Reliability of digital photography for assessing lower extremity alignment in individuals with flatfeet and normal feet types

Zinat Ashnagar a, Mohammad Reza Hadian b, *, Gholamreza Olyaei a, Saeed Talebian Moghadam a, Asghar Rezasoltani c, Hassan Saeedi d, Mir Saeed Yekaninejad e, Rahimeh Mahmoodi a

a Physical Therapy Department, School of Rehabilitation, Tehran University of Medical Sciences, Tehran, Iran
b School of Rehabilitation, Brain and Spinal Injury Research Center (BASIR), Tehran University of Medical Sciences, International Campus (TUMS, TUMS-IC), Tehran, Iran
c Department of Orthotics and Prosthetics, Faculty of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran
d Department of Epidemiology and Biostatistics, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran

ABSTRACT

Aim: The aim of this study was to investigate the intratester reliability of digital photographic method for quantifying static lower extremity alignment in individuals with flatfeet and normal feet types.

Methods: Thirteen females with flexible flatfeet and nine females with normal feet types were recruited from university communities. Reflective markers were attached over the participant’s body landmarks. Frontal and sagittal plane photographs were taken while the participants were in a standardized standing position. The markers were removed and after 30 min the same procedure was repeated. Pelvic angle, quadriceps angle, tibiofemoral angle, genu recurvatum, femur length and tibia length were measured from photographs using the Image j software.

Results: All measured variables demonstrated good to excellent intratester reliability using digital photography in both flatfeet (ICC: 0.79–0.93) and normal feet type (ICC: 0.84–0.97) groups.

Conclusion: The findings of the current study indicate that digital photography is a highly reliable method of measurement for assessing lower extremity alignment in both flatfeet and normal feet type groups.

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1. Introduction

Flatfeet or pes planus is characterized by a chronically dropped or abnormally low medial longitudinal arch (MLA) often in association with calcaneal eversion and excessive pronation of the subtalar joint (Angin et al., 2014; Banwell et al., 2014; Neumann, 2010).

The Foot Posture Index (FPI) is a clinical tool of foot posture assessment that has been proposed to evaluate multiple segments and planes of the foot in a variety of clinical settings (Redmond et al., 2008). The six-item criterion FPI is a simple, quick and observational method which allows the clinician to assess static standing foot posture and classify it as neutral, pronated, or supinated (Redmond et al., 2006). The FPI has shown moderate intertester and high intratester reliability and good construct validity (Cornwall et al., 2008; Keenan et al., 2007). During the assessment of the relationship between static foot posture and foot mobility, it has been demonstrated that individuals with higher FPI scores had greater foot mobility and those with lower FPI had less foot mobility (Cornwall and McPoil, 2011).

The relationship between the FPI and rearfoot plane motion during walking has been investigated (Buldt et al., 2013; Chuter, 2010). The results demonstrated a strong, positive correlation between increasing FPI score (more pronated posture) and maximum rearfoot eversion (Chuter, 2010).

Flatfeet rarely exist without some degree of hyperpronation.
(Gould, 1983). In this condition, the subtalar joint is excessively pronated or continues to pronate during the midstance phase of gait and consequently the foot remains in maximum pronation and therefore, supination cannot occur in terminal stance for push off (Khamis and Yizhar, 2007; Levangie and Norkin, 2005). It is hypothesized that this excessive pronation of the foot may alter the normal screw-home mechanism of the tibiofibormal joint during the midstance phase of gait. During knee extension, external rotation of the tibia is necessary to accomplish the screw-home mechanism and this external rotation of the tibia is accompanied by subtalar joint supination. In the case of excessive subtalar joint pronation, the femur instead must internally rotate to compensate the lack of tibial external rotation. Excessive internal rotation of the femur may alter the position of the patella and move it medially relative to ASIS (anterior superior iliac spine) and tibial tuberosity, therefore, increasing the quadriceps angle (QA) (Powers, 2003; Silva et al., 2013; Tiberio, 1987).

The foot acts as a linkage between the supporting surface and the lower extremity (Arnold et al., 2014) especially in closed kinetic chain. Therefore, the posture of the foot may affect the function of the lower limb (Redmond et al., 2006) as a result of the close biomechanical relationship between the subtalar joint and the tibiofemoral joint (Tiberio, 1987).

It has also been suggested that abnormal pronation may contribute to patellofemoral joint dysfunction (Hollman et al., 2006; Powers, 2003) and production of pelvic misalignment while maintaining the standing positions (Pinto et al., 2008). Therefore, the hyperpronated foot posture might influence the alignment of the entire kinetic chain. Considering the influence of foot misalignment on the proximal joints, it was hypothesized that the assessment of the entire lower extremity alignment in different foot types might be utilized as a clinical tool and therefore, could be used for preventing consequent lower limb injuries.

Full length lower extremity radiographs have been used for assessing biomechanical alignment of the lower extremity (Schmitt et al., 2008; Sheehy et al., 2015). Although radiography is considered the “gold standard” for determining limb alignment, concerns regarding over ionizing radiation and the need for specialized equipment exist (Schmitt et al., 2008; Sheehy et al., 2015).

A digital photographic method could potentially provide a safe, convenient, time-efficient and cost effective method of assessing lower extremity alignment within a variety of settings (Nguyen et al., 2013; Pohl and Farr, 2010). There are a few studies which investigate the reliability of the digital photographic method for quantifying lower extremity alignment (Moncrieff and Livingston, 2009; Nguyen et al., 2013; Schmitt et al., 2008; Sheehy et al., 2015) and most of them examined only the frontal-plane alignment (Moncrieff and Livingston, 2009; Schmitt et al., 2008; Sheehy et al., 2015).

Sagittal variables such as pelvic angle (PA) and genu recurvatum (GR) may also be measured using digital photography. Previous studies have mentioned difficulty in palpation of iliac spines (anterior superior and posterior superior) for measuring PA due to presence of excessive soft tissue and increased abdominal fat (Nguyen et al., 2013; do Rosário, 2014).

Accordingly, in the present study, a new method was introduced to identify the PSIS (posterior superior iliac spine) landmark mathematically and provide a possible solution to use even in the presence of excessive soft tissue.

Therefore, the purpose of the present study was to investigate the intra-tester reliability of a digital photographic method for identifying lower extremity alignment in individuals with flatfeet and normal feet types.

2. Method

2.1. Study design

Intrarater reliability of digital photography for measuring the static lower limb alignment was evaluated in normal and flexible flatfeet participants. Pelvic angle (PA), quadriceps angle (QA), tibiofemoral angle (TFA), genu recurvatum (GR), femur length (FL) and tibia length (TL) were assessed using digital photography. A Canon PowerShot SX710HS (Canon Inc., Tokyo, Japan) digital camera (20.3 megapixels) was used to capture sagittal and frontal plane images.

2.2. Participants

Twenty two females aged 18–35 years were recruited using advertisements through university communities. None of the participants reported recent trauma, lower limb fractures or surgical history or pain in lumbar spine and lower limb for at least three months prior to measurement. The study was approved by the ethical committee of Tehran University of Medical Sciences and informed written consent was obtained from all participants.

Based on the six items of foot posture index (FPI) (Redmond et al., 2006), normal and flatfeet foot types were classified as follows: 13 participants presented with flexible flatfeet (mean FPI 9.8 ± 1.5, range: 7–12) while 9 had normal feet types (mean FPI 3.1 ± 1.1, range: 1–4).

2.2.1. Procedure

A preliminary study was performed to assess the accuracy of the tester derived measures, a standard manual goniometer, made of transparent plastic material, was used as a criterion standard. Three custom-made reflective markers (22 mm diameter) were adhered to the center and at the end of each arm of the standard manual goniometer. The goniometer was attached to the wall and the tripod-mounted digital camera was positioned 3 m away from it. Before capturing each image, one of the authors (RM) moved one arm of the goniometer to create different angles. The images were captured by the tester (ZA) who was blind to the angle of the goniometer. Twenty angles were set and 100 images (i.e. five images for each angle) were captured.

The images were selected randomly and measured separately by the ZA who was blind to the magnitude of the angles. The Image J software (http://rsweb.nih.gov/ij/), was used to measure the angles. Before data collection, the tester (ZA), who was PhD candidate of physical therapy with several years of clinical experience, completed several training sessions for identifying the anatomic landmarks and also measuring the angles using the Image J software.

On each of the participants, 15 mm diameter circular, self-adhesive reflective stickers and 22 mm diameter custom made reflective markers were secured to the anatomic landmarks as described by Nguyen et al. (2013) while the participant was in a test position. Custom-made reflective markers were adhered to the ASIS, superior tip of the greater trochanter, the midpoint between ASIS and superior tip of the greater trochanter, medial and lateral joint lines of the knee and inferior tip of the medial malleolus using double-sided adhesive tape. (See Fig. 1, A).

Self-adhesive reflective stickers were attached to the lateral epicondyle of the femur, the center of the patella, tibial tuberosity, center of the knee joint (midpoint between medial and lateral joint lines) and the center of the ankle joint (midpoint between lateral and medial malleoli) and inferior tip of the lateral malleolus (See Fig. 1, B).

Participants were asked to stand on a 50 cm high table while...
their feet were positioned shoulder-width apart, toes facing forward in the equal distance from the center of the table. Participants were instructed to cross their upper extremities over their chest and look forward.

The digital camera was mounted on a tripod and at 3 m distance away from the center of the table. The tripod was adjusted at 80 cm height and leveled by a bubble level. The leveled camera was positioned while the optical axis of the camera was perpendicular to the center of the box.

The camera was adjusted to zoom in on the lower extremity maximally, while all the markers were seen in the image.

QA, TFA, FL and TL were measured using frontal plane images while GR and PA were assessed using sagittal plane images. In the frontal plane, QA was measured as the angle formed between two intersecting lines from the anterior superior iliac spine (ASIS) to the center of the patella and the center of the patella to the tibial tuberosity (Powers, 2003).

TFA was measured as the angle between anatomical axes of the femur and tibia. For measuring TFA, proximal and distal landmarks were marked. The midpoint between ASIS and superior tip of greater trochanter as the proximal landmark and midpoint between medial and lateral malleoli as distal landmark were described. By connecting proximal landmark to the knee joint center (the midpoint between medial and lateral joint lines) and the knee joint center to the distal landmark, the TFA was formed (Nguyen et al., 2013).

FL was described as the distance from the superior tip of greater trochanter to the lateral joint line of the knee. The distance from the medial joint line of the knee to the inferior tip of medial malleolus was described as TL (Nguyen et al., 2013).

In the sagittal plane, PA was measured as the angle between the lines from ASIS to posterior superior iliac spine (PSIS) with the horizontal line (Lopes et al., 2014; Lima et al., 2015).

Because of the presence of excessive soft tissue (i.e. fat) in the lumbar area especially in females, one additional custom-made marker was attached to the 5 cm plastic stem and used for PSIS.

To measure GR, the participants were required to contract their quadriceps muscle to maximally extend their knees (active-extension) while for other measurements the participants were asked to be relaxed (neutral-stance) (Nguyen et al., 2013). The angle formed between the line from the greater trochanter to the lateral epicondyle of the femur and the line from the lateral epicondyle to the lateral malleolus was measured as GR.

Two additional stickers were attached vertically to the wall 10 cm apart, parallel to the participant’s lower extremity, and used as a criterion standard for later measurements.

A frontal plane (neutral-stance) and two sagittal planes (neutral-stance and active-extension-stance) images were captured for each participant. All the images were taken by the one tester (ZA). To assess intratester reliability, all the markers were removed and the procedure (i.e. identifying the landmarks and attaching the markers) was repeated after 30 min.

All the variables were measured using Image j software. For measuring the angles, the angle tool of the software was selected. The center of each marker or sticker that represent the anatomic landmark was selected and connected manually by the angle tool while zooming in to 33%. The depicted angle was measured by the software and used for data analysis. The QA, TFA, GR were measured using the same procedure.

For measuring PA, two stages of measurement was required as following:

First, determining the real position of the PSIS on the body using trigonometric functions. Second, depicting the angle between the ASIS and the PSIS with horizontal line.

To calculate the real position of the PSIS on the body, the following process was done. First of all, a vertical line was drawn from the center of the PSIS marker (a). The stem with the marker was considered as the side of the right triangle (c). Next, the angle between the stem and vertical line (B) was measured by the angle tool of the Image j software. As a rule of triangle, all interior angles (angle, side, angle (ASA)) and according to the law of Sines and Cosines, the length of the other two sides (a and b) was calculated. Based on the results of the calculation, a and b were drawn (See Fig. 2). Therefore, the real position of the PSIS was identified mathematically.

Finally, the angle between ASIS and the identified PSIS with the
horizontal line was depicted by angle tool of the software to calculate pelvic tilt.

Before measuring the length of the femur and tibia, the scale was set in the software. The Image J software by default calculate distances in pixels, so there is a need to set scale in preferred unit. Therefore, to set the scale, the known distance between two additional stickers, which were attached to the wall, was measured as a criterion standard by using straight-line tool of the software and recorded as a 10 cm distance. Following to the scale setting, the defined landmarks for measuring the length of the femur and tibia were selected and measured by the software based on the known criterion standard.

Each variable was measured three times and the average of the three trials was calculated and used for data analysis.

3. Statistical analyses

Statistical analyses were performed using SPSS 22.0 (SPSS Inc., Chicago, IL). To assess the intratester reliability of measurements derived from digital photography, the intraclass correlation coefficient (ICC) with 95% confidence intervals (CI) and standard error of measurement (SEM) were calculated for each variable. The ICC values were interpreted as follows: if the ICC was less than 0.5 was considered as poor; if the ICC ranged from 0.5 to 0.75 was considered as moderate. If the ICC ranged from greater than 0.75 to 0.9 was considered as good and if the ICC was greater than 0.9 was considered as excellent (Portney and Watkins, 2015). To investigate the agreement between two measurement trials, 95% limits of agreement (LOA) were calculated and Bland-Altman plots were depicted for each variable. For the preliminary study, The Bland-Altman plot was depicted to show the mean difference between the goniometric angle and the angle derived from the photographic method.

Significance Level was set at P < 0.05.

4. Results

Thirteen females with flexible flatfeet (age: 24.9 ± 4.8 years, height: 162.5 ± 3.5 cm, mass: 60 ± 13.2 kg, BMI: 22.8 ± 5.1 kg/m²) and nine females with normal feet types (age: 25.4 ± 5.3 years, height: 161.1 ± 8 cm, mass: 62.11 ± 10.9 kg, BMI: 23.8 ± 2.9 kg/m²) participated in this study.

Means and SDs of first and second measurements for each lower extremity alignment in both groups are presented in Table 1. The ICCs with 95% CI and SEMs for intratester reliability of digital photographic method for each variable in flatfeet and normal feet type groups are presented in Tables 2 and 3, respectively. Intrater reliability was good to excellent for flatfeet (0.79–0.93) and normal feet type (0.84–0.97) groups (Tables 2 and 3). The SEM values were relatively low for all variables in flatfeet (SEM range: 1.61–2.78° and 0.53–1.56 cm) and normal feet type (1.25–2.48° and 0.33–0.79 cm), with the exception in the measurements of the QA in both groups (Tables 2 and 3).

The results of the Bland-Altman plot for the preliminary study, showed the small mean difference (–1.32 ± 0.47) and narrow limits of agreement (–0.4 to –2.24) between goniometric angle and the angle derived from the photographic method.

The Bland-Altman plots showing mean differences between first and second measurements and 95% upper and lower LOAs are shown for each variable in Fig. 3. The Bland-Altman results showed small mean differences between two measurements for PA, QA, TFA and GR (≤ 1.2°) and for FL and TL (≤ 0.6 cm) (See Fig. 3).

5. Discussion

The main goal of this study was to investigate the intratester reliability of digital photographic method for quantifying static lower extremity alignment in individuals with flatfeet and normal feet types. The results of the present study showed good to excellent intratester reliability in the measurement of PA, QA, TFA, GR, FL and TL using digital photography in both flatfeet and normal feet type groups.

In the present study, lower extremity alignment was assessed in both sagittal and frontal planes using digital photography. To our knowledge, only one study has assessed lower extremity alignment in both sagittal and frontal planes (Nguyen et al., 2013) while other studies determine the alignment only in the frontal plane (Moncrieff and Livingston, 2009; Schmitt et al., 2008; Sheehy et al., 2015). Nguyen et al. reported fair to excellent intratester reliability (0.7–0.99) for all variables of lower extremity alignment in sagittal (PA and GR) and frontal planes (QA, TFA, FL and TL) (Nguyen et al., 2013).

The alignment of the lower limb joints might affect the position of the pelvis during closed kinematic chain activities (Khamis and Yizhar, 2007; Pinto et al., 2008). Previous literature suggested that foot hyperpronation could lead to changes in the lower extremity alignment and pelvic position (Khamis and Yizhar, 2007; Pinto et al., 2008). In addition, contraction of the muscles that attach to the pelvis such as Rectus abdominis and erector spinae may also affect the pelvis position (Kendall et al., 2005; Nguyen et al., 2013).

The results of the present study demonstrated good intratester
the lower extremity (Schmitt et al., 2008; Sheehy et al., 2015) while or frontal-plane knee joint alignment. Some authors have assessed landmark in digital photographs. Therefore, in this study, we used a muscles surrounding the pelvis and presence of excessive soft tis-

eadhesive markers and digital photography. Contraction of the

and ASIS landmarks (Nguyen et al., 2013). In particular, the pres-

eence of excessive soft tissue or fat mass in the lumbar area may

prevent full visualization of the re-

There are some difficulties in assessing pelvic alignment using

adhesive markers and digital photography. Contraction of the

muscles surrounding the pelvis and presence of excessive soft tis-

sue, especially in females, can lead to difficulty in palpating PSIS

and ASIS landmarks (Nguyen et al., 2013). In particular, the pres-

ence of excessive soft tissue or fat mass in the lumbar area may

prevent full visualization of the reflector marker on the PSIS

landmark in digital photographs. Therefore, in this study, we used a

new method for assessing and analyzing the pelvic position.

However, further research is needed to validate this method.

Various methods of measurement were used to evaluate the TFA

or frontal-plane knee joint alignment. Some authors have assessed

the lower extremity alignment as a reflection of mechanical axis of

the lower extremity (Schmitt et al., 2008; Sheehy et al., 2015) while others have determined anatomical the axis of the femur and tibia (TFA) (Moncrieff and Livingston, 2009; Nguyen et al., 2013).The mechanical axis is defined as the line passing from the center of the hip joint to the center of the knee and ankle joints, while the anatomical axis of the femur and tibia extends longitudinally along the shaft of the femur and tibia, respectively (Kendall et al., 2005).

In the present study, we used the anatomical axis of the femur and tibia to measure the TFA. Our findings showed good intratester reliability and high level of precision in the TFA in both flatfeet (ICC: 0.86, SEM: 1.61) and normal feet type (ICC: 0.84, SEM: 1.25) groups. These results were similar to the previous studies who used the anatomical axis of the femur and tibia to measure TFA. Moncrieff and Livingston, showed moderate to excellent intratester reliability (ICC: 0.627–0.904) and Nguyen et al. reported excellent intratester reliability (ICC: 0.93–0.99) in the measurement of TFA (Moncrieff and Livingston, 2009; Nguyen et al., 2013).

It needs to be taken into consideration that despite some simi-

larities, a unique method of measurement was used in each study for measuring TFA or frontal-plane knee joint alignment. For example, to determine the proximal point or landmark, Sheehy et al. estimated the center of the hip joint from the inter-ASIS distance (Sheehy et al., 2015) while Schmitt et al. used the center of the widest horizontal line on the thigh circumference (Schmitt et al., 2008). On the other hand, Moncrieff and Livingston used the intersecting point of a horizontal line from the greater trochanter and a vertical line from the ASIS (Moncrieff and Livingston, 2009), while Nguyen et al. used the midpoint between the ASIS and the most prominent aspect of the greater trochanter to determine the proximal landmark (Nguyen et al., 2013).

The results of this study demonstrated that measuring the QA in a static standing position using digital photography had a good to excellent intratester reliability. Despite the good to excellent reliability, high measurement error was observed between two measurements in both flatfeet (SEM: 3.35) and normal feet types (SEM: 3.1). Moncrieff and Livingston showed poor to good intratester reliability (ICC: 0.458–0.845) and relatively high standard errors of measurement (SEM range: 2.16–3.92) in self-selected stance and Romberg-stance for measuring the QA using digital photography (Moncrieff and Livingston, 2009). On the other hand, Nguyen et al. reported good to excellent intratester reliability (0.84–0.97) in the measurement of the QA with a relatively high level of precision (SEM: 1.23–2.46). Although the method of the QA measurement was relatively similar in the mentioned studies and the present study, the results were somewhat different (Nguyen et al., 2013).

These discrepancies might be due to the magnitude of the QA in static standing position, as it somewhat depends on the magnitude of the quadriceps contraction. The patellar marker is the central point of the intersecting lines from the ASIS and tibial tuberosity, therefore, any change in the patella position as a result of the quadriceps contraction might lead to big differences in the magnitude of the QA (Moncrieff and Livingston, 2009). The variability of the quadriceps contraction within or between the two measurements and subsequent different positions of the patella may have resulted in a relatively high error of measurement. In the current study, a relatively small mean differences with a wide range of 95% LOA in the measurement of the QA (Fig. 3, B) provides further confirmation about the high variability between the two measurements especially in the flatfeet group. It appears that different states of quadriceps contraction might occur as a result of unequal weight distribution between the lower extremities. Although the participants were asked to equally distribute their weights between the lower extremities.

### Table 2

<table>
<thead>
<tr>
<th>Variables</th>
<th>Intraclass Correlation Coefficient</th>
<th>95% Confidence Interval</th>
<th>P value</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelvic angle</td>
<td>0.88</td>
<td>0.62–0.96</td>
<td>&lt;0.001</td>
<td>2.78</td>
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<tr>
<td>Quadriceps angle</td>
<td>0.82</td>
<td>0.41–0.95</td>
<td>0.001</td>
<td>3.35</td>
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<tr>
<td>Tibiofemoral angle</td>
<td>0.86</td>
<td>0.55–0.96</td>
<td>0.001</td>
<td>1.61</td>
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<tr>
<td>Genu recurvatum</td>
<td>0.85</td>
<td>0.52–0.96</td>
<td>0.001</td>
<td>2.3</td>
</tr>
<tr>
<td>Femur length (cm)</td>
<td>0.79</td>
<td>0.3–0.94</td>
<td>0.006</td>
<td>1.56</td>
</tr>
<tr>
<td>Tibia length (cm)</td>
<td>0.93</td>
<td>0.73–0.98</td>
<td>&lt;0.001</td>
<td>0.53</td>
</tr>
</tbody>
</table>

### Table 3

<table>
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<tr>
<th>Variables</th>
<th>Intraclass Correlation Coefficient</th>
<th>95% Confidence Interval</th>
<th>P value</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelvic angle</td>
<td>0.84</td>
<td>0.27–0.96</td>
<td>0.01</td>
<td>2.48</td>
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<td>Quadriceps angle</td>
<td>0.92</td>
<td>0.61–0.98</td>
<td>0.002</td>
<td>3.1</td>
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<tr>
<td>Tibiofemoral angle</td>
<td>0.84</td>
<td>0.27–0.96</td>
<td>0.01</td>
<td>1.25</td>
</tr>
<tr>
<td>Genu recurvatum</td>
<td>0.94</td>
<td>0.73–0.99</td>
<td>&lt;0.001</td>
<td>1.7</td>
</tr>
<tr>
<td>Femur length (cm)</td>
<td>0.94</td>
<td>0.79–0.99</td>
<td>&lt;0.001</td>
<td>0.79</td>
</tr>
<tr>
<td>Tibia length (cm)</td>
<td>0.97</td>
<td>0.88–0.99</td>
<td>&lt;0.001</td>
<td>0.33</td>
</tr>
</tbody>
</table>
Fig. 3. Bland-Altman plot showing difference between first and second measurements for A) PA, B) QA, C) TFA D) GR E) FL and F) TL. The solid line shows the mean difference and the dashed lines represent the 95% upper and lower limits of agreement. The horizontal axes show the average of two measurements and the vertical axes show the difference between two measurements.
weight on both feet, we did not control for it by using weighing scales or load cells.

The results of this study showed that FL and TL had a good to excellent intratester reliability in individuals with flatfeet (FL ICC: 0.79 & TL ICC: 0.93) and normal feet types (FL ICC: 0.94 & TL ICC: 0.97). These findings are in accordance with previous studies (Moncrieff and Livingston, 2009; Nguyen et al., 2013) who also used digital photography to measure FL and TL. Moncrieff and Livingston found good to excellent intratester reliability for measuring FL and Nguyen et al. showed excellent intratester reliability in the measurement of the FL and TL (Moncrieff and Livingston, 2009; Nguyen et al., 2013). Based on the current and the other results, it seems that digital photography is not only a reliable method to measure different angles of lower extremity alignment (e.g. PA, QA, TFA, GR) but also it is a useful tool to determine limb-length measurements.

The current study had some limitations. We only assessed intratester reliability of digital photographic method in the measurement of the lower extremity alignment; thus, whether the method would be reliable between different investigators were not assessed. In addition, this study was carried out on young, healthy women with flatfeet and normal feet, therefore, the results could not be generalized to males or other age ranges and also other foot problems. We proposed a new method of measurement for PA in the present study; however, we did not compare it with a criterion standard such as radiography.

6. Conclusion

The aim of this study was to assess the intratester reliability of digital photographic method for measuring static lower extremity alignment in individuals with flatfeet and normal foot types. The findings of the current study indicated that digital photography is a highly reliable method of measurement for assessing lower extremity alignment in both flatfeet and normal foot type groups. Using reflective markers and digital photography can be easily administered in clinical practice and research laboratories; however, further research are recommended to validate the photographic method especially in the sagittal plane with a criterion standard such as radiography.

Conflicts of interest

None.

Acknowledgements

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