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Correlation of Navicular Drop to Vertical and Broad Jump Measurements in Young Adults

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Abstract

Abstract

Background: Often clinicians attempt to correct the longitudinal arch of the foot in those with pes planus to improve physical performance, this theory has not been studied extensively. The purpose of this study was to determine the correlation between increased navicular drop/low arched feet and explosive jump performance in young adults.

Methods: A correlational design was used to carry out this study. The study took place at four centers and a convenience sample was selected from these locations. One-hundred and five healthy adults between the ages of 18 and 35, with a mean age of 23.23 (+/- 2.62) participated. The participant's measurement of hyper pronation was quantified through navicular drop test. Explosive performance was then measured through vertical and broad jump. A Pearson correlation and follow-up Spearman correlations were then performed to analyze the relationship between navicular drop and vertical and broad jump while keeping level of significance at alpha= .05.

Findings: There was no signifigant correlation between an individual's navicular drop and their vertical jump measurement (r=-0.077, p=.268; r_s=-.059, p=.550). or broad jump (r= 0.012, p=.382; r_s= .007, p= .945).

Interpretation: There was no correlation between navicular drop and vertical and broad jump measurements in young adults. A low arched foot did not predispose an individual to decreased explosive performance in the form of vertical and broad jump measurements. This could have implications on the decision to attempt to correct pes planus with measures such as orthotics or taping to improve performance.

Introduction

The longitudinal arch in the human foot can vary in height, and the amount of deviation from neutral can lead to painful foot conditions. Two common foot alignments resulting from arch height are pes planus and pes cavus. Pes planus, also known as flat foot, is defined as a decrease in the medial longitudinal arch of the foot[1]. Clinically, pes planus can be identified utilizing several measurements including the navicular drop test.[2] It is often customary practice to prescribe orthoses to those with pes planus to preserve the medial longitudinal arch[3] and prevent them from a list of associated issues. This is done even though there is currently debate about whether pes planus leads to injury[1,4,5-8]. Some researchers have found that pes planus has effects throughout the kinetic chain and potentially leads to overuse injuries such as tibialis posterior tendonitis, patellofemoral syndrome, ligamentous stress, shin splints and plantar fasciitis[1,4].

While some of the past research has suggested a link between pes planus and an increase in injury rate, other studies have found that those with pes planus are not at greater risk for injury and may in fact be at a decreased risk for stress fractures[5-7]. Michelson et al.[5] (2002) studied one-hundred ninety six collegiate athletes and found pes planus not to be a risk factor for lower extremity injury. Giladi et al.[7] (1985) found that those with pes planus were at a decreased risk for stress fractures compared to those with pes cavus. Cowan et al.[6] (1993) examined 246 United States Army trainees and corroborated that those with pes cavus were at a higher risk for injury than those with pes planus.

Prescribing orthoses to those with pes planus is common as the patient's foot structure deviates from what is considered normal; however, the benefit or non-benefit has been debated in the literature. Current research is mixed about the benefits of orthotics in this population[9-12]. Many researchers have investigated the problems caused by pes planus[1,4,5,8]. Researchers have also studied the effects arch structure have on lower extremity balance and strength[13-18]. There is currently debate over whether there is a difference in ground reaction forces between different foot types[17,18]. Rad[17] (2011) investigated thirty male students with both neutral arches and flat feet and found that individuals with pes planus have a larger ground reaction force as well as a shorter contact time to the ground. Shojaedin & Akbari[18] (2013) investigated thirty male participants with neutral, supinated, and pronated feet and found there were no differences in ground reaction forces between the three arch types. Some researchers found that those with flexible flat feet have greater muscle tone as well as that the amount of navicular drop correlated with metatarsophalangeal joint muscle strength while the foot is in in plantarflexion[13,14]. Researchers have also found that those with greater pronation showed decreased concentric plantarflexion compared to those with a neutral arch[15]. These differences may potentially predispose those with pes planus for injury. Hyong and Kang (2016) also found no difference in dynamic balance ability in those with pronated or supinated feet when compared to neutral arches.

While many studies have investigated the kinetic and strength differences as well as the potential conditions associated with pes planus, there is still little evidence on the correlation between lower extremity physical performance and arch height[1,4-8,13-19]. Some studies no relationship[19-21]. Zhao et al.[20] (2017) found that although there is a relationship between arch height and ankle muscle strength, there is no relationship between arch height and physical performance in tasks such as agility and explosive performance. This seems to be at odds with the current theories applied in many podiatry and physical therapy settings as many practitioners provide orthotic insoles or taping strategies to attempt to lift the arch of the foot to improve performance in athletics and daily tasks. Similarly, Tudor et al.[19] (2008) found no correlation between arch height and motor abilities, including speed, power, reaction time, and balance in children ages 11 through 15 years old. Oda[21] (2004) also found no correlation. Other researchers found that the vertical and broad jump are frequently utilized to identify athletic ability and explosive performance[22]. Past authors have also utilized jump measurements as markers of physical performance[20]. Existing debate warrants further research to investigate the relationship between arch height and gross lower extremity function. The current study also used these tests of explosive strength to identify whether arch height impacts gross lower extremity performance.

The aim of the present study was to determine the correlation between navicular drop and explosive jump performance measured by distance in jumping with the vertical and broad jumps. The authors hypothesized that there is no difference in dynamic explosive jump performance between individuals with greater or lesser navicular drop based on measurements of vertical and broad jump. The clinical application of this study is to identify if there is a clear justification for treatment options such as orthotics to raise the arch to improve dynamic function solely based on the presence of a low longitudinal arch.

Materials and Methods

The study design was a cross sectional correlational study. A convenience sample was pooled from one midwestern University and three local gyms in Ohio and West Virginia. Correlational analyses were completed with the data collected. One-hundred and five volunteers between the ages of 18 and 35 were recruited for this study.

After obtaining approval from the Institutional Review Board (IRB), volunteers were screened for the inclusion criteria. The inclusion criteria were any healthy volunteer between the ages of 18 and 35 and the participants could be male or female. The exclusion criteria were volunteers with the presence of any lower extremity injury that restricted them from work or exercise activity for longer than two weeks in the last year, or volunteers who had undergone lower extremity surgery within the last year. All participants signed the written consent form to participate in the study.

Each participant was assigned a number prior to beginning testing to ensure confidentiality. The researchers recorded each participant's age and gender. Each subject then underwent the testing procedure to record the participants navicular drop, followed by jumping tests to measure physical performance. The same researcher recorded navicular drop and jump tests to increase internal validity of measurements.

Participants were required to remove shoes and socks for all testing including navicular drop measurements and jumping. The participants' level of hyper pronation was then measured bilaterally using the navicular drop test. The researcher utilized a 4-inch Complete Medical goniometer to measure the height of the navicular bone from the floor on both feet in a relaxed standing position. The height of the navicular bone from the floor was then measured in a taller neutral position on both feet by one of the researchers. The difference in millimeters, known as navicular drop, was noted. An average of the left and right foot was taken to obtain a mean navicular drop per participant. Following navicular drop measurements, participants performed a broad jump test. The distance of participants' broad jump was measured using a Tool Shop 25' Tape Measure. Participants were instructed to stand behind the starting line and then jump as far forward as possible. The distance between the starting line and the position of the rearmost heal was measured and recorded. The test was repeated three times and the best measurement (longest broad jump) was recorded. Following the broad jump measurements, each participant's vertical jump was measured using a Tandem Sport Vertical Challenger. All participants vertical jumps were measured by the same researcher to ensure the best reliability. Baseline vertical height was first measured with participant standing with arm overhead. Participants were then instructed to jump as high as they could to reach for and tap the veins on the Tandem Sport Vertical Challenger. The difference between baseline vertical height and the participant's jumping reach was recorded as their vertical jump score. The test was performed three times and the best result (highest vertical jump) was recorded. Each session lasted approximately fifteen minutes.

Statistical analysis was then performed using SPSS statistical software version 25. A Fisher Z transformation was utilized for sample size estimation with the power set at .80, the beta set at .20 and the alpha set at .05. The estimated needed sample size for correlation was at least 47. A larger sample size of 105 was used to ensure external validity and strengthen study power.

A Shapiro-Wilk test for normality was run for each correlation variable and scatter plot diagrams were assessed to establish linearity. All variables met linearity assumptions, but failed normality assumptions. For this reason, follow-up Spearman correlations were run to assess the variables in non-parametric fashion. Two Pearson correlations and follow-up Spearman correlations per participant were run. The first set of correlation variables included the results of the participants navicular drop measurements and the participants broad jump measurements. The second set of correlation variables included the results of the participants navicular drop measurements and the participants vertical jump measurements.

Table I: Mean Study Values

Study Variable	Mean	S.D. +/-
Navicular Drop (n=105)	8.65 mm	4.6 mm
Vertical Jump (n=105)	54.48 cm	14.12 cm
Broad Jump (n=105)	177.04 cm	41.17 cm

Table II: Mean Study Values. S.D. +/-= standard deviation.

Correlation Values	*r* value, r_s value	p- values
Correlation between avg. Navicular Drop and Broad Jump	-0.07, .007	0.268, .945
Correlation between avg. Navicular Drop and Vertical Jump	0.012, -.059	0.388, .550

Results

All one-hundred and five participants, including 44 males and 61 females, successfully completed the test procedures. The mean age of the participants was 23.23 (+/- 2.62) and ranged from 18-32. The mean navicular drop was 8.65 mm (+/- 4.6), the mean vertical jump was 54.48 cm (+/- 14.12) and the mean broad jump was 177.04 cm (+/- 41.17) (Table I).

A Pearson correlation and follow-up Spearman correlation was computed to assess the relationship between average navicular drop and vertical/broad jump performance for each participant. (Table II). No significant correlation was found when correlating average navicular drop height with broad jump (*r*=-0.077, p=.268; r_s=.-.059, p=.550) (Table II or when correlating average navicular drop with vertical jump (*r*= 0.012, p=.382; r_s= .007, p= .945) (table II).

Results showed no relationship between one's level of navicular drop and explosive strength as measured through jump performance.

Discussion

It has been commonplace to assume a reduction in performance with low arched feet due to the thought that this creates a flexible, less rigid lever for propulsion and thus less force performance. It has also become common place in many settings to prescribe items such as orthotic insoles or taping procedures to lift the arch of one's foot to attempt to improve performance. Although this is practiced in many areas, it may not be valid.

Past research has shown a correlation between the height of the arch and ankle muscle strength, but actually those with low arched feet demonstrated greater ankle muscle strength[20]. Past research also suggested that there was no link between arch height and physical performance[19-21], and the findings in the current study have mirrored these findings. Just as Zhao et al.[20] (2017) found no correlation between longitudinal arch dynamics and performance measures.

While much of the past literature showed a possible relationship between low arched feet and injury or pain[1,4], as well as investigated the efficacy of correction of low arched feet with items such as orthotics with mixed results[9-12], the connection between a low arched foot and a reduction in physical performance has been theory based at best. In fact, again, the limited past literature in this area suggested that there is no connection[19,20,22].

In the current study, many individuals with pes planus performed better on these physical assessments than those with a neutral or high arched foot, however not statistically significant. This study lends implications to future practice of orthotic prescription and taping solely based on anatomical foot observation.

The authors' perspective is that the results of this study suggest that the long-held theory that low arched feet yielded lower physical performance or athletic performance is likely theory based at best. The findings of this study build upon the few past research articles that pointed to there being no correlation between longitudinal arch dynamics and performance.

Conclusion

In summary, this study explored the relationship between the level of navicular drop and physical performance. The results showed no correlation between a high value for navicular drop (a more planus foot) and a decrease in explosive performance in the form of broad or vertical jumps. This suggests that there is no correlation between longitudinal arch dynamics and physical performance in the form of explosive jump measurements. These results derive the question that the decision to attempt to improve physical performance through items such as orthotics and taping to correct pes planus should be considered. Future studies should be done to investigate the relationship in other physical performance areas such as agility and sport-specific markers.

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Conflicts of interest

No conflict of interests were involved with the completion of this work. The authors nor the affiliated University benefited financially from the completion of this work nor did any of the participants. There was also no conflict of interest related to employment or patents.

References

1. Magee D. Orthopedic Physical Assessment. Canada: Elsevier; 2014
2. Sabino G, Rocha I, Guimaraes C, et al. Reliability analysis of the clinical application of the navicular drop test. Physiotherapy in Movement. 2012;25(2):301-309.
3. Leung AKL, Mak AFT, Evans JH. Biomechanical gait evaluation of the immediate effect of orthotic treatment for flexible flat foot. Prosthetics and Orthotics International. 1998; 22(1): 25–34. https://doi.org/10.3109/03093649809164454
4. Bennett JE, Reinking MF, Rauh MJ. The relationship between isotonic plantar flexor endurance, navicular drop, and exercise-related leg pain in a cohort of collegiate cross-country runners. International Journal of Sports Physical Therapy. 2012; 7(3): 267-278.
5. Michelson JD, Durant DM, McFarland E. The injury risk associated with Pes Planus in athletes. Foot and Ankle International. 2002; 23(7): 629633. doi:10.1177/107110070202300708
6. Cowan DN, Jones BH, Robinson JR. Foot morphologic characteristics and risk of exercise-related injury. Archives of Family Medicine. 1993; 2(7): 773-7.
7. Giladi M, Milgrom C, Stein M, et al. The low arch, a protective factor in stress fractures. Orthopaedic Review. 1985; 14: 81-84.
8. Kosashvili Y, Fridman T, Backstein D, et al. The correlation between pes planus and anterior knee or intermittent low back pain. Foot and Ankle International. 2008; 29(9): 910-3.
9. Banwell AG, Mackintosh S, Thewlis D. Foot orthoses for adults with flexible pes planus: a systematic review. Journal of Foot and Ankle Research. 2014; 7(1): 23-41.
10. Christopher RC, Drouin JM, Houglum PA. The influence of a foot orthotic on lower extremity transverse plane kinematics in collegiate female athletes with pes planus. Journal of Sports Science and Medicine. 2006; 5(4): 646-655.
11. Kuhn DR, Shibley NJ, Austin WM, et al. Radiographic evaluation of weight-bearing orthotics and their effect on flexible pes planus. Journal of Manipulative Physiological Therapeutics. 1999; 22(4): 221-6.
12. Chen YC, Lou SZ, Huang CY, et al. Effects of foot orthoses on gait patterns of flat fleet patients. Clinical Biomechanics (Bristol,Avon). 2010; 25(3): 265-70.
13. Um GM, Wang JS, Park SE. An analysis on muscle tone of lower limb muscles on flexible flat foot. Journal of Physical Therapy Science. 2015; 27(10): 3089-92.
14. Saeki J, Tojima M, Torii S. Relationship between navicular drop and measuring position of maximal plantar flexion torque of the first and second-fifth metatarsophalangeal joints. Journal of Physical Therapy Science. 2015; 27(6).
15. Snook AG. The relationship between excessive pronation as measured by navicular drop and isokinetic strength of the ankle musculature. Foot and Ankle international. 2001; 22(3): 234–40.
16. Hyong IH, Kang JH. Comparison of dynamic balance ability in healthy university students according to foot shape. Journal of Physical Therapy Science. 2016; 28: 661-664.
17. Rad AG. Comparison of GRF in vertical jumping for heading the football in Flatfoot and safe male student. International Journal of Health, Wellness and Society. 2011; 1(1)
18. Shojaedin S, Akbari H. The Peak Vertical Ground Reaction Force Differences between Foot Types During Landing. International Research Journal of Applied and Basic Sciences. 2013; 4(10): 3134-3137.
19. Tudor A, Ruzic L, Sestan B, et al. Flat-footedness is not a disadvantage for athletic performance in children aged 11 to 15 years. Pediatrics. 2008; 123(3): e386-92.
20. Zhao et al. Association of Arch Height with Ankle Muscle Strength and Physical Performance in Adult Men. Biology of Sport. 2017; 34(2): 119-126.

21. Oda A. An experimental study on the effects of a flatfoot on physical motor performances: the relations of conditions evaluated from medial longitudinal arch to foot strength and physically functional motor capacities. Sendai College. 2004; 5: 139–148.

22. Eagles AE, Sayers MGL, Lovell DI. Ground reaction force and joint kinematic comparison between the standing vertical jump and the standing broad jump. International Journal of Physical Education, Sports and Health. 2016; 3(3): 562-566.