise and sport. However, most of the cases found were neglected and not treated properly. In order to highlight the effects of ankle injury on proprioception function and to provide a practical message, another purpose of this study was to examine the influences of ankle injury on proprioception.

Method

Subjects

Subjects were healthy male college students, and informed consent was obtained from each subject prior to his taking part in the study. The ankles of 16 subjects were tested: eight in the functional instability (FI) group and eight non-injured (NI) subjects in the control group. To be classified as FI, the subjects needed to satisfy the following criteria: they experienced at least one significant lateral-inversion ankle sprain of either the right or left ankle but not both, and the subject was unable to bear weight or was placed on crutches within the last year; there was no reported history of fracture to either ankle; subjects sustained at least one repeated injury or the experience of feeling of instability or "giving way" in either the right or left ankle but not both; the subject was not undergoing any formal or informal rehabilitation of the unstable ankle; and that there was no evidence of mechanical instability, as assessed by a physician using an anterior drawer test (Kaminski et al. 1999). At the time of the study, subjects were pain free and their ankles were full weight-bearing and without a limp.

Proprioception evaluation

Proprioception was defined as the ability to match reference joint angles without visual feedback (Payne et al. 1997). The Biodex System III isokinetic dynamometer (Biodex Medical System, Inc., New York) was used to assess ankle joint active and passive position sense. The subjects were positioned supine on a modified examination table with the lower leg parallel to the floor. This arrangement enabled proper placement of the subject's bare foot into the Biodex ankle inversion/eversion apparatus with the ankle plantar flexed 25°. After the subject's foot was properly aligned with the axis of the isokinetic dynamometer, according to the manufacturer's guidelines, straps were placed around the proximal tibiofibular joint and forefoot to provide stabilization. Subjects were required to close their eyes and wear an eyeshade during the testing procedures to eliminate visual feedback (Payne et al. 1997; Lentell et al. 1995).

Active and passive joint repositioning occurred at the following three test positions: 10° eversion, 0° subtalar neutral, and 15° eversion from maximum inversion. Subtalar neutral served as the 0° neutral position. These positions were individually determined by palpating for equal distribution of the head of the talus bone medially and laterally, while passively inverting and everting the foot (Szczerba et al. 1995). These positions were visually displayed in volts by the internal goniometer of the Biodex System III Dynamometer and exported by BioPac System MP150 to Acqknowledge, Ver. 3.7.1.

Prior to being tested, each subject received a practice session, followed by a 30-second rest period. The testing began by the investigator passively moving the subject's foot through its entire inversion and eversion range of motion. The foot was then passively moved into the preselected test position where it was held for 15 seconds. Once at the test position, the subjects concentrated on the test angle. The foot was then passively moved back to the starting position, which was the end range of maximal inversion for the 0° subtalar neutral and 10° eversion test positions, and the end range of maximal eversion for the 15° inversion from maximum inversion test positions.

While testing passive ankle joint reposition, the Biodex System III was set to move at 2°/s from maximum inversion to eversion (Lephart et al. 1996). The subjects were requested to use a hand-held switch to make a trigger signal when they reached the pre-selected position. The signal was immediately exported to Acqknowledge software and the voltage was recorded and calculated to actual angular variation. The active ankle joint reposition test was performed at 500°/s, to avoid additional resistance in the Biodex System III isokinetic dynameters. Subjects used a hand-held switch to trigger and send to the Acqknowledge software. Joint position sense measurements were recorded in degrees of error from the test position. Three trials were performed for each sequence. The absolute values of each error score were then averaged together and recorded for analyses.

Results

In order to clarify the diversity between left (LA) and right ankle (RA) and examine the possible differences between normal health (NH) and FI ankle, and an analysis of variance was performed in passive and active reposition. The Figure shows that subjects with frequent ankle sprains (FAS) demonstrated significantly lower passive reposition sense than subjects with the healthy ankle (HA), and the LA and RA in NH subjects ($p < 0.05$). Furthermore, the active reposition sense was significantly lower in FAS ankle than LA or RA in NH subjects ($p < 0.05$).

Discussion

Freeman (1965) first introduced the concept of FI to describe the feeling of "giving way", which was a symptom many of his patients experienced after an initial ankle sprain. A study conducted by Friden et al. (1989) found that healthy subjects have no significant differences between left and right leg in mean center of pressure (COP) distribution, mean sway amplitude and the number of sway movements exceeding 5 mm. The researchers also found that the injured patients had no significant differences between left and right leg in mean COP distribution and mean sway amplitude, but the number of sway movements exceeding 5 mm showed significant differences compared to both the uninjured side and the healthy subjects.

Isakov et al. (1986) showed that the peroneal latency times in healthy subjects were 69.3 ± 6.4 and 67.0 ±

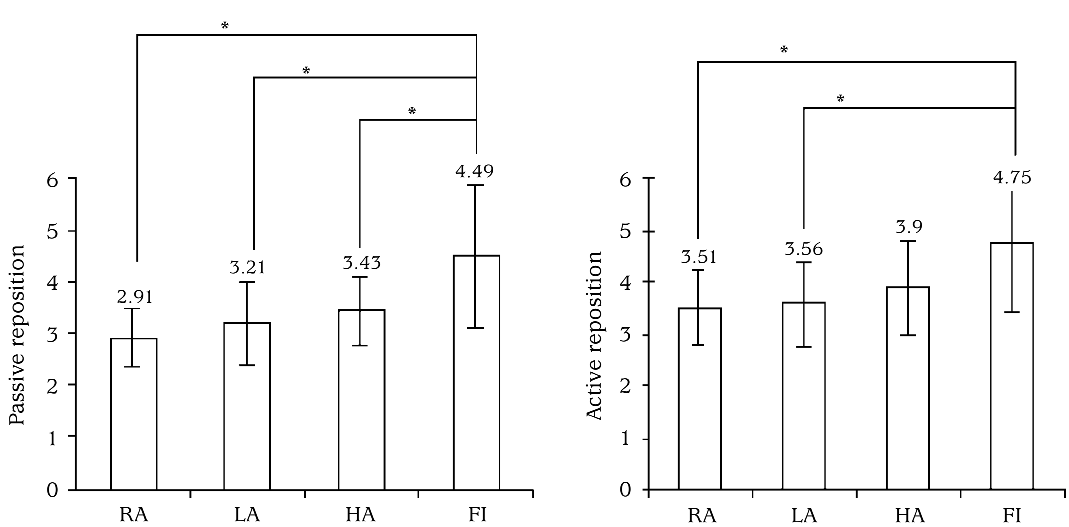

Fig. Results of passive reposition and active reposition in functional instability ankle (FI) and healthy ankle (HA) of FI group, and right ankle (RA) and left ankle (LA) of normal health (NH) subject group.

* $p < 0.05$.

5.4 ms in the LA and RA respectively, and 70.2 ± 7.4 and 68.3 ± 6.5 ms in the sprained and sound ankle, respectively. The investigators concluded that the differences between affected and uninjured ankles were not significant. However, Konradsen & Rave (1991) indicated that subjects with FI showed increased postural sway and peroneal reaction time. Bernier et al. (1997) also questioned if individuals with unilateral FI had a decreased ability of maintaining postural sway. Results showed that no significant differences were found in single-limb postural sway measure. However, there were significant differences in inversion peak torque between the dominant and non-dominant limbs of NI subjects. Another study conducted by Isakov and Mizrahi (1997) showed that foot/ground reaction forces in both anteroposterior and mediolateral directions were similar in normal and sprained ankles of each subject while standing with either open or closed eyes. Standing with closed eyes, however, irrespective of the ankle status, produced significantly higher reaction forces than those obtained with open eyes. It was concluded that the amount of postural sway during single leg standing is similar in the chronically sprained and the uninjured ankle joint.

It has been suggested that poor postural control diminished position sense and delayed postural reflexes (Konradsen & Rave 1991; Friden et al. 1989), and might contribute to risk of re-injury following a lateral ankle injury. This study showed that there were no differences in active and/or passive reposition sense between LA and RA in NH subjects. However, significant differences were found in the passive reposition sense between a FAS ankle and normal HA (left or right). This finding supported the earlier work by Garn and Newton (1988), which found a diminished awareness of passive motion sense into plantar flexion associated with multiple sprains of the ankle. It also demonstrated decreases in passive movement sense in those with a FI ankle, supporting the theory that FI was induced by a proprioceptive reflex defect (Konradsen & Rave 1991). Lentell et al. (1995) found significantly greater amount of motion and talar tilt for the FAS ankle, compared with HA. They also concluded that deficits in passive movement sense and anatomic stability were greater concerns than strength deficits when managing the ankle with FI. Several studies have to be conducted to compare conscious ankle proprioception between normal and pathologic groups. Although some investigators found deficits (Lentell et al. 1995; Garn & Newton 1988), others did not (Gross 1987). Possible explanations for the different results included the different instrument used in each study (self designed, custom-made, commercial dynamometers, etc.), inherent instrumentation differences (e.g. position of the patient with respect to gravity), and varying methodological approaches (e.g. angular position or speed of passive movements). This study was the first to utilize the modified BIODEX System III dynamometer to measure the active and passive proprioception in the ankle joint. A unique feature of this device is its ability to conduct assessment at very slow speeds (2°/s) and at very high speeds (500°/s) during passive and active reposition test. Slow speeds are used to target the slow-adapting mechanoreceptors, such as Ruffini endings or Golgi-type organs (Lephart et al. 1992). High speeds allow subjects to have free, unrestricted movement, unlike in other studies with a fixed speed only.

This study provided a precise and practical protocol to examine the influence of ankle sprains on proprioception. Once deficits and protocols are identified, investigators can utilize this setting to examine the efficacy and effects of some specific management strategies and rehabilitation programs in restoring ankle proprioception.

Furthermore, to our knowledge, this is the first study to measure the proprioception of ankle joint with a BIODEX III dynamometer. There was no report to verify the dynamometer in proprioception testing. The test positions chosen for this study were the most commonly assessed from previous studies (Lin et al. 2004; Lee et al. 2003), and also had the higher intraclass correlation coefficients (ICC) of another study conducted with a Kin-Com II dynamometer (Szczerba et al. 1995). This study used the same procedures to verify the inter-tester reliability of active and passive ankle joint reposition sense on BIODEX measurements, and revealed that both active and passive protocols yielded moderate to good inter-tester reliability (Lee 2004, ICC ranged from 0.85 ~ 0.92). The methods in this study provided a reliable assessment of ankle joint active and passive reposition sense.

Proprioception has traditionally been assessed in two ways. Kinesthesia, the perception of joint movement, has been measured via the threshold to the detection of passive motion method. Joint position sense, on the other hand, has been documented as an individual's ability to reproduce a predetermined joint angle either actively or passively. Szczerba et al. (1995) recruited 20 healthy subjects and randomly selected the ankle to test the active and passive joint position sense.

The degrees of error for passive/active were 6.11 ± 4.52/6.30 ± 4.68, 5.94 ± 4.86/6.03 ± 4.45, 7.30 ± 6.04 /6.71 ± 4.50 at 15° inversion, 0° neutral, and 10° inversion, respectively. Lentell et al. (1995) recruited 42 unilateral, chronic ankle instability recreational basketball athletes using specifically designed equipment to measure the inversion passive movement sense. The results showed that there were significant differences in the involved (4.3 ± 3.1°) and uninvolved (3.2 ± 1.8°) ankles. Payne et al. (1997) tested 31 female and 11 male college basketball players' inversion/eversion ankle joint positions with the ELGON on the Biodex. Results showed that the passive inversion/eversion absolute error degrees of women in LA and RA were 2.7 ± 3.8° – 2.8 ± 2.7° and 2.7 ± 2.4° – 2.7 ± 2.8°. However, the inversion/eversion absolute error degrees of men in LA and RA were 0.9 ± 1.2° – 5.0 ± 2.6° and 2.1 ± 1.8° – 5.4 ± 2.6°.

Previous studies citing FI subjects came up with poor proprioception and poor balance control ability (Brunt et al 1992; Tropp et al. 1985; Tropp et al. 1984; Freeman 1965), but Gross (1987) reported no differences in passive and active task on both FI and NH subjects. This study showed that there were no significant differences on ankle active reposition sense between NH subjects' stable ankles, but FI subjects demonstrated significantly poorer proprioception than HA.

In summary, this study showed than the ankle injury would significantly impair ankle proprioception. In view of the high prevalence of ankle injury, clinicians should continue to rehabilitate sprained ankles with strength and proprioceptive exercise (McKnight & Armstrong 1997). Noting that there are intrinsic and mechanical variations between active and passive proprioception, further studies are needed to clarify if ankle proprioception sense will improve or be influenced by specific training or rehabilitation sessions. These sessions may benefit the population by providing improved ankle injury prevention and better balance control.

Acknowledgement

This study was partially supported by the National Science Committee (Taiwan) Research Grant 93–2413–H–412–001.

References

Arnason A, Gudmundsson A, Dahl HA, Johannsson E (1996). Soccer injuries in Iceland. *Scand J Med Sci Sports* 6:40–5.

Bernier JN, Perrin DH, Rijke A (1997). Effect of unilateral functional instability of the ankle on postural sway and inversion and eversion strength. *J Athl Train* 32:226–32.

Bouet V, Gahery Y (2000). Muscular exercise improves knee position sense in humans. *Neurosci Lett* 289:143–6.

Brunt D, Andersen JC, Huntsman B, Reinhert LB, Thorel AC, Sterling J (1992). Postural responses to lateral perturbation in healthy subjects and ankle sprain patients. *Med Sci Sports Exerc* 24:171–6.

Freeman MAR (1965). Instability of the foot after injuries to the lateral ligament of the ankle. *J Bone Joint Surg* 47:678–85.

Friden T, Zatterstrom R, Lindstrand A, Moritz U (1989). A stabilomertric technique for evaluation of lower limb instabilities. *Am J Sports Med* 17:118–22.

Garn S, Newton R (1988). Kinesthetic awareness in subjects with multiple ankle sprains. *Phys Ther* 68:1667–71.

Gross MT (1987). Effects of recurrent lateral ankle sprains on active and passive judgments of joint position. *Phys Ther* 67: 1505–9.

Isakov E, Mizrahi J (1997). Is balance impaired by recurrent sprained ankle? *Br J Sports Med* 31:65–7.

Isakov E, Mizrahi J, Solzi P, Susak Z, Lotem M (1986). Response of the peroneal muscles to sudden inversion of the ankle during standing. *Int J Sport Biomech* 2:100–9.

Kaminski TW, Perrin DH, Gansneder BM (1999). Eversion strength analysis of uninjuried and functionally unstable ankles. *J Athl Train* 34:239–45.

Konradsen L, Rave JB (1991) Prolonged peroneal reaction time in ankle instability. *Int J Sports Med* 12:290–2.

Lee A JY (2004). The reliability and difference of ankle proprioception on BIODEX III. *Yu Da Academic Journal* 8:229–40.

Lee A JY, Lin WH, Huang CH (2003). The comparison of proprioception and static balance performance on ankle instability and normal subjects. *Med Sci Sports Exerc* 35:S357.

Lentell GL, Baas B, Lopez D, McGuire L, Sarrels M, Snyder P (1995). The contributions of proprioceptive deficits, muscle function, and anatomic laxity to functional instability of the ankle. *J Orthop Sports Phys Ther* 21:206–15.

Lephart SM, Giraldo JL, Borsa PA (1996). Knee joint proprioception: a comparison between female intercollegiate gymnasts and controls. *Knee Surg Sports Traumatol Arthrosc* 4:121–4.

Lephart SM, Kocher MS, Fu FH, Borsa PA, Harner CD (1992). Proprioception following anterior cruciate ligament reconstruction. *J Sport Rehabil* 1:188–96.

Lin WH, Lee Alex JY, Huang CH (2004). The effects of tennis and badminton exercise training on ankle proprioception. *Med Sci Sports Exerc* 36:S186.

McKnight CM, Armstrong CW (1997). The role of ankle strength in functional ankle instability. *J Sport Rehabil* 6:21–9.

Payne KA, Berg K, Latin RW (1997). Ankle injuries and ankle strength, flexibility, and proprioception in college basketball players. *J Athl Train* 32:221–5.

Robbins SE, Waked E (1998). Factors associated with ankle injuries: preventative measures. *Sports Med* 25:63–72.

Ryan L (1994). Mechanical instability, muscle strength and proprioception in the functionally unstable ankle. *Aust J Sci Med Sport* 37:211–7.

Szczerba JE, Bernier JN, Perrin DH, Gansneder BM (1995). Intertester reliability of active and passive ankle joint position sense training. *J Sport Rehabil* 4:282–91.

Tropp H (1986). Pronator muscle weakness in functional instability of the ankle joint. *Int J Sports Med* 22:601–5.

Tropp H, Ekstrand J, Gillquist J (1984). Stabilometry in functional instability of the ankle and its value in predicting injury. *Med Sci Sports Exerc* 16:64–6.

Tropp H, Odenrick P, Gillquist J (1985). Stabilometry recordings in functional and mechanical instability of the ankle joint. *Int J Sports Med* 6:180–2.

Wilkerson GB, Nitz AJ (1994). Dynamic ankle stability: mechanical and neuromuscular interrelationships. *J Sport Rehabil* 3:43–57.