Weak TGS Correlates with Hallux Valgus in 10–12 Year Old Girls: A Cross-Sectional Study

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Rec date: June 09, 2016; **Acc date:** June 20, 2016; **Pub date:** June 27, 2016

Abstract

Objective: Hallux valgus is one of the most common foot deformities. It is considered that hallux valgus is associated with foot arch height, footwear, sex and so on. Toe grip strength (TGS) is important for developing foot posture because it attributes to foot arch height. The relationship between hallux valgus and TGS in children is unknown, although childhood is a key period for developing foot posture. The objective of this study is to investigate the relationship between hallux valgus angle (HVA) and TGS in children.

Methods: A total of 671 (1342 feet) 10-12 year old children (boys, n = 317, age = 10.3 ± 0.7; girls, n = 354, age = 10.2 ± 0.7; means ± standard deviation [SD]) participated in this study. HVA, the angle between the first metatarsal axis and the proximal phalangeal axis, was measured using a goniometer. TGS was measured using a toe grip dynamometer. Differences in the data between boys and girls were analyzed using the Mann-Whitney U test. According to sex, single and multiple linear regression analyses with generalized estima=' ar[theiod]MdM− ax-Sanal[ba²]

TGS is also important because it contributes to medial longitudinal and transverse arch height [20], and low foot arches contribute to hallux valgus [14,20]. Also TGS is associated with the intrinsic foot muscle, which is important for developing foot posture and is associated with toe deformities, such as claw toe and hammer toe, when it is not functioning properly [21]. Therefore, for developing good foot posture, TGS is an essential element, especially in children who are in a key period for developing foot posture.

However, the relationship between hallux valgus and TGS in children is unknown. Understanding the relationship between hallux valgus and TGS in the potential or early stages of hallux valgus is helpful for prevention and treatment of hallux valgus. For this reason, in this study, we investigated the relationship between HVA and TGS in children.

Methods

Participants

In total, 671 (1342 feet) 10-12 year-old children (boys, n = 317, age = 10.3 ± 0.7; girls, n = 354, age = 10.2 ± 0.7; mean ± SD) participated in this study and were recruited from each elementary school in Tawaramoto, a town in Nara prefecture in Japan (Table 1). We obtained signed consent forms from the principals of these elementary schools for inclusion of their students in the study.

None of the participants reported having a history of foot surgery or congenital disorders. The methods and procedures used in this study were in accordance with the current local guidelines and the Declaration of Helsinki, and were approved by the Ethical Committee for Human Experiments (R0109) of Kyoto University.

Experimental protocol

The most common diagnostic method for hallux valgus is the evaluation of HVA, the angle between the first metatarsal axis and the proximal phalangeal axis. HVA was measured using a goniometer. The protocol of measuring HVA as described by Kilmartin [22].

Briefly, the participants were in standing position with bare feet. One arm of the finger goniometer was brought against the mid-line of the medial surface of the hallux, and the other arm was brought against the mid-line of the medial surface of the first metatarsal (Figure 1). Test-retest reliability of two measurements of HVA with a 1-week interval was excellent (intra-class correlation coefficient = 0.965) in a sample of 28 feet.

TGS was measured using a toe grip dynamometer (T.K.K3362; Takei Scientific Instruments, Niigata, Japan). We measured TGS in accordance with a previous study [23]. The participants were sitting upright in chairs without leaning on the backrest throughout the toe grip strength measurement. Both of their hips and knees were bent at about 90 degree angles and their ankles were held in a neutral position with a strap.

The first proximal phalanx was positioned at the grip bar, and the heel was stabilized with the heel stopper adjusted optimally. The students gripped the grip bar with their toes using maximal effort for approximately 3 seconds (Figure 1). Measurements were conducted alternately with both right and left feet and repeated twice. The maximum value of 2 trials in each foot was used for further analysis.

Figure 1: Measurement of hallux valgus angle (HVA) and toe grip strength (TGS). (a), HVA, the angle between the mid-line of the medial surface of the hallux and the mid-line of the medial surface of the first metatarsal, was measured using a goniometer. (b), TGS using a toe grip dynamometer. The first proximal phalanx was positioned at the grip bar, and the heel was stabilized with the heel stopper adjusted optimally.

Statistical Analysis

The characteristics of the participants and their feet were summarized by using means and standard deviation (SD) for continuous variables. The foot characteristics data is comprised of the data from both feet of a participant. Differences in the data between boys and girls were analyzed using the Mann-Whitney U test.

Simple and multiple linear regression analyses with generalized estimating equations, to account for potentially correlated outcomes for feet from same individual, were performed to determine the association between TGS and HVA, according to sex. In both simple and multiple linear regression analyses, HVA was considered as the dependent variable, and TGS was the independent variable.

The multiple linear regression analysis was conducted to adjust moderator valuables (age, height, and weight). The level of statistical significance was set at $p < 0.05$, and statistical analyses were conducted using the SPSS version 20.0 software package (IBM Corp, Armonk, New York).

Results

Table 1 shows the participants and feet characteristics. The height and weight of participants were 141.3 ± 7.9 cm (boys, 140.7 ± 0.7 cm; girls, 142.0 ± 8.3 cm, p = 0.024) and 35.2 ± 7.9 kg (boys, 35.1 ± 7.7 kg<ys-

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factors increasing HVA, such as genetics, length of first metatarsal and footwear are not taken into consideration. There's a possibility that hallux valgus is a hereditary disease or gene associated disease. Hallux valgus are found in the patients with disease seem to be autosomal recessive disorders [32] which may be caused by mutants within a certain imprinted gene. Therefore, for finding out what cause hallux valgus, it is worth to investigate genetic factor such as genomic imprinting [33,34]. We did not consider factors such as longitudinal and transverse arch height, alignment change, and foot pain, which may influence the relationship between HVA and TGS. Finally, due to the cross-sectional design, the causal association between HVA and TGS-whether weak TGS contributes to the increase of HVA or whether increased HVA causes the weakening of TGS-is unknown. Further research is required to reveal the relationship between HVA and TGS. However, our findings

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