Comparison of Hallux Valgus Angle Deformity in Korean Basketball and Non-basketball Players

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This study compared the range of hallux valgus angle (HVA) deformity between basketball players and same aged non-basketball players as controls. The participants included 21 basketball players (9 males, 12 females, mean age 18 years) and 36 age-matched college students (19 males, 17 females, mean age 20 years) who served as controls. After direct palpation of the first metatarsal and proximal phalange, we measured the HVA deformity using a photographic approach in the women basketball players and a goniometer for the men basketball players and all controls. The HVA was greater in basketball players than in the controls. Among female basketball players, the HVA was significantly greater in guards compared with forwards and centers.

In conclusion, playing basketball may increase the HVA. The greater increase in HVA among guards might arise because they are required to make diagonal and horizontal movements that increase the burden on the foot. In general insole or ergonomic shoes could reduce pain, improved walking ability, and hallux valgus angle for prophylactic or therapeutic approaches. Therefore, an appropriate preventive interventional program should be developed.

Keywords: hallux valgus angle, basketball players, physical therapeutic intervention

1. Introduction

Hallux valgus is one of the most common foot deformities in adults. About half the population has HVA deformities in juvenile women of United Kingdom, with a greater frequency in women (Lazarides et al., 2005). The prevalence of hallux valgus is described to increase with age with a figure of between 12% and 56% of those aged over 65 years in Western populations. In Korean, moreover, prevalence of hallux valgus presented 65% in rural Korean population aged between 40 and 69 years (Cho et al., 2009). Estimates of the community prevalence of hallux valgus range from 21 to 70% on foot pain and disability in women (Roddy et al., 2007). Hallux valgus is defined as a complex progressive deformity affecting the forefoot in which lateral deviation of the great toe is the most obvious feature (Thomas and Barrington, 2003). It is a deformity of the first metatarsophalangeal (MTP) joint, and is accompanied by possible callus, bursa, or bunion formation over the bony prominence. The deformity is characterized by progressive subluxation of the first MTP joint (Pique-Vidal et al., 2007). In most cases, a surgical procedure, such as the Lindyren, Turen, or Chevron procedure, is used for intervention (Saro et al., 2007).

The etiology of hallux valgus is complex and multifactorial. It may be affected by improper footwear, abnormalities in foot anatomy and foot biomechanics, limb inequality, occupational hazards, inflammatory joint diseases, and/or genetic and neuromuscular factors (Pique-Vidal et al., 2007). Numerous factors have been implicated in the etiology of the condition, including muscle imbalance, inherited structural variation in the alignment of the
metatarsals, flatfoot, and ill-fitting footwear (Menz and Munteanu, 2005). Flatfoot is a progressive acquired or developmental deformity that represents flattening of the medial arch. Flatfoot is so frequent deformity in the childhood, it may be a basis for numerous painful deformities in the adulthood (Kellermann et al., 2011).

The normal plantar pressure distribution is 17% on the 1st MTP, 13% on the 5th MTP, and 20% on the heel at each side of the foot in standing posture (Neumann, 2002). Zhu et al. (1995) reported that pressure distribution was increased a 60% followed by walking cadence (120 step/min) on 1st and 5th metatarsal bone, respectively. If a toe is absent or injured, the weight distribution can be altered. Almost twice the usual weight burden is distributed on 2nd to 4th metatarsal heads and the transverse arch of the foot, which is normally a non-weight bearing area, leading to fallen arches. Mid-stance phase well known a single leg weight bearing stage. It means that plantar pressure increased almost twice as compared with static stance posture. Interestingly, previous study elucidated that the highest plantar pressure recorded on 2nd and 3rd metatarsal heads and the transverse arch (Vanore et al., 2003). Thereby, they demonstrated that the forefoot does not behave like tripod (Kanatli et al., 2003).

The inter-metatarsal angle (IMA) and HVA should be measured to diagnose hallux valgus deformity. Hallux valgus is present when HVA > 15° and IMA > 9° (Lazarides et al., 2005). However, hallux valgus is also considered to be present when the angle formed between the longitudinal bisections of the first metatarsal and the proximal phalanx (often referred to as the hallux abductus angle) exceeds 15° (Lazarides et al., 2005). Hallux valgus is divided into three stages: stage 1, HVA < 25° and IMA < 12°; stage 2, HVA > 25° and IMA > 16°; and stage 3, HVA > 35° and IMA > 16° (Vanore et al., 2003).

Hallux valgus hampers mobility and doubles the risk of falls and fractures in the elderly (Gorter et al., 2000). Foot dysfunction in younger individuals might reduce worker productivity and increase the risk of injury, which may decrease the quality of life (Gorter et al., 2001). Hallux valgus is also associated with poor balance, immobility, and the risk of falling (Menz and Lord, 2001). Greater loads on the lateral metatarsal heads, which may lead to metatarsalgia, have been demonstrated in patients with hallux valgus. The load on the hallux appears to decrease with an increased HVA (Saro et al., 2007).

The current study examined the association between the HVA deforming force and playing basketball. Most research on hallux valgus has examined dancers, especially women (Shybut et al., 2008). Especially, hallux valgus patient showed that the fibular sesamoid bone become higher than the head of the first metatarsal when the angle of the hallux valgus exceeded 25° through axial radiographic evaluation (Suzuki et al., 2004). Research about rugby league in New Zealand found a foot shape and plantar load distribution in elite athletes of three different ethnicities (Gurney et al., 2009). Thereby, they suggest that footwear design needed to consideration followed by ethnicity.

Turf toe injury is occurring with increasing frequency at all levels of competition. Rodeo et al. (1990) attempted to quantify the incidence of turf toe injury by surveying 80 active players in the National Football League (NFL). They found that 45% of players had experienced a significant turf toe injury, with 83% of these occurring on artificial turf. Diagnosis of turf toe injury starts with a heightened index of suspicion in a patient presenting with hallux MTP pain and swelling following an acute incident. In addition to the mechanism of axial load, the patient may report decreased push-off strength and inability to participate in cutting activities (Rodeo et al., 1990). It is important to determine the mechanism of injury because many of these injuries are not solely the result of hyperextension but rather are the result of a degree of valgus stress. Such a force may create a more medially based soft-tissue injury pattern and put the athlete at risk of progressive hallux valgus (Anderson et al., 2010). However, we hypothesized that basketball players might be affected because they must make rapid horizontal and diagonal moves, which increases the plantar pressure on the hallux. This might affect the performance of basketball players and shorten their careers. To determine whether playing basketball increases the HVA, we compared this angle in basketball players and controls of the same age.

Surgical procedures such as the Chevron, Lindyren, and Turen distal procedures are the most common interventions for hallux valgus (Saro et al., 2007). However, there are several problems with these approaches, including the cost of surgery and the 12 months required for recovery after surgery (Saro et al., 2007). Surgery also alters the distribution of the load on the foot, which may affect
balance and the base of support.

Nonoperative care is always the first treatment option for hallux valgus deformity. Generally, commercial toe separators are available that can be placed between the first and second toes (Coughlin, 1997). However, there is not able to control of toe external rotation. Previous study suggested that new foot-toe orthosis is an effective alternative treatment for painful hallux valgus patient through control of external rotation of first toe (Tang et al., 2002). Other approach uses functional electrical stimulation (FES) to strengthen the abductor hallux and facilitate voluntary adduction of the hallux, which is limited in many cases and increases the deforming force (Song, 2007).

2. Methods

2.1. Participants

Our study included an experimental group consisting of 9 male and 12 female basketball players with a mean age of 18 years old registered in the Korean Basketball Association as minor league players, and non basketball players as a control group of 19 men and 17 women with a mean age of 20 years old from the department of Physical Therapy, Inje University, Korea. For the control group, we selected participants who did not have exercise regularly. Characteristics of participants are summarized in Tables 1 and 2.

2.2. Measurement of hallux valgus angle

We used two methods to measure the HVA. In one approach, the subjects stood on a platform and were instructed to walk in place for a few steps and then stand in a relaxed position (Menz and Munteanu, 2005). Thereafter we measured the HVA using a goniometer after palpating the first metatarsal and proximal phalange. The axis was placed on the first MTP joint (Neumann, 2002). The HVA of all members of the control group and of the male basketball players was determined using this method. For the women basketball players, we used a photographic approach. The feet of the basketball players were photographed after following the same procedure as in the manual approach. We then drew lines on the photographs along the longitudinal axes of the first metatarsal and proximal phalanx, as shown in Figure 1. All of the measurements were made by the same examiner.

Table 1 General characteristics of control group

<table>
<thead>
<tr>
<th></th>
<th>Age (years)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>20±1</td>
<td>175.6±3.7</td>
<td>69.4±6.9</td>
</tr>
<tr>
<td>Female</td>
<td>162.0±4.6</td>
<td>52.6±3.6</td>
<td></td>
</tr>
</tbody>
</table>

Table 2 General characteristics of basketball players

<table>
<thead>
<tr>
<th></th>
<th>Age (years)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>18±1</td>
<td>184.1±4.6</td>
<td>75.8±7.8</td>
</tr>
<tr>
<td>Female</td>
<td>176.2±5.1</td>
<td>65.3±4.8</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1 Clinical measurements made under standardized weight-bearing conditions. (A) The axis of the first metatarsal is marked by a line connecting the center of its head with the center of its base. (B) Autoradiograph demonstrating hallux valgus. The axis of the proximal phalanx is marked by a line from the center of its proximal articular surface to the center of the distal end of its diaphysis. The HVA is illustrated.
2.3. Statistical analysis

SPSS for Windows ver. 19.0 (IBM, New York, NY, USA) was used to analyze the data. All results are given as the mean ± SD. The HVA of the controls and the basketball players was compared using an independent $t$-test. One-way analysis of variance (ANOVA) was used to compare the mean HVA of the female basketball players, taking into consideration their playing positions. Where the ANOVA revealed a significant $F$ ratio, differences were inspected with the least significant difference (LSD) post hoc test. The HVA of male basketball players were compared using the independent $t$-test, also taking into account their playing positions. The significance level was $p<0.05$.

3. Results

There was a significant difference in the right HVA of both males and females between the basketball players and controls. Among males, the mean right HVA was $11.26±3.856 ^\circ$ in the controls and $21.22±5.890 ^\circ$ in the basketball players ($p=0.000$; Table 3). For females, the respective values were $11.59±2.210 ^\circ$ and $21.08±4.999 ^\circ$ ($p=0.000$; Table 4). For both male and female basketball players, the right HVA corresponded to mild hallux valgus (Vanore et al., 2003).

The left HVA was also significantly increased in both male and female basketball players (Table 4). In males, the mean value was $14.21±3.521 ^\circ$ in the controls and $18.56±7.367 ^\circ$ in basketball players ($p=0.042$). In females, the respective values were $10.29±2.544 ^\circ$ and $17.83±5.167 ^\circ$ ($p=0.000$). Again, both male and female basketball players had mild hallux valgus, in which the HVA ranges be-

Table 3 Comparison of the right HVA between basketball players and controls

<table>
<thead>
<tr>
<th>Gender</th>
<th>Group</th>
<th>Mean ± SD</th>
<th>$t$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>Controls (n = 19)</td>
<td>$14.21±3.521 ^\circ$</td>
<td>6.355</td>
<td>0.042</td>
</tr>
<tr>
<td></td>
<td>Basketball players (n = 9)</td>
<td>$21.22±5.890 ^\circ$</td>
<td>9.356</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Females Controls (n = 17) | $10.29±2.544 ^\circ$ | 6.964  | 0.000   |
| Basketball players (n = 12) | $17.83±5.167 ^\circ$ | 5.213  | 0.000   |

Data are the mean ± SD

Table 4 Comparison of the left HVA between basketball players and controls

<table>
<thead>
<tr>
<th>Gender</th>
<th>Group</th>
<th>Mean ± SD</th>
<th>$t$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>Controls (n = 19)</td>
<td>$23.33±5.774 ^\circ$</td>
<td>3.355</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Basketball players (n = 9)</td>
<td>$19.00±8.631 ^\circ$</td>
<td>5.555</td>
<td>0.958</td>
</tr>
</tbody>
</table>

Females Controls (n = 17) | $19.93±6.549 ^\circ$ | 3.181  | 0.008   |
| Basketball players (n = 12) | $21.34±8.567 ^\circ$ | 5.213  | 0.000   |

Data are the mean ± SD

Table 5 HVA according to the position of male basketball players

<table>
<thead>
<tr>
<th>Position</th>
<th>Height</th>
<th>Mean ± SD</th>
<th>$t$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right HVA</td>
<td>Forward (n = 3)</td>
<td>$185.67±2.887 ^\circ$</td>
<td>23.33±5.774</td>
<td>0.655</td>
</tr>
<tr>
<td></td>
<td>Guard (n = 5)</td>
<td>$180.80±4.775 ^\circ$</td>
<td>20.20±6.907</td>
<td>0.055</td>
</tr>
</tbody>
</table>

Left HVA Forward (n = 3) | $185.67±2.887 ^\circ$ | 19.93±7.506 | 0.055  | 0.958   |
| Guard (n = 5) | $180.80±4.775 ^\circ$ | 19.00±8.631 | 0.055  | 0.958   |

Data are the mean ± SD

Table 6 HVA according to the position of female basketball players

<table>
<thead>
<tr>
<th>Position</th>
<th>Height</th>
<th>Mean ± SD</th>
<th>$F$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right HVA</td>
<td>Forward (n = 6)</td>
<td>$175.50±4.324 ^\circ$</td>
<td>19.83±5.419</td>
<td>2.148</td>
</tr>
<tr>
<td></td>
<td>Guard (n = 4)</td>
<td>$173.50±4.359 ^\circ$</td>
<td>24.75±2.217</td>
<td>0.008</td>
</tr>
<tr>
<td></td>
<td>Center (n = 2)</td>
<td>$183.50±0.707 ^\circ$</td>
<td>17.50±4.950</td>
<td>8.671</td>
</tr>
</tbody>
</table>

Left HVA Forward (n = 6) | $175.50±4.324 ^\circ$ | 14.83±3.189 | 14.83±3.189 | 17.50±4.950 | 8.671  | 0.008   |
| Guard (n = 4) | $173.50±4.359 ^\circ$ | 23.50±1.732 | 17.50±6.364 | 15.50±6.364 | 8.671  | 0.008   |

Data are the mean ± SD
Table 7  Right HVA according to the height of basketball players

<table>
<thead>
<tr>
<th>Height (Mean ± SD)</th>
<th>Mean ±SD</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>176.00 ± 2.828 (n = 2)</td>
<td>23.00 ± 9.899</td>
<td>0.460</td>
<td>0.660</td>
</tr>
<tr>
<td>186.43 ± 5.345 (n = 9)</td>
<td>20.71 ± 5.345</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>173.38 ± 3.583 (n = 8)</td>
<td>23.63 ± 3.502</td>
<td>3.596</td>
<td>0.005**</td>
</tr>
<tr>
<td>181.75 ± 2.062 (n = 4)</td>
<td>16.00 ± 3.366</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data are the mean ± SD

between 15° and 25° (Vanore et al., 2003).

We compared the HVA according to team position for both male and female basketball players. In males, we found no significant differences among player positions (Table 5); there were too few centers to enable their comparison with the other positions.

Among female basketball players, the left HVA differed significantly between guards and forwards ($p = 0.003$) and between guards and centers ($p = 0.022$), while there was no difference between forwards and centers (Table 6).

When compared to the difference of right HVA according to the height of basketball players, we found significant differences the right HVA below 179 cm and more than 180 cm in women ($p = 0.005$) (Table 7).

4. Discussion

The central feature of hallux valgus is a progressive lateral deviation of the first toe. Although the deformity appears to involve primarily the metatarsophalangeal joint, hallux valgus is associated with excessive adduction of the first metatarsal about its tarsometatarsal joint. This is often referred to in the medical literature as “metatarsus primus varus” (Faber et al., 1999). The adducted position of the metatarsal bone eventually collapses the proximal phalanx into excessive abduction, thereby exposing the metatarsal head as a bunion. If the metatarsophalangeal joint assumes and abducted position in excess of 30 degrees, the proximal phalanx often begins to evert, or to rotate about its long axis. The bunion deformity is also referred to as “hallux abducto-valgus” in order to account for the deviation in both horizontal and frontal planes (Richardson, 1992). The progressive axial rotation of the abducted proximal phalanx creates a muscular imbalance in the forces that normally align the metatarsophalangeal joint. The abductor hallucis muscle shift toward the plantar aspect of the first metatarsophalangeal joint. The unopposed pull of the abductor hallucis and lateral head of the flexor hallucis brevis progressively increases the lateral deviation posture of the proximal phalanx. In time, the overstretched medial collateral ligament and capsule may weaken or rupture, removing an important source of reinforcement to the medial side of the joint (Kura et al., 1998). As a result, the plantar fascia may be overstretched with the subtalar joint excessively pronated, causing a rearfoot valgus posture, where the calcaneus is everted away from the midline (Kitaoka et al., 1998).

This study examined the influence of playing basketball on the HVA and showed that playing basketball is related to increased HVA. There were clinically significant differences between the basketball players and controls. The HVA was increased in basketball players, especially in female guards. Before we began this study, we hypothesized that basketball guards might have a higher HVA because these players are required to move rapidly both horizontally and diagonally more than other positions. By contrast, centers playing in low post are required to move vertically. For guards, the first MTP joint may be compressed by the diagonal force from the ground and the propulsive force, which might increase the deforming force. Recently reported study demonstrated that arch indices were significantly different followed by each sport players, including soccer players, wrestlers, weightlifters, handball players, and gymnasts. Especially, wrestlers and gymnasts shown a reduction of foot arch through increasing of diagonal force on metatarsal head (Aydog et al., 2005). In addition, previous research reported that gymnasts shown an attenuation of foot arch following training period in from teenage to 20 ~ 30 ages (Staheli et al., 1987).

Previous literature suggests that hallux valgus is induced in female more than male, and also there is related with age, body weight, shoes types (Roddy et al., 2008). In prevalence of basketball players, their position is related with lower extremities injury. Especially, ankle and knee joint was injured to guard position the greatest than other position in contact situation (Meeuwisse et al., 2003). Our study suggests that basketball players significantly increase
the HVA, which might reduce the performance of their activity during the match. Second, we examined the relationship between the increased HVA and basketball position. According to our results, in female guards, the left HVA was greater than in the control group. Furthermore, the height of the basketball players was related to the right HVA in women. The players below 179 cm tall had a mean right HVA of 23.63°, while those taller than 180 cm had a mean right HVA of 16°. The difference between these groups was significant (p = 0.005). However, the basketball players of men were not significantly different. Thus, we suggest that it should be disclosed the relationship between higher and playing years even if we did not conduct with major-league basketball players.

Hallux valgus is more common in women in their fourth to sixth decades of life than in men. A major extrinsic factor causing hallux valgus is wearing constricting footwear. Once the HVA increases, it affects the transfer of body weight from the lower limb to the end of the great toe, which weakens the soft tissues surrounding the first MTP joint. It also repositions the line of action, increasing the severity (Lazarides et al., 2005). The etiology of hallux valgus is still not totally clear. However, the full spectrum of severe hallux valgus is often associated with dislocation and osteoarthritis of the MTP joint, metatarsus varus (adductus), valgus of the first toe, bunion formation over the medial joint, hammer toe of the second digit, calluses, and metatarsalgia.

A wide variety of pathologic conditions affect the hallux. The medical literature focuses on surgical treatment of these conditions, but most conditions can be improved dramatically with shoe modifications and orthotics. Recently reported papers discussed about preservation and prophylactics approaches. Several studies discussed about a positive and negative effects of footwear and ergonomic shoes product using gait and postural analysis or pressure measurement system. For example, foot-wear is an important factor to rugby player, marathoner, osteotomy-experience patients, and older persons (Gurney et al., 2009; Lorei et al., 2006). Effective orthotic management is achieved by identifying specific mechanical problems and addressing those problems by mechanically altering the interface of the foot with the footwear or by altering the force that is transmitted through the foot by changing the materials in the shoe (Sammarco and Nichols, 2005). Insole or ergonomic shoes could reduce pain, improved walking ability, and hallux valgus angle for prophylactic or therapeutic approaches (Shybut, 1997; Tang et al., 2002).

Song (Song, 2007) used functional electrical stimulation (FES) to contract the abductor valgus muscle, which commonly loses its voluntary contractibility, and showed that FES treatment could decrease the deforming force on the hallux valgus.

The limitations in our study include the fact that we used a photographic approach and palpation, as these measurement methods are less precise than measurements from x-rays (Hopson et al., 1995). Although the repeatability and reliability problems caused by manual examination limit the application of these results, having just one person make all of the HVA measurements using the photographic approach and goniometer may have ameliorated this problem to some extent. While the traditional x-ray approach may give accurate results, it is not suitable for large surveys considering the costs and the radiation effects. The photographic approach yields good results without these problems (Kuo et al., 2006).

Unfortunately, we could not evaluate the role of hand dominance, as most of the study population was right-handed. An additional study should examine the deforming force patterns in left-handed basketball players. Furthermore, we could not investigate player with wide variety of age or playing period in this study. In future, it should be compared to relationship between not only age but also playing period and HVA to suggest beneficial prophylactic or therapeutic methods.

5. Conclusion

In conclusion, the diagonal and horizontal movements required to play basketball might increase the HVA, especially in guards. Therefore, an appropriate preventive intervention program should be developed, and additional studies of basketball players related to hallux valgus should be conducted to evaluate the effectiveness of such programs.

Acknowledgments

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• Melatonin function on neural rehabilitation in degenerative diseases.

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