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Quantification of the compensation of differences in limb length using heel raises

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Abstract

Background: The compensation of limb length discrepancy achieved using heel lifts is quantified.
Objective: To determine the increase in effective length of the lower limbs depending on the height of heel lift used.
Method: Five anatomical landmarks in 36 subjects are measured to quantify the increase in level, taking as reference the support surface of the pedoscope, when heel lifts of 6, 12, and 18 mm are used. The results of these measurements are compared to calculate the real increase in height achieved for lifts of known thickness.
Results: The use of heel lifts increases the height of the extremity by 76.4% of the maximum height of the lift measured at the posterior edge of the heel.
Conclusion: Real compensation value must be considerated using heel lifts in the treatment of limb length discrepancy.

Keywords: Heel lift; Limb length discrepancy; Real compensation

1. Introduction

In the clinical treatment of limb length discrepancy of the lower limb, orthotic treatment using full insoles or a heel raise is, in most cases, the main means of intervention [1,2].

When clinical examination detects a difference of length in the two lower limbs, the decision to control it totally or partially depends on the clinical experience of the therapist, the symptomatology shown by the patient, and the extent of the limb length difference. No description has been found in the literature of a standard protocol indicating the height of raise to be used for different values of limb length discrepancy [2].

The orthotic compensation of limb length discrepancy can be carried out using full insoles and heel raises. Various authors [1,3] have distinguished the effect of compensation achieved by the two treatments. It seems evident that a full insole applied under the shorter limb is able to increase the length of the limb by the height of the insole used. The use of a heel raise, however, does not mean a compensation of limb length discrepancy equal to the height of the raise used.

2. Objective

It is not the intention of the authors in this study to establish a protocol for the orthotic compensation of differences in limb length, nor to check the reliability and compatibility of the clinical tests normally used in evaluating limb length discrepancy of the lower limb [1,2,4,5]. The aim of the present study is to determine the increase in effective length of the lower limbs depending on the height of heel raise used. The null hypothesis is that the height of the limb increases by the height of the raise placed under the heel.

3. Material and method

The study was carried out in 36 volunteers (23 men and 13 women), podiatry students at Seville University, with a mean age of 24.6 years (between 19 and 31 years old). All subjects provided written consent.

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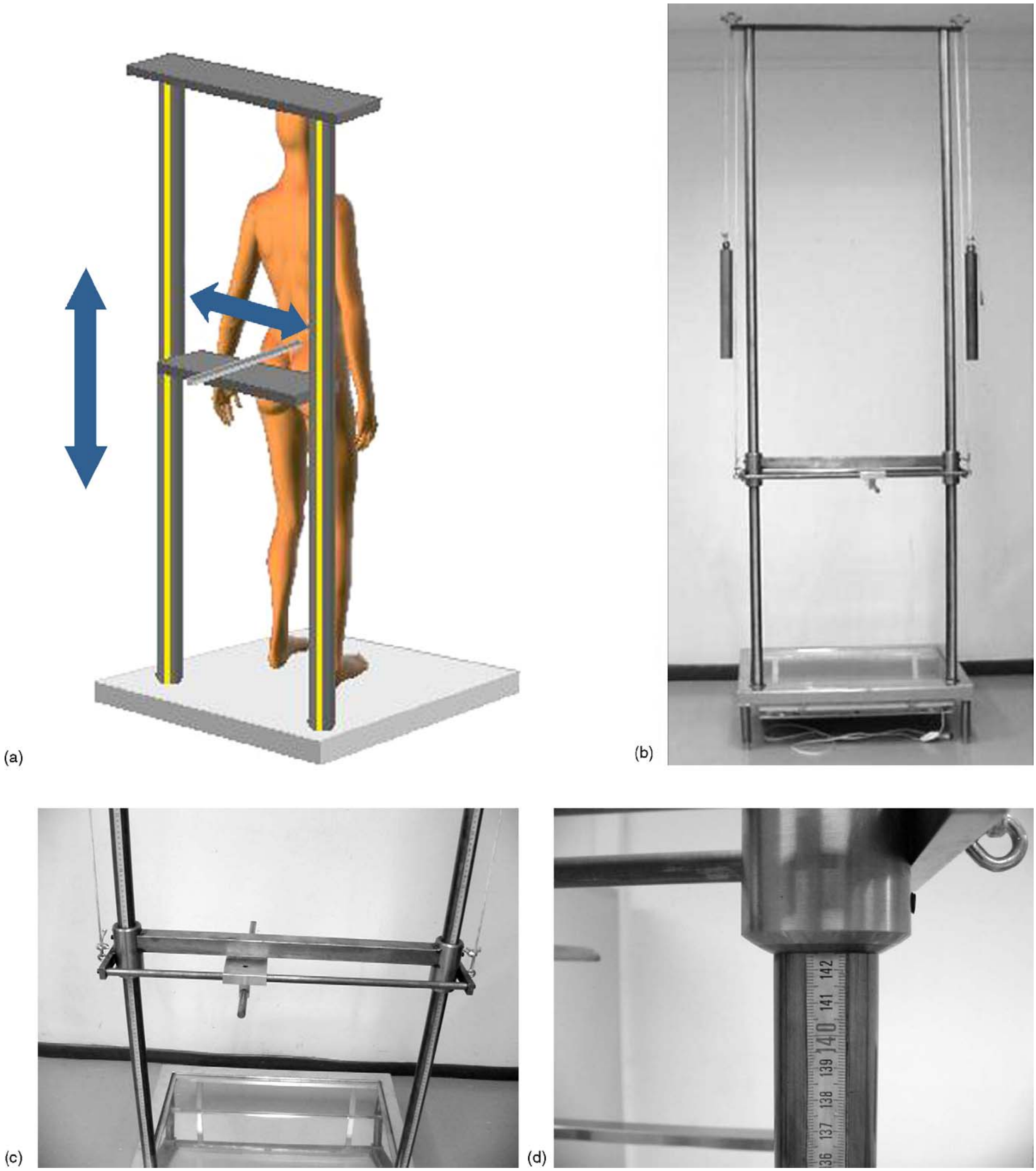

Fig. 1. (a)–(d) Height rod used for the measurements.

In each subject, marks were made on the skin over five anatomical landmarks: the centre of the left popliteal crease, the centre of the right popliteal crease, the left postero-superior iliac spine, the right postero-superior iliac spine, and the spinous process of the seventh cervical vertebra.

The study consisted of measuring the distance of these five marks from the support surface without the use of a raise

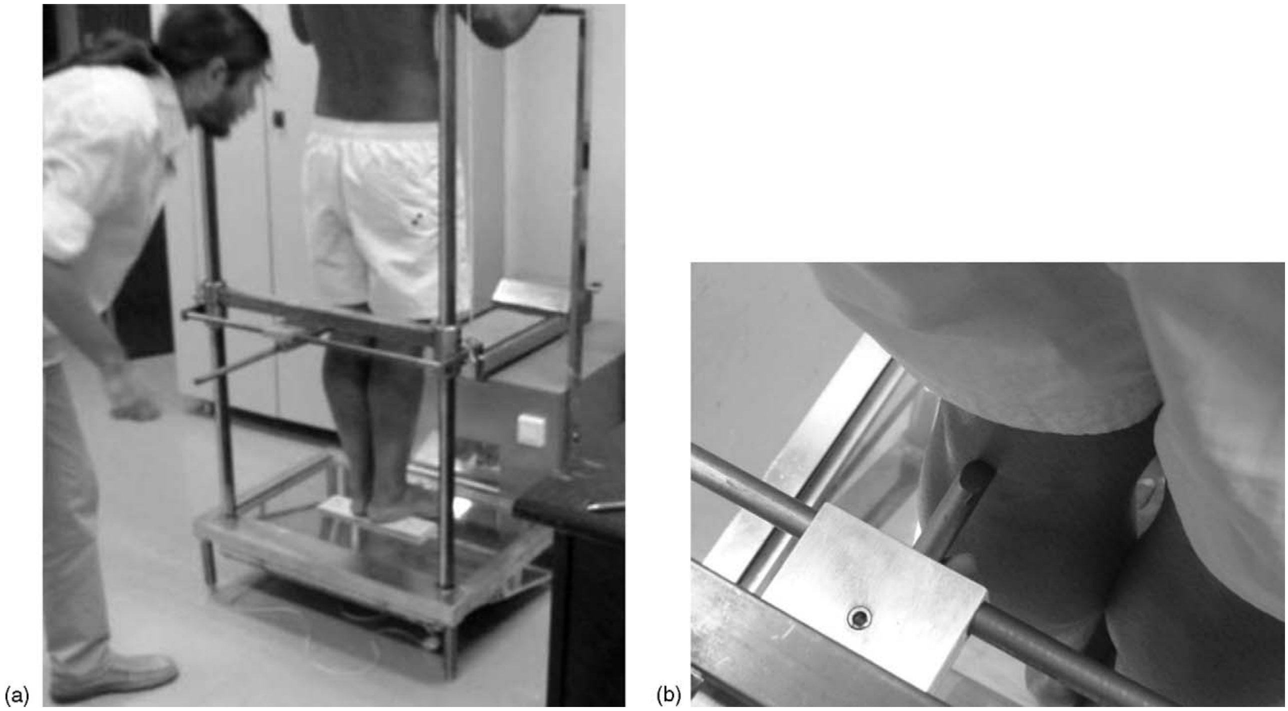

Fig. 2. (a) and (b) Measurements using different heights of heel raise.

and comparing it with that using heel raises of 6, 12, and 18 mm. To avoid skewed measurements, three observations were made for each measurement of the anatomical landmark for each height of raise used, and the mean value was calculated. Therefore, data were obtained during quiet standing.

Because *a priori* there is little difference expected between the height of raise used and the effective increase in length of the limb – some few millimetres – the system of measurement has to be reliable. In the author's opinion standard height rod, plumb, and measuring tape are ruled out as being not sufficiently reliable, with significant differences between repeated measurements of the same anatomical landmark.

To ensure a system of measurement that will minimize errors, a tempered steel height rod fitted to a pedoscope was designed. The apparatus comprises two vertical bars with a metric scale. A third, horizontal, bar slides up and down on these by means of two ferrules. The horizontal bar has a pointer sliding right and left, toward the subject on the pedoscope (Fig. 1a–d). Thus, by moving the pointer on the bars we can measure the distance to the floor of any point on the body, the measurements being more reliable than with any other system available, as showed by an intra-observer test.

The subject stood upright on the pedoscope, with the heels together and facing forward. A horizontal support bar at elbow height in front of the subject prevented unbalance. The distance of the five anatomical landmarks to the support surface was measured without heel raise (M_1). Three measurements were made for each mark, and the mean was calculated to reduce errors in the measurement. The level of the five marks was measured again after placing a raise of 6 mm (M_2), 12 mm (M_3), or 18 mm (M_4) under each foot (Fig. 2a and b). These measurements were employed to study the intra-observer reliability. The intra-class correlation coefficient was calculated. The measurements were made by the same examiner, with three observations for each mark, and the mean value was determined. The difference between measurements M_1 and M_2 showed the real increase in height of the markers for a heel raise of height 6 mm. The difference between measurements M_1 and M_3 was the increase in height of the markers using heel raises of 12 mm, and lastly, that between measurements M_1 and M_4 was the effective increase using raises of 18 mm.

4. Results

When the levels of the anatomical landmarks in the measurements M_1 and M_2 ($M_2 - M_1$) were compared, the increase in height of these markers when the height supplied by the heel raise is 6 mm was being evaluated. Similar evaluations apply when we compared the heights of the markers for measurements M_2 and M_3 ($M_3 - M_2$), and for measurements M_3 and M_4 ($M_4 - M_3$). The mean value of the comparisons between these three groups of measurements in the 36 subjects is shown in Table 1.

The real increase in height when using heel raises of 12 mm can be established by comparing the difference in

Table 1
Differences of 6 mm

	Left popliteal crease	Right popliteal crease	Left postero-superior iliac spine	Right postero-superior iliac spine	Spiny apophysis C_7
$M_2 - M_1$	4.8	4.7	3.9	4.0	4.6
$M_3 - M_2$	4.9	5.0	4.5	4.4	4.8
$M_4 - M_3$	4.8	5.0	4.4	4.4	4.4

Table 2
Differences of 12 mm

	Left popliteal crease	Right popliteal crease	Left postero-superior iliac spine	Right postero-superior iliac spine	Spiny apophysis C_7
$M_3 - M_1$	9.7	9.7	8.4	8.4	9.3
$M_4 - M_2$	9.7	10.0	8.9	8.8	9.1

Table 3
Differences of 18 mm

	Left popliteal crease	Right popliteal crease	Left postero-superior iliac spine	Right postero-superior iliac spine	Spiny apophysis C_7
$M_4 - M_1$	14.5	14.7	12.8	12.8	13.7

Table 4
Mean value of the differences in level

	mm	%
Height of lift 6 mm	4.6	76.6
Height of lift 12 mm	9.2	76.6
Height of lift 18 mm	13.7	76.1

level of the five markers between measurements M_1 and M_3 ($M_3 - M_1$). It can also be established comparing the difference in level of the markers between measurements M_2 and M_4 ($M_4 - M_2$). The real increase in height of the markers with a raise of 18 mm can be established comparing measurements M_1 and M_4 ($M_4 - M_1$). The mean value of the measurements made in the 36 subjects of the comparisons between these groups is shown in Tables 2 and 3, respectively.

The mean value of the increase in height for thicknesses of heel raises of 6, 12, and 18 mm is shown in Table 4.

All variables showed high intra-class correlation coefficient values in the intra-observer test, except "left postero-superior iliac spine using 6 mm heel rise" (0.619) and "left postero-superior iliac spine using 18 mm heel rise" (0.608).

5. Discussion

The results obtained show a difference between the height of heel raise used and the effective increase in length of the limb under which it is applied. Thus, the null hypothesis can be rejected. Effectiveness of heel raises compensating limb length discrepancy was not studied in this trial. As seen in Table 4, a rise of 6 mm at the heel gives an effective increase in the length of the limb of only 4.6 mm—that is, 76.6% of the height of heel raise used. The same percentage is obtained for a heel raise of 12 mm, and for raises of 18 mm, the percentage of effectivity is 76.1%—very similar to the former. In general, we can say that when a heel raise to increase the height of a shortened lower limb is used, only 76.4% of the height of the raise is effective, that is, the heel raise loses 23.6% effectivity of its height.

Baehler [1] states that ankle plantarflexion under which the heel raise is applied is responsible for this difference between the height of the raise and the value of difference in limb length compensated. If one wishes to compensate 5 mm of limb length discrepancy using a full insole of 5 mm in height, the insole gives an increase of 5 mm in the height of the extremity without altering the position of the ankle. However, if a heel raise is used to compensate the same value of limb length discrepancy, the ankle plantarflexion due to the raise means a greater height of insole due to the raising of the heel.

Michaud [3] established the line of action of the insole by the projection of the tibial malleolus on it, rather than on its most-posterior surface. Various authors [2,3] recommend measuring the height of the heel raise at this level to determine the increase in effective height. According to Michaud, the point of action of the heel raise is found at a distance of 1/3 of its most proximal point on the posterior edge of the heel, and at a distance of 2/3 of its most distal point on the metatarsal heads. From one end to the other, the heel raise acts as a postero-anterior wedge responsible of the ankle plantarflexion, with its maximum height at the posterior edge of the heel and decreasing progressively to 0 mm at the level of the metatarsal heads. According to this scheme, the effective height of the heel raise is 66% of its maximum height. Consequently, that author proposes increasing the difference in limb length value (D.L.L.V.) by 33% to compensate when using heel raises (Fig. 3).

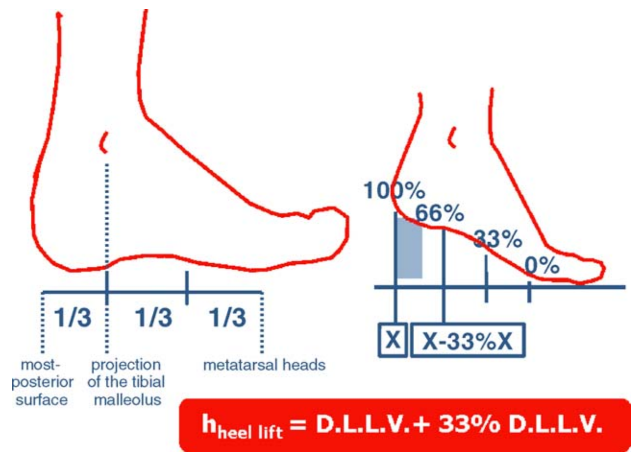

Fig. 3. Determination of the effective height of the heel raise according to Michaud.

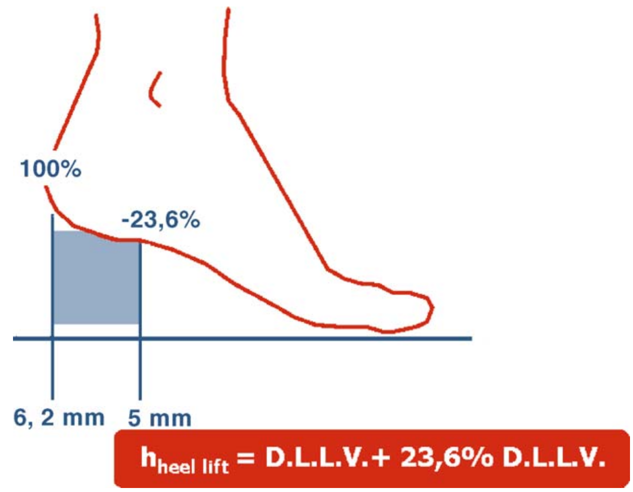

Fig. 4. Scheme of action in the compensations of limb length discrepancies according to the authors.

In this trial the authors employed flat raises. This device acts as a posterior–anterior wedge, in the same way as the wedge described by Michaud.

The results from this study show an effectivity loss of 23.6%, lower than the 33% reported by Michaud. This difference in effective height may be because the location of the line of action of the raise is more distal, and therefore, closer to the posterior edge of the raise at a higher point.

From the results obtained, the authors recommend increasing the value of limb length discrepancy to be compensated by 23.6% to determine the maximum height of the heel raise measured on its most-posterior surface. That is: maximum height of heel raise = D.L.L.V. + 23.6% D.L.L.V. (Fig. 4).

Although the indication for using full insole or heel raise can depend on different factors, such as the value of limb length discrepancy to be compensated, the capacity of the footwear or the presence of equinus ankle. The present study shows the difference between the maximum height of heel raise and its effective height. It is the latter value that is most important in the design of orthotic treatment, and the reason for which 23.6% of the maximum height of the raise must be subtracted to know the effect produced on the extremity to be treated.

Even in the absence of results from a very large sample, the coincidence in values obtained here using heel raises of 6, 12, and 18 mm in thickness seems to indicate that the mean value of effectivity established (−23.6% of the maximum height of the raise) is a reliable and referent parameter in the treatment of compensations of limb length discrepancy.

The authors agree real compensation value must be considerate using heel raises in the treatment of limb length discrepancy. Data show lack of effectiveness of the maximum height of the heel raise measured on its most-posterior surface compensating limb length discrepancy.

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