The Relationship Between Forefoot, Midfoot, and Rearfoot Static Alignment in Pain-Free Individuals

Kirsten Rossner Buchanan, PT, PhD, ATC
Irene Davis, PT, PhD

Study Design: Correlational study.
Objectives: To determine whether, and to what degree, a relationship exists between forefoot angle and weight-bearing midfoot and rearfoot position.

Background: There have been conflicting reports with regard to the degree to which the structure of the foot may influence the function. The influence of forefoot structure on weight-bearing midfoot and rearfoot position has not been extensively investigated.

Methods and Measures: Fifty-one healthy subjects participated in this study (26 male and 25 female). Forefoot angle was measured in prone as varus (positive numbers), neutral (0), or valgus (negative numbers). Navicular drop was measured from subtalar joint neutral to unilateral standing relaxed. Rearfoot angle was measured in relaxed single-limb stance as the angle between a line that bisected the calcaneus and a line that bisected the lower third of the leg. The relationships between forefoot angle and navicular drop, and between forefoot angle and relaxed rearfoot angle, were investigated. The same relationships were also investigated in the neutral forefoot subgroup when the sample was divided in 3 subgroups based on 1 standard deviation of forefoot angle.

Results: There is a significant relationship between forefoot angle and relaxed rearfoot angle ($r = 0.52, P < .001$), as well as between forefoot angle and navicular drop ($r = 0.55, P < .001$), in the whole sample ($n = 51$). Average degrees of forefoot angle in the neutral subgroup (between 1.0° and 8° of varus) are not associated with predictable positions of relaxed rearfoot angle ($r = 0.19, P = .24$) or navicular drop ($r = 0.01, P = .96$).

Conclusions: Based on the results of this study, there is a significant relationship between forefoot angle and relaxed rearfoot angle, as well as between forefoot angle and navicular drop, in healthy subjects. These relationships were not found when forefoot varus values were within a standard deviation of forefoot angle.

Key Words: biomechanics, foot position, pronation, subtalar joint

The relationship between the structure of the foot and its function is not well understood. Malalignments in structure of the forefoot, midfoot, and rearfoot are thought to lead to compensatory motion, which may ultimately result in injury.

Root et al.22 suggested that the forefoot should be aligned perpendicular to the bisection of the calcaneus when the foot was in subtalar joint neutral. Any deviation from this position, either varus or valgus, was considered abnormal and could lead to abnormal motion and potential injury. Root et al.22 also suggested that individuals with a forefoot varus alignment might compensate through excessive pronation and/or subtalar joint through excessive pronation. Much of the foundation for orthotic intervention is based on Root’s theories. Aside from Root’s hypothesis that forefoot varus is abnormal, there is no consistent body of research that speaks to how static foot measures relate to one another. Recent studies have suggested that a certain amount of forefoot varus or valgus may be normal in an adult population.6,8 Additionally, others reported no relationship between static measures of the forefoot and rearfoot position or motion.16,18

While rearfoot motion during gait has received much attention in the literature,11,18,25,26 few studies have addressed the relationship between forefoot alignment and weight-bearing midfoot and rearfoot position. McPoil et al.16 assessed the relationship between the static measures of forefoot position, navicular drop, and dynamic rearfoot motion. They found these static measures not to be predictive of rearfoot motion.16 However, they recognized that in their study the low sample size used for the number of static variables measured could have limited their statistical power.16 Mueller et al.18 studied the relationships between forefoot position, navicular drop, and rearfoot angle in subtalar joint neutral position. They found a significant relation-
ship between forefoot position and navicular drop ($r = 0.29-0.33$), but no relationship between forefoot position and rearfoot angle in subtalar joint neutral. This is not surprising, as the subtalar joint neutral position does not provide information regarding the amount of frontal plane compensation the rearfoot may exhibit in relaxed stance.

Static forefoot, midfoot, and rearfoot measures are presumed to be related to dynamic measures of pronation. Research suggests that excessive pronation is associated with pathology.\(^{1,20,25}\) Despite the sparse information regarding the relationship between forefoot structure and midfoot/rearfoot pronation in a normal population, clinicians often use structural forefoot measures as a basis for intervention in patients with pathology. Orthotic intervention today is an example. Much of the orthotic evaluation and intervention today is based on Root’s theory regarding relationships between forefoot alignment and midfoot/rearfoot compensation.\(^{22}\) For example, a patient with forefoot varus and an associated increase in midfoot and/or rearfoot pronation would be prescribed an orthotic with a medial forefoot post to balance the foot. This accommodation of the forefoot varus with a medial post is believed to decrease the need for compensatory midfoot and rearfoot motion. Forefoot measures are assumed to be related to midfoot and rearfoot measures based on Root’s theory, but this has not been clearly established. Therefore, the purpose of this study was to investigate the relationship between static forefoot angle and associated positions in the midfoot and rearfoot during stance. It was hypothesized that as forefoot varus increased, navicular drop and calcaneal eversion would also increase. It was also hypothesized that these relationships would not be present in those subjects with a near neutral forefoot alignment.

**METHODS**

Fifty-one subjects volunteered for this study: 26 male and 25 female (mean ± SD age, 34 ± 11.2 years; height, 170 ± 9.25 cm; body mass, 73.2 ± 15.7 kg). Subjects with a history of congenital deformity, surgery, or traumatic injury to either lower extremity in the previous 6 months were excluded. This study was approved by the Internal Review Board at the University of Virginia and all subjects provided informed written consent.

Static foot measurements, including forefoot angle, subtalar joint neutral rearfoot angle, relaxed rearfoot angle, and navicular drop, were taken by the primary investigator, who had over 6 years of experience making these measurements. All measurements were recorded by an assistant. All measurements were taken 3 times and an average was calculated. On 19 subjects the anatomical landmarks were erased after first set of measurements with an alcohol swab. The subject walked around the clinic for approximately 5 minutes and all marks were then redrawn. A second averaged set of 3 measurements for each static foot position was performed to determine intratester reliability. An intraclass correlation coefficient (ICC\(_{3,3}\)) was used to quantify intrarater reliability for these 19 subjects (a random sample of either right or left foot measurements was used) for forefoot angle, relaxed rearfoot angle, and navicular drop.

A gait template was constructed for each subject to ensure that the same foot placement angle was used for all standing measures. Each subject was asked to walk along a 4-m length at his/her preferred speed and come to a stop on a 45 × 60-cm piece of paper. Subjects were asked to end their walk in bilateral stance with both lower limbs in a foot placement angle that was most comfortable to them. Four practice trials were allowed and on the fifth trial each foot was traced with a ballpoint pen. The foot placement angle was recorded as the angle from the line of forward progression to a line that bisected the foot from the mid heel through the second toe.

With the subject lying prone, with 1 leg extended and the other leg externally rotated and bent at the knee at approximately 90°, the heel and lower leg were marked for rearfoot measurements (Figure 1). A line was drawn on the extended leg bisecting the lower one third of the leg and another line was drawn bisecting the calcaneus.\(^{8}\) Subtalar joint neutral
was then determined using the palpation method. With the subtalar joint held in neutral, the fourth and fifth metatarsal were loaded, bringing the ankle in dorsiflexion until firm resistance was felt (Figure 2). Subtalar joint neutral position in non-weight bearing was used as a reference position for forefoot measurements. While one hand held the subtalar joint in its neutral position, the opposite hand was used to align a goniometer for the forefoot measurement. Forefoot position was determined by placing the stationary arm of the goniometer at 90° to the bisection of the calcaneus and aligning the moveable arm along a plane that would bisect the metatarsal heads (Figure 3). Forefoot varus (positive degrees), neutral (0°), or valgus (negative degrees) was determined as the angle between the perpendicular to the bisection of the calcaneus and an imaginary line drawn through the metatarsal heads.

Then, each subject stood on a 22.5-cm–high box with the subject’s feet positioned in his/her gait template. The rearfoot angle was assessed in both the subtalar joint neutral and relaxed standing position. To assess rearfoot angle in subtalar joint neutral, each subject was placed in his/her gait template and subtalar joint in neutral was palpated. With the subtalar joint positioned in neutral, the rearfoot angle was measured as the angle between the bisection of the lower one third of the leg and the bisection of the calcaneus. The relaxed rearfoot angle was then measured using the same landmarks and gait template, with the subject in single-leg relaxed stance. For this measurement, the subject flexed the opposite knee and was allowed to touch that toe to the surface and hold onto a metal bar for balance, if necessary.

Navicular drop measurements were completed as per others in the literature. Navicular height was measured in subtalar joint neutral and relaxed stance. The navicular bone of each foot was palpated and a mark was made with a ballpoint pen on the most prominent aspect. The subject then stood in his/her gait template, on the box, in bilateral stance, and the subtalar joint in neutral position was palpated. An index card was placed vertically along the medial aspect of the foot and a mark was made on the card at the level of each marked navicular. Each subject then lifted 1 foot off the box, bending the knee, and the navicular was marked on the index card during relaxed unilateral stance. This was repeated for the opposite foot. The difference in navicular height measured during bilateral and unilateral stance was defined as navicular drop (Figure 5).
The relationships between forefoot angle and weight-bearing midfoot position (navicular drop), also between forefoot angle and relaxed rearfoot angle in stance, were determined using the Pearson product moment coefficient ($r$).18 For reasons of comparison to other research, correlations between forefoot angle and rearfoot angle in subtalar joint neutral, and between relaxed rearfoot angle and navicular drop, were calculated.

Data were collected on 51 subjects. Initial sampling included both feet for a count of 102 feet. Due to the strong association between the right and left foot for each person, a random sample of either left or right foot was chosen for correlational analyses for a total of 51.17,21 Correlations were examined in the whole group ($n = 51$) to investigate the relationship of the 3 measures. Based on the forefoot mean and 1 standard deviation of the data ($n = 51$), subjects were subsequently divided into 3 subgroups, based on degree of forefoot angle. Subjects whose forefoot angle fell between 1.0° and 8.0° were considered to have a “neutral,” those whose forefoot angle was greater or equal to 8.0° were considered to have a “high,” and those whose forefoot angle was less than or equal to 1.0° were considered to have a “low” forefoot varus angle. Then, correlations were examined in the neutral subgroup ($n = 38$) for all 3 measures; however, correlational analyses were not performed on the low ($n = 8$) and high ($n = 5$) subgroups because of an insufficient number of subjects in these groups.

**RESULTS**

ICC$_{3,3}$ for reliability was 0.97 for the measurement of forefoot angle, 0.90 for relaxed rearfoot angle, and 0.96 for navicular drop, based on a random sample of the left or right foot for 19 subjects. In the sample ($n = 51$), the mean (±SD) forefoot position was 4.4° (±3.4°) (Table 1). Using the subgroup classification for forefoot angle, 38 cases were considered neutral (75%), 5 cases were considered high forefoot varus (10%), and 8 cases were considered low forefoot varus (some being valgus, but not all) (15%) (Table 2).

The level of association between forefoot angle and rearfoot angle in relaxed stance in the aggregate data ($n = 51$) was $r = 0.52$ ($P<.001$). When the data were subdivided based on forefoot angle, there was no significant relationship noted in the neutral forefoot subgroup (1.0°<forefoot angle<8.0°) ($r = 0.19$, $P = .24$) (Figure 6).

The level of association between forefoot angle and navicular drop in the aggregate data was $r = 0.55$ ($P<.001$). There was no relationship noted between forefoot angle and navicular drop in the neutral forefoot (1.0°<forefoot angle<8.0°) subgroup ($r = 0.01$, $P = .96$) (Figure 7).

The level of association between relaxed rearfoot angle and navicular drop was $r = 0.45$ ($P = .002$). When the data were subdivided based on forefoot angle, there was no significant relationship between relaxed rearfoot angle and navicular drop in the neutral subgroup ($r = 0.32$, $P = .055$). The overall correlation between forefoot angle and rearfoot angle in subtalar joint neutral was not significant ($r = 0.17$, $P = .24$).

**DISCUSSION**

The purpose of this study was to investigate the relationships between forefoot angle and relaxed rearfoot angle, and between forefoot angle and navicular drop, in a healthy population. Measures of forefoot angle, relaxed rearfoot angle, and navicular drop were found to be reliable (ICC≥0.90). All measures were taken by a primary investigator and performed on the low ($n = 8$) and high ($n = 5$) subgroups because of an insufficient number of subjects in these groups.

<p>| TABLE 1. Descriptive statistics for a random sample of left or right feet ($n = 51$). |
|---------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|</p>
<table>
<thead>
<tr>
<th>Minimum</th>
<th>Maximum</th>
<th>Range</th>
<th>Mean</th>
<th>SEM</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forefoot angle (°)</td>
<td>–4.5</td>
<td>13.7</td>
<td>18.2</td>
<td>4.4</td>
<td>.48</td>
</tr>
<tr>
<td>Relaxed rearfoot angle (°)</td>
<td>3.0</td>
<td>16.0</td>
<td>13.0</td>
<td>10.5</td>
<td>.37</td>
</tr>
<tr>
<td>Navicular drop (mm)</td>
<td>–2.6</td>
<td>17.0</td>
<td>19.6</td>
<td>6.2</td>
<td>.63</td>
</tr>
</tbody>
</table>

Abbreviations: SEM, standard error of the mean; SD, standard deviation.
TABLE 2. Descriptive statistics for subgroups based on mean ±1 standard deviation of forefoot angle values.

<table>
<thead>
<tr>
<th>Forefoot Angle Subgroups/Foot Measurement</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Range</th>
<th>Mean</th>
<th>SEM</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>High (≥8° varus)</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Forefoot angle (°)</td>
<td>5</td>
<td>8.0</td>
<td>13.7</td>
<td>5.7</td>
<td>10.4</td>
<td>1.1</td>
<td>2.5</td>
</tr>
<tr>
<td>Relaxed rearfoot angle (°)</td>
<td>5</td>
<td>6.7</td>
<td>15.3</td>
<td>8.6</td>
<td>11.2</td>
<td>1.7</td>
<td>3.8</td>
</tr>
<tr>
<td>Navicular drop (mm)</td>
<td>5</td>
<td>10.8</td>
<td>17.0</td>
<td>6.2</td>
<td>13.2</td>
<td>1.1</td>
<td>2.4</td>
</tr>
<tr>
<td>Neutal (1.0°-8.0° varus)</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Forefoot angle (°)</td>
<td>38</td>
<td>1.3</td>
<td>7.7</td>
<td>6.4</td>
<td>4.8</td>
<td>0.3</td>
<td>1.7</td>
</tr>
<tr>
<td>Relaxed rearfoot angle (°)</td>
<td>38</td>
<td>5.3</td>
<td>16.0</td>
<td>10.7</td>
<td>11.0</td>
<td>0.3</td>
<td>2.1</td>
</tr>
<tr>
<td>Navicular drop (mm)</td>
<td>38</td>
<td>–1.2</td>
<td>13.3</td>
<td>14.5</td>
<td>6.1</td>
<td>0.6</td>
<td>3.7</td>
</tr>
<tr>
<td>Low (≤1.0° varus)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forefoot angle (°)</td>
<td>8</td>
<td>–4.5</td>
<td>1.0</td>
<td>5.5</td>
<td>–0.9</td>
<td>0.8</td>
<td>2.1</td>
</tr>
<tr>
<td>Relaxed rearfoot angle (°)</td>
<td>8</td>
<td>3.0</td>
<td>10.6</td>
<td>7.6</td>
<td>7.4</td>
<td>1.0</td>
<td>2.7</td>
</tr>
<tr>
<td>Navicular drop (mm)</td>
<td>8</td>
<td>–2.6</td>
<td>8.0</td>
<td>10.6</td>
<td>2.0</td>
<td>1.2</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Abbreviations: SEM, standard error of the mean; SD, standard deviation.

recorded by an assistant; however, it should be noted that while the primary investigator did not record the actual linear value, there might have been unintentional potential to recall general visual estimates. All of the intrarater reliability scores were considered excellent and in accordance with other authors. While measurements of subtalar joint neutral in non-weight bearing have not been found to be reliable, measurements in weight bearing have been found to have good intrarater reliability. Intrarater reliability has been proven to be better when the investigator is experienced and when more than 2 measures are taken for each position. Both strategies were used in our study.

We collected forefoot, rearfoot, and navicular drop measurements on 51 individuals, sampling both feet for an initial count of 102 feet. In this study, to respect the assumption of independence, only data from 1 foot (randomly selected for each subject) were used. Menz reported that there is a potential for data inflation when using measurements from the right and left foot of the same individual. He therefore advocated either averaging the left and right foot data, or randomly selecting either the right or left foot for analysis. The drawback in averaging data from the right and left foot is the potential for obscuring valuable information. While there is a potential for losing valuable information by randomly selecting either the right or left foot, the benefit is that assumption of independence is not violated.

In the data studied (n = 51) a forefoot varus angle was present in 92% and a forefoot valgus angle was present in 8% of the cases. The overall high incidence of forefoot varus angle compared to forefoot valgus angle is in agreement with data reported by Donatelli et al, who found a forefoot varus frequency of 90.5%, and by Garbalosa et al, who found a frequency of 87%. However, our results conflict with those of McPoil et al, who recorded forefoot varus in only 8.95% of their 27 subjects. This discrepancy may be due to variations in measurement technique, especially in the amount of force placed through the fourth and fifth metatarsal heads when loading the forefoot. There are potential reliability issues when using foot measurement techniques in the non-weight-bearing position. While good test-retest reliability was demonstrated in this study (ICC3,3 = 0.95) and in the study by Donatelli et al (ICC = 0.99), other authors have questioned the reliability of non-weight-bearing measurements. Due to these differences, we believe it is important to establish one’s own reliability, as well as sample mean and standard deviation, for these measures. Establishing good reliability of both the dependent and independent variables also helps to strengthen the internal validity of the study. Based on the measures from the investigator of this study, 1.0° to 8.0° of forefoot varus was considered neutral, as defined by the mean ± standard deviation. Our average navicular drop measure (mean, 6.2 mm) was in accordance with others who have reported averages ranging from 6.1 to 7.58 mm. Finally, our average rearfoot angle in single-limb stance (10.5° ± 2.7°) also fell within the ranges found by others (6.2° ± 3.9° to 12.2° ± 4.0°). Given the good reliability of the measures and general agreement of our values with others in the literature, we felt confident in studying relationships between variables.

The relationship between forefoot angle and relaxed rearfoot angle in stance is based on the principle that when a forefoot varus angle is present, the rearfoot will evert to bring the foot parallel to the ground. It is not known whether forefoot varus leads to midfoot/rearfoot pronation or if midfoot/rearfoot pronation over a long period of time creates a forefoot varus due to medial loading. Regardless, our results suggest that they are related. We noted an overall correlation between forefoot angle and relaxed rearfoot angle in stance of r = 0.52 (P<.001). This suggests that 27% of the variance in relaxed
FIGURE 6. (A) Relationship between forefoot angle and relaxed rearfoot angle across all subjects. (B) Relationship between forefoot angle and relaxed rearfoot angle in the neutral forefoot subgroup.

rearfoot angle may be related to forefoot structure. Donatelli et al. 6 assessed the relationship between forefoot varus and peak rearfoot angle during the stance phase of gait and also found a positive correlation.

Interestingly, there was no relationship between forefoot angle and relaxed rearfoot angle in the neutral subgroup \( (r = 0.19, \ P = .24) \). These data suggest that people with an average amount of forefoot varus do not necessarily exhibit the proposed relationship between forefoot and rearfoot position. However, as the structural malalignments increase, the relationship becomes more apparent. This is true of most structural deviations. A leg length discrepancy of 5 mm may not result in compensatory biomechanics; however, one of 20 mm is likely to lead to significant adaptations. This may explain, in part, the lack of significant findings in previous studies by McPoil and Cornwall 16 and Mueller et al. 18 where the forefoot angles studied may have been in a narrower neutral range of values. One could make the argument that if the neutral subgroup had a limited range of values, it would reduce the strength of the correlation. However, the range of values in our study

FIGURE 7. (A) Relationship between forefoot angle and navicular drop across all subjects. (B) Relationship between forefoot angle and navicular drop in the neutral forefoot subgroup.
in each of the subgroups was similar (high, 5.7°; neutral, 6.4°; low, 5.5°) and sample of 38 subjects in the neutral subgroup should have provided enough statistical power to see a correlation if there was one. The strength of our correlation between forefoot angle and relaxed rearfoot position seems to be driven by the high and low subgroups data. While we recognize that we do not have enough subjects in our high and low subgroups to be studied independently, future research investigating foot structure should include these extremes.

Mueller et al\textsuperscript{18} assessed the correlation between forefoot angle and rearfoot angle in subtalar joint neutral position as opposed to relaxed calcaneal stance.\textsuperscript{18} The authors found no correlation between rearfoot and forefoot position \((r = 0.004-0.14)\). This finding would be expected because their measure of rearfoot angle in subtalar joint neutral did not take into account possible pronation compensation. When we examined the relationship between forefoot angle and rearfoot angle in the subtalar joint neutral position, we also found no significant correlation.

While assessing the midfoot position with external markers is difficult, navicular drop provides an indication of midfoot pronation. Therefore, we also sought to examine the relationship between forefoot angle and navicular drop. The correlation between forefoot angle and navicular drop in the entire group of subjects was \(r = 0.55\) \((P<.001)\), with 30% of the variance in navicular drop explained by forefoot angle. Our values were higher than those found by Mueller et al\textsuperscript{18} \((r = 0.29\) and 0.33 for the right and left foot, respectively), who found 8% to 11% of the variance in navicular drop accounted for by forefoot angle. The discrepancy in the amount of explained variance between the 2 studies may be due to sample range as well as measurement technique. In measuring forefoot angle, Mueller et al\textsuperscript{18} data revealed a range of forefoot position from –6.0° to 6.0°, while our data ranged from –4.5° to 13.7°. This variation may either be due to the amount of pressure placed through the fourth and fifth metatarsal heads or it may indicate that we included a wider range of foot structures. Similar to the findings for the relaxed rearfoot angle, there was a lack of a relationship between forefoot angle and navicular drop in the neutral subgroup \((r = 0.01, P = .96)\). This supports our previous suggestion that when forefoot alignment is within a neutral range, there may not be a need to compensate through the midfoot or rearfoot.

Individuals may compensate in different ways for structural positions or malalignments. For example, if rearfoot motion is limited, compensation for forefoot varus may be seen in the midfoot. Midfoot pronation is difficult to measure clinically. Navicular drop has been used as a measure of midfoot pronation, or arch flattening.\textsuperscript{12,18,24} A possible limitation in using navicular drop is the potential for skin movement over the marked navicular. In our study it is important to note that while the navicular was marked in subtalar joint neutral, it was not remarked again in a standing relaxed position. This may have resulted in underestimation of the true excursion of the navicular drop.

Midfoot and rearfoot pronation are not always correlated. Some individuals have fairly vertical calcanei during stance in the presence of midfoot pronation. Lundberg et al\textsuperscript{13} found that during foot pronation, the largest amount of motion occurred in the talonavicular joint, followed by the talocalcaneal joint. The correlation between relaxed rearfoot angle and navicular drop in the entire group of subjects was \(r = 0.43\) \((P = .002)\), where 19% of the variance could be explained between the 2 variables. The findings of Cornwall and McPoil\textsuperscript{15} support this relationship. Their research determined that the calcaneus and navicular had interdependent motion during walking. Further, using a stepwise multiple regression analysis with 17 static measurements entered, McPoil et al\textsuperscript{16} found that navicular drop was the significant predictor selected in the prediction of maximal rearfoot eversion. Their correlation of \(r = 0.42\) matched that of Mueller et al,\textsuperscript{18} who also found a significant correlation of \(r = 0.42\) between rearfoot angle and navicular drop. Unlike our other findings, the correlation between relaxed rearfoot angle and navicular drop were very close to significant in our neutral subgroup \((r = 0.32, P = .055)\). This may imply that the movement between the rearfoot and midfoot may be associated even in feet that exhibit a neutral structural alignment.

Clinicians often perform static foot evaluations on patients with the underlying assumption that structure and function are related.\textsuperscript{15} Very little data exist regarding the relationships between static forefoot, midfoot, and rearfoot positions. Results of studies assessing the relationship between static measurements and function have been variable. Our study revealed that there is a moderate relationship between forefoot angle and associated relaxed rearfoot angle and navicular drop in a healthy sample. This relationship is absent in the neutral range of values, which implies that the significance of the correlation is derived from the high and low extremes of forefoot values. Therefore, the relationship between structure and function becomes most evident when considering foot positions that depart substantially from the mean. Again, it should be noted that our data were based on healthy subjects. It is unknown if foot structure relationships in a population with pathologies or pain would exhibit the same tendencies. A better understanding of forefoot, midfoot, and rearfoot relationships could help clinicians and researchers better refine specific interventions, such as foot orthotics. Future studies are needed to further
investigate the role of forefoot angle on static and dynamic measures of the foot in subjects with pathology.

CONCLUSIONS

Based on the results of this study, we conclude that there is a significant relationship between forefoot angle and relaxed rearfoot angle, as well as between forefoot angle and navicular drop in healthy subjects. These relationships were not found when forefoot varus values were within a standard deviation of the sample mean.

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REFERENCES


