

THE ANALYSIS OF THE ARCH OF THE FOOT IN THREE-YEAR-OLD CHILDREN – A CASE OF LJUBLJANA

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Abstract:

Movement activities in the preschool period represent an important factor in children's development process and should therefore be given as much attention as possible. At the same time, attention must be paid to each individual child; the fact that is forcing us to continuously observe and consequently adapt the physical education process. Appropriate planning and a professional approach in the educational process can help us to recognize and solve children's problems on time. One of the more frequent problems children have is flat arch of the foot. By means of plantogram evaluation, this research investigates the frequency of a fallen arch of the foot among three-year-old boys and girls. Flat feet have been evaluated using the Clark's method. The sample of subjects included 127 children from 18 kindergartens in Ljubljana, Slovenia. It has been ascertained that 8% children had healthy, normal feet, 20% represented the flat foot borderline cases, and 72% children had flat feet. The results of the analysis of variance indicated that there was no statistically significant difference between three-year-old boys and girls in the incidence of flat feet. We are of the opinion that one of the main reasons for such a high percentage of flat feet is that the development of the arch of the foot in some three-year-old children has not yet been completed. Despite that, it is important to note that we must enable children to perform a variety of movement activities on a daily basis since the development of motor skills is an important contributor in the locomotor system development, a part of which the feet are.

Key words: arch of foot, analysis, three-year-old boys and girls, comparison

DIE ANALYSE DES FUSSBOGENS BEI DREIJÄHRIGEN KINDERN

Zusammenfassung:

Bewegungstätigkeiten in der Vorschulperiode stellen einen wichtigen Faktor im Entwicklungsprozess der Kinder dar, und sollten folglich so viel Aufmerksamkeit gegeben werden, wie möglich. Gleichzeitig muss jedes einzelne Kind beachtet werden; die Tatsache, die uns zwingt, den Leibeserziehungsprozess ununterbrochen zu beobachten und anzupassen. Passende Planung und professioneller Zutritt im pädagogischen Prozess können uns helfen, Probleme der Kinder zu erkennen und zu lösen. Eins der häufigeren Probleme, die die Kinder haben, sind flache Füße. Mittels des Plantogrammsauswertung analysiert diese Forschung die Frequenz des gefallenen Fußbogens unter dreijährigen Jungen und Mädchen. Flache Füße wurden mit der Clarks Methode ausgewertet. Wir haben 127 Kinder aus 18 Kindergärten in Ljubljana gemessen. Die Resultate zeigten, dass fast 72% Kinder flache Füße hatten. Die Resultate der Varianzanalyse zeigten, dass es keinen statistisch bedeutenden Unterschied zwischen dreijährigen Jungen und Mädchen gab. Wir sind der Meinung, dass einer der Hauptgründe für einen so hohen Prozentsatz der flachen Füße war, dass die Fußbogen und Fußentwicklung bei dreijährigen Kindern noch nicht durchgeführt wird. Trotzdem ist es wichtig zu merken, dass man den Kindern ermöglichen muss, eine Vielzahl der Bewegungstätigkeiten täglich durchzuführen.

Schlüsselwörter: Fußbogen, Analyse, dreijährigen Jungen und Mädchen, Vergleich

Introduction

The preschool period is the fundamental period for the development of children's motor abilities. In early childhood, children are most affected by influences from society and the surrounding environment, which also influences the development

of their personalities. Experts have established that whatever is missed in early childhood is hard to be compensated for in later periods of life. In early childhood, regular movement activities represent an essential component of physical, motor, cogni-

tive, emotional, and social development (Videmšek & Karpljuk, 1999).

Each child has a right to optimal physical and mental development. This statement obliges each and every one of us, who are involved in children's education, to strive to maintain and improve our children's health. An increasing number of physical disorders are being observed and we must establish an environment in which children will feel comfortable. Among these physical disorders flat feet are very frequently discovered (Wilmore & Costill, 1994).

The preservation of the longitudinal and transverse arches is dependent on the bone structure, the ligaments of the foot and the lower limb and leg muscles (Riegerova, Žeravova, & Peštukova, 2005). In the prenatal period, the foot is composed of growing cartilages which are dome-shaped (*calcaneus, talus*) or rectangular (*tarsus*) in shape. The ossification process begins already in the third month of pregnancy. At the time of birth the ossification is 30% complete. The ossification process finishes at the end of the growing period. A foot grows fastest in the first year when it gains 4.5 cm in length. After the age of three, the speed of growing is not so intense and maintains the same speed until puberty. Due to a rather slow ossification and rapid growth in length, the foot is prone to physical disorders because of stress in the environment, in the uterus and after the birth. At the beginning of puberty, the foot reaches 97% of its optimal length. Late ossification of the midtarsal bones results in foot flexibility in the first year, which is an advantageous biomechanical basis for a conservative treatment of innate foot deformities (Herman, 1998).

Flat feet represent one of the toughest problems children have nowadays. Pridalova and Riegerova (2002) are of the opinion that an optimal foot, as described in various medical publications, is actually hard to find. Nowadays, we can observe a number of people with the so called Egyptian foot, which is a foot that can bear more weight (Riegerova, Žeravova, & Peštukova, 2005). Today, a high percentage of flat feet and toe deformities are being observed.

The foot arch enables a flexible body weight transfer and holds the entire body weight. The foot arch is formed only by activating the foot muscles and by means of specially designed exercises (Brecelj, 2000). This is why foot arches require special care and attention. Kindergarten teachers, parents, and physical education teachers should know about causes of the foot deformities and they should aim to prevent or at least minimize such disorders before a chronic and irreparable problem occurs (Pridalova, Seifertova, Elfmark, & Janura, 2003).

Rajtmajer (1991) lists the morphological status data of three-year-old children, based on medical

examinations in the years 1983, 1984 and 1985. Over 50% of children had more or less distinctive foot deformity. The author's opinion was that in kindergartens more attention should be paid to preventive and corrective gymnastics and exercises thus preventing the occurrence of serious and long-lasting problems.

Physical education teachers and kindergarten teachers can contribute most in foot deformity prevention. With an appropriate choice of elementary games and corrective exercises, a teacher can help children develop and strengthen the muscles needed to develop and maintain healthy feet arches (Kahle, Leonhardt, & Platzer, 1992). Tratnik (1994) is of the opinion that sport activity in general positively contributes to a lower occurrence of flat feet. The author established that among eleven-year-old girls there is no statistically characteristic correlation between the occurrence of flat feet and morphological and motor variables, yet there is a sign of correlation between the occurrence of flat feet, body weight, and balance skills.

Balanced children's development requires cooperation of all who are involved in a child's growing-up process (Kontrec, 1998). It is essential that parents, kindergarten teachers, physical education teachers as well as doctors communicate well (Burian, Strel, & Tratnik, 1995). Each should know about a child's medical problem, and each should use his/her expertise to contribute to maintenance and establishment of a child's optimal health.

Different authors have established flat foot status differences between boys and girls. Flat foot incidence was higher in boys than in girls. Flat feet occur in 48.3% of three-year-old boys, but only 23% in girls (Pridalova & Riegerova, 2005). Similar results were found by Štastna (2002; quoted by Pridalova & Riegerova, 2005): 53.3% of three-year-old boys and only 36.4% in girls.

Because flat feet nowadays represent one of the more frequent problems, the purpose of this study was to analyse the flat feet incidence, and the level of fallen arches among three-year-old boys and girls. The results were compared also according to the gender of the children.

Methods

Profile of subjects

The sample of subjects studied included 127 preschool children, 62 boys and 65 girls, aged 3 years (± 45 days) from 18 kindergartens in Ljubljana. The sample is representative only for the city of Ljubljana (Slovenia).

Sample of variables

The plantogram evaluation has been used in this research. Flat feet have been evaluated using the Clark's method (Pridalova & Riegerova,

2005), where the AB line connects the points between the inside of the heel and the foot. Point A is then connected with point C, which is determined on the deepest edge of the longitudinal arch. This forms an angle between points C-A-B (Figure 1) which is measured with a goniometer (results in degrees - °).

Criteria for flat feet:

- Points C-A-B = > 42° healthy foot
- Points C-A-B = 32° - 42° flat foot borderline case
- Points C-A-B = < 32° flat foot

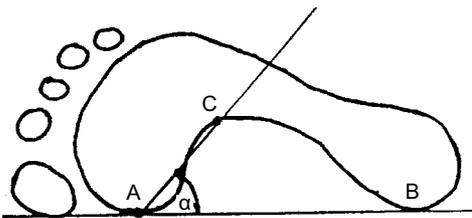


Figure 1. Clark's method.

Methods of data processing

The measured data has been processed in a computer data processing department of the Faculty of Sport, Ljubljana, Slovenia, using the SPSS-9.0 (Statistical Package for Social Sciences).

Basic statistical parameters have been calculated. For the purpose of determining the differences among the male and female subjects, the one-way analysis of variance (ANOVA) has been used.

Results

Table 1 shows the basic statistical parameters for angles (boys and girls), obtained using the Clark's method. The arithmetic mean of a measured angle was 22.7°. Taking into account the criteria used in this research (Clark's method), this value falls into the category of flat feet. The highest value measured was 52°, while the lowest was 2°. The standard deviation from the arithmetic mean was 12.4°, meaning the values varied quite a lot.

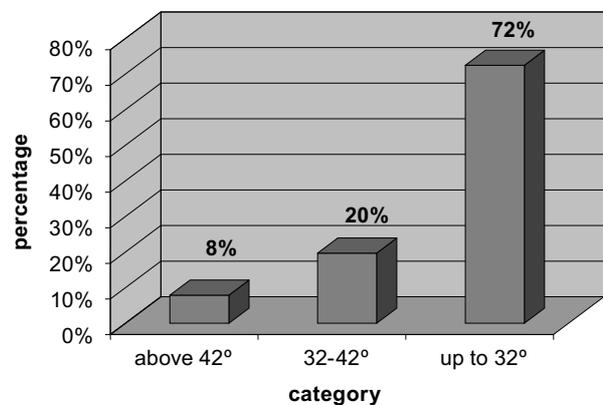
Table 1. Basic statistical parameters for measured angles (in goniometer's degrees) and differences between boys and girls (ANOVA).

Basic statistical parameters	Boys	Girls	Boys & Girls
Mean	21.7°	24.5°	22.7°
Standard deviation	12.1°	12.8°	12.4°
Minimum	2°	4°	2°
Maximum	49.5°	52°	52°

If we compare the boys' and girls' basic statistical parameters for the measured angles separately, we can establish that the minimum, maximum and average angle values obtained using the Clark's method are rather similar or do not differ significantly according to the child's gender.

In order to ascertain whether these values are statistically significantly different or not, an analysis of variance has been used. The results show (Table 1) that there are no statistically significant differences between boys and girls; in other words, gender does not represent a factor which would affect the occurrence of flat feet in three-year-old children from Ljubljana.

The data obtained has been classified into the Clark's categories.



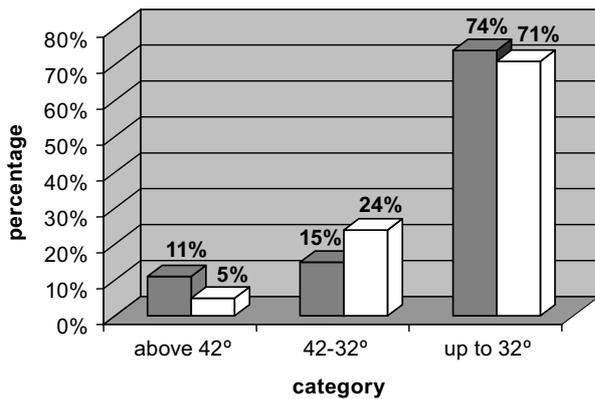
Legend: Categories by Clark (Pridalova & Riegerova, 2005): healthy foot > 42°, flat foot borderline case 32° - 42°, flat foot < 32°.

Figure 2. Classification of measured angle values (in goniometer's degrees) into the categories of flat feet in boys and girls.

The classification of measured angle values into individual categories (Figure 2) showed that almost three quarters (72%) of the subjects studied had flat feet, further 20% represented a borderline flat feet cases, and only 8% of the subjects studied had healthy feet.

Based on these results, we can confirm that most Ljubljana children had flat feet.

Analysis of variance	
F value	0.801
Significance	0.373



Legend: Categories by Clark (Pridalova & Riegerova, 2005): healthy foot > 42°, flat foot borderline case 32° - 42°, flat foot < 32°.

■ Girls □ Boys

Figure 3. Classification of measured angle values (in goniometer's degrees) into the categories of flat feet based on gender.

Figure 3 clearly indicates that healthy feet were found in 11% girls and 5% boys. The first conclusion could be that girls' feet arches do not fall as low as the boys' do. However, borderline cases with boys were found in 24% cases, with girls in 15% cases, and 74% girls and 71% boys had fallen foot arches. Therefore, healthy and fallen arches were more frequent with girls, and the difference was levelled out in borderline flat feet cases with more boys in this category.

Discussion and conclusion

The data obtained in this study have been classified into the previously explained categories (Pridalova & Riegerova, 2005; Figure 2). The classification shows that almost three quarters (72%) of the subjects studied had flat feet. A further 20% represent a borderline flat feet case, and 8% of the subjects studied had healthy feet. Based on these results, we can confirm that most of the 3-year-old children from Ljubljana, Slovenia, had flat feet.

There may be various factors causing such a high percentage (72%). The age of three to four is the age when the foot arches' development is completed. However, some children grow and develop at a slower rate (Kosinac, 1999); they may develop some other characteristics faster and will inevitably catch up in their foot arch development with time as well (Herman, 1998).

Another cause for flat feet can be found in some innate foot deformity. We distinguish two groups of such ailments: positional foot deformities and structural innate foot deformity. There are about 3.6% of deformity caused in the prenatal period, and about 2% of flat feet are genetically caused. About 5% of the subjects studied in this research can be classified as foot deformity (Herman, 1998).

Among these, the most common one is the innate flat foot. The innate flat foot (*pes planus, talus verticalus*) is a structural foot deformity. The midfoot is wider and the longitudinal foot arch is flat or even convex. A child puts pressure primarily on the in-step part of the foot. Typical for this deformation is that the talus is positioned vertically and articulates with the navicular bone. The medial soft tissues are longer or stretched. The outside and hind-foot soft tissues, ligaments and sinews are shortened. The other characteristics of a flat foot innate deformity are that there is no longitudinal foot arch at all; due to inappropriately developed ligaments, the foot bones are all on the same level. This deformation requires surgical treatment before a child starts to walk.

Despite the causes mentioned above, the percentage of flat feet is still very high. We cannot deny the fact that already at this age, a lot of children have flat feet, or their foot arches have already started falling or have not developed entirely yet. The reasons for such a situation could also lie in inappropriate footwear, early standing attempts, or are just the consequence of various diseases, such as infectious diseases, obesity, anemia, fractures, lack of walking barefoot, and lack of movement in general (Brecelj, 1997).

Children should not wear shoes that are too hard or even improperly fitting and already worn (Brecelj, 2000). Too much support for the bones can result in the lack of the muscle strengthening. Shoes that have been worn before can cause foot problems as well; even when the right size, such shoes have already been adjusted to a different foot.

Speeding up children's development or attempts to speed up their normal development can only be harmful (Kosinac, 1999). One of the consequences is also flat feet. Children will stand up on their own when they feel they are capable of doing so. If parents attempt to put children on their feet or into a baby walker too early, the muscles' development will be disturbed, and the result is a flat foot. It is important to be aware that each child will go through the development phases (holding his/her head up to look for somebody or something, sitting on his/her own, crawling, toddling, standing, walking with help and walking without help) at his/her own suitable time. Forcing a child can be very harmful.

Nowadays, we try to protect our children in every place. This, however, is sometimes rather harmful. Let's take an example of walking barefoot. When walking with no shoes on, a foot has to adjust to a variety of surfaces with every step he/she makes. This way, the muscles are strengthened and form a foot arch, which is very significant for the entire body statics (Kontrec, 1998).

The development as a whole plays an important role in the development of healthy feet. We must pay

attention to healthy eating habits, because excess body weight can cause flat feet (Brecelj, 2000). We must also make sure that children's diet includes plenty of minerals, vitamins and other nutritional substances in appropriate proportions to prevent illnesses.

Fractures can also cause problems with one's feet. We should consult a doctor, and if necessary, see a physiotherapist who will recommend exercises to maintain the muscles' strength.

While trying to protect our children, we practically eliminate any possibility for them to gain new experience and to strengthen their bodies. Children should be allowed and enabled to crawl, jump, climb and perform a variety of movements, because this is how they discover things, gain new experiences, and strengthen their bodies. This way children will develop their motor skills, an important contributor in the locomotor system development, which feet are a part of (Illingworth, 1987). If we allow children to fulfil their needs to move, we will enable them to develop strength, movement coordination, balance and other skills. At the same time, we will prevent their arches from falling and, consequently, prevent flat feet (Rheker, 1993).

The second category includes one fifth of all the subjects studied. These represent the borderline cases, meaning that their feet are in the process of completing the development, or their arches may have already fallen for some of the previously mentioned reasons (shoes, lack of walking barefoot, movement, congenital dispositions, etc.). With healthy children we often observe that a foot arch, which is flat when bearing weight, forms a normal arch when standing on tiptoes, or when the big toe is stretched out. Such feet normally do not obstruct children in any way. In terms of anatomy and functionality, such feet are equivalent to feet with normal foot arches. Staheli (1995) discusses the correlation between pain and flat feet. The pain, which 20 to 30 percent of children suffer in their feet, is statistically very highly correlated with the occurrence of fallen foot arches (resumed from: Herman, 1998).

Kindergarten teachers, parents, and, above all, physical education teachers can help children who fall into this category most. These children should do as many as possible such activities which will help them to strengthen the muscles that hold the arch in place.

The rest of 8% children studied had very well developed foot arches and thus healthy feet and proper body statics. These children had probably undergone healthy development filled with plenty of movement and walking barefoot.

The analysis of variance results indicated that there was no statistically significant difference between boys and girls in the incidence of flat feet. We can infer that flat feet were equally represented and that the gender of a child did not represent a factor which would affect the occurrence of flat feet.

With this research we have ascertained that flat feet or fallen foot arches very frequently occurred among three-year-old children from Ljubljana, Slovenia. Most likely it is the consequences of the civilized way of life, like too much weight bearing when constantly walking on the hard and flat surfaces, like sidewalks covered with asphalt, and the inappropriate treatment in the period when the foot is still developing (lack of movement and walking barefoot, inappropriate footwear). A certain percentage of flat feet could be the result of non-completed foot arch development at the age of three and innate arch deformity. Despite that, the problem of fallen foot arches remains a serious and urgent one.

It is important that parents, kindergarten teachers and physical education teachers cooperate well. With their good example, demonstration and encouragement they can save many a child from a number of problems. All the kindergarten staff, not only the medical staff in charge of regular medical examinations, should be aware of the problems of flat feet, because kindergarten teachers in cooperation with the medical staff can substantially contribute to preventive and curative treatments in this area. Children, namely, are our wealth and we must take good care of them and their development.

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ANALIZA SVODOVA STOPALA U TROGODIŠNJE DJECE – SLUČAJ LJUBLJANE

Sažetak

Uvod

Spuštena stopala danas predstavljaju jedan od najvećih problema dječje populacije. Idealno stopalo, opisano u različitim medicinskim publikacijama, zapravo se vrlo rijetko nalazi. U današnje vrijeme uočava se mnogo osoba s tzv. egipatskim stopalom, koje može podnijeti veću težinu. Također se uočava visok postotak spuštenih stopala i bolesti nožnih prstiju.

Svod stopala omogućava fleksibilan prijenos tjelesne mase te nosi cjelokupnu masu tijela. Svod stopala se oblikuje samo aktiviranjem stopalnih mišića i pomoću specifično oblikovanih vježbi (Brecelj, 2000). Stoga svodovi stopala zahtijevaju osobitu brigu i pažnju. Njegovatelji/ce u dječjim vrtićima, roditelji i nastavnici tjelesne i zdravstvene kulture trebali bi biti upoznati s uzrocima deformiteta stopala te djelovati u cilju prevencije ili barem umanjavanja takvih poremećaja prije no što nastupe kronični i nepopravljivi problemi.

S obzirom na to da spuštena stopala u današnje vrijeme predstavljaju jedan od najčešćih problema, cilj ovog istraživanja bio je analizirati učestalost pojavljivanja spuštenih stopala, kao i razinu spuštenih stopalnih svodova u trogodišnjih dječaka i djevojčica, stanovnika Ljubljane, Slovenija.

Metode

Uzorak ispitanika uključivao je 127 predškolske djece - 62 dječaka i 65 djevojčica u dobi od 3 godine (± 45 dana) iz 18 ljubljanskih dječjih vrtića. Uzorak je reprezentativan samo za grad Ljubljanu.

U istraživanju je korištena evaluacija plantograma. Spuštena stopala evaluirana su pomoću Clarkove metode, u kojoj spojnica AB povezuje točke na medijalnoj strani pete i prednjem dijelu stopala. Točka A se zatim povezuje s točkom C, koja se određuje na najvišem rubu uzdužnog svoda. Time se dobiva kut između točaka C-A-B, koji se mjeri goniometrom (rezultati u stupnjevima - °).

Kriteriji za spuštena stopala (slika 1):

Točke C-A-B = $> 42^\circ$	zdravo stopalo
Točke C-A-B = $32^\circ - 42^\circ$	granični slučaj spuštenih stopala
Točke C-A-B = $< 32^\circ$	spušteno stopalo

Izmjereni podaci obrađeni su na Odsjeku za računalnu obradu podataka Fakulteta za šport, Ljubljana, programom SPSS-9.0 (Statistical Package for Social Sciences).

Izračunati su osnovni statistički parametri. Jednosmjerna analiza varijance korištena je za određivanje razlika između dječaka i djevojčica.

Rezultati, rasprava i zaključak

Podaci dobiveni u ovom istraživanju klasificirani su u tri ranije objašnjene kategorije. Gotovo tri četvrtine (72%) izmjerenih ispitanika imalo je spuštena stopala, 20% ispitanika činilo je kategoriju graničnih slučajeva spuštenih stopala, a preostalih 8% imalo je zdrava stopala. Na temelju tih rezultata možemo ustvrditi da većina trogodišnje djece u Ljubljani ima spuštena stopala.

Da bi se provjerilo postoji li statistički značajna razlika između vrijednosti izmjerenih u dječaka i djevojčica, koristila se analiza varijance. Rezultati su pokazali da ne postoje statistički značajne razlike između dječaka i djevojčica; drugim riječima, spol ne predstavlja čimbenik koji bi utjecao na učestalost pojavljivanja spuštenih stopala u trogodišnje djece.

Rezultati jasno pokazuju da su zdrava stopala nađena kod 11% djevojčica i 5% dječaka. Prvi zaključak mogao bi biti da se svodovi stopala kod djevojčica ne spuštaju nisko kao kod dječaka. S druge strane, graničnih slučajeva je kod dječaka nađeno 24%, kod djevojčica 15%, dok su u 74% djevojčica i 71% dječaka nađeni spušteni svodovi stopala. Slijedom navedenoga možemo reći da su zdravi i spušteni svodovi češći u djevojčica, a razliku poravnava kategorija graničnih slučajeva spuštenih stopala, u kojoj je više dječaka.

Visok postotak spuštenih stopala (72%) mogli su prouzročiti različiti čimbenici. Dob od tri do četiri godine predstavlja razdoblje u kojem završava razvoj svodova stopala. Međutim, neka djeca sporije rastu i razvijaju se. Kod njih se neke druge karakteristike mogu razviti brže, ali će i oni s vremenom svakako dostići i razvoj svodova stopala.

Drugi uzrok spuštenih stopala mogu biti i neki prirodni deformiteti stopala. Razlikujemo dvije skupine takvih otklona: posturalni (malpozicijske) deformiteti stopala i strukturni prirodni deformiteti stopala. Oko 3,6% deformiteta nastaje u prenatalnom periodu, a oko 2% spuštenih stopala uzrokovano je genetskim poremećajima.

Oko 5% slučajeva izmjerenih u ovom istraživanju može se klasificirati u prirodne deformitete. Najčešće među njima je prirodno spušteno stopalo. Prirodno spušteno stopalo (*pes planus, talus verticalis*) je strukturni deformitet stopala. Središnji (tarzalni) dio stopala je širi, a uzdužni svod stopala je ravan ili čak konveksan. Dijete prvenstveno opterećuje metatarzalni dio stopala. Ovoj deformaciji je svojstveno da je talus postavljen okomito i spojen s navikularnom kosti. Meka tkiva medijalne strane stopala su duža ili istegnuta. Meka tkiva, ligamenti i tetive lateralne i stražnje strane stopala su skraćena. Drugi oblik spuštenog stopala karakterizira potpuno nepostojanje uzdužnog svoda. Uslijed nepravilnog razvoja ligamenata, sve su kosti stopala na istoj razini. Ova deformacija zahtijeva kirurško liječenje prije no što dijete započne hodati.

Unatoč gore navedenim razlozima, postotak spuštenih stopala još uvijek je vrlo visok. Ne možemo osporiti činjenicu da već u ovoj dobi velik broj djece ima spuštena stopala ili su im se svodovi stopala već počeli spuštati ili još nisu potpuno razvijeni.

Uzroci takve situacije mogu se također tražiti u neprikladnoj obući, preranim pokušajima da se djeca osove na noge ili su, pak, posljedica različitih bolesti, poput zaraznih bolesti, pretilosti, anemije, prijeloma, nedovoljnog hodanja bosih nogu ili, općenito, nedovoljnoga kretanja (Brecelj, 1997).

Važno je da roditelji, njegovatelji/ce u dječjim vrtićima i nastavnici tjelesne i zdravstvene kulture dobro surađuju. Svojim dobrim primjerom, pokazivanjem i ohrabrenjem, djecu mogu poštediti brojnih problema. Problem spuštenih stopala morao bi biti dobro poznat svom osoblju svih dječjih vrtića, a ne samo medicinskom osoblju zaduženom za redovite zdravstvene preglede. Njegovatelji/ce u suradnji s medicinskim osobljem mogu znatno pridonijeti preventivnim i kurativnim tretmanima u ovom području. Djeca su, naime, naše bogatstvo i moramo dobro brinuti o njima i njihovu razvoju.