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Attainment of gross motor milestones in children with Down syndrome in Kosovo - developmental perspective

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ABSTRACT

Aim To investigate the age (in months) at which motor skills are developed in children with Down syndrome (DS), and compare it to the age of the development of the same skills in both, children with typical development (TD), and children with DS reported by four other studies.

Methods Sixteen children (7 girls and 9 boys) were monthly assessed for the development of nineteen motor skills between 2008 and 2011. The mean ages when the skills were accomplished were presented using descriptive statistics. Independent T-samples test (significance < 0.05) was used to compare the mean developmental ages from our study with those seen in children with TD (Comparison 1) and also in children with DS reported by four other authors (Comparison 2a-2d).

Results Children with DS developed at a significantly slower pace compared to children with TD (p=0.005). Generally, delay and variance of developmental age in children with DS increased chronologically with the complexity of the skills. No significant difference was found between developmental age in children from the present study and children with DS from other studies.

Conclusion The rate of attainment of motor skills is delayed in children with DS in comparison to children with TD, however, the developmental sequence is the same. The delayed development is more prominent in more complex skills.

Keywords: motor skills, physical therapy, early intervention

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INTRODUCTION

Down syndrome is the most frequent genetic intellectual disability (1). From 2005 until now 878 cases with Down syndrome (DS) have been recorded in the Republic of Kosovo, while approximately 30-35 children with this syndrome are born annually (S. Beqiri, personal communication, 2017). The prevalence of live births of children with DS is 11.2 in 10,000 births in Europe (2), while 9.0 to 11.8 in 10,000 births in 10 regions of the United States (3).

One of the challenges faced by children with DS are the difficulties in motor development. According to some authors, motor development of children with intellectual disabilities, and those with DS in particular, is delayed compared to typically developing (TD) children (4,5). On the other hand, other authors claim that motor development of children with intellectual disabilities differs from that of children without disability, especially applying to children with DS, arguing that their central nervous system has different physical construction due to chromosomal deviations and that they also have a unique learning style (6).

Children with DS have dominance of tracks of primitive muscle response controlled by the spinal cord, compared to tracks of more coordinated movements (7). This happens due to poor myelination of descending brain and stem neurons and a reduced number of connections of neurons in higher nerve centres, such as the motor cortex, basal ganglia, cerebellum, and brain stem. These pathophysiologic processes in the brain change in size at maturity, and disorders in the central nervous system are observed especially after the 6th month of life (8,9).

Characteristic motor disturbances which appear in children with DS and which seem to influence their motor development are reduced postural tone as a typical neuromuscular symptom, inadequate postural control and reactions, insufficient stabilizing myogenic contractions around joints, disturbed proprioception and joint hypermobility (7,10). It is considered that cerebellum hypoplasia is responsible for low muscle tone, problems of trunk control, balance, coordination and speech disorders. Furthermore, commonly accompanying health problems such as heart defect, decreased thyroid gland function, difficulties with vision and hearing, and obesity can impact the motor function of a person with DS (11).

There is a limited number of studies that evaluated the effect of early motor development intervention in children with DS. Gross motor and fine motor skills of children with DS who participated in Early Intervention Programs had shown to improve over time (12). However, interventions in accordance with the principles of Neurodevelopmental Treatment or Vojta (techniques that facilitate movement with the assistance of a therapist using passive handling), or functional skills training, did not show to accelerate development or improve quality of movement, and interventions that aim to stimulate the child's exploration of active motor behaviour was seen as a potential method to positively affect motor development (13,14).

Even fewer studies, such as the one carried out by Malak et al. (15) assessed the effect of physical therapy (PT) on gross motor function in children with DS. They found that standing and walking skills, among other motor skills, were significantly delayed despite PT treatment.

The aim of this study was to prospectively follow children with DS who are treated with PT and identify their age at the time of development of 19 motor skills, and to compare the motor skill developmental age of the same children with DS to that of TD children, and to that of children with DS as reported by four other authors.

EXAMINEES AND METHODS

Examinees and study design

Sixteen children with DS (7 girls and 9 boys) participated in this study. All of them are of Kosovar nationality and registered members of the Down Syndrome Kosova (DSK) organization (a non-governmental organization representing the community of people with DS in the Republic of Kosovo). The participants were receiving PT sessions as part of the Early Intervention and Education (EIE) program offered by the DSK between 2008-2011. Their mean age at the start of treatment was 10.56 months ± 6.28 months. Five of these children presented congenital medical problems: heart disease, umbilical hernia, epigastric hernia, congenital cataract, right hemiparesis, and strabismus.

The permission for the development of this study was granted by the Oversight Board for Professional Ethics of the Ministry of Health in the Republic of Kosovo. An informed consent was obtained from all children's parents/guardians.

Methods

Sixteen (16) children participated in this prospective study. They underwent PT sessions once a week and each session lasted for 45 minutes. Sessions were offered by two physical therapists recruited by the DSK, and were performed only within the premises of this organization in the city of Prishtina. The mean duration of the treatment was 9.5 months.

The approach used focused on strategically teaching the chronologically sequenced motor skills, and targeting the skills of the next higher level. The equipment used were mats, pillows, sofa cushions, a table, an exercise ball, and other items usually found at home. Toys were a very important component and played a crucial role in motivating a child to perform desired moves needed to practice a new skill. The therapists, using holding and moving techniques, guided the child in performing the new skills, while embracing all components needed to learn those particular skills. During the mastering of a new skill, the tendency to use compensatory patterns was avoided. Parents/guardians were present during each session and were instructed to practice the skill/s at home daily, several times a day.

Nineteen motor skills were observed and recorded. The list of observed milestones was derived from already well-established data on motor milestones of TD children (16,17). The description, testing method and performance criteria for all motor skills observed in this study are found in Table 1. During the course of the treatment, each child was assessed once a month for identification of a newly accomplished skill/s. Achievement of milestones did not have to follow an exact sequence. Each of the skills was recorded as accomplished if the child was able to perform it three times. Only those milestones witnessed by the therapists were taken into consideration and the exact age of their accomplishment recorded (skills 0-16). After the children ended the PT program (could walk with support), respective parents/guardians were asked to report the age of achievement of remaining motor milestones (skills 16-19).

The motor milestones were in most cases presented in a successive pattern coinciding with what is generally seen in the literature (18). Sometimes it happens that general sequential presentation is reversed between two or more motor milestones, or already observed milestones might be inhibited later (19). In certain cases, development of a milestone was skipped, or did not occur at all, such as crawling. Hence, the age of achievement of those particular milestones is left blank.

Statistical analysis

Using descriptive statistics, the following was presented for each examined motor skill: number of children for whom the exact age of the skill accomplishment is recorded, range, minimal and maximal values, mean, standard deviation, standard error, variance, skewness, and kurtosis.

In order to compare the means of motor skill developmental age found in children with DS who participated in our study to that of TD children (comparison 1), and also to that of children with DS as reported by four other authors, Cunningham (20) (comparison 2a), Berry, Andrews & Gunn as seen in Sacks & Buckley (5) (comparison 2b), Winders (21) (comparison 2c) and Melyn&White (22) (comparison 2d), an Independent T-samples test was used. Values $p< 0.05$ were considered statistically significant. A Cohen's d, as an effect size measure, was also calculated. For comparison 1, means of 19 motor skills, were used. For comparisons 2a-2d, means of the skills which were commonly assessed in both comparison groups were used: comparison 2a - 8 skills, comparison 2b – 5 skills, comparison 2c – 11 skills, and comparison 2d – 6 skills.

RESULTS

In table 2 descriptive statistics were used to present the participants' mean age (in months) of development of motor skills.

In general, all motor skills were delayed. The delay was more prominent in the development of a fine motor skill 'grasps using thumb and index finger' (18.3 months), and in skills which also incorporate the trunk and lower limb muscles such as ''stands with support'' (16.9 months), ''gets to

Table 1. Testing method and performance criteria of 19 motor skills

	Motor skills	Testing method	Performance criteria
1	Holds head straight without support	Support the child in sitting, holding him/her firmly around his/her chest or shoulders.	Child holds her/his head steady for five seconds, the chin should not bob forward or to the side.
2	Grasps small objects and puts them into mouth	Place a toy or object in a child's hand, wait for him/her to grasp it, and observe. Choose a light, well-balanced object.	The child grasps the toy and brings his/her hand to his/her mouth while still holding the toy.
3	Routinely rolls from stomach to back and back to stomach	Observe the child when he/she is playing on his/her tummy/back, with the toys to the side out of reach.	The child deliberately rolls to his/her back/tummy to reach the toys.
4	Pushes down against a surface when in vertical position	Place the child in standing, supporting him/her around his/her upper trunk.	The child maintains the standing position while taking most of his/her own weight.
5	Sits unsupported	The child is placed in a sitting position. Then he/she is given a toy to play using both hands so that he/she does not use arms for support.	The child sits up straight with the head erect at least for 10 seconds. The child does not use arms or hands to balance body or support position.
6	Grasps objects with one hand and puts into the other	Place a toy (e.g. a rattle) in one hand.	The child transfers a rattle to the other hand.
7	Grasps using thumb and index finger	Place a small object on the table, e.g. a raisin or similar sized-object. Draw the child's attention to it and direct him to 'take'.	The child picks up the object with thumb and fingers in opposition.
8	Stands with support	Place the child standing and holding onto a table or another stable object, with toys to play with.	The child can maintain the position, supporting himself/herself with the hands. The child no longer leans his/her chest or arms on the support.
9	Gets to sitting position from tummy without assistance	Place the child on tummy and encourage him/her to sit up or observe him/her during play.	The child gets from tummy to sitting without assistance.
10	Pulls self-up to standing position at furniture	Place the child in a crawl or sitting position, in front of the table with a toy on it. Show the child the toy and encourage him/her to take it.	The child pulls up to stand by pushing down strongly on his/her arms, at the same time straightening both legs.
11	Crawls	Place the child on tummy or in the crawl position with toys two meters in front.	The child crawls for two meters without stomach touching the supporting surface.
12	Walks holding onto furniture	Place the child so that he/she is standing at a low table. Use toys to encourage him/her to cruise around the table.	The child travels around the table, half-turned in the direction of his/her travel.
13	Stands without support	Stand the child in the middle of the floor, or lean the child against the wall and then gently pull him/her forward away from the wall. Or lean the child forward against a couch and encourage him/her to stand by himself/herself.	The child stands unsupported for 10 seconds.
14	May walk two or three steps without support	Place a child standing against the first support. Put the toys on the other support at a distance two to three steps away. Encourage the child to reach to the second support by walking.	The child can get himself/herself from one support to the next.
15	Walks independently	Place your child standing in the middle of the floor or leaning back against a wall or supported by furniture. Encourage him/her to walk to you.	The child walks alone for four or five steps.
16	May climb stairs	Ask the child to walk up the stairs.	The child steps up one step at a time, holding the rail with one hand, and with the other hand free. He/she may go up two feet to a step.
17	May run gently	Encourage the child to run by either chasing him/her, or getting him/her to chase you or a ball or another child.	The child runs for at least 2 meters; a stiff, upright run on the whole foot, rather than the toes.
18	Climbs onto and down from furniture unsupported	Ask the child to climb up a table, a chair or another piece of furniture.	The child can climb up and down a piece of furniture without assistance.
19	Walks on tiptoes	Ask the child to walk on tiptoes or demonstrate.	The child can walk on tiptoes without his/her heels touching the ground for 3 meters.

Adapted from Pieterse & Treloar (43)

sitting position from tummy without assistance'' (16.8 months), and so on. The skills that developed the slowest were ''pulls himself/herself up to the standing position at furniture'' (21.8

Table 2. Descriptive statistics for developmental age (months) of 19 motor skills in children with Down syndrome (N=16)

	Motor skills	N (16)	Range	Min.	Max.	Mean	Std. err	Std. Deviation	Variance	Skewness	Kurtosis
1	Holds head straight without support	9	7.0	4.0	11.0	6.4	0.8	2.74	7.5	0.6	1.5
2	Grasps small objects and puts them into mouth	8	4.0	4.0	8.0	5.4	0.4	1.5	2.3	0.7	2.0
3	Routinely rolls from stomach to back and back to stomach	13	12.0	5.0	17.0	8.9	0.8	3.0	8.9	1.6	4.1
4	Pushes down against a surface when in vertical position	14	20.0	4.0	24.0	9.0	1.4	5.1	25.8	2.3	5.9
5	Sits unsupported	15	7.0	5.0	12.0	8.2	0.5	2.0	4.0	0.5	0.1
6	Grasps objects with one hand and puts into the other	14	24.0	6.0	30.0	11.9	1.6	6.0	36.0	2.4	6.7
7	Grasps using thumb and index finger	12	24.0	12.0	36.0	18.3	1.9	6.7	45.5	1.7	3.9
8	Stands with support	14	37.0	11.0	48.0	16.9	2.5	9.4	88.7	3.1	10.7
9	Gets to sitting position from tummy without assistance	13	25.0	11.0	36.0	16.8	1.7	6.3	39.3	2.6	8.3
10	Pulls self-up to standing position at furniture	13	39.0	14.0	53.0	21.8	2.9	10.5	110.6	2.5	6.9
11	Crawls (quadruped)	12	16.0	11.0	27.0	18.2	1.4	4.9	24.0	0.4	-0.5
12	Walks holding onto furniture	15	34.0	14.0	48.0	20.8	2.3	9.0	81.7	2.2	5.6
13	Stands without support	14	35.0	13.0	48.0	21.3	2.3	8.6	73.6	2.7	7.9
14	May walk two or three steps without support	12	42.0	18.0	60.0	29.0	3.3	11.5	131.3	1.9	4.8
15	Walks independently	10	44.0	19.0	63.0	32.5	3.9	12.3	152.1	1.7	4.4
16	May climb stairs	9	37.0	19.0	56.0	30.2	4.1	12.2	149.9	1.3	1.3
17	May run gently	8	52.0	20.0	72.0	37.9	5.4	15.3	235.6	1.7	4.2
18	Climbs onto and down from furniture unsupported	10	36.0	17.0	53.0	28.2	3.5	11.0	122.0	1.4	1.9
19	Walks on tiptoes	5	35.0	25.0	60.0	44.2	5.8	12.9	166.2	-0.6	1.0

months), ‘’may walk two or three steps without support’’ (29 months), and ‘’may run gently’’ (37.9 months). On the contrary, the delay in the age of development of the skill ‘’climbs onto and down from furniture unsupported’’ was not that large (28.2 months).

The values of standard deviation (SD) mainly showed an increase with chronological development of skills: they were lowest in skills that developed first, such as ‘’grasps small objects and puts them into mouth’’ (SD=1.5), whereas largest values were seen in the latter skills such as ‘’may run gently’’ (SD=15.3). The range and variance values followed the same trend as SD.

Five different comparisons of means of motor skill developmental age were done. Comparison 1: Children with DS from the present study vs. children with TD (p=0.005, Cohen’s d=1.6). Comparisons 2a-2d: Children with DS from the present study vs. children with DS reported by Cunningham (20) (p=0.86); Berry, Andrews & Gunn as seen in Sacks & Buckley (5) (p=0.72); Winders (21) (p=0.29); Melyn&White (22) (p=0.63). These results show that a statistically significant difference, with a very high Cohen’s d, was found only in Comparison 1 (Table 3).

In table 4, the mean developmental ages of the same motor skills as seen in TD children, and as seen in children with DS were descriptively presented in order to contribute to better interpretation of Table 3.

Table 3. Overview of comparisons of mean motor skill developmental age

	Comparison 1*	Comparison 2a†	Comparison 2b‡	Comparison 2c§	Comparison 2d¶
p	0.005	0.86	0.72	0.29	0.63
Cohen’s d	1.6	0.02	0.23	0.46	0.3

*Children with DS (our study sample) vs. children with TD; †Children with DS (our study sample) vs children with DS according to Cunningham (20); ‡Children with DS (our study sample) vs. children with DS according to Berry, Andrews & Gunn as seen in Sacks & Buckley (5); §Children with DS (our study sample) vs children with DS according to Winders (21); ¶Children with DS (our study sample) vs. children with DS according to Melyn&White (22)

DISCUSSION

In this study children with DS underwent PT sessions once a week and during this period the developmental age of motor skills was recorded. Descriptive statistics were used to present the sequence and age of attainment of 19 observed motor skills. These data were further compared to existing data on motor development in children with TD, and to that of children with DS who participated in four other studies. A significant difference was only found in the first comparison, whereas the developmental age of motor skills of children with DS observed in our study matched quite well with the data on developmental age of motor milestones in the same population reported by other studies.

From the motor development presented in table 4 we understand that the sequence of development of motor skills in this study matches the one observed in TD children. No big difference was seen in the age of attainment of first two motor skills

Table 4. The mean age (in months) of development of motor skills in typically developing children, in our study sample of children with Down syndrome, as well as in four other studies involving children with Down syndrome

	Motor skills	N (16)	Typical development (16,17)	Our study	Cunningham (20)	Berry, Andrews & Gunn as seen in Sacks & Buckley (5)	Winders (21)	Melyn& White (22)
1	Holds head straight without support	12	4.0	6.4	5	-	-	4
2	Grasps small objects and puts them into mouth	12	4.0	5.4	-	-	-	-
3	Routinely rolls from stomach to back and back to stomach	13	6.0	8.9	8.0	6 to 7	6 to 7	6.4
4	Pushes down against a surface when in vertical position	14	6.0	9.0	-	-	-	-
5	Sits unsupported	15	8.0	8.2	9.0	11	11	11.8
6	Grasps objects with one hand and puts into the other	14	9.0	11.9	-	-	-	-
7	Grasps using thumb and index finger	12	9.0	18.3	20.0	-	-	-
8	Stands with support	14	9.0	16.9	-	-	-	-
9	Gets to sitting position from tummy without assistance	13	9.0	16.8	-	-	17	-
10	Pulls self-up to standing position at furniture	13	9.0	21.8	15.0	17	15-17	-
11	Crawls (quadruped)	12	9.0	18.2	-	-	17	12.2
12	Walks holding onto furniture	15	12.0	20.8	-	-	18	-
13	Stands without support	14	12.0	21.3	18.0	21	21	20.9
14	May walk two or three steps without support	12	12.0	29.0	-	24.0	26	-
15	Walks independently	10	18.0	32.5	23	-	26	24.4
16	May climb stairs	9	18.0	30.2	-	-	20	-
17	May run gently	8	18.0	37.9	48	-	-	-
18	Climbs onto and down from furniture unsupported	10	24.0	28.2	-	-	20-22	-
19	Walks on tiptoes	5	24.0	44.2	-	-	-	-

('holds head straight without support', and 'grasps small objects and puts them into mouth') between children from our study and TD children. From the 3rd skill onwards ('routinely rolls from stomach to back and back to stomach') the difference in age increases, with the exception of the 5th skill ('sits unsupported'), where hardly any difference is seen. The skill 'routinely rolls from stomach to back and back to stomach' was achieved at the mean age 8.9 months in the present study (range 5-17 months old), somewhat later than what Cunningham (8 months) (20) and Berry, Andrews & Gun (6-7 months) (5), Winders (6-7 months) (21), and Melyn&White (6.38 months) (22) reported. Palisano et al. (7) predicted the probability for achieving the rolling skill by 6 months of age to be 51%, and by 18 month 74%.

The unsupported sitting was achieved at around 11-15 months of age according to Berry, Andrews & Gun (5), Winders (21), Melyn&White (22), and Vasques (23). However, the participants of our study showed to have achieved the same skill at a mean age of 8.2 months, which is similar to the finding of Cunningham (20) that children with DS sit unsupported at the mean age of 9 months.

When compared to children with TD, a more pronounced difference is found in the 7th skill ("grasps using thumb and index finger"), where mean age of its achievement in children with DS is 18 months, whereas in TD children it is 9 months. When compared to other studies involving children with DS, according to Cunningham (20), the same skill was attained at a mean age of 20 months, similar to what was noted in this study.

The mean developmental age of the 13th skill ("stands without support"), which is one of the most reported milestones, was achieved by the participants of this study at a mean age of 22.3 months. This corresponds to the mean developmental age for the same skill reported in several other studies: 21 months (5,21), 21.2 months (20), and 18.97-22.17 months (22). The maximal age for the unsupported standing seen in this study is 48 months, which coincides with the estimated probability of Palisano et al. (4) according to whom all children with DS are expected to achieve this skill by 48 months of age.

In comparison to TD children, the trend of increasing difference is seen in all skills, particularly in the 14th and 17th ("may walk two or three steps without support" and "may run gently"). The age of attaining these two skills is more than twofold in children with DS compared to those with TD. The 15th skill ("walks independently") was attained at the mean age of 32.5 months in this study. When other studies involving children with DS were consulted, a variability in the mean age of attainment of the same skill was found. It appeared to had been acquired sooner according to a few authors, such as at 26 months (5) and 22.72-26.09 months

(22). However, our mean age for the walking skill compares favourably with the mean age reported by Vasques (23), which is 30.2 months and Hall B (24), who stated that the debut of walking usually occurred at the age of 30 months. Similarly, according to Palisano et al. (4) the estimated probability of walking by 30 months is 74%, while by 36 months 92%. Also, Centerwall (25) and Carr (26) reported that 78-80 % of children with DS were able to walk by the age of 36 months. According to Malak et al. (15), only 10% of children with DS under three years of age walked at expected age, while 95% of those 3-6 years old.

The data for the last skill ('walks on tiptoes') was reported for only 5 children in the present study, and the difference in age is almost doubled compared to children with TD (TD-24 months, DS-44.2 months). On the other hand, the difference in the mean age of attainment of the 18th skill ("climbs onto and down from furniture unsupported") is only 4 months of age (TD-24 months, DS-28.2 months). The probable reason for expressed and increased difference in age of attainment of motor skills after the 6th month of life are the pathophysiological processes in cerebrum, change in its size, and disorders in central nervous system maturation, observed in children with DS notably after the 6th month of life (9). The slower motor development of children with DS seen in this study coincides with the existing data on delayed motor and postural control development in this population (4, 27-29). However, it is still ambiguous whether the motor development is just delayed or if it is a result of differently constructed central nervous system and unique learning style (5,10).

High values of standard deviation (DS) indicate a large variability within the sample, showing that 16 children developed same skills at quite different ages. Standard error (SE) values are high as well, meaning that mean ages of the development of skills in this sample cannot be very representative for the whole community of children with DS. The difference in mean age of skill attainment between the observed sample and reference values for TD children increases with the complexity of the skill. The values of SD and SE follow the similar trend, letting us understand that the more complex the skill, the larger the variability in age of its development in children with DS. The lowest values of SD and SE were found in the 2nd skill ('grasps small objects and puts them into mouth'), 1.5 and 0.4, respectively, whereas the largest range value, 52, was seen in the 17th skill ('may run gently').

Consistent with the findings of this study, a large variability in the age of the development of motor skills in children with DS is also reported by other authors (5, 20-22). When comparing the results of these authors with each other, we note that according to Melyn&White (22) and Winders (21) motor skills were acquired earlier than what is seen in the studies of Cunningham (20), and Berry, Andrews & Gun (5).

As expected, in this study we found a statistically significant difference ($p=0.005$) with a very high Cohen's d (1.6) between the developmental age of motor skills between the study sample of children with DS and the reference developmental age of the same skills in children with TD. This finding agrees with the previous studies that claim that motor development in children with DS is delayed compared to children with TD (4,5). Children with DS often present with health problems (30). Participants included in the present study had noticeable health difficulties. Ill health negatively impacts motor performance in TD population (31-33), and it is expected that the same applies to persons with DS. The slower motor development seen in the participants of our study was probably affected by the above mentioned health implications.

Our results also show that children with DS who participated in this study presented with a motor developmental sequence, which did not differ from that of children with TD, supporting the stands of Cunningham (20) and Winders (21), while contrasting the stands of Haley (32) who claims the opposite.

Another important finding was a lack of statistically significant difference between the results from our study in comparison to the results of four authors described in the statistical analysis section, which possibly tells us that children with DS from our study, who were treated with PT as part of early intervention program, did not physically develop differently from what is generally reported for the same population. Differently from the children in our study who were being treated with PT, some of the studies which our results were compared to (5,22) were carried out before the spread of early intervention programs, whereas others did not provide any information regarding whether their par-

ticipants took part in early intervention programs. Perhaps PT, being widely offered within the framework of early information programs, does not affect sooner development of motor milestones in children with DS as commonly assumed. The role of PT might instead be a promotion of more efficient motor skills and reduction or avoidance of compensatory movements, which might lead to orthopaedic problems if left untreated (35). This issue has not been discussed in the present study, but should be explored in the future knowing from current studies that impaired posture and walking can lead to changes in step characteristics in adolescence and adulthood such as slower walking, wider strides, longer stance and double support (36,37), greater lower limb muscles' co-contraction during swing phase of gait (38), and lesser stability (39). Accordingly, it has been suggested that physical therapists continue to address impairments in children with DS enhancing their participation in sport and leisure activities with their peers by focusing on coordination and balance problems, and strengthening of the trunk and the legs (40).

The mean age of participants in our study at the time of dismissal from PT was 20.5 months, whereas according to Winders (41), PT should follow the child's development until the age of six. This stand is very much acceptable having in mind that more complex skills, as seen in this study, develop notably later in comparison to TD children. This is especially evident for the skills requiring body vertical position. Consistent with our results, the study of Pereira (42) showed that only 40% of children with DS managed to pull themselves to stand with support by 12 months of age. In our study this skill was achieved at a mean age of 21 months. In addition, as previously mentioned, the study of Malak (15) showed that walking was achieved by 95% of children with DS only at the age of six. In compliance with the aforementioned author, our results show that maximal age at which the 15th skill ('Walks independently') was developed was 63 months or slightly more than 5 years. Also, the maximal age for the 17th skill ('May run gently') was 72 months or 6 years. Seeing the large variability and delay in the development of motor skills in children with DS, which is especially emphasized in subjects dealing with accompanying health problems, in order for PT to have greater impact, we believe the treatment should last until a toddler with DS achieves all motor skills needed for efficient motor function, including those developing after independent walking, such as running and using stairs independently.

Limitations of this study are a relatively small sample size of participants and a short duration of PT treatment (9.5 months). There was also a variability in the age of start of the treatment (4-29 months). Input from parents regarding the amount of time weekly dedicated to the application of home exercises prescribed by physical therapists was not taken into consideration. For future studies, we recommend that the possible effect of PT on acceleration of mastering of motor skills should be more thoroughly investigated in a larger sample size and randomly assigned participants into the treated and untreated groups who do not have accompanying health problems. Also, standardized tests, validated for children with DS should be used. We consider that active involvement of parents in carrying out stimulating daily exercises as instructed by a physical therapist is mandatory and a key factor in optimizing motor function and efficiency in children with DS. The effect of parent engagement should be comprehensively examined in future studies, together with effects of PT on efficiency of motor skills and prevalence of compensatory movements in this population.

This longitudinal study showed a significantly delayed development of 19 motor skills in children with DS when compared to the reference developmental age for the same skills in children with TD. As much as this was expected, it was interesting to find that, despite the treatment with PT, no significant discrepancy was found between the motor developmental age of our study sample and other four studies involving children with DS. A large variability in the age of attainment of the skills was observed, which increased chronologically with the complexity of the skill.

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