Impact of intellectual disability on longitudinal arch and symmetry of the lateral and medial load of the foot

Wpływ niepełnosprawności intelektualnej na wysklepienie podłużne oraz symetrię obciążenia bocznej i przyśrodkowej strony stopy

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Summary

Introduction: Frequent occurrence of bone deformities and orthopedic problems affecting feet is also observed in the population of people with intellectual disabilities (ID). They are associated with a change in the load on individual zones of the plantar side of the foot, which not only affects the deterioration of its functional fitness, but often contributes to discomfort, pain and predisposes to the development of adverse lesions in the upper body segments. The purpose of the study was to assess the impact of intellectual disability with an etiology other than Down Syndrome on the longitudinal arch and symmetry of the lateral and medial load of the foot.

Materials and methods: The study involved 38 people with mild to moderate intellectual disability, with an average age of 23 years as well as 44 young able-bodied people, with an average age of 20.8. The main measurement tool used to assess the arch and load of individual zones within the foot was the BTS P-WALK baroresistive platform. The measurement included analysis in static conditions and lasted 30s.

Results: Comparison of both groups showed no significant differentiation in terms of medial and lateral forefoot and hindfoot load. Among persons with ID, normal arch of the foot was observed in 52.6% of subjects within the right foot and 57.9% within the left foot, while in the comparative group in 56.9% both in the right and left foot. People with intellectual disabilities were characterized by more frequent occurrence of flat feet compared to able-bodied people. The hollow foot was more frequently observed among able-bodied subjects than among persons with ID.

Conclusions: Among people with intellectual disabilities with an etiology other than Down Syndrome, flat feet are diagnosed more often compared to able-bodied peers who do not differ in body weight and BMI. Intellectual disability is associated with a greater burden on the medial part of the forefoot.

Keywords: foot, foot arching, ground pressure, intellectual disability

Introduction

People with intellectual disabilities are a very heterogeneous group in which, in addition to the lower level of intellectual functioning and co-occurring deficits in adaptive functioning, additional health problems often arise. It is well known that people with ID have a much worse state of health than the population of people with the normal intelligence ratio [1, 2]. In addition to such diseases as hypertension, diabetes, obesity or hypercholesterolemia, bone deformities and orthopedic problems also affect feet in this group [3, 4]. Specific foot disorders include clubfoot, bunion and flat foot [5–8]. There is no doubt that the correct morphological structure of the foot, and in particular the formation of longitudinal and transversal arches determine the optimal efficiency of the foot, and thus have an impact on mobility, which is extremely important for disabled people. Incorrect shaping of the foot, as well as improper load of individual zones of the plantar side of the foot not only affects the deterioration of its functional fitness, but often contributes to discomfort and pain. Considering that the foot is one of the links in the proprioceptive kinetic chain of a human body, any dysfunctions in this area may predispose to the development of adverse lesions also in higher body segments [9]. The problems of disabled people

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regarding feet, although they are common and significantly reduce the quality of life, they are often underestimated.

The purpose of the study was to assess the impact of intellectual disability with an etiology other than Down Syndrome on the quality of longitudinal arch and symmetry of the lateral and medial load of the forefoot and hindfoot.

Materials and methods

The study included 82 persons. The first group included 38 persons under care of occupational therapy workshops in the 19–31 age range, with mild or moderate intellectual disability. Disability was most often caused by perinatal factors, hereditary factors and of unknown etiology. Persons with Down Syndrome were excluded from the study. The second control group consisted of able-bodied 44 young persons, in the 20–24 age range, maintaining the proportion of females and males. The average age in the first group was 23.0, in the second – 20.8 and did not significantly differentiate the study subjects.

Body height of the study subjects was measured with a GPM anthropometer according to generally accepted principles with an accuracy of 0.5 cm. Body weight was measured in light clothing without shoes, on a Tanita scale with an accuracy of 0.1 kg. The Body Mass Index (BMI) was calculated based on body height and weight data.

The main measurement tool used to assess the arch and load of individual foot zones was the BTS P-WALK baroresistive platform enabling the analysis of static force density distribution during standing. The measurement lasted 30 seconds and was performed in silence, in an isolated room. The pressure exerted onto the floor by lateral and medial forefoot as well as lateral and medial hindfoot [Kpa], and also the Arch Index value were analyzed. This index is characterized by high reliability and determines the ratio of the surface area of the middle part of the foot print to the area of the entire foot excluding fingers [%]. Normal values are in the range of 21% to 28%, higher ones indicate flat foot, lower ones indicate hollow foot [10–12].

The collected data were analyzed in the Statistika v10 program. Basic descriptive characteristics were used, contingency tables were prepared and the significance of intergroup differences was tested using the Mann-Whitney U test assuming the level of significance $\alpha = 0.05$.

Results

The study subjects from the control group had a higher average body weight of 2.17 kg and were higher than persons with intellectual disabilities by an average of 8.86 cm. In the group of persons with ID, BMI values were higher by an average of 1.89 kg/m^2. Only differences in body height were statistically significant [Table 1].

Table 1.

The level of basic somatic features in the groups under study

Variable	Group	Mean	Median	Min.	Max.	Stand. Dev.	P
Age [years]	Control	20.84	21.00	20.00	24.00	0.81	0.052
	with ID	22.97	23.00	19.00	31.00	3.74	
Body height [cm]	Control	173.49	173.00	156.00	193.00	8.62	>0.001*
	with ID	164.63	164.25	146.60	182.00	9.12	
Body weight [kg]	Control	69.30	70.00	50.00	98.00	12.20	0.39
	with ID	67.13	63.95	43.20	111.40	16.58	
BMI [kg/m^2]	Control	22.91	22.50	16.71	29.38	2.94	0.18
	with ID	24.80	22.95	17.09	48.54	6.23	

* statistically significant difference

Quality of the foot arch was determined on the basis of the Arch Index. Flat foot was significantly more common among persons with intellectual disabilities in both the right and left foot. The hollow foot was more often observed among students (left foot 29.5%, right foot 31.8%) than among persons with ID (left foot 18.4%, right foot 26.3%). In the group of persons with ID a higher arch rate of the left foot was noted, indicating a lower longitudinal arch compared to the right foot (AI equal to 24.71 in the left foot and 23.28 in the right foot), while in the control group AI in both feet was similar (22.70 left foot and 22.39 right foot). Among the students, the same percentage of persons had a normally arched right foot as the left, while among ID persons foot defects more often related to the right foot (Table 2).

In both feet in the control group, compared to the ID group, there was a tendency to a greater load on both the lateral and medial hindfoot, but only the intergroup differences regarding the left foot were statistically significant. There were no significant differences between the control group and persons with ID in terms of forefoot load in either the right or left foot. Among all study subjects, the hindfoot load was clearly higher than the forefoot load. In both groups under study, the medial side of the forefoot of the right and left foot was loaded more than the later-

Table 2.

The quality of the longitudinal arch of the feet in the group of people with ID and in the control group

Group	foot	normal	flat	hollow
Control	left	56.9%	13.6%	29.5%
	right	56.9%	11.4%	31.8%
with ID	left	57.9%	23.7%	18.4%
	right	52.6%	21.1%	26.3%

al side. However, the differences in load in zone M1 (head of the first metatarsal) and zone M5 (head of the fifth metatarsal) were greater in the group of patients with ID (1.19 kPa for the right foot and 1.42 kPa for the left, and control group 0.06 kPa right foot and 0.1 kPa left foot respectively). The load on the right part of the hindfoot in both groups was greater than the load on the medial part of the hindfoot. In the left foot, the opposite hindfoot load pattern was noted in both groups: the medial part was loaded more than the lateral one (Tables 3 and 4).

Discussion

Issues related to the structure and function of the foot are raised in numerous scientific publications, often also in the context of their abnormalities. Flat feet are considered one of the most frequently observed defects in the lower limbs, although the results regarding the incidence of this deformation are divergent and largely depend on the methodology of the study [13–16]. Usually, there is a relationship between the occurrence of flat feet and age, sex, race, somatic build and incorrect selection of footwear in childhood. Deformations are also favored by staying in one position for a long time, lack of proper amount of movement or improper setting of the feet. Some authors also indicate an increased problem among persons with comorbidities such as diabetes [6–8,16–19]. Among disabled persons, the persons with intellectual disabilities appear to be a group particularly at risk of developing flat feet. Intellectual disability is a heterogeneous group of disorders with diverse etiology, clinical picture and course. Usually, problems related to reduced intellectual performance and adaptability limitations come to the fore, while other health problems can be underestimated. A review of the literature shows that problems related to morphology and foot function are common in the group of persons with ID, although the vast majority of analyzes involve persons with Down Syndrome. Concolino et al. found flatfoot in 60% of children with Down Syndrome aged 4–8 years. In the control group under study, this problem affected only 10% of persons. What's more, this and other foot abnormalities were responsible for changes

Table 3.

Average load [kPa] of selected right foot zones in the group of people with ID and in the control group

Variable	Group	Mean	Median	Min.	Max.	Stand. Dev.	P
M1	Control	7.97	7.45	2.60	19.00	3.69	0.49
	with ID	8.34	7.95	0.80	16.60	3.52	
M5	Control	7.91	7.50	2.70	12.60	8.62	0.13
	with ID	7.15	7.20	3.60	10.60	1.96	
MH	Control	19.25	19.30	10.00	30.30	4.42	0.61
	with ID	18.73	18.40	5.80	28.30	4.28	
LH	Control	19.72	20.10	4.10	30.40	4.60	0.49
	with ID	18.99	18.55	6.70	29.40	5.59	

* statistically significant difference

Table 4.

Average load [kPa] of selected left foot zones in the group of people with ID and in the control group

Variable	Group	Mean	Median	Min.	Max.	Stand. Dev.	P
M1	Control	7.10	6.70	3.40	14.00	2.37	0.21
	with ID	8.42	7.50	2.50	22.80	4.27	
M5	Control	7.00	7.00	1.70	10.70	1.77	0.99
	with ID	7.00	6.85	0.90	12.10	2.51	
MH	Control	22.02	21.85	13.70	30.90	3.54	0.02*
	with ID	20.02	19.85	11.30	27.20	3.91	
LH	Control	21.47	21.95	14.00	27.60	3.05	0.002*
	with ID	18.70	18.15	9.30	28.60	5.00	

* statistically significant difference

in body posture [5].

In the next group under study with Down Syndrome in the age range of 5 to 18 years, the average Arch Index (SD) was 29.0 (0.08), and the incidence of flat feet was 76%. [6]. Subsequent studies, which included adults with Down Syndrome (aged 15–44 years) showed that as many as 92% of them have various dysfunctions within the foot, including flat feet in everyone in this group [7]. Prasher et al. in their study also indicate an increased incidence of podiatric disorders in the group of persons with Down Syndrome, although they link these lesions mainly with chromosome 21 trisomy, and not intellectual disability in itself. In the groups under study, flatfoot was present among 58% of children with Down Syndrome, but only 20% in the group of children with learning disabilities excluding Down Syndrome and in the group of able-bodied children [8]. These views are not confirmed by own study, which only includes the results of study on persons with intellectual disabilities other than Down Syndrome. In this group, compared to able-bodied peers, flat foot was diagnosed almost twice as often. This observation concerned both feet. It is also worth noting that the groups under study were not differentiated by body weight or BMI, and this is one of the factors commonly associated with flat feet. In addition, the groups under study were significantly differentiated by the load on individual hindfoot zones in terms of statistics. Increased load on the medial side of the left hindfoot suggested greater pronation of the foot. This hypothesis is confirmed by the lower longitudinal arch of the left foot, illustrated by a higher value of the Arch Index.

Studies show that the shaping of longitudinal and transverse arches determines the optimal efficiency of the foot, thereby affecting the quality of gait and the efficiency of daily activities of persons with ID and those within the intellectual norm. Increased pronation of the flat foot during gait may additionally contribute to injuries [20–23]. What's more, a number of analyzes indicate the impact of flat feet on the occurrence of pain within the foot, knees, as well as the spine and overall quality of life [24–26]. In the context of the independence of the disabled, this seems particularly important. Currently, this social group is more and more often perceived not from the perspective of its deficits, but from the perspective of skills and abilities. In the light of such approach, it seems necessary to treat persons with ID comprehensively. Recognizing the problem and all the risks associated with foot irregularities can help in avoiding serious physical and mental problems in the future.

It should be remembered that persons with intellectual disabilities have different, sometimes more complex health problems than other social groups. These persons are in a particularly difficult situation, because they are usually not able to take care of their own needs. Lack of prophylaxis and disregard for foot lesions may lead to serious health, functioning and mobility problems in the future.

Conclusions

1. The incidence of longitudinal flat feet is higher among persons with ID with an etiology other than Down Syndrome compared to able-bodied participants who did not differ in weight or BMI.
2. Persons with ID tend to put load on the medial forefoot compared to able-bodied persons.
3. Exercises shaping the correct arch and foot load should be the one of the elements of rehabilitation programs for persons with ID.

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Streszczenie

Wstęp: W populacji osób niepełnosprawnych intelektualnie (ID) obserwuje się częste występowanie deformacji w układzie kostnym oraz problemy ortopedyczne dotyczące także stóp. Wiążą się one ze zmianą obciążenia poszczególnych stref podeszwowej strony stopy, co nie tylko wpływa na pogorszenie jej funkcjonalnej sprawności, ale często przyczynia się do dyskomfortu, dolegliwości bólowych oraz predysponuje do rozwoju niekorzystnych zmian w wyższych segmentach ciała. Celem badań była ocena wpływu niepełnosprawności intelektualnej o etiologii innej niż zespół Downa na wysklepienie podłużne oraz symetrię obciążenia bocznej i przyśrodkowej strony stopy.

Materiał i metody: Badaniami objęto 38 osób z niepełnosprawnością intelektualną w stopniu lekkim i umiarkowanym, o średniej wieku 23 lata oraz 44 młode pełnosprawne osoby, o średniej wieku 20,8. Głównym narzędziem pomiarowym służącym do oceny wysklepienia oraz obciążenia poszczególnych stref w obrębie stopy była platforma barorezystywna BTS P-WALK. Pomiar obejmował analizę w warunkach statyki i trwał 30s.

Wyniki: Porównanie obu grup wykazało brak znaczącego zróżnicowania w zakresie obciążenia przyśrodkowej i bocznej części przodo– i tyłostopia. Wśród osób z ID prawidłowe wysklepienie stopy zaobserwowano u 52,6 % badanych w obrębie stopy prawej i 57,9 % stopy lewej, natomiast w grupie porównawczej u 56,9 % zarówno w stopie prawej, jak i lewej. Osoby niepełnosprawne intelektualnie charakteryzowały się częstszym występowaniem płaskostopia w stosunku do osób pełnosprawnych. Stopę wydrążoną częściej obserwowano u pełnosprawnych badanych niż u osób z ID.

Wnioski: U osób z niepełnosprawnością intelektualną o etiologii innej niż zespół Downa płaskostopie diagnozuje się częściej niż u pełnosprawnych rówieśników nie różniących się masą ciała i wartością BMI. Niepełnosprawność intelektualna jest związana z większym obciążeniem przyśrodkowej części przodostopia.

Słowa kluczowe: stopa, stan wysklepienia, nacisk na podłoże, niepełnosprawność intelektualna