Research Paper Technology

Deformation Characteristics of Elderly Feet

* N. Schindlerova ** B. Foltynova *** P. Hlavacek

* Thomas Bata University in Zlín & Nad Stranemi 4511, 760 05 ZLIN

** Thomas Bata University in Zlín & Nad Stranemi 4511, 760 05 ZLIN

*** Thomas Bata University in Zlín & Nad Stranemi 4511, 760 05 ZLIN

ABSTRACT

The article discusses a casuistic study of seniors in the context of anthropometric measurements, evaluation and processing of measured results. Entirely new data were obtained regarding the deformation characteristics for the soles of the elderly population and only in the region of the toe joints in more than thirty seniors. Outputs from the performed measurements note the necessity for changes in the rules related to designing special footwear and its material resolution, particularly for seniors who are susceptible to deformities and shape deviations of the foot thanks to advanced age.

Keywords : anthropometry, measurements, deformation, senior

INTRODUCTION

Even in the healthy population, the individual shape of the foot significantly differs from the shapes of offered footwear [1]. This is given by production options, fashion trends and technological limitations in production [11]. The shape of footwear can be marked as a certain aesthetization of foot shape. As a result, it is common overall that the shape differences between the selected foot and shape of purchased (worn) footwear in the majority of cases is so great that a shod foot is more or less deformed by the footwear [2, 5, 9, 11, 13]. This fact is much more marked in groups of older people [10, 15], where the increased occurrence of deformities [6, 8, 14] and shape deviations [3, 4, 7, 12] have been repeatedly demonstrated.

For this reason, a special instrument was developed by which it is possible to measure the deformation characteristics of the foot in the scope of forces acting on the foot imitating the worn shape differing footwear.

The recognition of the course of deformation in the shod feet of elderly people may be marked as practically significant, because the knowledge of the course of foot deformation could be used for improving the quality of footwear and subsequent facilitation of options for movement. A significant application of the aforementioned regularity may be expected also in the area of prevention particularly in the case of footwear for diabetics with neuropathic affliction of the lower limbs. The course of deformation may be used during the development of new types of footwear intentionally modified for the population of elderly people etc.

Measurement methodology

Measurement of seniors took place in three social facilities in the Zlín region. In each of these, all the seniors were indicated for the process of measurement and evaluation of data, while the measurement itself was voluntary. Everyone had the opportunity to refuse to participate in the experiment. Overall, 33 subjects consented to the measurement, of whom 27 were women and 6 were men. The age fluctuated between 62 to 96 years of age. The largest number of seniors was in age from 66 to 70. Basic physiological data was obtained for each senior - age, weight and height. Another area of interest was anthropometric measurement of the foot, specifically measured when circumference of finger joints were in a standing or sitting position, the circumference of the instep and heel and finally a print of the foot on a plantogram. The last part of the experiment was measurement of the circumference of finger joints in connection with the tensile force of a strip encircling the area in question. This was performed on special equipment for measuring deformation repercussions of the sole, where the subject strip consists of a conventional measuring tape.

When evaluating the measured data, at each subject the BMI was calculated form height and weight. Determined from the plantograms were direct sole length, foot width, isthmus width and other data that were compared with values acquired from measurement of deformation repercussions for soles on specially constructed equipment. This device consists of two boards and auxiliary equipment (fig. 1). Located on the base surface (1) is tensile equipment with a handle (2), on which a tensile line is wound. Located between the line and the conventional measuring tape is a force gauge (3), which is placed on the skid (4), provided with lengthwise grooves, which serve to guide the force gauge when pulling the handle (6). The shape and elasticity of the flexible parts of the force gauge were selected with regard to its measuring range and on the method for subtracting the values of the given deformation. A conventional measuring tape (7), which is attached to a digital force gauge, passes through a pulley (8) to the upper section of the instrument panel (5). In this state, it forms a tightening loop through two pulleys (10) and wraps around a PVC pipe (9) - this serves to arrest the measuring tape so that it does not come loose.

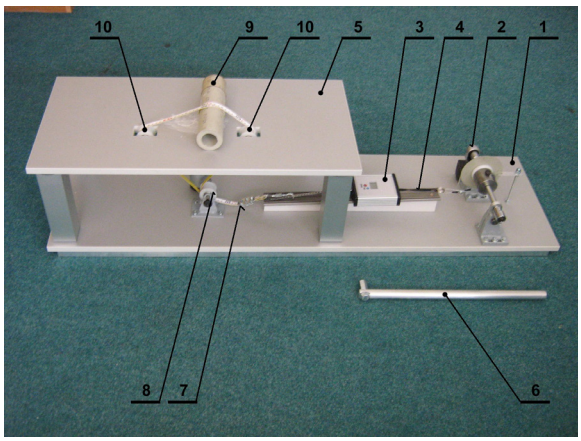


Figure 1: Equipment for measuring deformation repercussions to the sole

Measurement was implemented on the aforementioned equipment for measuring repercussions to the sole. The principle for measuring rests in the fact that the foot is pulled by a measuring strip (conventional measuring tape) in the area of the toe joints. The pulling itself is performed with the help of levers and the pull value is subtracted from the display which is part of the device. The left and right foot are pulled separately. According to the age of the subjects, the maximum value of pulling the foot was established at a level of 65 N. If the pulling was painful, unpleasant or could not be completed for health reasons - the measurement was immediately stopped. Recorded in this a case was the last bearable measured value at the given moment for the senior.

RESULTS

From the values acquired on the above described device, it was possible to design the graphic course of deformation curves, separately for the left and right foot. Displayed in figure 2, by reason of transparency, are only eight dependent changes in circumference of finger joints when under load. This concerns the left foot.

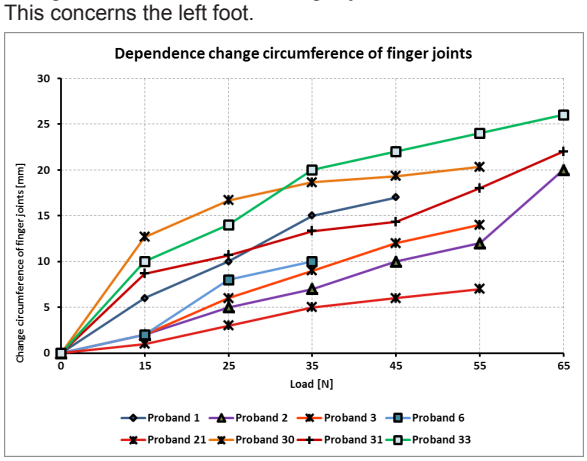


Figure 2: Course of deformation curves for 8 subjects

As is apparent from the graph, all have a practically linear character. This determination offered the option to verify whether or not the guidelines for resulting curves did not correlate with other recorded values such as age (fig. 3), weight, height, as well as circumference of finger joints under load and without load, instep circumference (fig. 4) and heel, BMI (fig. 5), straight length of feet (fig. 6) etc.

Apparently, in regard to the higher occurrence of various types and different stages in the development of foot deformities of the measured seniors, mainly Hallux Valgus, the higher occurrence in flat foot values, it was not possible to confirm any dependency between investigated parameters and the guidelines for deformation curves.

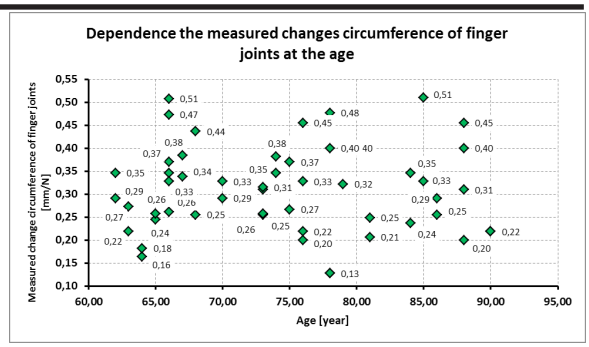


Figure 3: Dependence the measured changes circumference of finger joints at the age

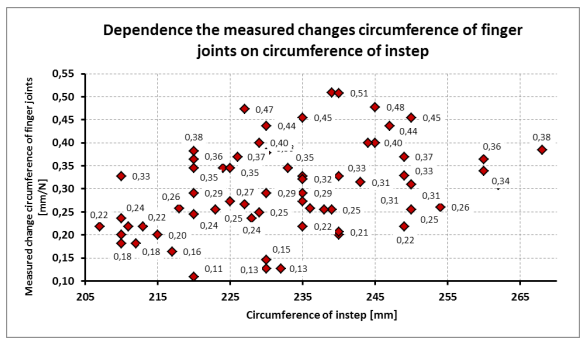


Figure 4: Dependence the measured changes circumference of finger joints on circumference of instep

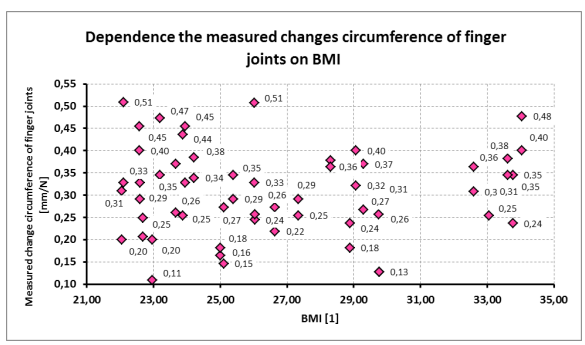


Figure 5: Dependence the measured changes circumference of finger joints on BMI

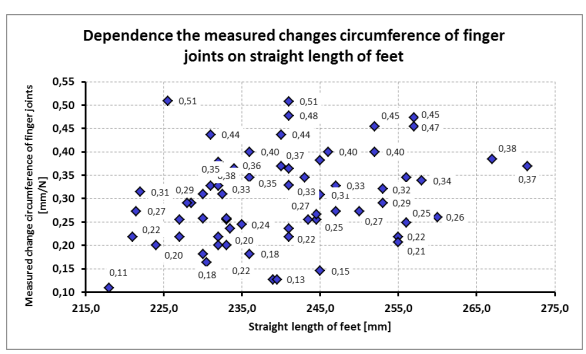
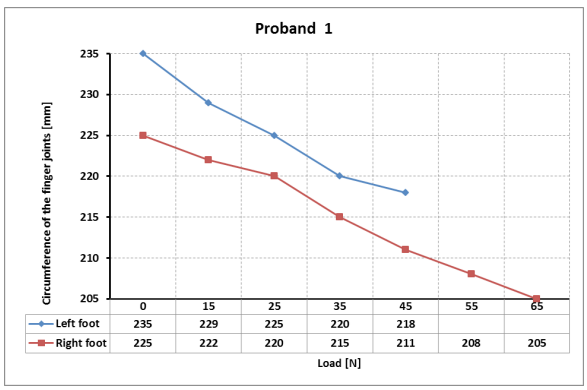


Figure 6: Dependence the measured changes circumference of finger joints on straight length of feet

Even though it was not possible to confirm the existence of general laws of deformation behaviour of the feet of seniors pulled in the area of the toe joints, the measurement provided very interesting results. Selected for interpretation of the results was subject no. 1, who was a woman with the following parameters: age - 71, height - 155 cm, weight - 68 kg, BMI - 28.3). Graphic dependence of the circumference of finger joints under load, see fig. 7.

On axis y is the adequate value of circumference of finger joints during specific load, the maximum value of which in this case equaled 45 N for the left foot and 65 N for the right foot. Reducing the original values of circumference of finger joints from non-load status, when pulled at a force of 65 N equals 20 mm (decline from 226 to 205 mm). If the difference between width groups of manufactured footwear is 6 mm, then a mere force of 65 N leads to easy constriction of the foot by more than three width groups. Although in theoretical works and professional publications, it is recommended to manufacture footwear in more widths, in practice footwear in more widths is not offered on shop counters. A reduction in the values of foot girths in the area of the metatarsal-phalangeal joint can be reached with relatively little force.



	0	15	25	35	45	55	65
Left foot	235	229	225	220	218		
Right foot	225	222	220	215	211	208	205

Figure 7: Graphic illustration of changes circumference of the finger joints on the load

CONCLUSIONS

An analysis of the measurements demonstrated that deformation characteristics of the foot in the elderly population are relatively high. By merely pulling a measuring tape with a force of 65 N, the value of circumference of finger joints is changed by 20 mm. As has already been noted above, according to norms, the width of footwear is intensified by 6 mm. In other words, common forces beneath the threshold of pain, footwear may pull the foot by 2 to 3 width groups. This determination is alarming because it may be a cause for further deformation, discomfort and the source of health complications.

The acquired results may be considered as the first step toward a study of the laws for mechanical comfort of footwear, as the globalized production of footwear (particularly sports shoes) does not take into account the national characteristic proportions of the foot and attempt to manufacture footwear universally.

ACKNOWLEDGEMENTS

This experiment was financially supported thanks to the Internal Grant Agency number IGA/FT/2013/023 granted the Tomas Bata University in Zlin, Faculty of Technology.

REFERENCES

[1] Australasian journal of podiatric medicine: AJPM [online]. Collingwood, Vic.: Australian: Podiatry Council, 1997, ISSN 1328-0694.| [2] BAEHLER, André. Orthopädietechnische Indikationen [Orthopedics Technical Indications].1. Aufl. Bern: Hans Huber, 1996, 592 s. ISBN 3-456-82784-9. | [3] CAPEZUTI, Liz. Evidence-based geriatric nursing: protocols for best practice. 3rd ed. New York: Springer Publishing Company, c2008, xxxiii, 698 s. ISBN 978-0-8261-1103-6. | [4] ELIOPOULOS, Charlotte. Gerontological nursing. 6th ed. Philadelphia: Lippincott Williams & Wilkins, c2005, xix,601 s. ISBN 0-7817-4428-8. | [5] HOHMANN, Dietrich a Ralf UHLIG. Orthopädische Technik [Orthopedic technology]. 9., überarbeitete und neu gestaltete Aufl. Stuttgart: Georg [Stuttgart], c2005, viii,567 s. ISBN 3-13-135929-3.| [6] KALVACH, Zdeněk. Geriatrické syndromy | a geriatrický pacient [Geriatric syndromes and geriatric patients]. Vyd. 1. Praha: Grada, 2008, 336 s. ISBN 978-80-247-2490-4. | [7] KALVACH, Zdeněk. Selected chapters from geriatric and chronic status medicine: (for studying medical departments and practical physicians). Praha: Karolinum, 1995. ISBN 80-7184-001-7.| [8] KANE, Robert L. Essentials of clinical geriatrics. 6th ed. New York: McGraw-Hill Medical, c2009, xxii, 576 s. ISBN 978-0-07-149822-7. | [9] KAPANDJI, Ibrahim A. Funktionelle Anatomie der Gelenke: schematisierte und kommentierte Zeichnungen zur menschlichen Biomechanik [Functional anatomy of the joints: annotated drawings for schematic and human biomechanics]. 2. unveränderte Aufl. Translated by Jürgen Koebke. Stuttgart: Enke, 1992, x,245 s. ISBN 3-432-94642-2. | [10] KIRTLEY, Christopher. Clinical gait analysis: theory and practice. 1st pub. Edinburgh: Elsevier, 2006, xii, 316 s. ISBN 0-443-10009-8. | [11] LARSEN, Christian. Zdravá chůze po celý život [The Healthy walking through life]. Olomouc: Poznání, 2005, 154 s. ISBN 80-86606-38-4. | [12] PERRY, Jacquelin. Gait analysis: normal and pathological function. Thorofare, NJ: SLACK, c1992, xxxii, 524 s. ISBN 1-55642-192-3. | [13] VALMASSY, Ronald L. Clinical biomechanics of the lower extremities. Saint Louis: C. V. Mosby, c1996, xviii, 510 s. ISBN 0-8016-7986-9.| [14] VAŘEKA, Ivan a Renata VAŘEKOVÁ. Kineziologie nohy [Kinesiology of feet]. 1. vyd. Olomouc: Univerzita Palackého v Olomouci, 2009, 189 s. ISBN 978-80-244-2432-3. | [15] WHITTLE, Michael. Gait analysis: an introduction. 4th ed. Edinburgh: Butterworth-Heinemann, 2007, 255 s. ISBN 978-0-7506-8883-3.