Original Clinical Article

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Motor abilities in 182 children treated for idiopathic clubfoot: a comparison between the traditional and the Ponseti method and controls

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Abstract

Purpose The aim of the study was to examine motor abilities in children treated for idiopathic clubfoot with either the traditional extensive surgery method or the Ponseti method, and compare their motor skills with a control group without clubfoot.

Methods A total of 89 children treated according to the traditional method (mean age 9.0 years, 7 to 10) and 93 treated ad modum Ponseti (mean age 8.8 years, 7 to 10) were recruited from a multicentre clinical study in Norway. A total of 45 age-matched children without clubfoot were recruited from a nearby school. They were all assessed with the Movement Assessment Battery for Children – Second Edition (MABC-2), which evaluates motor performance. We applied Analysis of Covariance for comparison of the two treatment methods and adjusted for gender, laterality, comorbidity, achillotomy or more extended surgery, physiotherapy and the age when the child walked independently.

Results We found no significant difference in any of the various components or the total score of the MABC-2 between patients treated with the two different methods. In all, 76% of the children treated according to the traditional method and ad modum Ponseti, and 96% in the control group, respectively, were classified as having normal motor abilities.

Conclusion About three-quarters of children aged nine years and treated for idiopathic clubfoot had normal motor abilities. We found similar results in patients treated with the traditional method and the Ponseti method.

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Keywords: clubfeet; Ponseti; Movement Assessment Battery for Children; motor abilities; controlled study

Introduction

Congenital talipes equino varus, also known as congenital idiopathic clubfoot, is one of the most common birth defects involving the musculoskeletal system.[1] The severity of the condition varies from the most rigid cases to milder forms. The aetiology is unknown but is believed to be multifactorial. Some researchers have reported signs of a general deficit in motor skills in patients with idiopathic clubfoot,[2] others have found that children with clubfoot cope relatively well with physical activity[3] and some researchers have found inferiority in gait.[4] Only a few studies reveal motor skills or functional results in the age group five to 11 years[2,4-6] and very few have looked into motor skills also involving upper extremities in the same age group.[2,4] To our knowledge only one study has specifically looked into motor abilities in clubfoot patients treated ad modum Ponseti in the same age group as the present study.[6]

Clubfoot can be managed by conservative treatment or surgery. Conservative treatment commonly includes stretching and serial casting for a few weeks followed by bracing ad modum Ponseti.[7] In most cases the Ponseti method also includes an achillotomy when the child is a few months old.[7] The Ponseti method has been widely used for decades and has been reported to reduce the need for major foot surgery.[8,9] The traditional method includes posteromedial or posterior release as the primary surgical intervention.[10] No randomized clinical trial has compared results with the Ponseti method against the traditional method, and only few non-randomized studies have compared the two methods.[11] Only a few small studies have evaluated motor ability or skills, which is considered to be an important outcome measure in the growing child.[2]

The aim of the present study is to evaluate motor abilities among children with clubfoot according to a standardized test: the Movement Assessment Battery for Children – Second Edition (MABC-2).[12] The primary objectives are to compare motor ability in patients treated with the Ponseti method and the traditional method. The secondary objectives are to compare the patients' motor abilities with children without clubfoot and to evaluate static and dynamic balance in patients with unilateral *versus* bilateral involvement.

Patients and methods

Study design and ethics

This was a retrospective cross-sectional cohort study that included children with clubfoot treated with two different methods and age-matched children without clubfoot.

The study was approved by the Regional Committee for Medical and Health Research Ethics of Western-Norway (REK Vest), 2010/1882.

Participants

In all, 56 girls and 126 boys with clubfoot and 45 age-matched children without clubfoot participated. All patients had idiopathic congenital clubfoot and had been treated according to the traditional method (n = 89, mean age 9.0, 7 to 10) or the Ponseti method (n = 93, mean age 8.8, 7 to 10) (Table 1). The patients were examined in 2010 and 2014, respectively, and they could therefore be compared according to age.

Table 1 Patient demographics

	Traditional (n = 89)	Ponseti (n = 93)
Age (yrs), mean (range)	8.9 (7-10)	8.7 (7-10)
Gender (boys), n (%)	60 (67)	66 (72)
Height (cm), mean (SD)	137.9 (6.8)	137.0 (7.7)
Weight (kg), mean (SD)	34.8 (7.8)	33.0 (6.9)
Laterality, n (%)*		
Right	29 (31)	39 (42)
Left	17 (18)	21 (22)
Bilaterally	44 (49)	33 (36)
Comorbidity (yes), n (%)*	20 (23)	8 (9)
Physiotherapy at hospital (yes), n (%)*	42 (47)	68(74)
Physiotherapy at municipality (yes), n (%)	61 (69)	522 (57)
Physiotherapy in kindergarten (yes), n (%)	34 (38)	37 (40)
Walks independently, mean (SD)	14.7 (3.3)	14.1 (2.8)
Organized sports (yes), n (%)	72 (81)	78 (85)
Stretching		
Daily first year, median (range)	3 (1-9)	3 (0-4)
Total years, mean (SD)	5.7 (2.6)	5.6 (2.4)
Heart failure	2	0
Asthma	7	1
Serious infections disease	1	1
Leg fracture	1	1
Congenial hips dysplasia	3	0
Comorbidity	8.0	5.0

*the number with bilateral involvement (p = 0.04) and comorbidity (p = 0.01) was higher in the traditional group and the number given physiotherapy at the hospital was higher in the Ponseti group (p < 0.01)

Between 2002 and 2003, most hospitals in Norway introduced the Ponseti method for treating clubfoot. The children were recruited from a multicentre clinical study, The Norwegian Clubfoot Study, conducted at four hospitals (Bergen, Trondheim, Stavanger and Oslo).[13] None of the hospitals treated more than ten newborns with clubfoot yearly.

A total of 45 children without clubfoot, 22 boys and 23 girls (mean age 8.7, 7 to 9), were recruited from a school near Oslo University Hospital and included as a control group.[14]

Interventions

Patients treated with the traditional extensive surgery method had posterior or posteromedial release and an Achilles tendon lengthening.[10] The Ponseti method included serial manipulations and castings beginning a few days after birth. Percutaneous tenotomy of the Achilles tendon was performed in most cases at the age of two to four months followed by two weeks casting. A foot abduction brace was applied thereafter and bracing was continued for four to five years. Long-term bracing is a mandatory and important part of the Ponseti programme.[7]

Demographics and outcome measures

Demographic characteristics included variables such as age, gender, age when walking independently, laterality (unilateral/ bilateral), whether major surgery was conducted, comorbidity and physiotherapy at the hospital (Table 1). Comorbidity indicates that the child has or had another disease that may influence motor ability, for example, previous leg fracture or infection after surgery, asthma or heart failure.

The MABC-2[12] is a revision of the Movement ABC[15] and is one of the most widely used assessment tools in the field of Development Coordination Disorder.

A recent methodological study, assessing the intra- and intertester reliability of the MABC-2 in a healthy population, suggested that the MABC-2 might be more suitable for diagnostic or clinical decision-making purposes, than for evaluation of change over time.[14]

MABC-2 evaluates motor performance according to hand function, ball skills and balance (static and dynamic). The revised version makes it possible to identify and describe impairments in motor performance of children at the age of three to 16 years (divided into three age bands, 1: three to six years; 2: seven to ten years; and 3: 11 to 16 years). Scores can be used to identify children who are significantly behind their peers in motor development.[12] The validity of the MABC-2 for the study group

JOURNAL OF CHILDREN'S ORTHOPAEDICS

can be questioned but motor performance is an important domain for seven- to ten-year-old children and the total score has to be included for comparison with other groups of children, while dynamic and static balance is of particular interest for children with clubfoot. In order to test our hypotheses and compare results with children without motor abilities we applied the complete MABC-2 battery and specific scores to each domain including hand function and ball skills along with static and dynamic balance, particularly involving the lower limbs, along with the total scores.

There are eight items which are specific within each age band. For children aged seven to ten years these are: hand function or manual dexterity (placing pegs, threading lace and drawing trail), ball skills or aiming and catching (catching with two hands and throwing beanbags onto mats) and static and dynamic balance (one-board balance, walking heel- to- toe forwards and hopping on mats). It takes about 20 to 30 minutes to complete the test.

Age-adjusted standard scores and percentiles are provided for the three components of the battery and for the total score. The best score was used for data analysis when there were items with more than one test trial. Because two of the items, 'placing pegs' and 'one-board balance' involved testing of both preferred and non-preferred limbs, 11 raw item scores were obtained from a total of eight MABC-2 tasks.

On the basis of the raw scores, standard item scores, component standard scores, total test scores (TTS) and total standard scores (TSS) were calculated. In addition, the TSS was classified into: red zone (≤ fifth percentile): TTS ≤ 56 points; yellow zone (fifth and the 15th percentile): TTS 57-67; green zone (> 15th percentile) TTS > 67 points.[16] Based on this, each child was categorized into one of three movement categories: green zone, no movement problems detected; yellow zone, potential motor problems; and red zone, impaired motor problems.

Procedure

Children were individually assessed with the MABC-2 in a suitable room. One physiotherapist (VSA) with more than 30 years of clinical experience examined all the children. The examiner was not blinded to the treatment given (Ponseti or traditional), but blinded to foot mobility because the patients wore shoes and the range of movement of the feet was not assessed.

Statistical analysis

Mean (sd), median (range), mean difference (95% confidence interval (CI)) or numbers (percentages) are given. We compared single item MABC-2 scores in children treated by the traditional method and the Ponseti method and for all children who had major surgery *versus* those who did not have major surgery, applying independent *t*-tests. Analysis of covariance (ANCOVA) was used as the primary analysis to compare scores in children treated by the traditional method and the Ponseti method. We adjusted for age, gender, age of walking independently, laterality (unilateral/ bilateral), major surgery, comorbidity, stretching, physiotherapy at the hospital, organized sport and major surgery. Similar adjustment was applied for evaluation of static and dynamic balance in patients with unilateral or bilateral involvement. Scores in the two-intervention group and the control group were compared using ANCOVA and Tukey's *post hoc* test. We analyzed the number (percentages) of children in the three groups categorized as having normal motor function (green zone), clumsiness (yellow zone) or having motor problems (red zone) with the chi-squared test.

Results

Patient characteristics are described in Table 1. The number of patients with bilateral involvement and comorbidity was higher in the traditional group, while the number of physiotherapy receivers at hospital was higher in the Ponseti group (Table 1). The type of surgery performed is described in Table 2. More patients in the traditional group had major surgery ($p < 0.001$) and they were older at first surgery ($p < 0.001$). We found no significant difference in any of the MABC-2 scores comparing children with or without major surgery. The mean difference for balance standard score was -0.4 (95% CI -1.5 to 0.8, $p = 0.53$) and the mean difference for total standard score was -0.2 (-1.1 to 0.8, $p = 0.74$). The single items of the MABC-2 were not significantly different (Table 3). There was no difference between treatment groups in adjusted results in

Table 2 Surgery in the two groups. Values are numbers (percentages) unless stated otherwise

	Traditional (n = 89)	Ponseti (n = 93)
First operation, type		
None	10 (11)	14 (15)
Achillotomy*	12 (13)	79 (84)
Neonatal bilateral tendinotomy	6 (7)	0
Achilles tendon lengthening	8 (9)	0
Posterior release	30 (34)	1 (1)
Posteromedial release	18 (20)	0
Tibialis anterior transposition	2 (2)	0
Other open tendon operation	3 (3)	0
Later operations		
More than one operation	45 (51)	37 (39)
Number of total major operations*	38 (43)	11 (12)
	17 (19)	1 (1)
Mean age in months (sd) at first operation*	8.3 (15.3)	2.2 (0.7)

*the number who had achillotomy was higher in the Ponseti group and the number of major operations and age was higher in the traditional group ($p < 0.001$).

Table 3 Movement Assessment Battery for Children – Second Edition standard scores for single items in the traditional method and Ponseti method. Values are mean unadjusted scores (sd) in each group and mean unadjusted difference (95% confidence interval (CI)) between treatment groups. Independent t-tests were used to compare groups

	Traditional (n = 89)	Ponseti (n = 93)	Difference	95% CI	p-value
Hand					
Placing pegs	9.0 (2.7)	8.7 (2.6)	0.2	(-0.5 to 0.4)	0.54
Treading lace	8.7 (2.7)	8.9 (2.5)	0.2	(-1.0 to 0.5)	0.59
Drawing trail	8,3 (3.2)	8.3 (3.4)	0.03	(-0.9 to 1.0)	0.95
Ball					
Catching with two hands	9,6 (2.8)	9.6 (2.4)	0.1	(-0.8 to 0.7)	0.86
Throwing bean bag onto mat	10.2 (2.7)	10.2 (3.1)	0.0	(-0.8 to 0.8)	0.99
Static balance					
One-board balance	10.2 (3.4)	10.1 (2.8)	0.03	(-0.9 to 0.9)	0.95
Dynamic balance					
Walking heel-to-toe forwards	8.5 (3.8)	8.3 (3.7)	0.2	(-0.9 to 1.3)	0.72
Hopping on mats	8.6 (3.5)	9.2 (3.1)	0.6	(-1.6 to 0.4)	0.23

Table 4 Movement Assessment Battery for Children – Second Edition (MABC-2) scores in the traditional method and Ponseti method (n = 182) and controls (n = 45). Values are mean unadjusted scores (SD) in each group and mean adjusted* difference (95% confidence interval (CI)) between treatment groups. ANCOVA was used to compare groups

	Control (n = 45)**	Traditional (n = 89)	Ponseti (n = 93)	Adjusted difference	95% CI	p-value
Hand						
Standard score	10.0 (2.4)	8.7 (2.9)	8.7 (2.8)	0.2	(-0.7 to 1.2)	0.63
Percentile	51.0 (25.6)	38.6 (27.5)	37.5 (27.2)	2.9	(-6.6 to 12.4)	0.55
Ball						
Standard score	11.7 (2.3)	10.4 (3.0)	10.4 (2.9)	0.6	(-0.4 to 1.6)	0.26
Percentile	67.6 (23.0)	52.2 (27.1)	52.6 (26.7)	6.0	(-3.4 to 15.0)	0.21
Balance						
Standard score	12.5 (2.6)	9.1 (3.9)	9.1 (3.5)	0.3	(-1.0 to 1.6)	0.62
Percentile	75.3 (25.0)	44.4 (33.5)	42.7 (31.6)	4.5	(-7.0 to 16.0)	0.44
Total						
Test score	85.0 (9.9)	73.0 (16.5)	73.2 (15.1)	1.5	(-3.8 to 6.8)	0.58
Standard score	11.5 (2.4)	9.0 (3.3)	9.0 (3.1)	0.5	(-0.6 to 1.6)	0.42
Percentile	66.6 (23.4)	42.5 (30.5)	41.3 (29.4)	6.1	(-4.3 to 16.6)	0.25

*adjusted for age, gender, laterality (unilaterally/bilaterally), major surgery ($p > 0.3$), co-morbidity ($p < 0.05$), physiotherapy at hospital and age of walking independently ($p < 0.05$ except for the ball category). P-values describes that co-morbidity and the age of walking independently (except for the ball category) were significantly associated with MABC-2 scores, but not treatment method and major surgery

**hand and ball scores ($p < 0.05$) balance and total scores ($p < 0.001$) different from both treatment groups ($p < 0.05$)

any of the MABC-2 categories or in the total score (Table 4). The control group had significantly better scores in all tests and the difference was largest for balance ($p < 0.001$) (Table 4 and Fig. 1). We found no significant ($p = 0.39$) difference in static and dynamic balance between the traditional and the Ponseti group (Table 4 and Fig. 1). In total, 71 (76%) patients in the Ponseti group and 68 patients in the traditional group (76%) had normal function (green zone) compared with 43 (96%) children in the control group (Table 5 and Fig.2). We found no significant ($p = 0.56$) difference in balance between patients with unilateral or bilateral involvement (Table 6). Of the adjusted variables, comorbidity (p-values from 0.001 to 0.039 for the different MABC-2 categories) and age when walking independently (p-values from 0.002 to 0.049 for the different MABC-2 categories except for the ball category) were significantly associated with results.

Discussion

We found that about three-quarters of children treated for idiopathic clubfoot had normal motor abilities at the age of nine years. Assessed with MABC-2 they had poorer mean motor abilities than children without clubfoot. The difference was largest for static and dynamic balance. By comparing the Ponseti method and traditional method we found no significant differences in any of the items or total scores. Findings in the present study comparing children with and without clubfoot are in agreement with results from most of the previously published smaller studies.[2]

The lack of difference between interventions at the age of nine years and the observation that three-quarters of the children had normal motor abilities, suggest that other factors play a role. Nevertheless, we were surprised that the Ponseti group, in which few children had no major surgery, did not have superior static and dynamic balance. The impact of treatment method and extended surgery may have larger impact on other outcomes and at an older age. Preferably long-term follow-up should be conducted both at adolescence and at adult age. In the adjusted analysis comorbidity and age when walking was significantly associated with almost all MABC-2 categories. Because numbers are small, this association should be interpreted with caution. However, in a recent study

JOURNAL OF CHILDREN'S ORTHOPAEDICS

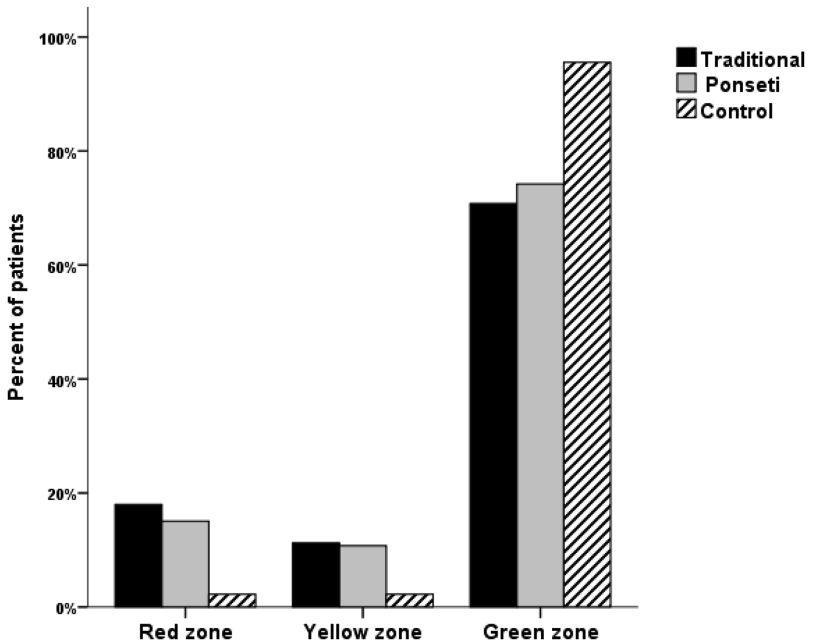

Fig. 1 Performance on the M-ABC-2, subtest Balance, for the Ponseti method (n = 93), traditional method (n = 89) and controls (n = 45).

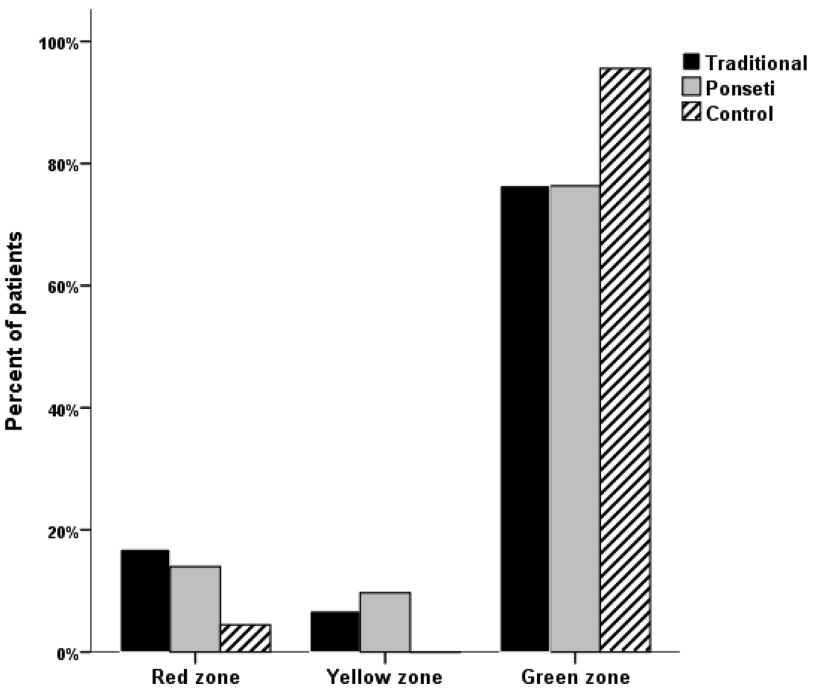

Fig. 2 Performance on the M-ABC-2, total test, for the Ponseti method (n = 93), traditional method (n = 89) and controls (n = 45).

Table 5 Categorization according to motor function

	Normal motor function (green zone)	Clumsiness (yellow zone)	Motor problem (red zone)
Traditional (n = 89), n (%)	68 (76.9)	6 (6.7)	15 (16.9)
Ponseti (n = 93), n (%)	71 (76.3)	9 (9.7)	13 (14)
Children without club foot (n = 45), n (%)	43 (96)	0 (0)	2 (4)

Table 6 Mean unadjusted scores (SD) and adjusted differences (95% confidence interval) in balance between children with unilateral and bilateral clubfoot. ANCOVA was used to compare groups

	Unilateral (n = 105)	Bilateral (n = 77)	Difference*	p-value
Standard score	9.5 (3.4)	8.6 (4.0)	0.4 (-0.7 to 1.5)	0.45
Percentile	46.2 (31.4)	39.9 (33.7)	2.9 (-7.0 to 12.8)	0.56

*adjusted for age, gender, treatment method, comorbidity (p = 0.01), major surgery, physiotherapy at the hospital and age of walking independently (p = 0.03). P-values describes that comorbidity and the age of walking independently were significantly associated with balance independent of unilateral or bilateral involvement

including patients with another type of deformity, idiopathic scoliosis, comorbidity was associated with reduced health-related quality of life.[17] Limitations of the present study include the retrospective and non-randomized design and the use of a limited number of outcomes.

The strengths of the present study are the relatively large number of patients and the fact that few patients were lost to follow-up. All the children were aged between seven and ten years, and were tested by one experienced paediatric physical therapist (VSA) according to the same age-band of the MABC-2. The examiner was blinded to the children's foot status including joint mobility, muscle function and movement quality and the treatment and clinical history of the patients.

The present study population was also included in the Norwegian multicentre study by Sætersdal et al,[6] who assessed other outcomes and additional patients. They found that the traditional group had a statistically significant, but small reduction in range of movement. In addition, the parents of the children in the traditional group were less satisfied with outcome. We consider the difference in outcomes as interesting. Future studies should assess the long-term results and the association between outcomes. Different outcomes may be considered important for the child and its parents, the physiotherapist and the orthopaedic surgeon, respectively.

The introduction of the Ponseti method in Norway late in 2002 represents a major shift from extensive surgery to more conservative treatment. We had expected a difference in motor ability between the two interventions at the mean age of nine years, assuming that stiffer feet in children treated with the traditional method would play a role. Apparently, this did not influence the motor ability evaluated in this relatively large sample of children at the age of nine years but may have detrimental influence at an older age. Studies on motor abilities and athletic performance in children treated for idiopathic congenital clubfoot are rare and small. Andriesse et al[2] included 20 children with clubfoot assessed with MABC. They found a difference in motor abilities, such as jumping, ball skills and one leg stand compared with normal values. Their findings are in line with the present study and support the conclusion that children with clubfoot should have more thorough neuromotor assessment.

Kenmoku et al[3] reported that the athletic performance of primary school children with clubfoot was excellent with 96.6% performing above 2 sd of the average school child. Their conclusion was that children with satisfactory treated clubfoot did not have impaired athletic performance. However, analysis of the Z-scores for each event showed that clubfoot patients tended to perform well doing repetition side steps and relatively poorly at running and standing long jump. Despite reporting excellent performance, they found that children with clubfoot had problems transmitting power to the ground efficiently while moving straight ahead, because the pressure did not pass the great toe in the toe-off phase. When moving laterally they apparently transmit the power to the ground which might correlate with adduction of the forefoot.

Two small studies and a larger study suggest that physical performance in children with clubfoot is slightly decreased.[5,18,19] The present study suggests various factors play a role in these children's motor skills. The static balance item as one leg stand is a test for postural control incorporating both motor control and sensory and cognitive processes. The lack of difference between treatment groups may suggest that children with more stiffness in their ankle may compensate by e.g. flexing the hips or stretching the knees to obtain the balance.

Karol et al[4] included 81 children with idiopathic clubfoot (29 treated with the Ponseti method, 23 with the French Physical Therapy method and 29 with surgical intervention before five years of age) in a non-randomized study. Participants were tested by both gait analyses and with the Peabody Developmental Motor Scale test. They found that the children treated non-operatively showed better function at five years of age. The Peabody Scale like the MABC-2 test does not comprise skills only for the lower limbs.

We reported that almost all the children participated in sports like football, handball, skiing and dancing. Unfortunately, we did not ask how frequently they performed the sport. Future studies should assess the frequency of participation in physical activities and sports and look at how this correlates with motor performance.

From a physiotherapeutic point of view, it would be preferable to test all children with clubfoot in kindergarten and at early school age in order to provide better motor training in those with motor problems or clumsiness. In kindergarten it is important to focus on activities that stimulate static and dynamic balance. The practice and experience of sports and daily activities is necessary to develop motor skill competence and social interactions required for well-being.[20]

Conclusion

We found that about three-quarters of children treated for idiopathic clubfoot had normal motor abilities at nine years of age. Comparable results were found in patients treated according to the traditional method and ad modus Ponseti method. We suggest that motor abilities should be assessed early to improve possible motor impairment in children with idiopathic clubfoot.

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COMPLIANCE WITH ETHICAL STANDARDS

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OA LICENCE TEXT

ETHICAL STATEMENT

Ethical approval: The study was approved by the Regional Committee for Medical and Health Research Ethics of Western-Norway (REK Vest), 2010/1882.
Informed consent: Written informed consent was obtained from the parents of all participants.

ICMJE CONFLICT OF INTEREST STATEMENT

None declared.

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