

Rehabilitation and Physiotherapy Department, Chair of Rehabilitation,  
Physiotherapy and Balneotherapy, Faculty of Nursing and Health Sciences  
with Extramural Section, Medical University of Lublin  
Rehabilitation Department, Children's Clinical Hospital in Lublin

JOLANTA TACZAŁA, PIOTR MAJCHER, CEZARY SKIBIŃSKI,  
TOMASZ SENDEREK

*Pathogenesis of secondary deformations in plano valgus feet  
with shortening of the Achilles tendon in children*

Contracture of the calf triceps muscle and shortening of the Achilles tendon are the reasons for persistence of plano valgus feet deformation beyond the period of its physiological occurrence. The defect may even become gradually worse. Therefore, when examining feet the physician cannot neglect the evaluation of calf triceps tone and the range of foot dorsiflexion. This evaluation can be assisted by looking for other features of neuro-muscular disorders, even quite distant from feet (looking for subspasticity features within whole lower limbs and even in the upper limbs).

A very useful tool in detecting calf triceps muscle contracture is the "provoked spasticity test"(15), which is called the "quick stretch test" in English literature (12). The test takes advantage of the difference in the range of foot dorsiflexion achieved at slow dorsiflexion and during doing that movement quickly, or even abruptly. If there occurs a contractile overreaction of the calf triceps muscle to stretching, then, after a few movements the foot dorsiflexion decreases by 5–10 degrees or more, in proportion to the achieved range during a slow movement, which is a proof of calf triceps muscle overreaction to stretching. It is a characteristic feature of muscles with hypertonia, that is of spastic muscles. The provoked spasticity test allows for detection of the imminent shortening of the Achilles tendon when it is not the structural, but only functional contracture. Such an examination method makes it possible to apply the treatment before the secondary valgus instep positioning becomes fixed.

The objectives of the paper were: to define the frequency of the Achilles tendon shortening in children with plano valgus feet deformation; to define the frequency shortening of the Achilles tendon in the population of healthy preschool and school children and to determine its effect on the formation of plano valgus feet deformation; to analyze the fetal, neonatal and infancy period of the examined children and to try and find the connection between the pathologies of these periods and plano valgus feet deformations.

## MATERIAL AND METHODS

## STUDY GROUPS OF CHILDREN

The subject of the study were plano valgus feet of the children treated in the Rehabilitation Outpatient Clinic in the Children's Clinical Hospital and of the children from six kindergartens and two primary schools in the town of Lublin.

28 children aged 3–4 years were treated in the Rehabilitation Outpatient Clinic because of plano valgus feet deformation. That group of children had been observed from infancy (6–12 months) because of disorders and retardations of their motor development. At the age of 3 years they had plano valgus feet deformations. Most of these children were from the so-called perinatal risk group, that is with pregnancy, labour, neonatal, or infancy pathologies.

The preschool and schoolchildren aged 3–15 years constituted the most numerous and at the same time the basic study group for this paper. The study comprised 515 children from 4 Lublin kindergartens and 2 schools, ca. 100 children in particular age groups. All children in selected forms were examined.

Table 1. The number of examined preschool and schoolchildren, with regard to sex and age

Sex	Group 1 3–4 years	Group 2 6–7 years	Group 3 8–9 years	Group 4 11–12 years	Group 5 14–15 years	Total
Boys	51	59	57	56	48	271
Girls	50	43	51	44	56	244
Total	101	102	108	100	104	515

## FEET EVALUATION METHODS

The feet examination included orthopedic examination, measurement of heel-shin angle and pantography to determine the plano valgus deformation. The most important thing for the subject of the paper was the evaluation of the degree of the Achilles tendon shortening, neurological evaluation of the foot and the analysis of perinatal, neonatal and infancy periods.

**Evaluation of the Achilles tendon shortening.** Evaluation of the Achilles tendon shortening was performed as follows: during examination in seating (reclining) position the lower limb was straightened in the knee joint, instep was put into the orthostatic position, forefoot slightly supine (ca. 10–20 degrees) and a bit adducted, so that the calcanean bone was positioned intermediate in relation to the talus, i.e. was in the shin axis. Then the maximum dorsiflexion of the foot was slowly performed and the angle between the long axis of the limb and plantolateral edge of the foot was measured with an orthopedic protractor. Shortening of the Achilles tendon was found when the foot dorsiflexion angle equalled 0 degrees, or was negative (9, 12).

**Neurological evaluation of the foot.** Neurological evaluation of the foot included the evaluation of tendon reflexes in lower limbs, the presence of the Babiński reflex, the calf triceps muscle tone, and the presence of idiopathic or induced foot clonus. Another symptom that facilitates the diagnosis of neuro-muscular dysfunction is the phenomenon of idiopathic claw-like positioning of the hallux and toes.

Analysis of the fetal, neonatal and infancy periods in the examined children. Parents of all the children received charts to fill-in, containing questions about the course of pregnancy, labour and early development of the child. The examination chart was arranged on the basis of the states of threat to the fetus, presented by Michałowicz, which might be the cause of perinatal injury to the central nervous system (8). The action of just one injuring factor is enough for pathology to occur, so only the examination charts in which no irregularities were found were regarded as normal, i.e. not overburdening further development of the child. In the remaining cases it was decided that overburdening anamnesis may be related to a pathology of the neuro-muscular system and, consequently, with feet deformations.

## RESULTS

All children treated in the Rehabilitation Outpatient Clinic had plano valgus feet deformations, because this irregularity was the condition qualifying them to the study group. Preschool and schoolchildren constituted the population of healthy children, among whom feet deformations were "looked for". On the basis of the performed clinical examinations and tests we distinguished in the study groups: normal feet, plano valgus feet and hollow feet.

Figure 1 presents the frequency of various types of feet in all the examined children, Figure 2 – the same issue with regard to age groups.

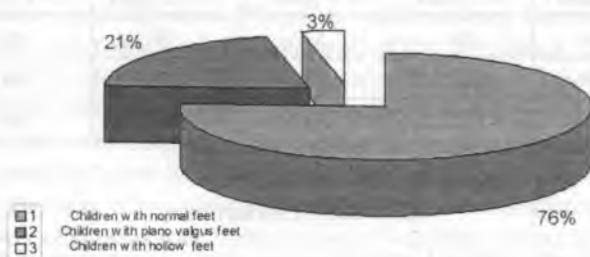


Fig. 1. The occurrence of normal, plano valgus and hollow feet in preschool and schoolchildren

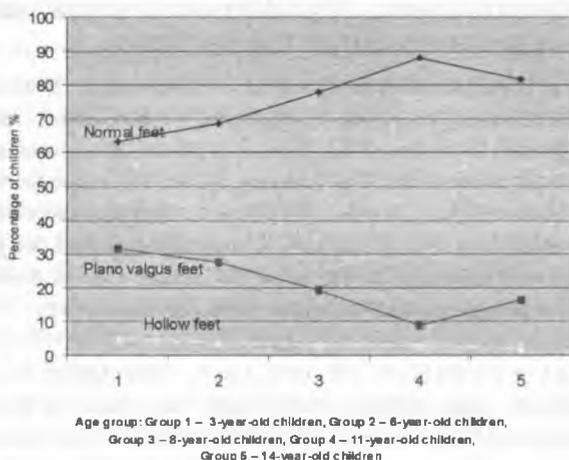


Fig. 2. Children with normal, plano valgus and hollow feet in particular age group

## CALF TRICEPS MUSCLE CONTRACTURE AND THE SHORTENING OF ACHILLES TENDON

In the group of children from the Rehabilitation Outpatient Clinic in 24 out of 28 limitation of feet dorsiflexion was found, and it was ca. 0-5 degrees, whereas in the quick stretch test this range decreased by 5-10 degrees more. Besides, in children from that group, being under care of the Rehabilitation Outpatient Clinic from the first year of their limes, gradual increase of calf triceps muscle contracture was observed. Initially it was manifested by frequent, spontaneous positioning of the foot in the position of plantar flexion (persistent tonic neck reflexes, persistent supporting reflex, persistent grasp reflex of the toes), extorsory position of the lower limbs and tiptoeing. It was after some time when the children "stood" on their feet, but it caused the compensatory instep valgity.

In the group of preschool and schoolchildren the pathologies were scarce. On the basis of examinations through which we found shortening of the Achilles tendon, we calculated the frequency of this phenomenon in the population of the examined children. Among the children with plano valgus feet the limitation of feet dorsiflexion was present in 77% examinees. This proves the distinct connection of the Achilles tendon shortening with flat-abducted deformation. It was observed that the frequency of the calf triceps muscle contracture in plano valgus feet increases with age. It results from the fact that the presence of the Achilles tendon shortening causes the "persistence" of valgus foot deformation and makes idiopathic repair impossible. The presence of the calf triceps muscle contracture and the Achilles tendon shortening in all plano valgus feet of the older children confirms that fact.

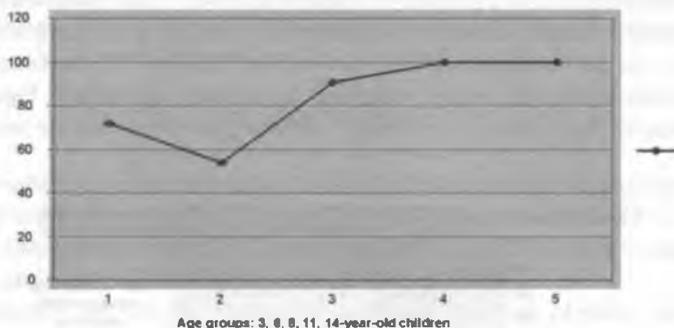


Fig. 3. The frequency of the Achilles tendon shortening in children with plano valgus feet in particular age groups

## TRACE NEUROLOGICAL SYMPTOMS IN CHILDREN WITH PLANO VALGUS FEET DEFORMATIONS

In all 3-year-old children from the Rehabilitation Outpatient Clinic neurological irregularities were found. We observed the positive provoked spasticity test, intensified muscle tone in the lower limbs, and especially the triceps. The analysis of the occurrence of trace neurological symptoms in preschool and school children reveals that for the plano valgus feet the frequency of neurological symptoms is distinctly higher than for normal feet. Figure 4 presents it graphically.

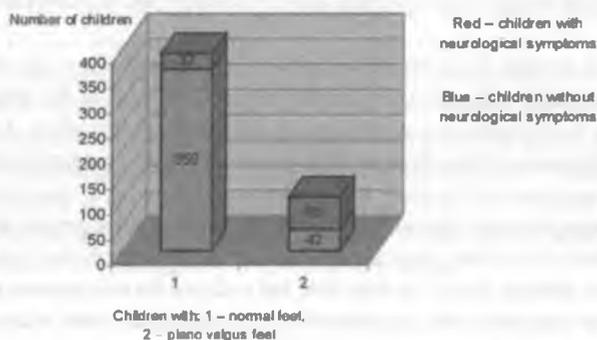


Fig. 4. The occurrence of trace neurological symptoms in children with normal and plano valgus feet

#### THE RELATIONSHIP BETWEEN FETAL, NEONATAL AND INFANCY PATHOLOGIES AND THE OCCURRENCE OF PLANO VALGUS FEET DEFORMATION

The parents of all examined children received questionnaires to fill in about the course of pregnancy, labor, neonatal period and infancy. In the group of 515 examined children we received 418 answers, which is 81.2%, so a group of 418 children underwent statistical analysis. The abnormal course of pregnancy, labour, neonatal period and infancy, indicating the possibility of even very small lesions to the central nervous system was found in 35.65% of all the examined preschool and schoolchildren, and for the children with plano valgus feet it was 62.92%. Figure 5 shows the relationship between the frequency of pregnancy and labor pathologies and the particular types of feet.

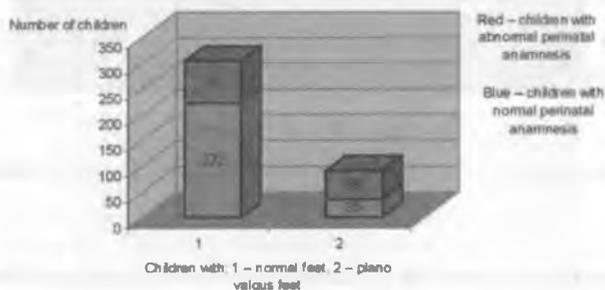


Fig. 5. Children with normal and abnormal perinatal anamnesis with regard to normal and plano valgus feet

#### RESULTS AND DISCUSSION

Shortening of the Achilles tendon as a reason for plano valgus feet secondary deformation is a frequently occurring phenomenon. Most authors suggest that there is a connection with neuromuscular irregularities. This phenomenon is described in both Polish (4, 5, 6, 11) and foreign literature (1, 2, 12, 13, 14).

Evident shortening of the Achilles tendon, causing equine foot positioning is easily noticeable. However, if the child walks on their whole feet and, additionally, they are “flat”, the calcanean tendon is often disregarded in examination. Even more so that usually the active movement of foot dorsiflexion is present, but it is made through valgity. When the instep is positioned orthostatically, it turns out that there is a distinct deficit of dorsiflexion. Reimers (12) reported that if the foot can be passively dorsiflexed only to the right angle with extended knee (shortening of the Achilles tendon is present), quick foot dorsiflexion movements will “inhibit” the foot earlier, so there will be even more limitation of movement. This phenomenon can be explained in the following way: too quick and abrupt movements intensify spasticity by means of reflexes from Golgi corpuscles. The provoked spasticity test is therefore a sensitive means of detecting the triceps muscle contracture.

Assuming that the grounds of the calf triceps muscle contracture are neurogenic, we cannot neglect the course of perinatal period of the examined children. It is a fact that the pathology of this period not always manifests itself by the lesion of the neuromuscular system, but also the other way round – spastic pareses occur in children without overburdening perinatal anamnesis.

Injury to the central nervous system may cause varied degree of foot muscles pareses. In substantial pareses, typical of clinically evident form of infantile cerebral palsy, feet deformations are obvious. In pareses of single muscles, e.g. calf triceps muscle, experience is needed for detection of the defect. Banks (3) reports that even small, untreated spastic deformations may gradually lead to substantial disfigurements. Lloyd-Roberts (7) in the book entitled *Orthopedics in Infancy and Childhood* reports that unilaterally occurring heel valgity may be a symptom of mild hemiplegia.

Whereas severe injuries to the central nervous system give obvious neurological symptoms, the development of plano valgus foot may be the first and only manifestation of a mild form of cerebral palsy (10, 14).

## CONCLUSIONS

1. Examination of preschool and schoolchildren with plano valgus feet, aged 3–15 years revealed that the frequency shortening of the Achilles tendon is 77.57%. These results indicate how important is the determination of the extent of Achilles tendon shortening during feet examination.

2. Shortening of the Achilles tendon makes the natural curing of plano valgus feet quite difficult.

3. The contracture of calf triceps muscle and shortening of the Achilles tendon has usually a neurogenic basis. The detection of spastic muscle tone often becomes possible through performing the “quick stretch” / “provoked spasticity”/ test. This test frequently allows for detection of a non-fixed, functional spastic contracture of the calf triceps muscle.

4. We demonstrated the relationship between the pathologies of pregnancy, labor, neonatal and infancy period with the frequency of plano valgus feet deformations. While in the total number of children the frequency of the irregularities in the discussed period was 35.65%, in the group of children with plano valgus feet deformations it was 62.92%.

5. Treatment of secondary plano valgus feet deformations with shortening of the Achilles tendon requires active procedures, mainly including redressment of the contracted tendon and the appropriate orthotic supply.

## REFERENCES

1. Aharonson Z. et al.: Foot-ground pressure pattern of flexible flatfoot in children with and without correction of calcaneovalgus. *Clin. Orthop. Rel. Res.*, 78, 177, 1999.
2. Barry R. J., Scranton P. E.: Flat feet in children. *Clin. Orthop.*, 181, 68, 1983.
3. Banks H. H.: The management of spastic deformities of the foot and ankle. *Clin. Orthop. Rel. Res.*, 122, 70, 1997.
4. Karski T. et al.: Wtórna spastyczna stopa koślawa – samoistna, wskutek wadliwego usprawniania i jatrogena pooperacyjna. *Post. Rehab.*, VII-B, 2, v. 93, 1993.
5. Karski T. et al.: Kompleksowe leczenie ortopedyczne zaburzeń czynnościowych i przykurczów u dzieci z porażeniem mózgowym. *Chir. Narz. Ruchu Ortop. Pol.*, 61, Supl. 3B, 171, 1996.
6. Konera W.: Badanie nad patomechanizmem rozwoju wadliwych stereotypów czynnościowych i przykurczów stawów kończyn dolnych u dzieci z MPDz. Doctoral Dissertation, Medical University, Lublin 1991.
7. Lloyd-Roberts G. C., Fixen J.: *Orthopaedics in Infancy and Childhood*. II Ed., 203, 1988.
8. Michałowicz R.: Mózgowe porażenie dziecięce. PZWL, 38, Warszawa 1993.
9. Miller G. R.: The operative treatment of hypermobile flat feet in the young child. *Clin. Orthop. Rel. Res.*, 122, 95, 1997.
10. Morley A. J. M.: Knock-knee in children. *BMJ*, 976, 1957.
11. Okoński M. et al.: Feet problems in children and adolescent with shortening of Achilles tendon. Convention report, Rapello, Nierethoza, 1997.
12. Reimers J.: Foot deformity and the length of the triceps surae in Danish children between 3 and 17 years old. *J. Ped. Orthop.*, B, 4, 71, 1995.
13. Rose G. K. et al.: The diagnosis of flat foot in the child. *J. Bone Joint Surg.*, 67-B, 71, 1985.
14. Smith M. A.: Flat feet in children. *BMJ*, 301, Oct. 942, 1990.
15. Taczała J.: Przykurcz mięśnia trójgłowego łydki i skrócenie ścięgna Achillesa przyczyną deformacji płasko-koślawych stop u dzieci. Doctoral Dissertation, Medical University, Lublin, 1998.

## SUMMARY

Plano valgus and valgus feet deformations in children are usually secondary, as effects of other primary pathologies, for instance concerning the nervous-muscular system. Shortening of the Achilles tendon is a frequent cause of the deformation discussed here and requires the application of appropriate treatment, different from that applied in the typical plano valgus feet in children. The aim of the paper was to determine the frequency of the Achilles tendon shortening in flat-abducted feet in 28 children treated in the Rehabilitation Outpatient Clinic and in 515 healthy preschool and schoolchildren. We also analyzed the connection of the Achilles tendon shortening with abnormal course of pregnancy and perinatal period. The study comprised 3-year-old children treated in the Rehabilitation Outpatient Clinic in the Children's Clinical Hospital because of plano valgus feet deformation. The second group was that of preschool and schoolchildren aged 3–14 years. The evaluation methods were: orthopedic examination, pantography, evaluation of the degree of Achilles tendon shortening, neurological evaluation of the foot and the analysis of perinatal and neonatal period, as well as infancy. Study results indicate the presence of Achilles tendon shortening in 85% of the children with plano valgus feet treated in the Rehabilitation Outpatient Clinic and in 77% of

the children with plano valgus feet in the population of preschool and schoolchildren. Overburdened perinatal anamnesis occurred in a substantial number of children with flat-abducted feet deformation. Secondary plano valgus feet deformations with shortening of the Achilles tendon are often the only symptom of mild infantile cerebral palsy.

#### Patogeneza wtórnych deformacji płasko-koślawych stóp ze skróceniem ścięgna Achillesa u dzieci

Deformacje płasko-koślawe i koślawe stóp u dzieci są przeważnie wtórne, wskutek innych pierwotnych patologii, na przykład dotyczących układu nerwowo-mięśniowego. Skrócenie ścięgna Achillesa jest częstą przyczyną omawianej deformacji i wymaga zastosowania odpowiedniego leczenia, różniącego się od stosowanego w typowej deformacji płasko-koślawej stóp u dzieci. Celem pracy było określenie częstości występowania skrócenia ścięgna Achillesa w stopach płasko-koślawych u 28 dzieci leczonych w Poradni Rehabilitacyjnej oraz u zdrowych 515 dzieci przedszkolnych i szkolnych. Analizowano również związek występowania skrócenia ścięgna Achillesa z nieprawidłowym przebiegiem okresu ciąży-porodowego. Badaniami objęto 3-letnie dzieci leczone w Poradni Rehabilitacyjnej Dziecięcego Szpitala Klinicznego z powodu deformacji płasko-koślawych stóp. Drugą grupę stanowiły dzieci przedszkolne i szkolne w wieku 3 – 14 lat. Metodami oceny były: badanie ortopedyczne, pantografia, ocena stopnia skrócenia ścięgna Achillesa, ocena neurologiczna stopy oraz analiza okresu okołoporodowego i noworodkowo-niemowlęcego. Wyniki badań wskazują na obecność skrócenia ścięgna Achillesa u 85% dzieci ze stopami płasko-koślawymi leczonych w Poradni Rehabilitacyjnej oraz u 77% dzieci ze stopami płasko-koślawymi w populacji dzieci przedszkolnych i szkolnych. Obciążony wywiad okołoporodowy występował u znacznej liczby dzieci z deformacją płasko-koślawą stóp. Wtórne deformacje płasko-koślawe stóp ze skróceniem ścięgna Achillesa są często jedynym objawem łagodnej postaci mózgowego porażenia dziecięcego.