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Evaluation of the long-term effect of physiotherapy on degree of hallux valgus angle in standing position and foot load during walking in individuals with hallux valgus.

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SUMMARY/ABSTRACT

Starting point: Hallux valgus affects the physiological loading of the foot during walking. The aim of this study was to assess the long-term effect of physiotherapeutic intervention on the degree of hallux valgus angle in standing and foot load during walking in individuals with hallux valgus.
Group: The study included 9 female participants (age 41.9±2.3 years; height 169.6±5.8 cm; weight 71.8±16.7 kg; hallux valgus angle 37.8±11.6°) which had no history of lower limb injuries or other serious medical conditions.
Methods: The measurements were taken before the physiotherapeutic intervention, after ten therapy sessions, and three months after the therapy ended. A goniometer was used to evaluate the hallux valgus angle under load during standing with the feet placed hip-width apart. The foot load during walking was assessed using a dynamic treadmill, h/p/cosmos® Rehawalk®, with zebris software. Therapy sessions were conducted once a week for a total of ten sessions, with additional exercises performed individually at home according to the therapist's instructions.
Results: After the intervention and three months post-intervention, there was a significant reduction in the hallux valgus angle in standing compared to the initial measurement. During walking, there was significantly higher force loading on the rearfoot during weightbearing following initial contact, and on the forefoot during toe-off.
Conclusions: Therapy aimed at re-educating foot function and involving hallux in the physiological walking pattern optimized the position of the hallux and supported functional stabilization of the first ray during foot roll-off and propulsion during walking in the observed group of participants.

KEYWORDS
gait analysis, physiotherapy, zebris.

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1 INTRODUCTION

Hallux valgus (hallux abducto valgus, bunion) is one of the most common forefoot deformities. It is a complex, three-dimensional deformity of the forefoot that progresses over time, characterized by valgus positioning and rotation of the big toe, along with increased varus of the first metatarsal and medial prominence of its head. The cause and progression of hallux valgus are multifactorial, complex, and not well understood. Hallux valgus is among the most frequently treated orthopaedic conditions. Pain is often the primary reason for seeking professional help and can also be the sole motivation for patients to change their movement patterns. Other reasons include limitations during walking or difficulties wearing conventional footwear. Patients often opt for surgical intervention as a first choice, frequently due to a lack of information or as a solution that does not require their active participation. However, every surgery carries significant risks, and there are studies with inconclusive results regarding the long-term effects of surgery (Dungl, 2014; Frank, 2021; Rapi, 2016; Zirngibl et al., 2017).

The foot is a crucial link connecting the human body to the ground during bipedal locomotion. Lewitová (2016) highlights the importance of understanding the function of the foot in relation to its flexibility and ability to provide support, which is then reflected in the quality of the foot's contact with the ground and the subsequent push-off during walking. Correct foot function requires proper functional stabilization of the first ray, which is disrupted in the presence of hallux valgus deformity. The most important structures for load transfer during walking are the big toe, the first metatarsophalangeal (MTP) joint, and the plantar aponeurosis, which also plays a key role in stabilizing the longitudinal arch of the foot. If the medial ray of the longitudinal foot arch is compromised, excessive pronation of the foot occurs during walking (Kozáková et al., 2010; Kulašiková and Čolláková, 2018). Pronation is a prerequisite for the potential absorption of ground reaction forces upon initial foot contact. However, when combined with foot hypermobility, hyperpronation can develop, which may contribute to the development of hallux valgus—lateral deviation of the big toe and medial deviation of the first metatarsal (Frank, 2021). Valmassy (1996) states that adequate dorsal flexion of the first MTP joint during push-off requires plantar flexion of the first ray during midstance and propulsion. Proper propulsive function of the big toe requires the correct function of the sesamoid bones and normal functioning of the muscles that stabilize the first MTP joint. Active and sufficient plantar flexion of the first ray is primarily a matter of the intrinsic muscles of the foot, particularly the abductor hallucis muscle. In hallux valgus deformity, the tendons of the extensor hallucis longus and flexor hallucis longus muscles deviate laterally, creating a bowstring effect on the joint. In more advanced stages of hallux valgus, walking occurs practically without propulsion.

The importance of the intrinsic and extrinsic foot muscles for its movement and stabilization is often given insufficient attention by doctors. As such, these muscles are rarely addressed in therapeutic programs. Conservative interventions for foot-related problems are more often focused on external support of the foot rather than on training the physiological function of these muscles (Buchtelová et al., 2018; McKeon et al., 2015). The activation of intrinsic foot muscles increases with higher postural demands. These muscles are very important in postural control and are engaged in a highly coordinated manner to stabilize the foot and maintain balance in both the anteroposterior and mediolateral directions, especially during the single-support phase of walking (Buchtelová et al., 2018; Kelly et al., 2012). Therefore, it is important to approach the treatment of hallux valgus actively from the patient's side. Through targeted and correctly chosen kinesiotherapy, it is possible to optimize the axial alignment of the first ray segments, restore the physiological movement pattern, improve its execution during support and push-off in both standing and walking, and alleviate the patient's subjective complaints (Kolář, 2009; Kozáková et al., 2010). The choice of therapy considers the degree and stage of deformity, the nature of symptoms, levels of pain, and the patient's functional demands, as well as any potential comorbidities (Zirngibl et al., 2017). According to Kolář (2009) and Lewit (1996), before kinesiotherapy itself, it is important to treat the soft tissues of the foot, restore joint play, and center individual segments using mobilization techniques. An integral part of therapy involves recommendations from the physiotherapist for the patient's everyday life, in this case, information on the impact of footwear on foot structure and function, thereby influencing gait kinematics and kinetics (Franklin et al., 2015). This study examines the effect of targeted kinesiotherapy on the hallux valgus angle in standing and on selected parameters of foot load in individuals with hallux valgus. It also considers the duration of the therapeutic effect after its completion.

2 GROUP AND METHODS

2.1 PARTICIPANTS

The study included a total of 9 female participants with mild to moderate hallux valgus deformity (age 41.9 ± 2.3 years; height 169.6 ± 5.8 cm; weight 71.8 ± 16.7 kg; hallux valgus angle 37.8 ± 11.6°). Of these, 7 participants had unilateral hallux valgus and 2 had bilateral hallux valgus. The participants had no history of lower limb injuries or axial skeletal issues, no other severe illnesses, were not equipped with orthotic devices, and did not experience pain in the area of the first metatarsophalangeal joint. Recruitment of participants was facilitated through social media. All participants signed an informed consent form confirming their participation in the study and agreeing to the use of the collected data. The research methodology was approved by the Ethics Committee of the Faculty of Medicine at the University of Ostrava (reference number 01/2021).

2.2 METHODS

To determine the degree of hallux valgus (hallux valgus angle, HVA), a finger goniometer for small joints was used. The evaluation of selected gait parameters was performed using a dynamic treadmill, h/p/cosmos®Rehawalk®, equipped with the zebris FDM (Force Distribution Measurement) software (zebris Medical GmbH, Germany).

2.3 MEASUREMENT PROCEDURE

Each participant visited the Biomechanics Research Center laboratory at the Clinic of Rehabilitation and Sports Medicine, Faculty of Medicine, University of Ostrava. The initial examination included taking medical history and conducting a kinesiological analysis focusing on the pelvis and lower extremities, particularly the foot. The results were recorded in a standardized protocol, along with the results of the final examination. The hallux valgus angle was measured on the medial side of the foot between the first metatarsal and the proximal phalanx of the big toe while the participant stood still with base at hip width (Figure 1). Foot size was determined by tracing the outline of the bare foot while standing in a static position. The assessment of selected gait parameters on the h/p/cosmos®Rehawalk® treadmill with zebris FDM software for each subject was conducted three times – before the start of the therapy series, after the final tenth therapy session, and three months after the therapy had ended. The gait measurements were performed barefoot. A minimum of 20 valid trials (records showing the entire foot roll-off) of barefoot walking at a constant speed of 3.5 km/h were required for successful data collection.

Figure 1 Measurement of the hallux valgus angle under load in a static standing position with a stance at hip width.

2.4 THERAPY PROCESS

Following the initial kinesiological assessment, the following therapeutic goals were defined: release of the skin, subcutaneous tissue, fascia, and muscles; normalization of muscle tone; elimination of muscular imbalances in the foot; support of the transverse arch; even distribution of weight across the feet; reduction of the valgus angle of the MTP joint of the big toe; centering and stabilization of the MTP joint of the big toe, restoration of its joint play; reduction of pain in the MTP joint of the big toe after loading; reeducation of foot function; activation of the deep stabilization system; use of appropriate footwear. To achieve these goals, a rehabilitation plan was developed that included: soft tissue and mobilization techniques; myofascial treatment; sensomotor stimulation; Kinesio Taping® Method; Spiral Dynamics®; elements from developmental kinesiology and Dynamic Neuromuscular Stabilization; acral coactivation therapy. The therapy unit lasted 45 minutes and was conducted by the same physiotherapist once a week for a total of ten sessions. The composition of the exercises was the same for all probands, the only differences were in possible modifications in terms of simplification or greater difficulty of the exercises. As the number of therapy units increased, the postural and coordination difficulty of the exercises increased. Exercises focused on the foot area, the position of the big toe and the segments of the upper limbs, and postural stability in static and dynamic loading. The therapeutic units were gradually followed with increasing number of exercises and emphasis on the quality of execution. The foot therapy included exercises in lightening and static and dynamic loads, facilitation and stimulation of foot receptors using various aids and massage (massage and stimulation balls, overball, theraband, sensomotor walkways made of natural materials or plastic, etc.), passive and active exercises of the leg muscles with emphasis on awareness of this area and the so-called "active foot". Using the concept of Spiral Dynamics®, we worked on correct foot support, big toe position, and lower limb weight bearing joints. Exercises inspired by developmental kinesiology loaded the postural system of the probands gradually, from posturally less demanding exercise positions to higher, posturally more demanding positions. In addition, ipsilateral and contralateral developmental patterns were used, with an emphasis on working mainly in closed kinematic chains, in accordance with breathing and better participation of the spinal stabilisation system. Kinesio Taping® Method was used at the end of therapy, where care was taken to optimise big toe position. Therapy was also carried out individually at home as directed by the therapist for 10 minutes per day. Additionally, participants continued with individual exercises at home according to the therapist's instructions for 10 minutes per day.

2.5 MEASURED PARAMETERS, DATA PROCESSING AND EVALUATION

The measured parameters for the foot with hallux valgus: hallux valgus angle [°]; foot length [cm]; maximum force exerted by the foot during load transfer after initial contact with the ground (F1) and during push-off (F2) [N]; center of pressure (CoP) trajectory [mm].

The force exerted was normalized to the participant's body weight using the figure:

$$nF\ (\%) = (F/G) \times 100\ \%,$$

where F is the measured force value, G is the gravitational force of the participant calculated using the figure $m \cdot g$ (where m is the participant's mass in kg and g is the acceleration due to gravity 9.81 m/s^2).

The CoP trajectory was normalized using the figure:

$$nCoP\ (\%) = (CoP/l) \times 100\ \%,$$

where CoP is the measured trajectory in cm and l is the participant's foot length in cm.

2.6 STATISTICAL DATA PROCESSING

For each measured variable, the arithmetic mean, standard deviation, median, and 95% confidence interval were calculated. Statistical analysis was performed using the PAST4.03 software (Hammer et al., 2001). Due to the small sample size, non-parametric tests were employed. The paired Wilcoxon test was used to assess differences in the observed parameters between the measurements. Differences were considered statistically significant at the $\alpha = 0.05$ level. The practical significance of the differences was evaluated using the effect size coefficient r, calculated using the formula $r = Z/(\sqrt{N})$, where Z is the value of the test statistic and N is the number of measured pairs. Cohen (1992) interprets the magnitude of practical significance as follows: $r < 0.1$ trivial; 0.1–0.3 small; 0.3–0.5 moderate; $r > 0.5$ large.

3 STARTING POINT, OBJECTIVE, TASKS

The aim of this study was to assess the long-term effect of physiotherapeutic intervention on the degree of hallux valgus angle in standing and foot load during walking in individuals with hallux valgus.

4 RESULTS

Table 1 presents the basic statistical characteristics of the measured parameters and the results of the comparisons of measurements taken at different time points.

Table 1 – Median values, lower and upper quartiles, and results of statistical comparisons of measurements.

Parameter	Measurement 1	Measurement 2	Measurement 3
Hallux valgus angle [°]	33 (30; 45)	25 (20; 25)#	20 (15; 25)#$
Foot length [cm]	24.0 (23.0; 26.1)	24.2 (23.1; 26.4)#	24.2 (23.2; 26.4)#
nF1 [%]	99.4 (98.2; 103.6)	105.9 (103.9; 111.0)#	107.6 (105.5; 113.4)#$
nF2 [%]	97.3 (91.7; 99.7)	99.1 (97.5; 100.0)#	104.5 (101.7; 105.8)#$
nCoP [%]	83.1 (80.2; 84.2)	84.6 (83.8; 87.3) #	85.0 (84.6; 88.6)#

* Note: Measurement 1 – Baseline measurement; Measurement 2 – Post-therapy measurement after ten weeks of therapy; Measurement 3 – Measurement three months after the last therapy session; nF1 – Normalized maximum force exerted by the foot during load transfer after initial contact with the ground; nF2 – Normalized maximum force exerted by the foot during push-off; nCoP – Normalized center of pressure (CoP) trajectory. #Statistically significant difference compared to Measurement 1. $Statistically significant difference compared to Measurement 2. All statistically significant differences were also found to be of practical significance.

In participants with hallux valgus, both ten weeks after therapy and three months after the last therapy session, compared to baseline measurements, the following differences were observed:

- Statistically ($p < 0.01$) and practically ($r > 0.5$) significant decrease in the hallux valgus angle during standing;
- Statistically ($p < 0.01$) and practically ($r > 0.5$) significant increase in foot length during standing;
- Statistically ($p < 0.01$) and practically ($r > 0.5$) significant increase in the force exerted by the foot during load transfer after initial contact with the ground during walking;
- Statistically ($p_{12} < 0.05$; $p_{13} < 0.01$) and practically ($r > 0.5$) significant increase in the force exerted by the foot during push-off while walking;
- Statistically ($p < 0.01$) and practically ($r > 0.5$) significant increase in the center of pressure (CoP) trajectory length during foot contact with the ground while walking.

When comparing the parameters measured after ten weeks of therapy to the values recorded three months after the end of the therapy, the following was observed:

- Statistically ($p < 0.05$) and practically ($r > 0.5$) significant decrease in the hallux valgus angle during standing;
- Statistically and practically insignificant differences in foot length during standing;
- Statistically ($p < 0.05$) and practically ($r > 0.5$) significant increase in the force exerted by the foot during load transfer after initial contact with the ground during walking;
- Statistically ($p < 0.01$) and practically ($r > 0.5$) significant increase in the force exerted by the foot during push-off while walking;
- Statistically insignificant but practically significant ($r > 0.5$) differences in the length of the center of pressure (CoP) trajectory during foot contact with the ground while walking.

5 DISCUSSION

In the observed group of participants with mild to moderate hallux valgus, there was a significant reduction in the hallux valgus angle after therapy, and this correction was maintained even three months after the final therapy session. This represents a highly positive clinical outcome for conservative management of this condition through kinesiology. The positive impact of active foot exercises for patients with hallux valgus is also highlighted in the study by Moon-Hwan et al. (2015). The authors evaluated the effect of conservative treatment in a group of patients with mild to moderate hallux valgus who used orthoses, as well as in a group that combined orthotic use with active toe abduction exercises, particularly for the big toe. The therapy's effectiveness was assessed based on the hallux valgus angle measured by X-ray, the cross-sectional area of the abductor hallucis muscle, and the hallux valgus angle during active abduction. After eight weeks of therapy, there were no significant differences in the group using only orthoses, whereas the combined therapy group (orthoses and active exercise) achieved significant changes in all three parameters.

A significant reduction in the hallux valgus angle in patients with mild deformity was also observed with the use of manual techniques, which were also applied in our study. The study by Moon et al. (2021) assessed the immediate effect of a fifteen-minute therapy session, while Hong et al. (2018) evaluated the effect after a four-week series of therapies. It is important to note that in these studies, a reduction in the valgus angle of the big toe was accompanied by an increase in foot length. This needs to be considered when selecting footwear, and participants were advised accordingly. Each participant's existing footwear was checked to ensure sufficient room and width at the toe area. If the parameters were inadequate, new footwear was recommended to eliminate factors that support the valgus deviation of the big toe. Hallux valgus not only affects the big toe but also alters the biomechanics of the entire foot, leading to a chain reaction up the lower limb.

Studies by Blomgren et al. (1991), Hofmann et al. (2019), and Hurn et al. (2015) address the loading of the foot with hallux valgus during walking. In our study, higher foot loading during load transfer after initial contact with the ground was observed, even three months after therapy ended. According to studies by Blomgren et al. (1991) and Hofmann et al. (2019), this indicates a possible optimization of foot loading during its roll-off phase. Both studies compared patients with hallux valgus to healthy controls and found increased loading in the rearfoot area during walking. Additionally, we observed increased loading during push-off while walking, which persisted three months after therapy, suggesting that the correction of the valgus position of the big toe better stabilizes the foot for load transfer. This may lead to improved functional stabilization of the first ray, where the big toe and the first MTP joint play a crucial role in stabilizing and propelling the foot, as noted by Kozáková et al. (2010). Stabilization of the first ray facilitates forward body movement (Valmassy, 1996). Hurn et al. (2015) reported lower forefoot loading in participants with hallux valgus compared to those without hallux valgus, attributing this lower loading to pain associated with moderate to severe hallux valgus deformity, which results in reduced loading of the forefoot during walking. They also noted that unilateral hallux valgus leads to asymmetric loading of the lower limbs and potential overloading of the non-valgus foot. Plantar loading during the stance phase of walking is closely related to the movement of the CoP. Therapy aimed at re-educating foot function and incorporating the big toe into a physiological gait pattern affects the extension of the CoP trajectory to the big toe, similar to that seen in healthy participants (Kirtley, 2006). Changes in the CoP trajectory are indicators of foot function and treatment effectiveness. Accurate study of CoP movement helps analyse the forces acting on proximal joints during walking and determine rehabilitation strategies (Luo et al., 2021). In our study, the CoP trajectory length was statistically significantly greater after ten therapies and three months after the last therapy compared to the baseline measurement. The practical significance of these differences is large. It should be noted that when examining changes in CoP trajectory and foot loading, the degree of pain during walking, which affects the shortening of the trajectory due to discomfort during foot loading, must also be considered (Clarke et al., 2020; Galica et al., 2013; Hurn et al., 2015; Wen et al., 2012). Pain in the feet with hallux valgus was not observed in the participants of our study.

5.1 STUDY LIMITS

The study has several limitations that should be acknowledged. The sample size was relatively small and included both unilateral and bilateral hallux valgus cases. Additionally, the study was conducted with a voluntary sample of women, which may introduce selection bias. The study was carried out during the unfavourable epidemiological situation caused by the COVID-19 pandemic. This context may have influenced participant recruitment and adherence to therapy. There were significant interindividual differences among the participants, including variations in age, genetic predispositions, psychomotor development, structural differences, functional changes in the musculoskeletal system, physical activity levels and footwear. Radiographic data on the hallux valgus angle was not available. Instead, clinical measurements were taken with a goniometer by a single individual under consistent laboratory conditions. The therapy was administered by a single therapist on a weekly basis. The effectiveness of the therapy was dependent on adherence from the participants, who were expected to perform home exercises daily at least once. Participants kept a diary to monitor their exercise sessions, noting the duration and progress. This was then assessed at the next visit to the physiotherapist.

6 CONCLUSIONS

Our study demonstrated that a reduction in the hallux valgus angle in participants with mild to moderate hallux valgus deformities can be achieved through the normalization of muscle tone, correction of muscle imbalances in the foot, centralization and stabilization of the first MTP joint and training of a physiological walking pattern. Targeted therapy enhanced the functional stabilization of the first ray during load transfer in the foot's rollover phase and during push-off while walking. These improvements persisted even three months after the last therapy session. A key factor for the long-term effectiveness of the therapy is the participants' intrinsic motivation and the integration of foot care into daily life, including the selection of appropriate footwear.

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REFERENCES

Blomgren, M., et al. (1991). “Gait analysis in hallux valgus”. *The Journal of Foot Surgery.* 30 (1). pp70-71. PMID: 2002190.

Buchtelová, E., et al. (2018). „Využití senzomotoriky v rehabilitaci dolní končetiny“. *Rehabilitácia*. 55 (1). pp50-57. ISSN 0375-0922.

Clarke, G. R., et al. (2020). “Hallux valgus severity, great toe pain, and plantar pressures during gait: A cross-sectional study of community-dwelling adults”. *Musculoskeletal Care.* 18 (3). pp383-390. https://doi.org/10.1002/msc.1472.

Cohen, J. (1992). „A power prime“. *Psychol Bull.*112 (1). pp155–159. doi:10.1037/0033-2909.112.1.155.

Dungl, P. (2014). *Ortopedie* (2., přeprac. a dopl. vyd). Grada. 1192 p. ISBN: 978-80-247-4357-8.

Frank, C. J. (2021). „Hallux Valgus”. *Emedicine.* https://emedicine.medscape.com/article/1232902-overview#showall.

Franklin, S., et al. (2015). “Barefoot vs common footwear: A systematic review of the kinematic, kinetic and muscle activity differences during walking”. *Gait.* 42 (3). pp230-239. https://doi.org/10.1016/j.gaitpost.2015.05.019.

Galica, A. M., et al. (2013). “Hallux valgus and plantar pressure loading: the Framingham foot study”. *Journal of Foot.* 6 (1). pp1-18. https://doi.org/10.1186/1757-1146-6-42.

Hammer, O., et al. (2001). „PAST: Paleontological statistics software packagefor education and data analysis“. *Palaeontologia Electronica.* 4 (1). pp1-9. http://paleo-electronica.org/2001_1/past/issue1_01.htm.

Hofmann, U. K., et al. (2019). „Transfer of plantar pressure from the medial to the central forefoot in patients with hallux valgus”. *BMC Musculoskeletal Disorders*. 20 (1). p149. https://doi.org/10.1186/s12891-019-2531-2.

Hong, W. P., et al. (2018). “Comparison of Joint Mobilization with Manual Stretching Exercises in the Treatment of Hallux Valgus”. *Journal of International Academy of Physical Therapy Research*. 9 (4). Pp1614-1618. https://db.koreascholar.com/Article/Detail/365429.

Hurn, S. E., et al. (2015). “Functional Impairments Characterizing Mild, Moderate, and Severe Hallux Valgus”. *Arthritis care*. 67 (1). pp80-88. https://doi.org/10.1002/acr.22380.

Kelly, L. A., et al. (2012). “Recruitment of the plantar intrinsic foot muscles with increasing postural demand”. *Clinical Biomechanics*. 27 (1). pp46-51. https://doi.org/10.1016/j.clinbiomech.2011.07.013.

Kirtley, C. (2006). *Clinical Gait Analysis: Chapter 5 - The ground reaction in normal gait*. Churchill Livingstone. https://doi.org/10.1016/B978-0-443-10009-3.50009-6.

Kolář, P. (2009). *Rehabilitace v klinické praxi*. Galén. 713 p. ISBN 978-80-7262-657-1.

Kozáková, J., et al. (2010). „Hallux valgus z pohledu fyzioterapeuta aneb Je hallux valgus pouze deformita palce?“. *Rehabilitace a fyzikální lékařství*. 17 (2). pp71-77.

Kulašiková, M. Čolláková, K. (2018). „Oporná funkcia nohy“. *Rehabilitácia*. 55 (1). pp19-30. ISSN 0375-0922.

Lewit, K. (1996). *Manipulační léčba v myoskeletální medicíně* (4. ed.). J.A. Barth Verlag. 348 p. ISBN:3-335-00401-9.

Lewitová, C. -M. H. (2016). “O dospělých nohách”. *Umění fyzioterapie*. (2). pp5-8.

Luo, X. -dong, et al. (2021). “Study on the relationship between the toe-out gait and foot hallux valgus in the elderly Chinese”. *Leather*. 21 (3). pp183-192. https://doi.org/10.24264/lfj.21.3.5.
McKeon, P. O., Fourchet, F. (2015). “Freeing the Foot: Integrating the Foot Core System into Rehabilitation for Lower Extremity Injuries”. *Clinics in Sports Medicine*. 34 (2). pp347-361. https://doi.org/10.1016/j.csm.2014.12.002.
Moon-Hwan, K., et al. (2015). “Effect of toe-spread-out exercise on hallux valgus angle and cross-sectional area of abductor hallucis muscle in subjects with hallux valgus”. *Journal of physical therapy science.* 27 (4). pp1019-1022. https://search.ebscohost.com/login.aspx?direct=true&db=edswsc&an=000354780200010&scope=site.
Moon, K. A., et al. (2021). “Effect of the Manual Stretching Maneuver for Hallux Valgus”. *The Foot*. (51). https://doi.org/10.1016/j.foot.2021.101900.
Rapi, J. (2016). “Statické deformity přednoží - diagnostika a terapie”. *Umění fyzioterapie*. (2), 9-16.
Valmassy, R. L. (1996). *Clinical Biomechanics of the Lower Extremities*. Mosby. 528 p. ISBN 0801679869.
Wen, J., et al. (2012). „Adaptive changes of foot pressure in hallux valgus patients”. *Gait*. 36 (3). pp344-349. https://doi.org/10.1016/j.gaitpost.2012.03.030.
Zirngibl, B., et al. (2017). „Ätiologie, diagnostische und therapeutische Prinzipien“. *Der Orthopäde*. (46). pp283-296. https://doi.org/10.1007/s00132-017-3397-3.