2016

The Relationship Between Foot Arch Height and Two-legged Standing Vertical Jump Height in Male College-age Students

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THE RELATIONSHIP BETWEEN FOOT ARCH HEIGHT AND TWO-LEGGED STANDING VERTICAL JUMP HEIGHT IN MALE COLLEGE-AGE STUDENTS

by

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B.S. Beijing Sport University, 2013

A Research Paper

Submitted in Partial Fulfillment of the Requirements for the

Master of Science

Department of Kinesiology

in the Graduate School

Southern Illinois University Carbondale

May, 2016

RESEARCH PAPER APPROVAL

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In the field of Kinesiology

Approved by:

Dr. M. Daniel Becque, Chair

Dr. Michael Olson

Graduate School
02/26/2016

AN ABSTRACT OF THE RESEARCH PAPER OF

YANG HU, for the Master of Science degree in KINESIOLOGY, presented on March 2, 2016, at Southern Illinois University Carbondale.

TITLE: THE RELATIONSHIP BETWEEN FOOT ARCH HEIGHT AND TWO-LEGGED STANDING VERTICAL JUMP HEIGHT IN MALE COLLEGE-AGE STUDENTS

MAJOR PROFESSOR: Dr. M. Daniel Becque

The purpose of this study was to examine the relationship of foot arch to the standing vertical jump in university students. Sixty-six healthy, male students from Southern Illinois University Carbondale were recruited for this study. Participants completed three vertical jump tests on a force platform with a Vertec positioned over the force platform. The force data were recorded for further calculation and the Vertec measurement of jump height. Partial correlation between vertical jump height and foot arch height were computed while controlling for the effect of stature, body mass, and foot size. The results showed that a weak negative linear partial correlation was found (r = -.1159) between the Vertec jump height and dominant foot arch height. A weak negative linear partial correlation was found (r = -.0313) between the force platform jump height and dominant foot arch height. In conclusion, there was no relationship between two-legged vertical jump height and dominant foot arch height.

Key words: flat feet, foot arch height, force platform, vertical jump

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INTRODUCTION

When the foot works properly it is an amazing, adaptive, and powerful aid during jumping, and in walking or running locomotion in flat, up or down hills, and over uneven ground. Dysfunction of the foot can often arise from the foot losing its normal structural support, thus altering its shape (Van Boerum, & Sangeorzan, 2003). On the one hand, some foot structural changes are present by heredity. On the other hand, an imbalance in the forces that tend to flatten the arch and those that support the arch can lead to loss of the medial longitudinal arch. Weakness of the muscular, ligamentous, or bony arch supporting structures will lead to collapse of the arch (Pinney, & Lin, 2006; Van Boerum, & Sangeorzan, 2003).

It is widely believed that the navicular height（Roth, Roth, Jotanovic, & Madarevic, 2013）is one of the best ways to determine foot arch height (Chu, Lee, Chu, Wang, & Lee, 1995; Queen, Mall, Hardaker, & Nunley, 2007; Richie, 2007; Yalçin, Esen, Kanatli, & Yetkin, 2010). Navicular height indicates the height of navicular bone. Foot arch can be classified into three types: flat feet, normal foot arch, and high foot arch.

There is some belief that flat footed individuals have reduced vertical jumping capabilities. But in daily life, there are many examples that suggest flat feet have no influence on jumping ability. A search of the literature reveals that foot disorders and foot posture may influence jumping ability (Hagedorn, et al., 2013; Lee, & Kim, 2014). Research indicates that flat feet will reduce the vertical force during gait and vertical jump (Prapavessis, & McNair, 1999). Using an insole they showed an increase in vertical take-off force in the two legged vertical jump (Arastoo, Aghdam, Habibi, & Zahednejad, 2013). However, it seems that there is limited research focusing on the relationship between flat feet and the standing vertical jump. Based on these studies, it may be that foot arch might influence standing vertical jump performance.

Thus, the purpose of this study was to examine the relationship of foot arch height to standing vertical jump height in male university students. Therefore this study hypothesized that there will be no relationship between foot arch height and standing vertical jump height.

METHODS

Participants

Sixty-six healthy, male students (stature 176.7±5.8 cm, mass 77.7±14.0 kg, age 21.6±3.2 years, dominant foot navicular height 37.1±8.4 mm, dominant foot size 26.2±1.2 cm) from Southern Illinois University Carbondale were recruited for this study. All the participants were orally informed of the research process. After oral acknowledgement of a willingness to participate, they read and signed a written informed consent for this study. Southern Illinois University Human Subjects Committee had previously approved this study.

Study design

The participants reported to the Exercise Physiology lab on one day. Testing took approximately 30 minutes. The participants were measured for height, body mass, foot size, and foot arch height. After the measurements, all participants were given instructions about how to perform maximal two-legged vertical jumps. After the instructions, each participant practiced two-legged vertical jumps several times. After the practice the participants completed three vertical jump tests on a force platform (AMTI SGA6-1) with a Vertec (Sports Imports, Hilliard, OH) positioned over the force platform. The force data were recorded for further calculation and the Vertec measurement of jump height. All procedures were performed without shoes.

Independent variables

Stature was measured with a standard stadiometer to the nearest millimeter. Participants stood on the stadiometer without shoes and socks, put their heels together, and their toes were pointed up. Body mass was measured in kilograms with a standard scale to the nearest hundred grams. The participant stood on a table in an anatomical position with feet shoulder width apart. The feet were palpated for the navicular bone. The top of the navicular bone was marked with dermal pen. Foot arch height was measured from the top of the table to bottom of the mark to the nearest tenth of a millimeter. Foot size was measured with a ruler to the nearest tenth of a millimeter for both feet of each participant. Every participant was asked which was their dominant foot. If they didn't answer what is your dominant foot, they were asked, what leg would you kick a ball.

Dependent variables

Two-legged vertical jump height. Two-legged vertical jump was defined as a two-legged standing vertical jump with counter movement and arm swing. The counter movement was completed to approximately 90° knee flexion. Participants were encouraged to vigorously swing their arms to reach as high as possible during the jump. The two-legged vertical jump was chosen because it is the most common method of take-off for standing vertical jumping. Therefore, it is easy for participants to learn and perform during the test. Height of the two-legged vertical jump was measured immediately with a Vertec. The Vertec was placed right beside the force platform. Before each jump trial, participants were asked to stand under the Vertec, raise their hand above their head and push the measurement vane of the Vertec forward to measure standing arm extended height. After each jump trial, jump height was recorded as the difference between the initial and the vane deflected during the jump. The difference between each Vertec vane was 0.5 inch (1.27 cm).

The vertical jump was also recorded with a force platform collecting data at 1200 Hz synchronized with Qualisys Track Manager software. Raw vertical force output was measured for each jump. The take-off and touch down points were visually picked by researcher from the data. To avoid missing the actual take-off and touch down points, one hundred data points before take-off and one hundred data points after touch down were included in the calculation. Impulse was calculated as the raw vertical force times sample time (1/1200 s). The sum of the impulse from take-off to touch down was divided by the participant's body mass to calculate the take-off velocity. Jump height was equal to the square of the take-off velocity divided by two times gravity.

Statistical Analyses

All statistical data were analyzed with Microsoft Excel 14.4.1. Descriptive data (mean and standard deviations) were calculated first. One way analysis of variance was used to test the difference between the force platform jump height and the Vertec jump height. A Pearson correlation was employed to assess the relationship between the force platform jump height and the Vertec jump height. Partial correlations were computed between jump height and foot arch height while controlling for the effect of stature, body mass, and foot size.

RESULTS

Participant characteristic correlations

A moderate positive linear relationship was found (r = .3000) between stature and body mass. A moderate positive linear relationship was found (r = .5305) between dominant foot size and stature. A moderate positive linear relationship was found (r = .5550) between dominant foot size and body mass.

Two-legged vertical jump height

The mean Vertec jump height was .49 ± .08 m. The mean force platform jump height was .45 ± .1 m. A strong positive linear relationship was found (r = .8862) in two-legged vertical jump height between the Vertec jump height and the force platform jump height. A weak negative linear relationship was found (r = -.1601) between the Vertec jump height and dominant foot arch height. A weak negative linear relationship was found (r = -.0078) between the Vertec jump height and dominant foot size. A weak negative linear relationship was found (r = -.1233) between the Vertec jump height and stature. A weak negative linear relationship was found (r = -.1643) between the Vertec jump height and body mass.

A weak negative linear relationship was found (r = -.1004) between the force platform jump height and dominant foot arch height. A weak negative linear relationship was found (r = -.0358) between the force platform jump height and dominant foot size. A weak negative linear relationship was found (r = -.2060) between the force platform jump height and stature. A weak negative linear relationship was found (r = -.1862) between the force platform jump height and body mass.

Partial correlation between two-legged vertical jump height and dominant foot arch height was calculated controlling for the effects of stature, weight, and dominant foot size. A weak negative linear partial correlation was found ($r = -.1159$) between the Vertec jump height and dominant foot arch height. A weak negative linear partial correlation was found ($r = -.0313$) between the force platform jump height and dominant foot arch height.

DISCUSSION

The purpose of this study was to examine the relationship of foot arch height to two-legged standing vertical jump in university students. The major finding of this study was a weak negative linear relationship between foot arch height and two-legged vertical jump height irrespective of body mass, stature, and foot size. These results indicate that flat feet do not influence standing vertical jumping ability. These results counter the belief of the adverse effects of flat feet on motor ability which has influenced the selection of athletes and military recruitment in Taiwan.

The idea of using flat feet to exclude individuals from some sports in Mainland China and also for military recruitment in Taiwan is supported by claims that flat feet are a foot dysfunction which may lead to motor ability disadvantages. Some research even has suggested that a higher foot arch results in a higher vertical jump (Yuan, 2013). Flat feet have been positively associated with several foot disorders like hammer toes, hallux valgus, and overlapping toes (Hagedorn et al., 2013). These often lead to pain, injury, and reduced motor ability. Research by Lee and Kim (2004) found the activities of most muscles while walking up hill with flat feet were significantly different from the muscle activities in the subjects with normal feet. Lee and Kim (2004) felt that flat feet would lead to overuse injuries because the muscle activation differences would lead to foot weaknesses and injury. However, there is no evidence which indicates that flat feet themselves lead to injury or decreased motor ability.

Lack of jumping ability could result from pain due to a pathological flat feet. It is suggested that it is necessary to differentiate physiological flat feet from pathological flat feet. Physiological flat feet, flat feet without pain, do not reduce an individual's motor ability. In this study, only one participant used an insole because of foot pain. The rest of the study participants with flat feet had physiological flat feet, i.e. flat feet without pain. Some previous studies also support this study that foot arch height has no influence on motor ability. Chen et al. (2001) found the performance of vertical jump, standing long jump, and triple jump in a flatfeet group was not different from those in a non-flatfeet group. Li, Jiang, and Li (2007) recruited 42 male wrestlers and compared their jumping ability in the vertical jump and standing long jump. They found that there was no significant difference in jumping ability between a flatfeet group and a normal feet group. Furthermore, Wang et al. (2007) tested 208 participants and created two groups: flatfeet and normal feet. There were no significant differences in standing long jump between the flatfeet group and normal feet group.

Research by Arastoo, Aghdam, Habibi, and Zahednejad (2013) indicated that insoles enabled flatfeet athletes to develop more effective take-off kinetics for vertical jumping. Their results suggested that the ground reaction force and stance duration of a flat feet with insole group were similar to a normal feet without insole group. In the vertical direction, they found there were significant differences in ground reaction force between flatfeet individuals with and without the use of insoles. However, they didn't compare the normal foot individuals and flatfeet individuals without the use of insoles. It is possible that, using an insole can help flatfeet individuals have better sports performance, but it doesn't mean individuals with flat feet cannot maintain the same sports ability as normal foot individuals. In other words, participants with flatfeet have the same jumping capability as participants with normal feet. The present study controlled for the effect of body size and there was no relationship between foot arch height and jump height. Therefore, this study supports the idea that flat feet participants have the same jumping capacity as normal feet participants.

There are other hypotheses which suggest that jumping ability is related to different characteristics of the foot. For example, Shi (1987) suggested that a bigger foot size will result in higher vertical jumps. Further studies should be done to determine the most important characteristic of the foot that influences vertical jump height. Moreover, the muscle groups and muscle fiber characteristics involved in jumping should also be examined for their effects.

CONCLUSION

The results of this study suggest that there is no relationship between two-legged vertical jump height and dominant foot arch height. This study provides evidence that foot arch height should not be used as a factor to judge jumping ability.

REFERENCES

Arastoo, A., Aghdam, E., Habibi, A., & Zahednejad, S. (2013). Kinetic factors of vertical jumping for heading a ball in flexible flatfooted amateur soccer players with and without insole adoption. *Prosthetics And Orthotics International*, *38*(3), 204-210.

Chen, J.Y., Liu, X.T., Lv, H., Xu, W.L., Chen, Z.H., Wang, Z.T., Yang, H.C., Xiang, H.S., & Song, S.A. (2001). Study on the Relation of foot arch to motor ability in young men from armed police unit. *J Prev Med Chin PLA, 19*(3), 185-188. doi :10.13704/j .cnki .jyyx.2001.03.011

Chu, W., Lee, S., Chu, W., Wang, T., & Lee, M. (1995). The use of arch index to characterize arch height: a digital image processing approach. *IEEE Transactions On Bio-Medical Engineering*, *42*(11), 1088-1093.

Hagedorn, T., Dufour, A., Riskowski, J., Hillstrom, H., Menz, H., Casey, V., & Hannan, M. (2013). Foot disorders, foot posture, and foot function: the Framingham foot study. *Plos One*, *8*(9), e74364. doi:10.1371/journal.pone.0074364

Lee, C., & Kim, M. (2014). The Effects on Muscle Activation of Flatfoot during Gait According to the Velocity on an Ascending Slope. *Journal Of Physical Therapy Science*, *26*(5), 675-677. doi:10.1589/jpts.26.675

Li, J.S., Jiang, N., & Li, Y.F. (2007). Influence of Flatfoot on the Balance of Man Wrestler. *Journal of Capital Institute of Physical Education, 19*(3), 62-64. doi: 10. 14036 /j . cnki . cn11 -4513. 2007. 03. 019

Pinney, S., & Lin, S. (2006). Current concept review: acquired adult flatfoot deformity.

Foot & Ankle International, 27(1), 66-75.

Prapavessis, H., & McNair, P.J. (1999). Effects of instruction in jumping technique and experience jumping on ground reaction forces. *J Orthop Sports Phys Ther; 29*(6): 352–356.

Queen, R., Mall, N., Hardaker, W., & Nunley, J. (2007). Describing the medial longitudinal arch using footprint indices and a clinical grading system. *Foot & Ankle International*, *28*(4), 456-462.

Richie, D. (2007). Biomechanics and clinical analysis of the adult acquired flatfoot. *Clinics In Podiatric Medicine And Surgery, 24*(4), 617.

Roth, S., Roth, A., Jotanovic, Z., & Madarevic, T. (2013). Navicular index for differentiation of flatfoot from normal foot. *International Orthopaedics*, *37*(6), 1107-1112. doi:10.1007/s00264-013-1885-6

Shi, H. (1987). Foot Morphology and Talent Selection of Athletes. *Sport Science And Technology.* doi: 10. 14038 /j . cnki . tykj . 1987. 04. 009

Van Boerum, D., & Sangeorzan, B. (2003). Biomechanics and pathophysiology of flat foot. *Foot And Ankle Clinics, 8*(3), 419-430.

Wang, L., Jing, L.X., Hui, J.L., Mou, Z.X., Lu, L.H., Yin, A.H., & Liu, Y. (2007). Study on the Relation of flat foot to motor ability. *Chin J Sch Health, 28*(4), 372-373.

Yalçin, N., Esen, E., Kanatli, U., & Yetkin, H. (2010). Evaluation of the medial longitudinal arch: a comparison between the dynamic plantar pressure measurement system and radiographic analysis. *Acta Orthopaedica Et Traumatologica Turcica,* *44*(3), 241-245. doi:10.3944/AOTT.2010.2233

Yuan, D. (2013). Empirical Study on Morphology of Wushu Athlete's Foot. *Journal of Southwest China Normal University (Natural Science Edition), 38*(8), 61-65. doi:10.13718/j.cnki.xsxb.2013.08.006

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