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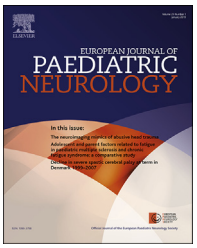

Original article

Obstetric brachial plexus palsy – A prospective, population-based study of incidence, recovery and long-term residual impairment at 10 to 12 years of age

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ABSTRACT

Aim: To assess the long-term outcome and evaluate prognostic factors in obstetric brachial plexus palsy (OBPP).
Methods: Of all 114 children with OBPP born in western Sweden in 1999–2001, 98 (61 males, 37 females) were invited to participate. A questionnaire on the symptoms of the OBPP was sent out and those with persisting symptoms were examined in terms of muscle strength, range of motion (ROM), activities of daily living (ADL), pain and sensibility at the age of 10–12 years. Contact was made by 87 children.
Results: The incidence of persisting OBPP at 10–12 years of age was calculated as 19 per 38,749 live births or 0.49 per 1000. Symptoms were reduced muscle strength and ROM in the arm. Eight children reported pain, four had impaired sensibility and ten children described some difficulties in ADL. Muscle strength in forearm supination, shoulder external rotation and elbow flexion at three months of age can be used to predict outcome.
Interpretation: Most children with an OBPP recover completely, but one in five has symptoms of the injury at 10–12 years of age. Muscle strength in the arm at three months of age can be used to predict outcome.

1. Introduction

Obstetric brachial plexus palsy (OBPP) is defined as a flaccid paresis of the arm at birth with a larger passive than active range of motion (ROM). OBPP is the consequence of a complicated delivery and is caused by injury to the nerves from the fifth cervical root (C5) to the first thoracic root (Th1). The incidence of OBPP has been reported to be between 0.42 and 5.1 per 1000 live births.[1–3] In a study of OBPP in western

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Sweden, the incidence was reported to be 2.9 per 1000 live births and the prevalence of persisting OBPP at 18 months was 0.46 per 1000.[3] The prognosis for OBPP varies; some recover completely and others suffer permanent disability of varying severity.[2–5] It has been suggested that active elbow flexion, shoulder external rotation and forearm supination at three months can be used to predict outcome.[3] A high level of dissatisfaction has been reported among the parents of children with OBPP, particularly with respect to receiving inaccurate and misleading information from health-care professionals regarding the prognosis.[6]

A study of children with OBPP from the Netherlands[5] reported that more than 45% had pain in the affected arm.[5] In a Finnish study of children with OBPP,[7] who had undergone nerve reconstruction, it was found that one third of the children needed help with everyday activities such as washing, dressing and cutting up food and many of the children had pain in the affected arm.[7] In a Swedish follow-up study of children with OBPP,[8] it was found that grip strength in the affected hand was almost unchanged over time, in contrast to the ROM of the elbow which increased over time. Sheffler et al.[9] reported that 48% of children with OBPP had an elbow flexion contracture. Muscular imbalance in the shoulder may increase with age and may result in glenohumeral joint deformity.[10] Pain, impaired sensibility and arthritis that may affect activities of daily living (ADL) are described in adults with OBPP.[11] Pondaag et al.[12] emphasised the importance of following children with OBPP because only long-term follow up will answer questions about the proportion of these children who will suffer from functional impairment, secondary joint deformities, increased fatigability or pain.

Treatment options for children with OBPP are physiotherapy, occupational therapy, nerve reconstruction and orthopaedic surgery.[1,13] The aims of treatment are to prevent contractures and reduce muscle imbalance and joint deformities.[1] In Sweden, children with permanent OBPP are offered contact with a physiotherapist at a habilitation centre. In the health-care programme, it is recommended that the children should have contact with a physiotherapist, but the extent of the contact is not regulated.

The aim of this study was to assess the long-term outcome and evaluate prognostic factors in obstetric brachial plexus palsy.

2. Method

2.1. *Participants*

In a multicentre study in Sweden from November 1999 to November 2001,[14] all deliveries at the seven obstetric units in the health-care region of western Sweden were recorded. The purpose was to determine the incidence, risk factors at delivery, recovery rate and residual impairments of OBPP.[3,14] Of all deliveries (n = 38,749), 114 children had an OBPP. Ninety-eight of these children were regularly followed by a physiotherapist until 18 months of age in terms of muscle strength, ROM, hand preference and functional ability.[3]

All these 98 children[3] were invited to participate in this study at the age of 10–12 years. At the examination at 18 months of age, eighteen of the 98 children had residual symptoms and 80 were considered to have recovered (Fig. 1).

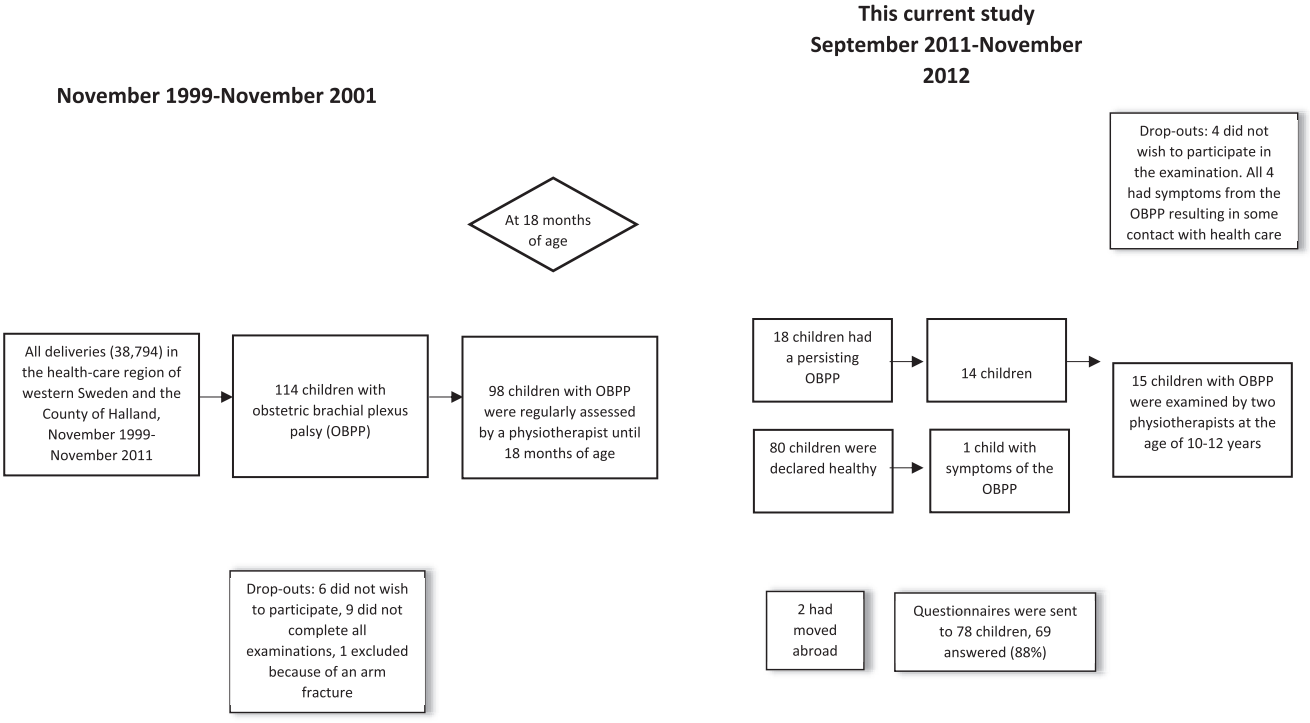

Fig. 1 – Original study "Obstetric brachial plexus palsy; a prospective population-based study of incidence, recovery and residual impairment at 18 months of age".[3]

The 18 children who, at 18 months of age, still had symptoms of the OBPP were invited to participate in a physiotherapy assessment of muscle strength, ROM, activities of daily living (ADL), pain, sensibility and hand preference. A questionnaire was sent to the parents of the remaining 80 children with a previous OBPP. The questionnaire included questions about the previously affected arm in terms of symptoms, differences between the arms and contact with health care. If the answers suggested that the child had symptoms, the child was invited to a physiotherapy assessment together with the children with persisting OBPP. Thirteen examinations were performed at the physiotherapy department at the Queen Silvia Children's Hospital in Gothenburg, Sweden, while one examination was performed at the habilitation centre in Varberg and one at a school in Kalmar. Each examination lasted 2 h. The first examination took place in September 2011 and the last in November 2012. All examinations were performed by two physiotherapists (AJ, A-LL).

2.2. *Measurements*

Muscle strength was measured with two kinds of hand-held dynamometer, the Jamar (Clifton, N.J, 07012 USA) and the Chatillon (Chatillon PFM-100). The Jamar measures hand grip strength.[15] The test situation was standardised with the children sitting and the elbow in 90° of flexion. The child squeezed the Jamar as hard as possible with each hand. The Chatillon dynamometer was used to measure muscle strength in eight different muscle groups in the shoulder, elbow and wrist.[16,17] Reference values are available for children for shoulder abductors, elbow flexors and elbow and wrist extensors.[18] The test situation was standardised.[16] The children were instructed to press against the Chatillon dynamometer and resistance was gradually built up for 5 s. Three efforts were performed with each arm for both dynamometers and the best result for each muscle group in both arms was noted. The results were compared with the healthy arm, reference values[18] and with the outcomes at 18 months of age.

Passive ROM in the shoulder, forearm and wrist was measured by goniometry[19] and compared with the healthy arm. The participants lay in a supine position.

Fourteen of the 18 children, who at 18 months of age had symptoms of the OBPP, agreed to participate in the assessment. Telephone contact with the four families who had declined to participate revealed that all their children still had symptoms of the OBPP and had contact with health care. Two of the 80 children, who were considered to have recovered from the OBPP at 18 months of age, had moved abroad. A questionnaire was sent to the parents of the remaining 78 children and 69 (88%) of them answered. One of these children was reported to have symptoms of the earlier OBPP.

The fourteen children who, at 18 months, had symptoms of the OBPP and the child who was previously regarded as healthy but now had symptoms of the OBPP were examined by two physiotherapists. The demographic data for these children are presented in Table 1.

The predictive factors, active elbow flexion, shoulder external rotation and forearm supination against gravity, were checked. The healthy arm was used as a control.[4] The children were also asked if they had undergone surgery in the affected arm.

Sensibility was tested by two-point discrimination (TPD) and stereognosis. The test leader also touched the child's arm with her finger and the child had to describe where the test leader had touched.[22] In TPD, the child has to identify whether one or two blunt sticks are pressed against the skin and, in stereognosis, the child has to identify five different objects. All the tests were performed without looking.

Hand preference was documented by asking which hand the children used when writing.

Pain was self-rated by the children with a visual analogue scale (VAS).[21] The children also marked the position of the pain in a picture and were asked when they had pain.

Table 1 – Gender, age at the last assessment, level and side of the injury, hand preference, number and localisation of orthopaedic surgery in the affected arm of the children with remaining symptoms of an obstetric brachial plexus palsy.

Child number	Gender	Age (years)	Level of injury	Side of injury	Hand preference (18 months)	Hand preference (10–12 years)	Orthopaedic surgery
1	Female	11.8	C5-Th1	Left	Right	Right	2 (shoulder)
2	Female	11.6	C5-Th1	Right	Both	Right	1 (shoulder)
3	Female	12.3	C5-C7	Right	Both	Right	0
4	Female	11.2	C5-C6	Right	Left	Right	1 (shoulder)
5	Female	11.7	C5-C6	Right	Both	Right	0
6	Female	10.9	C5-Th1	Left	Right	Right	1 (shoulder)
7	Male	11.0	C5-C7	Right	Right	Left	0
8	Female	11.3	C5-Th1	Left	Right	Right	0
9	Male	10.8	C5-C7	Left	Right	Right	1 (shoulder)
10	Female	10.2	C5-C7	Right	Left	Left	1 (shoulder)
11	Male	10.1	C5-Th1	Left	Right	Right	2 (shoulder)
12	Female	10.9	C5-C6	Right	Right	Right	0
Neuro surg. treated:							
13	Male	11.4	C5-Th1	Left	Right	Right	1 (wrist)
14	Male	11.3	C5-Th1	Right	Left	Left	2 (shoulder + hand)
15	Female	10.9	C5-Th1	Right	Left	Left	2 (hand)

C5, C6, C7 = cervical roots 5,6 and 7.
Th1 = thoracic root 1.

ADL were self-rated by the children using the Children's Hand-use Experience Questionnaire (CHEQ).[20] The CHEQ has been developed for children and adolescents aged six to 18 years with unilateral hand dysfunction. The questionnaire includes questions on how the children are able to manage bimanual ADL.[20] A note was made of whether the children were able to bicycle and swim.

The study was approved by the local medical ethics committee at the University of Gothenburg, Sweden. Informed consent was given by the parents and the children.

2.3. Statistical analysis

Statistical analyses were performed in SPSS (version 21.0). The results are presented as medians and ranges. Wilcoxon's signed rank test was used to compare the strength and ROM in the affected and healthy arm. Spearman's rank correlation coefficient was used to compare muscle strength at 18 months and 10–12 years of age. Standard deviations were used to compare muscle strength values with references values. A probability value of $\leq$0.05 was considered significant.

3. Results

The incidence of persisting OBPP at 10–12 years of age was calculated to be 19 per 38,749 live births or 0.49 per 1000.

3.1. Muscle strength

There were significant differences in muscle strength (maximum isometric contraction) between the affected and the healthy arm in shoulder flexion, extension, abduction, internal and external rotation, elbow flexion and extension, wrist extension and grip strength. The greatest differences were found in shoulder flexion, shoulder internal rotation, elbow flexion and grip strength (Table 2). There are three missing measurements for shoulder abductions because one child was unable to hold its arm in the right position, one had pain in its arm and one had recently had a vaccination. There was one missing value for wrist extension because of measurement error.

Muscle strength in shoulder abduction, elbow flexion/extension and wrist extension was compared with reference values[18] and standard deviations were calculated for age and gender (Table 3). Elbow flexion and wrist extension were the weakest muscle groups. Strength was $\leq$ -2SD in elbow flexion in 14 children and in wrist extension in nine children.

3.2. Range of motion

There were significant differences in passive ROM in shoulder flexion, internal and external rotation and elbow extension between the affected and healthy arm (Table 4). Shoulder rotation and elbow extension were most impaired. No significant differences were seen in elbow flexion, forearm supination and pronation or extension of the wrist.

3.3. Sensibility

Two-point discrimination was impaired in three children. Superficial sensibility was impaired in one child. None of the children had problems with stereognosis.

3.4. Hand preference

Four children used the left hand and eleven used the right hand to write. Five of the eleven right-handed children preferred to write with the injured hand.

3.5. Pain

Eight children reported pain in the shoulder and/or the elbow of the affected arm. One of them, a girl with a lesion involving C5 to C6, reported pain every day. None of the neurosurgical treated children had daily pain. The other seven children said that they experienced pain during prolonged writing or some activities during physical education at school. Two of them had pain in the affected arm when swimming.

3.6. Activities of daily living

Ten children described no problems with ADL when they answered the CHEQ questionnaire. Five stated that they had

Table 2 – Muscle strength in Newtons (N) in the affected and the healthy arm in children with obstetric plexus palsy at 10–12 years of age, measured with the Chatillon and Jamar dynamometers, and the differences between the arms.

	Affected arm Muscle strength (N) Median (range)	Healthy arm Muscle strength (N) Median (range)	Differences between injured and healthy arm (N)	P-value
Chatillon dynamometer:				
Shoulder flexion (n = 15)	67.1 (31.1–106.0)	113.0 (63–143)	45.9	0.001
Shoulder extension (n = 15)	78.3 (18.6–94.5)	96.6 (58.6–138)	18.3	0.001
Shoulder abduction (n = 12)	62.0 (17.0–98.9)	77.2 (54.4–96.9)	15.2	0.009
Shoulder internal rotation (n = 15)	49.5 (9.3–78.0)	78.5 (57.2–101.5)	29.0	0.001
Shoulder external rotation (n = 15)	59.2 (22.9–93.3)	79.7 (50.1–93.3)	20.5	0.001
Elbow flexion (n = 15)	76.7 (42.8–113.0)	116.4 (77.9–156)	39.7	0.001
Elbow extension (n = 15)	71.7 (6.7–114.3)	96.8 (62.9–122.5)	25.1	0.003
Wrist extension (n = 14)	56.2 (22.4–95.6)	81.3 (44.9–106.1)	25.1	0.001
Jamar:				
Grip strength (n = 15)	177.0 (58–215)	215.0 (137–275)	38.0	0.001

Table 3 – Muscle strength in Newtons (N) in the affected and healthy arm in shoulder abduction, elbow flexion and extension. (SD) = Standard deviation from references values.[18]

Child number	Shoulder abduction affected arm (SD)	Shoulder abduction healthy arm (SD)	Elbow flexion affected arm (SD)	Elbow flexion healthy arm (SD)	Elbow extension affected arm (SD)	Elbow extension healthy arm (SD)	Wrist extension affected arm (SD)	Wrist extension healthy arm (SD)
1	98.9 (−1.2)	83.7 (−1.8)	101.7 (−2.8)	140.4 (−1.3)	97.9 (−0.4)	83.7 (−0.9)	55.2 (−3.6)	91.4 (−1.3)
2	73.7 (−2.2)	78.9 (−2.0)	76.7 (−3.8)	108.5 (−2.5)	70.5 (−1.5)	96.8 (−0.5)	74.6 (−2.3)	88.9 (−1.4)
3	46.4 (−2.8)	57.0 (−2.4)	89.5 (−2.8)	146.0 (−0.8)	62.5 (−2.3)	122.5 (0.5)	67.0 (−2.6)	89.5 (−1.4)
4	75.4 (−2.1)	90.3 (−1.5)	84.2 (−3.5)	113.3 (−2.4)	78.9 (−1.2)	90.7 (−0.7)	Missing	Missing
5	Missing	Missing	113.0 (−2.4)	130.5 (−1.9)	94.5 (−0.5)	140.0 (−0.2)	55.0 (−3.6)	68.0 (−2.8)
6	56.7 (−1.4)	77.2 (−0.2)	72.8 (−2.9)	81.9 (−2.5)	76.8 (−0.4)	93.5 (0.5)	57.6 (−1.3)	76.3 (−0.2)
7	76.0 (−0.8)	90.8 (−0.5)	96.3 (−1.9)	130.7 (−0.7)	86.3 (−0.5)	117.9 (0.5)	76.0 (−1.3)	86.1 (−0.7)
8	75.9 (−2.1)	87.6 (−1.6)	83.6 (−3.5)	114.4 (−2.3)	90.2 (−0.7)	106.4 (0.1)	95.6 (−1.0)	106.1 (−0.4)
9	17.0 (−4.6)	54.4 (−3.1)	76.9 (−5.1)	116.4 (−3.0)	06.7 (−6.3)	62.9 (−3.2)	42.4 (−3.7)	72.2 (−1.3)
10	55.0 (−1.5)	75.6 (−0.3)	61.0 (−3.5)	77.9 (−2.7)	71.7 (−0.6)	65.8 (−0.9)	57.2 (−1.3)	61.1 (−1.1)
11	91.8 (−1.7)	96.9 (−1.5)	74.0 (−5.2)	156.0 (−0.9)	114.3 (−0.3)	114.7 (−0.3)	76.0 (−2.1)	85.5 (−1.7)
12	Missing	68.9 (−0.7)	122.1 (−4.2)	130.0 (−0.6)	44.5 (−1.9)	89.0 (0.3)	55.0 (−1.5)	76.5 (−0.2)
Neuro-surg treated								
13	49.1 (−1.6)	71.9 (−1.0)	67.9 (−2.8)	125.2 (−0.9)	68.7 (−1.1)	100.1 (−0.1)	22.4 (−4.1)	77.1 (−1.2)
14	Missing	71.7 (−1.0)	42.8 (−3.7)	116.3 (−1.2)	41.6 (−2.0)	112.7 (0.3)	24.6 (−4.0)	91.3 (−0.5)
15	42.2 (−2.3)	76.5 (−0.3)	57.6 (−3.6)	79.9 (−2.6)	28.4 (−2.8)	74.1 (−0.5)	29.0 (−3.0)	44.9 (−2.1)

problems in some of the 29 activities. These activities were opening a soda bottle, cutting meat, opening a milk carton and snapping a necklace. They were able to perform the activities, but they said they were difficult and they required longer than their peers. All the children were able to bicycle and swim.

3.7. *Predictive value*

Nineteen (21.8%) of the children born with OBPP still had symptoms at 10–12 years. These children had been unable to perform active forearm supination against gravity at three months of age, compared with two of the 68 who had recovered.

At three months of age, the positive predictive value (PPV) of recovered elbow flexion, that is the chance that the child would recover completely if the muscle strength in elbow flexion was as least against gravity, was 88% (confidence interval (CI) = 79.2–94.1%). When shoulder external rotation and forearm supination were used, the PPVs were 96% (CI = 89.0–99.2%) and 99% (CI = 92.6–99.9%), respectively. The corresponding sensitivity values were 100%, 100% and 97%, while the specificity values were 47%, 84% and 95%, respectively.

3.8. *Muscle strength and ROM at 18 months of age compared with outcome at 10–12 years of age*

There was a positive correlation between reduced muscle strength in wrist flexion at 18 months and weak handgrip strength at 10–12 years of age, r = 0.69 (p = 0.001).

At 18 months of age, four children had reduced ROM in shoulder external rotation and five children had reduced ROM in elbow extension compared with the healthy arm. At 10–12 years of age, the corresponding numbers were 13 children for both movements.

4. Discussion

This study showed that all children with persisting OBPP at 18 months of age, and one of the children who were considered healthy at 18 months, still had symptoms at 10–12 years of age. Of the children born with OBPP, 21.8% still have symptoms at the age of 10–12 years, resulting in an incidence of persisting OBPP of 0.49 per 1000 live births. The recovery rate was the same as that Poondag et al.[2] reported in a review of the natural history of OBPP, where studies with high methodological quality found residual deficits in 20%–33%.[2] The children with persisting OBPP had reduced muscle strength and ROM in the affected arm. The children managed ADL fairly well, but about half of them experienced pain in the affected arm in some physical activities.

The strengths of this study were that it was population based, prospective and used standardised methods. One weakness was that the parents of the children who were considered to have recovered at 18 months of age only received a questionnaire in which they were asked to state whether the child still had any symptoms of the OBPP. No physical examination was performed in this group, except in

Table 4 – Values for passive shoulder range of motion (ROM) and passive elbow ROM in the affected and healthy arm of children with an obstetric plexus palsy at 10–12 years of age and the differences between the arms (n = 15).

	Affected arm median (range)	Healthy arm median (range)	Differences between affected and healthy arm	P- value
Shoulder flexion	174° (130°–180°)	180° (165°–180°)	6°	0.004
Shoulder internal rotation	45° (30°–75°)	70° (50°–90°)	25°	0.001
Shoulder external rotation	65° (45°–90°)	90° (70°–110°)	25°	0.002
Elbow extension	−10° (−20°–10°)	10° (0°–15°)	20°	0.001

one girl where the parents reported symptoms. It is possible that a physical examination of all the children could have revealed differences between the arms in some of the children.

Several studies have reported reduced muscle strength in children with OBPP.[3,7,8,23,24] Little is known about the mechanisms involved in the early development of strength, muscle growth and function in OBPP. The reduced strength is probably primarily due to insufficient innervation which can in turn affect the muscle volume. Ruoff et al.[23] reported that the mean cross-sectional area of elbow flexor and extensor muscles on the affected side is already reduced shortly after birth in infants with OBPP compared with the muscles on the unaffected side. However, they were not able to find any connection between muscle size and residual muscle function.[23]

In this study, as well as in the previous ones, physiotherapists regularly assessed ROM and muscle strength in the injured arm of the children with OBPP in order to be able to predict recovery and determine the need for and effect of additional therapeutic or surgical interventions, as Hale et al. have recommended.[13] It is important to further establish guidelines for the assessments that should be included in the examination.

Measuring ROM with a goniometer is a frequently used method, despite varying positions in which the movements are measured. It is therefore difficult to evaluate and compare results from different studies, especially regarding rotation in the shoulder. In the present study, shoulder external rotation was measured in a supine position with 90° shoulder abduction. A more functional way to measure external rotation would have been in the sitting position with the shoulder adducted. Hale et al.[13] recommended that passive internal/external rotation of the shoulder should be measured both in adduction and in 90° abduction of the shoulder in children with OBPP.

Reduced passive ROM in the shoulder and elbow were found in the present study. It is important to follow the changes in ROM over time, because a strong association has been found between shoulder contracture and osseous deformity of the glenohumeral joint,[25] together with the fact that an elbow flexion contracture increases with age.[8,9] However, the aetiology of the contractures is unknown.

The result of the CHEQ questionnaire showed that the children had problems with only a few activities in daily life. This was possibly due to the fact that all the children in the study were able to use the affected hand in some way. Another reason may be that the children were too young to recognise their difficulties. According to the authors of the questionnaire, the children need to be 12 years old to be able to estimate their difficulties by themselves.[20] Despite the reduced strength and ROM, children with OBPP managed most of their ADL, possibly because they are born with the disability and have developed compensatory strategies at an early age.

Half the children described pain in the affected arm, but it was seldom severe or continuous. It was difficult for the children to describe when and how much pain they experienced in the arms because it varied and was intermittent. To better understand when, where and how often the children felt pain, they could have used a diary over a longer period. However, it is important continuously to follow the pain, as it may increase with age, as described by Partridge et al.[11]

5. Conclusion

One in five children born with an OBPP still has symptoms of the injury at 10–12 years of age. Active forearm supination, shoulder external rotation and elbow flexion at three months may be useful for predicting outcome. Children with a persisting OBPP have reduced muscle strength and ROM but manage ADL fairly well. It is important to follow children with an OBPP with standardised physiotherapeutic measurements in order to be able to predict recovery and determine the need for and the effect of therapeutic and surgical interventions.

Conflict of interest

None.

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