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Joint contributions of the shoulder complex and cervical spine in children with obstetric brachial plexus palsy during reaching tasks

PROGRAMA DE PÓS-GRADUAÇÃO EM REABILITAÇÃO E DESEMPENHO FUNCIONAL
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Daiane Lazzeri de Medeiros

Tese

DAIANE LAZZERI DE MEDEIROS

Joint contributions of the shoulder complex and cervical spine in children with obstetric brachial plexus palsy during reaching tasks

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Thesis presented to Ribeirão Preto Medical School of University of São Paulo to obtain a doctoral degree (PhD) in Sciences.

Area: Physical Therapy

Advisor: Professor Anamaria Siriani de Oliveira, PhD
Co-Advisor: Professor Luis Mochizuki, PhD

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Contribuições articulares do complexo do ombro e coluna cervical de crianças com paralisia obstétrica do plexo braquial durante tarefas de alcance

Tese apresentada à Faculdade de Medicina de Ribeirão Preto da Universidade de São Paulo para obtenção do título de Doutor em Ciências

Área de concentração: Fisioterapia

Orientador: Profa. Dra. Anamaria Siriani de Oliveira
Co-orientador:Prof. Dr Luis Mochizuki

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“*Conheça todas as teorias, domine todas as técnicas, mas ao tocar uma alma humana, seja apenas outra alma humana”.*

Carl Jung

Abstract

Medeiros DL. Joint contributions of the shoulder complex and cervical spine in children withobstetric brachial plexus palsy during reaching tasks [thesis]. São Paulo: University of São Paulo, Ribeirão Preto Medical School, 2019. 111 p.

Objectives: To compare the upper limb function and quality of life (QOL) between children with neonatal brachial plexus palsy and unaffected controls. Moreover, we aimed to investigate the movement patterns and intersegmental coordination in NBPP children and matched controls during reaching tasks at different execution speeds. **Methods:** Children with NBPP and typical children aged 4 to 14 years were evaluated. The upper limb function was assessed using the Modified Mallet Scale (MMS) and Active Movement Scale (AMS). The quality of life was evaluated through the Pediatric Outcome Data Collection Instrument (PODCI) and the Child Health Questionnaire (CHQ). The three-dimensional kinematic evaluation was recorded by the 3 SPACE Liberty (*Polhemus. Inc, Colchester, VT*) with 120 Hz sampling frequency. Kinematic of the injured limb of NBPP children and the dominant limb of unaffected controls were recorded during a high-reach task (touch a ball), hand-to-back-pocket task, hand-to-head task and elevation and lowering of the arm in the frontal plane. The first three tasks were performed in two conditions within two speeds, preferred speed and as fast as possible speed. We analyzed the range of motion of the upper limb, scapula and cervical during the reach tasks, and the scapula movements during the arm elevation and lowering. We also performed the vector coding analysis of the shoulder flexion - head flexion coupling angle in the hand to head task, shoulder flexion - elbow extension coupling angle during high reach task, and the coupling angle of scapula movements – shoulder abduction/aduction in the elevation and lowering of the arm. **Results:** Children with NBPP presented lower scores for most of the QOL domains evaluated through PODCI and CHQ. The NBPP children has lower limb upper arm function compared to the unaffected controls evaluated through MMS and AMS. The NBPP children and controls used different scapulothoracic, shoulder, elbow and head kinematic movement patterns in the reach tasks. In the arm elevation and lowering the scapula movement were similar between the groups, however, the coordination strategy of scapula protraction during the arm lowering was different. Furthermore, the coordination of NBPP children was different compared to unaffected controls in the hand on ball task, and presented similar coordination in the hand to head task. **Conclusions:** The NBPP has a negative influence on the quality of life and upper limb funcion of these children. The NBPP children and controls used different scapulothoracic, shoulder, elbow and head kinematic movement patterns in the reach tasks. The coordination of NBPP children was different compared to unaffected controls when performing arm movements in the external environment (hand on ball task), and presented similar coordination when movements were made to their own body, as in the hand to head task. The NBPP children present similar scapular movement patterns to execute the arm elevation and lowering in the frontal plane, but the coordination strategy of scapula protraction movement during the lowering arm was different between the groups.

Key words: Quality of life, Movement, Upper limb, Child, Biomechanics.

Resumo

Medeiros DL. Contribuições articulares do complexo do ombro e coluna cervical de crianças com paralisia obstétrica do plexo braquial durante tarefas de alcance [tese]. São Paulo: Universidade de São Paulo, Faculdade de Medicina de Ribeirão Preto, 2019. 111 p.

Objetivos: Comparar a função do membro superior e qualidade de vida (QOL) entre crianças com paralisia obstétrica do plexo braquial (POPB) e controles. Além disso, investigar os padrões de movimentos e coordenação intersegmentar de crianças com POPB e típicas durante tarefas de alcance em diferentes velocidades de execução. **Métodos:** Foram avaliadas crianças com POPB e típicas com idade entre 4 e 14 anos. A função do membro superior das crianças com POPB foi avaliada por meio da *Modified Mallet Scale* (MMS) e *Active Movement Scale (AMS)*. A qualidade de vida dessa população foi avaliada por meio do *Pediatric Outcome Data Collection Instrument* (PODCI) e *Child Health Questionnaire* (CHQ). A avaliação cinemática tridimensional foi registrada pelo equipamento 3 SPACE Liberty (*Polhemus. Inc, Colchester, VT*) com taxa de aquisição de 120 Hz. A avaliação cinemática foi realizada no membro comprometido da criança com POPB e no membro dominante da criança típica durante as tarefas de alcance alto (tocar uma bola posicionada acima da cabeça), colocar a mão sobre o bolso traseiro da calça, colocar a mão na cabeça, elevação e abaixamento do braço no plano frontal. As três primeiras tarefas citadas acima, foram realizadas em duas condições, velocidade preferida e velocidade rápida. Foram analisadas as amplitudes de movimento do membro superior, escápula e cervical utilizadas durante as tarefas mão na bola, mão no bolso e mão na cabeça, e os movimentos da escápula durante a elevação e abaixamento do braço. Foi realizada a análise de codificação do vetor, do ângulo de acoplamento flexão do ombro-flexão da cabeça para a tarefa mão na cabeça, flexão do ombro-extensão de cotovelo para a tarefa mão na bola, e os ângulos de acoplamento dos movimentos da escápula-adução/abdução do ombro na elevação e abaixamento do braço no plano frontal. **Resultados:** As crianças com POPB apresentaram menores pontuações na maioria dos domínios avaliados por meio do PODCI e CHQ. As crianças com POPB tiveram menor função do membro superior avaliado por meio da MMS e AMS quando comparadas as crianças típicas. As crianças com POPB apresentaram diferentes padrões de movimento da escápula, ombro, cotovelo e cabeça comparados as crianças típicas nas tarefas de alcance. Na elevação e abaixamento do braço os movimentos da escápula forma similares entre os grupos, no entanto, a estratégia de coordenação da protração da escápula durante o abaixamento do braço foi diferente. Além disso, a coordenação das crianças com POPB foi diferente na tarefa mão na bola quando comparado as crianças típicas, e apresentaram coordenação similar na tarefa mão na cabeça. **Conclusão:** A POPB influencia negativamente a qualidade de vida e a função do membro superior dessas crianças. As crianças com POPB e típicas utilizaram diferentes padrões de movimento da escápula, ombro, cotovelo e cabeça nas tarefas de alcance avaliadas. A coordenação das crianças com POPB foi diferente quando comparadas as típicas ao realizar movimento voltado ao ambiente externo como na tarefa mão na bola e apresentou coordenação semelhante quando o movimento foi realizado no próprio corpo (mão na cabeça). As crianças com POPB apresentam padrões de movimento escapular semelhantes para executar a elevação e abaixamento do braço no plano frontal, mas a estratégia de coordenação do movimento de protração da escápula durante o abaixamento do braço foi diferente entre os grupos.

Palavras-chave: Qualidade de vida, Movimento, Membro superior, Criança, Biomecânica.

Abbreviation List

ANOVA: Univariate analysis of variance

CHQ: Child Health Questionnaire

ES: effect size

GE-SPR: glenohumeral elevation - scapular protraction/retraction

GL-SPR: lowering glenohumeral - scapular protraction/retraction

GE-APT: glenohumeral elevation - scapular anterior/posterior tilt

GL-APT: lowering glenohumeral-scapular anterior/posterior tilt

GE-LMR: glenohumeral elevation - scapular lateral/medial rotation

GL-LMR: lowering glenohumeral - scapular lateral/medial rotation

MANOVA: Multivariate analysis of variance

MMS: Modified Mallet Scale

NBPPG: Neonatal Brachial plexus palsy Group

NBPP: Neonatal Brachial plexus palsy

PODCI: Pediatric Outcome Data Collection Instrument

QOL: Quality of life

ROM: Range of motion

SPSS: Statistical Package for Social Sciences

SD: standard deviation

UCG: unaffected control group

UC: unaffected control

95% CI: 95% Confidence interval

SUMARY

1 Theoretical contextualization

Neonatal Brachial plexus palsy (NBPP) is a hypotonic paresis of the upper limb with a greater active range of motion than passive[1]. It is due to the unilateral traction exerted on the brachial plexus during birth, usually when there is shoulder dystocia[2]. The upper roots of the brachial plexus are the most affected, resulting in a winged scapula[3], weakness of the mm. biceps brachii, deltoid and shoulder external rotator, with possible development of contractures during the shoulder internal rotation[2,4,5], shoulder adduction[3], and elbow flexion[6]. The NBPP incidence ranges between 0.42 and 5.1 per thousand live births[1,7].

The NBPP newborns can be characterized into four groups[8]: Group I) high or Erb paralysis; C5-C6 roots injured; shoulder abduction and external rotation, and elbow flexion are impaired; Group II) extended Erb's palsy, C5, C6 and C7 roots injured; besides the muscular group involved in the Erb's palsy, the wrist extension is affected; Group III) full hypotonic paralysis of the upper limb, all roots of the plexus (C5, C6, C7, C8, T1) injured, the hand function is recovered in most cases; Group IV) full hypotonic paralysis of the upper limb with Horner syndrome, this group presents the worst prognosis.

Along the NBPP evolution, usually there is spontaneous recovery, but a functional deficit persists in 20% of cases[9]. Such functional deficit constrains NBPP children to do reaching tasks[6,10], which are fundamental for independent daily life activities[11,12]. Then, the limited range of motion of the injured upper limb affects their quality of life (QOL)[13].

The upper limb function of NBPP children can be tested by the Modified Mallet Scale (MMS)[14] and Active Movement Scale[15]; while the QOL, functional and participation activities related to the daily routine can be evaluated by the Pediatric Outcome Data Collection Instrument (PODCI)[16–18], and health status, degree of satisfaction and well-being by the Child Health Questionnaire (CHQ)[13,19].

Children with NBPP perform functional tasks using compensatory patterns, with variability in function[5,6,20]. For the hand in the back pocket task, these children showed shorter shoulder extension, shoulder external rotation, elbow flexion, and forearm supination[5]. For the high reach task and hand on the head task, the injured limb of NBPP children showed shorter shoulder abduction and shoulder external rotation. In addition, in the high reach task, the NBPP children presented less shoulder flexion and more elbow flexion; whereas in the hand on the head task, the opposite occurred and cervical flexion increased[5].

The contractures and deformities of the NBPP child develop during the simultaneous growth of bone and muscle tissue, as well as during the improvement of motor control. The nerve damage and concomitant abnormal muscle development, and altered motor planning constrain glenohumeral joint range of motion. This sequence of events changes the rhythm of the glenohumeral and scapulothoracic joints, and bone alterations[21].

The humerus movement occurs due to the coordination of the scapulothoracic and glenohumeral joints[22]. Russo et al. (2014) evaluated how NBPP children use the scapulothoracic and glenohumeral joints with the MMS. This scale evaluates the upper limb function in five positions: abduction, external rotation, external rotation with abduction (put the hand at the neck's nape), internal rotation with adduction (put the hand as high as possible on the spine) and internal rotation with horizontal adduction (put the hand on the mouth)[23]. The NBPP children used less the glenohumeral joint in all positions of the MMS, while they used more the scapulothoracic joint for the external rotation and the hand on the mouth task[20]. Russo et al. (2015) just evaluated the hand on the mouth task and confirmed such findings. Besides, it was observed winged scapula during movement and even in resting position.

Herisson et al. (2017) showed good and excellent reliability for the scapulothoracic and glenohumeral angulations for MMS tasks. They found greater scapular protraction and scapular posterior tilt in the hand on the mouth task, and greater use of the scapulothoracic joint in relation to the glenohumeral joint in the injured limb in the hand in the neck task, elevation of the arm in the scapular plane and hand in the mouth[24].

Mahon et al. (2018) measured the glenohumeral, thoracohumeral and scapulohumeral joints motion during the tasks of MMS. They have found increased shoulder internal rotation in all postures, reduced glenohumeral excursion, and habitual “trumpet” posture to perform the hand on the mouth task. Such strategy compensates the poor active glenohumeral external rotation and weak elbow flexion[25]. Furthermore, they observed changes in posture and movement of the scapulothoracic joint in tasks that require small scapulothoracic and glenohumeral movements, such as internal rotation and the hand on the mouth task[25].

Duff et al. (2007) found that the contribution of the scapulothoracic and glenohumeral joints depends of active shoulder elevation degree. NBPP children with limited shoulder elevation (≤75º) use more the scapulothoracic joint than the glenohumeral; while children with higher elevation of the upper limb (>75º) do the opposite[26]. The reduced glenohumeral motion, not the increased scapulothoracic motion, changes the scapulohumeral rhythm in children with NBPP[25]. However, the scapulothoracic joint's potential to compensate for reduced glenohumeral joint motion is task dependent[25].

Traditional methods in biomechanics focus on the analysis of discrete motion variables or linear relations in the times series of the system; while the dynamic system approach evaluates the behavior over the entire time series[27]. Although the assessment of discrete scapular angles during humerus elevation allows the identification of changes in motion, this approach failures to identify other characteristics of movement, such as the coordination between two segments throughout the movement[28]. The motion analysis based on the dynamic systems approach provides a useful way to study movement coordination[28]. The movement of the humerus occurs due to the coordination between the scapulothoracic and glenohumeral joints[22,29]. The vector coding analysis assess the coordination of the coupling of two anatomical structures[30]. This analysis has been used for walking[31] and in walking and grasping tasks[32].

Mayfield et al. (2017) analyzed the coordination of NBPP children and adolescents during reach-to-grasp task considering the entire time series (Arm Profile Score and Multi-joint Coordination) and found changes in the coordination of scapula (lateral/medial rotation, anterior/posterior tilt and protraction/retraction), wrist (flexion/extension) and glenohumeral plane of elevation joint trajectories.

Considering the particularities of the NBPP child, and how their injured upper limb deals with functional tasks, how does it may affect their QOL in the different domains? Moreover, understanding motor strategies and the coordination between head and shoulder, shoulder and elbow, and scapula and shoulder segments during reaching tasks is important to improve the assessments and therapeutic interventions aiming functional independence. This thesis will present three manuscripts, developed during the doctoral project. First, we compare the upper limb function and QOL between children with NBPP and unaffected controls (Study 1). Next, we investigate the upper limb function at individual joints and segments, and intersegmental coordination in NBPP children and matched controls during reaching tasks at different execution speeds (Study 2). Finally, we compare the movement patterns and intersegmental coordination of scapula and humerus in NBPP children and matched controls during elevation and lowering of the arm in the frontal plane (Study 3).

2 STUDY 1

Article 1- accepted for publication in the Revista Paulista de Pediatria

Quality of life and upper limb function of children with neonatal brachial plexus palsy

Quality of life and function of children with NBPP

Qualidade de vida e função do membro superior de crianças com paralisia obstétrica do plexo braquial

Qualidade de vida e função crianças com POPB

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Resumo

Objetivo: Comparar a função do membro superior e qualidade de vida entre crianças com paralisia obstétrica do plexo braquial e crianças típicas.

Métodos: Foram avaliadas 24 crianças com paralisia obstétrica do plexo braquial e 24 crianças típicas, ambos os grupos com 10±3 anos. A função do membro superior foi avaliada pela Escala Mallet Modificada e *Active Movement Scale,* já a qualidade de vida foi avaliada por meio das escalas *Pediatric Outcome Data Collection Instrument* e *Child Health Questionnaire.* Foram realizados testes U de Mann Whitney para investigar diferença entre os grupos nas escalas utilizadas.

Resultados: As crianças com paralisia obstétrica do plexo braquial apresentaram menor função do membro superior quando comparadas às crianças típicas em ambas as escalas utilizadas. Essas crianças também apresentaram menores pontuações para a maioria dos domínios do *Pediatric Outcome Data Collection,* quando comparado às do grupo controle, exceto para conforto/dor. Além disso, as crianças com paralisia obstétrica do plexo braquial apresentaram menores pontuações nos seguintes domínios do *Child Health Questionnaire*: função física, dor, comportamento, saúde mental, percepção da saúde em geral, impacto emocional nos pais e pontuação psicossocial resumida.

Conclusões: A paralisia obstétrica do plexo braquial afeta negativamente a função do membro superior e a qualidade de vida das crianças, principalmente em relação à saúde geral, mobilidade básica, função física, psicossocial, felicidade, dor, comportamento, saúde mental, funcionalidade do membro superior e impacto emocional nos pais.

Palavras-chaves: Criança; Qualidade de vida; Extremidade superior; Movimento; Plexo braquial; Saúde da criança.

Abstract

Objective: To compare the upper limb function and quality of life between children with neonatal brachial plexus palsy and unaffected controls.

Methods: Twenty-four children with neonatal brachial plexus palsy and 24 unaffected controls were evaluated, both groups with 10±3 years. The upper limb function was assessed by Modified Mallet Scale and Active Movement Scale; whereas, quality of life was assessed by Pediatric Outcome Data Collection Instrument and the Child Health Questionnaire. Mann-Whitney tests investigated the differences between groups in the scales.

Results: The children with neonatal brachial plexus palsy has lower limb function compared to the unaffected controls. The children with neonatal brachial plexus palsy presented lower score for most of the Pediatric Outcome Data Collection Instrument domains, except for comfort/pain. In the Child Health Questionnaire domains, differences were observed in the physical functioning, body pain, behavior, mental health, change in health, emotional impact on parents, and psychosocial summary score.

Conclusions: The children with neonatal brachial has a negative influence on the upper limb function and quality of life of affected children, mainly in relation to overall health, basic mobility, physical function, happiness, pain, upper limb function, behavior, mental health, and the emotional impact on their parents, as well as on the psychosocial summary score.

Keywords: Child; Quality of life; Upper Extremity; Motion; Brachial plexus; Child health.

2.1 Introduction

Neonatal brachial plexus palsy (NBPP) could result in weakness of biceps, deltoid, and external rotators of shoulder, and eventual contractures development.[1] The NBPP incidence in the United States is 1.5 per 1000 total births and in other countries is 1.3 per 1000 total births.[2] Usually NBPP cases resolve spontaneously, but functional deficits persist in approximately 20% of the cases. When spontaneous recovery does not occur, the upper limb has deficits, such as muscle weakness, soft tissue contractures, limited range of motion (ROM), and shortened forearm and hand independent of motor function.[3,4] Thus, NBPP children have reduced upper limb function compared with controls.[5]

Performing simple daily tasks can be difficult for NBPP children.[1] Some children undergo several types of treatment including surgical interventions and therapeutic rehabilitation. Early home management with parent involvement is necessary to improve the upper limb function.[6] Home-based interventions aim to increase the ROM of affected limb and consequently to improve the function as well as quality of life (QOL) of this population.[7]

The World Health Organization defines QOL as “perception of individuals about their position in life in the context of culture and value systems in which they live, and in relation to their goals, expectations, standards, and concerns.”[8] The diagnosis of NBPP negatively impacts QOL;[5,9–11] probably, due to functional impairments, pain, psychosocial problems,[5,9–11] and limitation in sports activities.[3,12,13] Personal and environmental factors can influence the QOL of children with NBPP with regard to coping mechanisms to psychological, financial, family, therapeutic, aesthetic, and body image issues.[5]

Given the challenges faced by NBPP children, as well as relation between functional deficits of upper limb and their QOL, it is essential to understand how NBPP influences the QOL and upper limb function. Combining the assessment tools for upper extremity function with QOL measures can assist practitioners with caring for whole child. Exploring these parameters can aid physical therapists in addressing functional limitations in upper extremity and QOL as it relates to the components of the International Classification of Functioning, Disability and Health Model, particularly with regard to "participation" in daily life. Furthermore, there is no publication evaluating the QOL and upper limb function in Brazilian children with NBPP. Thus, the main objective of this study was to compare the upper limb function and QOL between children with NBPP and unaffected controls.

2.2 Method

This was a cross-sectional study. Children with NBPP were recruited by reviewing data records of patients at Medical and Statistical Archiving Service that were attended at the Clinics Hospital of Ribeirão Preto in the period from 2002 to 2012. We obtained 47 contacts of NBPP children. The first contact was made over the phone, the phone numbers of 10 patients were outdated, 37 families were contacted, eight parents refused to consent to their child's participation in the study; therefore, leaving a subject pool of 29. However, five were excluded due to achieving full recovery. Twenty-four unaffected controls included normal children from a convenience sample of children taking swimming classes. Children's parents or guardians were informed about the study objective and procedures and provided signed written informed consent. The children also signed the consent agreement terms approved by the Research Ethics Committee of the Medical School of Ribeirão Preto of the University of São Paulo (process number 16172/2015).

Participants were classified into two groups based on their conditions: the NBPP group (NBPPG) and unaffected control group (UCG) matched by sex and age. In the UCG, 24 children (aged: 10±3 years, weight: 38.0±11.1kg, height: 1.4±0.1m) and in the NBPPG, 24 children with NBPP (aged: 10±3 years, weight: 45.4±16.5kg, height: 1.4±0.1m), 13 had a right limb injury and 11 had left limb NBPP diagnosis. Both groups were composed of 13 girls and 11 boys. The NBPPG were classified into following types: upper Erb's palsy (7), extended Erb's palsy (10), and total palsy with no Horner syndrome (7). The lesion level was verified using electroneuromyography (shown in medical records) and classified by Narakas classification.[14]

The inclusion criteria were diagnosis of NBPP and age between 5 and 14 years old. The exclusion criteria were bilateral plexus lesions, complete recovery of NBPP lesions, musculoskeletal and neurologic disorders, and cognitive, auditory, and visual impairments.

The upper limb function was evaluated through Modified Mallet Scale (MMS) and Active Movement Scale (AMS). For MMS, children were asked to perform the following movements: global abduction, external and internal rotation; hand to neck, hand to spine, and hand to mouth movements. Each movement was classified from 1 (no movement) to 5 (ROM symmetrical to unaffected side).[15] MMS scale showed kappa value 0.78 for inter-observer reliability of individual elements and 0.76 for intra-observer reliability.[16]

The performance of following upper limb movements was assessed using AMS: flexion, abduction, adduction, shoulder internal and external rotation, elbow flexion and extension, forearm pronation and supination, wrist flexion and extension, finger flexion and extension, thumb flexion and extension.[17] AMS evaluated both movements without influence of gravity and movements against gravity. Each movement was scored from zero to seven (Table 1).

This scale presented moderate to excellent inter-rater and intra-rater reliability for NBPP children in all movements evaluated.[16,17] The UCG presented full active ROM and perfect function of upper limb, these children will hit maximum scores.

Table 1. Scores for the Active Movement Scale

	Score
Gravity eliminated	
No contraction	0
Contraction, no motion	1
<50% Range of motion	2
>50% Range of motion	3
Full motion	4
Against gravity	
<50% Range of motion	5
>50% Range of motion	6
Full motion	7

The QOL were evaluated by Pediatric Outcome Data Collection Instrument (PODCI) and Child Health Questionnaire – Parent Form 28 (CHQ). Both versions were used and are "parent forms", which were self-completed by parents of the children. The evaluator instructed the parents to answer the questionnaires, containing questions related to daily-life activities covering a 7-day period for the PODCI and 4 weeks for the CHQ.

The PODCI has 48 items to address overall function of the child or adolescent from parents perspective, under five domains: upper limb function, transfers and basic mobility, sports and physical function, comfort/pain, happiness with physical condition, and global function.[11] PODCI has been validated for Brazilian children and adolescents with juvenile idiopathic arthritis.[18] PODCI is a subjective measurement tool that assesses children and adolescents from 2–10 and 11–18 years old with moderate to severe orthopedic diseases. The PODCI has four to six options per question. The final score for each domain ranges from 0 to 100: higher the better condition of evaluated domain. The final score was obtained using Microsoft Excel™ software.[19]

The degrees of health, satisfaction, and wellbeing were evaluated with CHQ - 28 items. Those items related to following domains: overall health perceptions, physical function, role/social limitations due to emotional/behavioral difficulties, role/social limitations due to physical health, body pains, behavioral/mental health, self-esteem, and change in health.[20] Additionally, CHQ assessed the impact of child's health on QOL of the parents via domains related to emotions and parents time, family activities, and family cohesion.[20] Ten concepts were then aggregated and averaged into two scores, namely psychosocial and physical summary scores. Each question presented four to six options. The score was transformed into a scale ranging from zero to 100. The higher is the better function. A worksheet was developed for scores using Microsoft Excel™ software.[20] This questionnaire was transculturally adapted to Brazilian population,[21] and presented test-retest reliability with Intraclass Correlation Coefficient of 0.50–0.78 for eight domains as well as for psychosocial summary score.[22]

All the evaluations were performed by a properly trained physiotherapist with 7 years' experience in pediatric rehabilitation.

Descriptive statistical analyses of variables were performed using mean and standard deviation, as well as 95% confidence intervals of the groups. Non-parametrical tests were used due to non-normally distributed data. Mann-Whitney tests investigated differences between groups (NBPPG and UCG) in the MMS, AMS, CHQ and PODCI.

The effect size was classified as small, moderate, and large effects, for 0.2, 0.5, and 0.8 respectively.[23] All statistical analyses were performed using Statistical Package for Social Sciences (SPSS) version 20.0, and the significance level was <0.05.

2.3 Results

The NBPPG has lower limb function than the UCG (Table 2). There were differences between groups in most of PODCI domains, but comfort/pain (Table 3). In the CHQ domains, there were differences between groups for physical functioning, body pain, behavior, mental health, change in health, emotional impact on parents, and psychosocial summary score (Table 4).

Table 2. Comparison of upper limb function between the groups by Active Movement Scale (AMS) and Modified Mallet Scale (MMS).

		NBPPG Mean± SD	Median	95% CI	UCG Mean± SD	*P*	ES
MAS	Shoulder flexion	5.0±2.0	6.0	4.0-6.0	7.0±0.0	≤ 0.001	1.4
	Shoulder Abduction	5.0±2.0	6.0	4.0-6.0	7.0±0.0	≤ 0.001	1.4
	Shoulder Adduction	5.0±2.0	6.0	4.0-6.0	7.0±0.0	≤ 0.001	1.4
	Internal Rotation	5.0±2.0	6.0	4.0-6.0	7.0±0.0	≤ 0.001	1.4
	External Rotation	3.0±2.0	5.0	2.0-5.0	7.0±0.0	≤ 0.001	2.8
	Elbow flexion	6.0±2.0	6.0	5.0-7.0	7.0±0.0	≤ 0.001	0.7
	Elbow Extension	6.0±2.0	6.0	5.0-6.0	7.0±0.0	≤ 0.001	0.7
	Forearm pronation	5.0±2.0	7.0	4.0-7.0	7.0±0.0	≤ 0.001	1.4
	Forearm Supination	5.0±2.0	6.0	4.0-6.0	7.0±0.0	≤ 0.001	1.4
	Wrist flexion	5.0±2.0	6.0	4.0-6.0	7.0±0.0	≤ 0.001	1.4
	Wrist extension	5.0±2.0	6.0	4.0-6.0	7.0±0.0	≤ 0.001	1.4
	Fingers flexion	6.0±1.0	7.0	6.0-7.0	7.0±0.0	0.02	1.4
	Fingers extension	6.0±2.0	7.0	4.0-7.0	7.0±0.0	≤ 0.01	0.7
	Thumb flexion	5.0±3.0	7.0	4.0-7.0	7.0±0.0	≤ 0.01	0.9
	Thumb extension	5.0±3.0	7.0	4.0-6.0	7.0±0.0	≤ 0.01	0.9
MMS	Global abduction	3.0±1.0	4.0	3.0-4.0	5.0±0.0	≤ 0.001	2.8
	Global external rotation	2.0±1.0	2.0	2.0-3.0	5.0±0.0	≤ 0.001	4.2
	Hand to neck	3.0±1.0	3.0	2.0-4.0	5.0±0.0	≤ 0.001	2.8
	Hand to spine	3.0±1.0	3.0	2.0-3.0	5.0±0.0	≤ 0.001	2.8
	Hand to mouth	3.0±1.0	4.0	3.0-4.0	5.0±0.0	≤ 0.001	2.8
	Internal rotation	3.0±1.0	3.0	3.0-4.0	5.0±0.0	≤ 0.001	2.8

NBPPG: neonatal brachial plexus palsy group; UCG: unaffected control group; SD: standard deviation; 95%CI: 95% Confidence interval, ES: effect size.

Table 3. Comparison between groups in the Pediatric Outcome Data Collection Instrument domains.

	NBPPG			Control				
	Mean± SD	**Median**	**95% CI**	**Mean± SD**	**Median**	**95% CI**	***P***	**ES**
Upper extremity	74.9±17.7	79.0	67.2-82.6	98.0±5.1	100.0	95.8-100.1	≤ 0.001	1.7
Mobility	95.8±5.7	97.0	93.3-98.3	99.4±1.2	100.0	98..8-99.9	≤ 0.001	0.9
Sports/Physical	90.4±10.2	92.0	85.9-94.8	96.7±7.0	100.0	93.7-99.6	≤ 0.001	0.7
Comfort/Pain	86.2±17.3	89.0	78.7-93.6	92.4±12.8	100.0	87.0-97.8	0.14	0.4
Happiness	82.6±15.4	85.0	75.9-89.2	94.6±9.0	100.0	90.8-98.4	≤ 0.01	0.9
Global function	86.7±7.7	88.0	83.4-90.1	96.6±4.7	98.5	94.6-98.6	≤ 0.001	1.5

NBPPG: neonatal brachial plexus palsy group; UCG: unaffected control group; SD: standard deviation; 95%CI: 95% Confidence interval, ES: effect size.

Table 4. Comparison between the groups in the domains of the Child Health Questionnaire

	NBPPG			Control				
	Mean± SD	**Median**	**95% CI**	**Mean± SD**	**Median**	**95% CI**	***P***	**ES**
General Health Perceptions	88.1±13.0	85.0	82.6-93.6	95.0±7.2	100.0	91.9-98.0	0.04	0.6
Physical Functioning	88.5±20.4	100.0	79.9-97.0	95.8±20.4	100.0	87.2-104.4	≤ 0.01	0.3
Role/Social-Emotional/Behavioral	90.1±18.6	100.0	82.3-97.9	95.8±15.1	100.0	89.4-102.1	0.14	0.3
Role/Social-Physical	91.6±24.6	100.0	81.2-102.0	100.0±0.0	-	-	0.07	0.5
Bodily Pain	81.7±17.6	80.0	74.2-89.1	91.7±11.7	100.0	86.7-96.6	0.04	0.7
Behavior	53.4±25.9	50.0	42.4-64.3	71.2±23.9	75.0	61.1-81.3	0.02	0.7
Mental Health	73.8±18.3	75.0	66.1-81.5	85.8±16.4	91.8	78.9-92.7	0.01	0.7
Self Esteem	81.7±19.9	87.5	73.3-90.0	87.5±22.8	100.0	77.9-97.2	0.17	0.3
Parent Impact – Emotional	60.4±26.3	62.0	49.3-71.5	84.9±20.5	88.0	76.3-93.7	0.001	1.0
Parent Impact – Time	88.9±18.1	100.0	81.3-96.6	92.3±22.5	100.0	82.8-101.8	0.20	0.2
Family Activities	82.8±19.9	88.0	74.4-91.2	90.1±24.1	100.0	79.9-100.3	0.05	0.3
Family Coesion	76.0±19.4	85.0	67.8-84.2	78.3±20.0	78.3	69.8-86.8	0.63	0.1
Physical Summary	54.4±9.3	57.0	50.4-58.3	58.5±4.2	59.0	56.7-60.3	0.09	0.6
Psychosocial Summary	45.2±9.9	45.0	41.1-49.4	53.1±10.1	55.3	48.8-57.4	0.003	0.8

NBPPG: neonatal brachial plexus palsy group; UCG: unaffected control group; SD: standard deviation; 95%CI: 95% Confidence interval, ES: effect size

2.4 Discussion

The aim of this study was to compare the upper limb function and QOL between children with NBPP and unaffected controls. Parent's subjective evaluation showed they believe NBPP children have worse overall function and lower QOL. This information may be useful for clinicians to realize that NBPP negatively affects the QOL of affected children in multiple aspects based on perception of their parents, including the emotional impact on their families. Psouni et al.[24] verified that children who suffered a NBPP are at a higher risk of using psychotropic medication in adolescence, compared to control group. Furthermore, female adolescents and lower family income were at higher risk of being prescribed and using psychotropic drugs. Belfiore et al.[25] believe that an interdisciplinary approach is necessary to determine the need for mental health referral.

Children with NBPP showed reduction in upper limb function. Squitieri et al.[5] using MMS in NBPP teenagers and Akel et al.[9] using AMS in children have found similar results. According to Akel et al.[9] there were children with total brachial plexus and with upper trunk lesions; however, this division was not performed in the present study. The NBPPG had lower scores and larger effect sizes on shoulder external rotation on both AMS and MMS, just like Squitieri et al.[5] The external rotation movement is widely used with other movements to perform functional tasks, such as combing the hair. Tasks involving placement of the hand on back neck also received low scores in MMS in NBPP children.

The impaired upper limb function is the domain that mostly decreases the QOL in NBPP children. The PODCI domain with the lowest score in NBPP children was upper limb function, corroborating other findings.[10,11,26] Such result emphasizes how hard is to manipulate objects with the upper limbs in activities such as lifting heavy books, pouring half gallon of milk, opening a jar that has been opened before, using cutlery, combing the hair, buttoning clothes, putting on a coat, and writing with pencil.[19] The effect size of this domain was the highest, and reinforces the impact of NBPP on the upper limb function. Besides, the effect size of global function domain was also raised. Both domains may be related to the limited ROM in these children, which is impaired by muscle weakness, simultaneous activation of antagonists, difference in length of affected limb, and contractures.[4] Then, NBPP children show restrictions in performance of functional tasks,[1] which are fundamental for independence in daily life activities and QOL,[3] as well as for tasks that require fine motor skills (e.g., writing).[27]

Children with NBPP have low participation in sports activities. The PODCI domain of sports and physical function was reduced in the NBPPG compared with the UCG, confirming other findings.[3,10,11] Sports and physical function domain cover tasks such as walking, running, climbing stairs, and cycling, as well as participation in non-competitive sports and games, in comparison to sports competitions with other children of the same age.[19]

In the CHQ, differences in physical functioning was observed between groups; however, the effect size was small. Physical functioning domain covered limitations related to physical functions of lower limbs, for NBPP children without limitations. The difference in PODCI physical function domain might be related to the difficulty of NBPP children to join in activities that require the upper limb use, such as volleyball and swimming, which were some of the examples mentioned in the questionnaire. Children with NBPP have the perception that limited ROM and reduced strength affects their performance of certain movements in sports or school activities;[3,12,13] however, in the current study, the parents were who showed reduced perception in the sports and physical function domain. In Kirjavainen et al.,[12] NBPP children (n=79, 71%) had limitations in performing activities such as cycling, cross-country ski and swimming, these activities were questioned because are usual to Finnish population and require bimanual function. On the other hand, Bae et al.[24] reported that NBPP children were similar to the published normative pediatric data, 75 (88%) of NBPP children played sports, with 61 (72%) involved in individual and 54 (63%) in team sports. These results showed representative participation in several sports including those requiring upper extremity dexterity such as baseball, swimming, and gymnastics.[24]

Children with NBPP may be less happy than children with typical development. The NBPPG presented lower scores in the PODCI happiness domain, which addressed questions about the children's satisfaction with their appearance, body, clothes and shoes, ability to do the same things as their peers, and overall health.[19] Children with NBPP use compensatory patterns to perform tasks such as opening a jar, typing, and complained about apparent physical discrepancies when they are wearing half or quarter-length sleeves.[5] The lowest scores in this domain may have been related to feelings of irritation, distress, and frustration, which are frequent in children owing to the differences in level of performance of same tasks from their normal counterparts.[9,28] In addition, these children often feel ashamed of their appearance or size discrepancies their limbs.[3,5]

Children with NBPP have low basic mobility. Transfers and basic mobility were also reduced in NBPPG, corroborating other findings.[10,11]. In this domain, lower scores were obtained for tasks that required upper limbs use, as limited ROM affected the functionality of such children.[13]

For the parents' perception, NBPPG have more pain than the unaffected controls children. The pain domain was assessed using the CHQ and PODCI, higher perceptions of pain were reported by parents of NBPP children in the CHQ alone. On the other hand, this phenomenon was reported by Bae et al.[10] with the PODCI alone and by Squitieri et al.[5] with both questionnaires. The CHQ asks about the frequency of pain/discomfort in the body in the last four weeks. On the other hand, the PODCI is more specific, it asks if the children had pain/discomfort during the last week and if the pain interfere with your child's activities and how much pain interfere in the child's normal activities, including at home, outside of the home and at school. These results could be related to the numbness in the limb or pain experienced in the morning as reported by NBPP children.[13] In addition, Akel et al.[9] found that NBPP children with greater injury to the upper limb (total lesions) showed a higher perception of pain and discomfort in the affected limb than children with upper trunk lesions. However, subdivision of lesion levels was not performed in the current study.

The perception of the overall health of NBPP children' parents is reduced. The perception of overall health of the parents of NBPP children were worse than those among parents of the unaffected controls, corroborating the findings of Akel et al.[9] In addition, greater emotional impact was observed among the parents of affected children, in agreement with previous studies on children[9] and adolescents with NBPP.[5] The low scores observed in these domains could be related to the concerns associated with the chronic condition. From birth, affected children often experience momentary limitations when performing activities of daily living. In addition, they undergo routine rehabilitation programs and surgeries.[9] NBPP poses several challenges for the children and their parents throughout their lives. Matsumoto et al.[29] observed that parents had higher expectations from treatment than did their children, however, this treatment routine often creates a sense of guilt and concern for the parents, which influences their perception of their child's overall health, in addition to the emotional impact on their own lives.

The NBPP children have low mental health in the parents' perception. Mental health in the NBPPG was also markedly reduced compared to the UCG, corroborating others studies.[5,9] In this domain, the CHQ had questions about feeling alone and acting in a nervous, uncomfortable, and upset manner. These behaviors could be related to feelings such as anger or irritation due to the differences in task performance when compared to that in other children.[9] In addition, NBPP children are undergo several therapies without a guarantee of functional improvement,[30] and this uncertainty of outcomes could also trigger negative emotions such as anxiety or fear,[13] which could influence these results. However, the self-esteem domain was surprising that parents of NPBB children reported scores similar to those of unaffected controls.

The behavior of NBPP children is different of control children. The behavior domain was also reduced in NBPP children corroborating with findings of Akel et al.[9] and disagreeing with the results of Squitieri et al.,[5] in this domain had questions about argued a lot, had difficulty concentrating or paying attention and lied or cheated. This inconsistency in results present in the literature may be related to characteristics of personality of each child.

The NBPP children have lower QOL than control children of the same age and sex. Although QOL is influenced by cultural and social aspects,[8] in the present study, Brazilian children with NBPP presented similar results to studies conducted in other countries.[5,9-11,26] The QOL involves several components of health, including the ability to perform routine functional tasks, emotional wellbeing, and the absence of pain.[29] The evaluation of QOL in children is difficult because they are continuously developing, thus, the perspective of their parents seems to be the best measure. However, studies have shown inconsistencies in the responses about QOL from the perspective of the parents and their own children.[31] Owing to these response inconsistencies, the QOL assessment from the perspective of the parents could be considered a limitation of the current study. As NBPP is a relatively rare condition, the small sample size can also be considered a limitation, and these results cannot be generalized for the NBPP population. Outra limitação que pode ser considerada é o grupo controle se

In conclusion the results of the present study showed that NBPP children presented lower upper function in the AMS and MMS when compared to unaffected controls. Parents consider NBPP has a negative influence on the QOL of their children, mainly in relation to upper limb function, overall health, basic mobility, physical function, happiness, pain, behavior, mental health, and the emotional impact on their parents, as well as psychosocial summary score. Coping approaches should be included by health professionals with the aim of improving the QOL of these children and their families.

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3 STUDY 2

Article 2 - Submitted to Human Movement Science and underevision

Upper limb function and coordination of children with neonatal brachial plexus palsy during reaching tasks at different execution velocity

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Abstract

The aim of this study to investigate the upper limb range of motion (ROM), and intersegmental coordination in NBPP children and matched controls during reaching tasks at different execution speeds. Thirteen age- and gender-matched pairs of children participated of the current study. The ROM was assessed with the Modified Mallet Scale and Active Movement Scale. Kinematics of the upper limb and head were recorded during an external reach task (touching a ball) and two tasks moving the hand to the body (head and back pocket), all at preferred and faster speed. Coordination analysis using vector coding was applied to assess coupling between shoulder, elbow and head. The NBPP children present reduction of ROM of the upper limb. The NBPP group and UC group used different movement patterns of scapula, shoulder, elbow to perform all the tasks, and NBPP children did greater head flexion in the hand to head task. In the external reach task, the NBPP group and controls used different modes coordination and in the hand to head there was no difference between groups. The results indicate that the NBPP may interfere with the coordination of external reach tasks.

Keywords Child; Biomechanics; Coordination; Upper limb; Neonatal brachial plexus palsy; Reach task.

3.1 Introduction

Neonatal brachial plexus palsy (NBPP) may result in weakness of the brachial biceps, deltoid and external rotator muscles of the shoulder, with possible development of shoulder internal rotation (AL-QATTAN et al., 2009; Andersen, Watt, Olson, & Van Aerde, 2006; Mosqueda et al., 2004), adduction (Russo, Loeffler, et al., 2014) and elbow flexion contractures (Sheffler, 2012). Due these limitations, the children with NBPP use compensatory movement patterns to perform functional tasks. This compensation changes the variability in the performance of the function (Mosqueda et al., 2004; Raat, Botterweck, Landgraf, Hoogeveen, & Essink-Bot, 2005; Sheffler, 2012) and induces coordination deficits (Bellows, Bucevska, & Verchere, 2015). In the evolution of NBPP, the recovery may be spontaneous, but the functional deficit persists in 20% of the cases (Fitoussi et al., 2009). In this condition, children with NBPP present restrictions to perform reaching tasks (Roberval et al., 2012; Sheffler, 2012) that are fundamental to independence in daily life activities (Sarac et al., 2013; Van Der Heide, Fock, Otten, Stremmelaar, & Hadders-Algra, 2005). Compensations made due to limitations in the structure and function of joints, bones and muscles spread to unaffected areas because all these bodily structures are physical or functionally coupled. Currently, the coordination changes under such circumstances in NBPP children are not well understood.

In reaching tasks, the coordination of the scapulothoracic and glenohumeral joints allows the motion of the humerus (Donnelly et al., 2002). Russo et al. (2014) evaluated the use of the scapulothoracic and glenohumeral joints of the affected and unaffected limbs of children with NBPP in the tasks of the Modified Mallet Scale (MMS) (global abduction, global external rotation, hand to neck, hand to spine and hand to mouth). The affected limb of the NBPP children used the glenohumeral joint less to reach all positions of the MMS and used the scapulothoracic joint more in the external rotation and hand to mouth tasks (Russo, Kozin, et al., 2014). Duff et al. (2007) found that the contribution of the scapulothoracic and glenohumeral joints depends on the degree of active shoulder elevation.

Compensatory patterns also occur in the execution of high reach, hand to head and hand to back pocket tasks (Mosqueda et al., 2004), but the scapulothoracic contributions to these tasks are unknown. Although Mosqueda et al. (2004) have indicated compensations, such as a greater cervical flexion in the hand to head task and less shoulder flexion and greater elbow flexion in the high reach task, it is not known how these changes in range of motion affect the coordination between these segments.

One way to assess changes in coordination or segment coupling of two anatomical structures is relative motion. The relative motion between two segments can be quantified by the coupling angle using vector coding analysis (Van Emmerik, Miller, & Hamill, 2013). This analysis has been used during walking (R. Chang, Van Emmerik, & Hamill, 2008) and in walking and grasping tasks (Rinaldi, Emmerik, & Moraes, 2017). We propose to evaluate intersegmental coordination between shoulder and elbow during an external reach task (touching a ball) and between the shoulder and head in the hand to head task through vector coding analysis (R. Chang et al., 2008; Rinaldi et al., 2017; Van Emmerik et al., 2013). The stability and transition dynamics of movement pattern can be revealed through of manipulation of a nonspecific control parameter (Van Emmerik et al., 2013), thus, we evaluated the tasks in two speed of execution.

Given the limitations that NBPP children commonly face and evidences about the use of compensatory patterns in reach task. The knowledge about scapula, upper limb and head kinematic pattern and coordination strategies in different types of reach can improve the coordination approach in clinical practice.

Therefore, the purpose of this study was to investigate the ROM at individual joints and segments, and intersegmental coordination in NBPP children and matched controls during reaching tasks at different execution speeds. We addressed the following four research questions: 1) Does NBPP affect the ROM at individual joints and segments of children's upper limb? 2) What scapula, shoulder, elbow and head kinematic patterns NBPP children use to perform reach task? 3) How is the intersegmental coordination affected in NBPP children? And 4) Does increasing speed influence the strategy of movement and coordination during reaching tasks?

3.2 Methods

3.2.1 Participants

This was a cross-sectional, exploratory, comparative, and descriptive study. Parents or guardians of the children were informed about the study objective and procedures and provided signed written informed consent. The children also signed the assent agreement terms approved by local Ethics Research Committee (protocol 16172/2015).

The NBPP group comprised of 13 children (10±2 years old, 47.6±15.9 kg mass, 1.47±0.15 m tall, of which 6 had upper Erb's palsy and 7 had extended Erb's palsy). The unaffected control (UC) group included 13 healthy children (10±2 years old, 41.2±12.6 kg mass, 1.45±0.14m tall) matched for sex and age. The inclusion criteria for the NBPP group were a diagnosis of NBPP and age between 5 and 14 years. The exclusion criteria were bilateral plexus lesion, difficulty in communicating with the evaluator, auditory and visual disorders, limiting the range of motion of the upper limb that made it impossible for the child to perform most of the tasks of reaching and present complete recovery of the lesion. Sixteen children were excluded, 11 due to severe limitation of range of motion (ROM) and unable to perform most of the tasks assessed and 5 due to complete recovery of the injury. In the hand to back pocket task four children were excluded from analysis of the NBPP group due to the restriction of the range of motion and inability to reach the endpoint of the task.

3.2.2 Procedures

To characterize the sample, a medical history form was used to collect information regarding the child's age, anthropometric measurements (height and body mass), and all data related to the exclusion criteria. Body mass was measured using a digital scale (Filizola, accurate to within 100 g), and height with a stadiometer (precise to within 1 mm).

The function of the upper limb was evaluated using the Modified Mallet Scale (MMS) and the Active Movement Scale (AMS), by a properly trained physiotherapist with 7 years experience in pediatric rehabilitation. For the MMS evaluation, children were asked to perform the following movements: global abduction, external and internal rotation; hand to neck, hand to spine, and hand to mouth movements. Each movement was classified from 1 (no movement) to 5 (ROM symmetrical to the unaffected side) (Mallet, 1972). This scale had 0.78 for the kappa value for inter-observer reliability of individual elements and 0.76 for intra-observer reliability (Bae, Waters, & Zurakowski, 2003). For the AMS evaluation, the performance of the following upper limb movements were assessed: flexion, abduction, adduction, internal and external rotation of the shoulder, elbow flexion and extension, forearm pronation and supination, wrist flexion and extension, finger flexion and extension, thumb flexion and extension (Curtis, Stephens, Clarke, & Andrews, 2002). This scale evaluates how movements are performed in relation to gravity, and ranges from zero, when it is not possible to observe muscle contraction, to four, when it has complete movement perpendicular to the gravity line. It also evaluates movements against gravity, five when ROM <50%, six when ROM is> 50% and seven when ROM is completely against gravity. The AMS scale presents moderate to excellent inter-rater and intra-rater reliability for children with NBPP in all movements evaluated (Bae et al., 2003; Curtis et al., 2002). The UC group presented full active ROM and perfect function of upper limb; therefore, these children assumed maximum scores n both scales. The AMS presents moderate to excellent inter and intra-rater reliability for NBPP children for the 15 movements (Bae et al., 2003; Curtis et al., 2002).

The motion analysis was done with the *The Motion Monitor (Chicago, MI, EUA),* which is a biomechanical interface program and the 3D tracking system *Liberty* (*Polhemus. Inc, Colchester, VT*). This electromagnetic device has a root mean square accuracy of 0.076 cm for sensor position and 0.15 for sensor orientation. The transmitter was fixed 110 cm above the floor and emitted an electromagnetic signal to the sensors attached to the participant. The sensors were attached to the sternum, to the flat surface of the acromion process, just below the insertion of the deltoid muscle, back of the hand and on the forehead, which were fixed with adhesive tape. Another sensor was attached to a pointer to manually digitize the bony landmarks to create local coordinate systems on the thorax (suprasternal notch, xiphoid process, spinal processes of C7 and T8), scapula (acromial angle, root of the spine, inferior angle), humerus (medial and lateral epicondyle) and forearm (radial styloid, ulnar styloid and third phalanx) (Wu et al., 2005).

Before data collection, the participants practiced the tasks for familiarization with the procedure. In the data collection, each task was repeated 20 times: 10 trials at the preferred or self-selected speed and 10 trials at fastest speed possible. The order of the tasks was randomized; however, these always started with the self-selected speed to avoid the influence of the fast speed. In an orthostatic position, three tasks were evaluated: 1) touching a ball, with the palm of the hand, which was positioned by the evaluator at a height that required 110º anterior flexion of the shoulder relative to the trunk; a goniometer was used to determine the angulation; 2) putting the hand on the back pocket of pants or shorts; and 3) putting to hand on the highest point of the head (Figure 1 a, b, and c, respectively). The UC group performed the tasks with the dominant limb and the NBPP group with the affected limb.

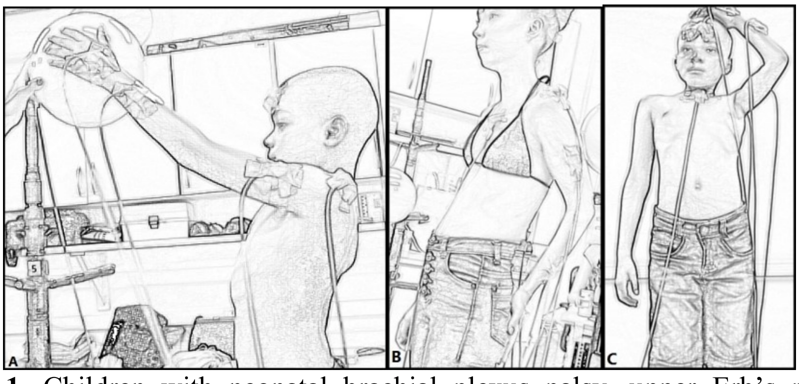

Figure 1. Children with neonatal brachial plexus palsy, upper Erb's palsy type performing the reaching tasks of reaching: A) Hand on ball B) Hand on the back pocket and C) Hand to head.

3.2.3 Data Processing and Analysis

3.2.3.1 Upper limb function

Each movement of the MMS was classified from 1 to 5, and the AMS ranged from zero to seven; for both scales, a higher score indicates better upper limb function. The final score was obtained using the Microsoft Excel™ software.

3.2.3.2 Kinematic data

The three-dimensional coordinates were preprocessed and exported by the program *The MotionMonitor (Innsport Inc.)*. The movements of the scapula in relation to the thorax (external/internal rotation, upward/downward rotation and anterior/posterior tilt) were analyzed using the sequence of Euler angles YX'Z'' and movements of the humerus relative to the thorax (humeral elevation, elevation plane and axial axis of rotation) using the sequence of Euler angles XZ'Y'(Phadke, Braman, LaPrade, & Ludewig, 2011). The movements of the forearm in relation to the arm (flexion/extension) by sequence (ZX'Y'') (Wu et al., 2005) and the movements of the head relative to the thorax chest (flexion/extension, right/left rotation and right/left tilt) by sequence (Z, Y', X''). The mean velocity of each movement was calculated as the difference between final and initial angular position divided by the number of data points in that interval.

The beginning of the movement was based on the angular acceleration of the shoulder. The criterium to define the acceleration onset was the first acceleration higher than 5% of the peak. The shift direction in shoulder angular velocity was defined as the end. A script (Matlab, MathWorks®. R2013b, EUA) calculated and plotted the shoulder velocity and acceleration; while the acceleration onset was centered in the graph. Manual inspection was provided to confirm the acceleration onset. The angular range of motion during the tasks was defined as the difference between the final angular value and the initial angular value. After low-pass filtering (5 Hz, fourth order *Butterworth* filter), data were resampled to normalize the movement from 0 to 100% to do the point-to-point comparative analysis.

We performed the vector coding analysis of the shoulder flexion-head flexion coupling angle (SF-HF) of the hand to head task and shoulder flexion-elbow flexion coupling angle (SF-EF) of the hand on ball task (R. Chang et al., 2008; Rinaldi et al., 2017; Van Emmerik et al., 2013). This analysis provides information on coordination between two segments, where the x-axis comprises the proximal segment, for example the angular displacement of the shoulder in the hand on ball task, and the y-axis comprises the distal segment, in this case the elbow in the hand on ball task. The angular values of the movement of the head and the humerus are projected on a graph, each point has an x and y coordinate. A coupling angle is the angle of the vector formed between two adjacent data points relative to the right horizontal (Figure 2).

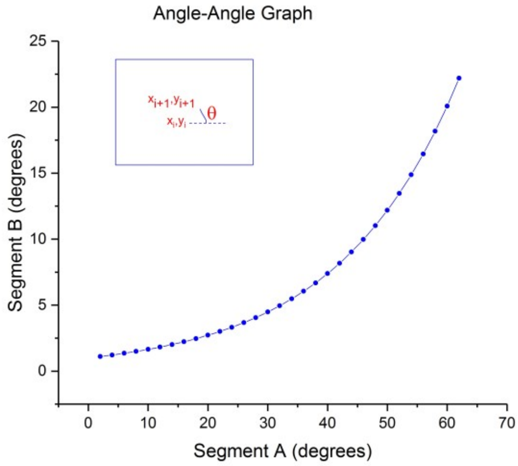

Figure 2. Angle-angle graph to illustrate the coupling angle

The coupling angle (θ) was calculated during the whole movement, by means of the slope defined by the pair of variables X and Y in relation to the horizontal, according to equation 1.

$$\theta = \tan^{-1}\left(\frac{Y_{i+1} - Y_i}{X_{i+1} - X_i}\right) \tag{1}$$

Where $\tan^{-1}$ is the inverse tangent of the vertical variation of segment X relative to the horizontal variation of segment Y.

Angular results have polar distribution (0-360°) and are divided into four sectors that correspond to the four coordination modes. In-phase: 22.5°<θ<67.5° e 202.5°<θ<247.5°; Anti-phase: 112.5°<θ<157.5° and 292.5°<θ<337.5°; Proximal phase: 337.5°<θ<22.5° e 157.5°<θ<202.5°; and Distal phase: 67.5°<θ<112.5° e 247.5°<θ<292.5°(R. Chang et al., 2008; Rinaldi et al., 2017; Van Emmerik et al., 2013). In-phase coordination is the positive diagonal (45° and 225°) when both segments move in the same direction, such as shoulder flexion (+) and head extension (+) (both the shoulder and head angulations increase or decrease in the coordinates y and x). Anti-phase coordination occurs when the movements have opposite direction, such as shoulder flexion (+) and head flexion (-), that is, an increase in the y coordinate and a decrease in the x coordinate). Proximal phase occurs when there is a predominance of shoulder flexion, that is, an angular increase only in the y coordinate. Finally, distal phase oocurs when the angular increase is only in the x coordinate, such as with the predominance of head flexion. The angular amplitude of one of the segments can be much bigger, what as the formula (1) can cause a predominance of this segment phase. In order to avoid this predominance of angular displacement of the shoulder, all angles were normalized by dividing by its maximum range, so they are now the same range, from -1 to 1.

3.2.4 Statistical analysis

Descriptive statistics of the variables were performed using mean and standard deviation of the mean, as well as the mean differences between the groups with 95% confidence intervals. The Mann-Whitney U test was used to verify the difference between groups on the MMS and AMS.

Data distribution was verified using the Shapiro-Wilk test. Levene's test was used to verify the homogeneity of variances ($P > .05$). The normality of the data was verified using the Shapiro-Wilk test; based on this test it was necessary to perform the square root of some kinematic variables to obtain the normality of the data. For the hand on ball task these were: scapular upward/downward rotation, and scapular anterior/posterior tilt; HBP: scapular internal/external rotation, scapular upward/downward rotation, elbow extension. For the hand to head task these were: head flexion, head right/left tilt) and coordination modes (head phase and in-phase) to SF-HF coupling angle and (shoulder phase and elbow phase) to SF-EF coupling angle.

One-way multivariate analysis of variance (MANOVA) was performed to compare (1) the discrete angles of the kinematic variables, and (2) the different coordination modes for both coupling angles to assess group (NBPP and UC) and speed condition effects (auto-selected velocity and fast velocity), as well as the interaction between group and condition. There was a group effect for some angular variables in the three reaching tasks. Thus, univariate analysis of variance (ANOVA) was performed to verify for which variables there were differences between groups. Two-factor repeated measures ANOVAs (group X velocity) were used to identify differences of velocities during the reach tasks. The effect size was calculated by dividing the difference between the group means by the pooled standard deviation of the two groups. The magnitude of effect size was classified as 0.2, 0.5, and 0.8 for small, moderate, and large effects, respectively (Cohen, 1988).

Statistical analyses were performed with *Statistical Package for the Social Sciences* (SPSS, version 20.0, USA).

3.3 Results

The NBPP group presented reduced scores of upper limb function on both MMS and AMS scales, compared to the UC group (Table 1).

In the hand on ball task (Table 2), there was a group effect in the kinematic variables (Wilks Lambda $F_{6,34}$=8.1 p<0.001). The NBPP group presented less shoulder flexion, less scapular internal rotation and greater scapular posterior tilt (F>10.4, p<0.01).

In the hand on the back pocket task (Table 3), there was a group effect in the kinematc variables (Wilks Lambda $F_{5,22}$=11.9 p<0.001). The shoulder extension, elbow flexion, scapular external rotation, and scapular anterior tilt were lower in the NBPP group when compared to UC group (F>5.65, p<0.02).

In the hand to head task (Table 4), there was a group effect in the kinematic variables (Wilks Lambda $F_{7,41}$=6.4 p<0.001. The NBPP group used greater scapular posterior tilt, greater head flexion and lower elbow flexion when compared to the UC group (F>7.8, p<0.01). There were no main velocity (F>0.1, p<0.96) and interaction effects between group and velocity condition (F>0.1 p<0.95) on all kinematic variables.

Table 1. Mean, standard deviation and median of the evaluation of upper limb function of children with obstetric brachial plexus (NBPP) n = 10 and unaffected control (n=13) through the by Active Movement Scale and Modified Mallet scale.

		NBPPG Mean (SD)	NBPPG Median	95% IC	UCG Mean (SD)	*p*	ES
Active Movement Scale	Shoulder flexion	6.0(1.0)	6.0	6.0-7.0	7.0(0.0)	≤ 0.001	1.4
	Shoulder Abduction	6.0(2.0)	6.0	6.0-7.0	7.0(0.0)	≤ 0.01	0.7
	Shoulder Adduction	6.0(1.0)	6.0	6.0-7.0	7.0(0.0)	< 0.001	1.4
	Internal Rotation	6.0(2.0)	6.0	5.0-7.0	7.0(0.0)	≤ 0.01	1.4
	External Rotation	5.0(2.0)	5.0	4.0-6.0	7.0(0.0)	≤ 0.001	0.7
	Elbow flexion	6.0(1.0)	6.0	6.0-7.0	7.0(0.0)	≤ 0.01	1.4
	Elbow Extension	6.0(2.0)	6.0	5.0-7.0	7.0(0.0)	≤ 0.01	0.7
	Forearm pronation	7.0(1.0)	7.0	6.0-7.0	7.0(0.0)	0.06	0.0
	Forearm Supination	6.0(1.0)	6.0	6.0-7.0	7.0(0.0)	≤ 0.001	1.4
	Wrist flexion	6.0(1.0)	6.0	6.0-7.0	7.0(0.0)	≤ 0.001	1.4
	Wrist extension	6.0(1.0)	6.0	6.0-7.0	7.0(0.0)	≤ 0.01	1.4
	Fingers flexion	7.0(0.0)	7.0	-	7.0(0.0)	1.0	0.0
	Fingers extension	7.0(1.0)	7.0	6.0-7.0	7.0(0.0)	0.30	0.0
	Thumb flexion	7.0(0.0)	7.0	-	7.0(0.0)	0.30	0.0
	Thumb extension	6.0(2.0)	7.0	5.0-7.0	7.0(0.0)	0.30	0.7
Modified Mallet scale	Global abduction	4.0(1.0)	4.0	4.0-5.0	5.0(0.0)	≤ 0.001	1.4
	Global external rotation	3.0(1.0)	3.0	2.0-4.0	5.0(0.0)	≤ 0.001	2.8
	Hand to neck	4.0(1.0)	4.0	3.0-4.0	5.0(0.0)	≤ 0.001	1.4
	Hand to spine	3.0(1.0)	3.0	2.0-4.0	5.0(0.0)	≤ 0.001	2.8
	Hand to mouth	4.0(1.0)	4.0	3.0-5.0	5.0(0.0)	≤ 0.001	1.4
	Internal rotation	4.0(1.0)	4.0	3.0-4.0	5.0(0.0)	≤ 0.001	1.4

NBPPG: neonatal brachial plexus palsy group; UCG: unaffected control group; SD: standard deviation; 95%CI: 95% Confidence interval. ES: effect size.

Table 2- Comparison of range of motion during the hand on ball task in different velocity execution between neonatal brachial plexus palsy group (n=13) and unaffected control group (n=13).

		NBPPG Mean (SD)	UCG Mean (SD)	Difference of mean (95% CI)	ES
Auto-selected Velocity	Scapular Internal rotation	4.22(15.72)	19.89(7.11)	15.68(5.96;25.40)	1.28
	Scapular upward rotation	30.63(19.55)	37.91(7.20)	7.28(-1.76;16.32)	0.51
	Scapular posterior tilt	15.80(9.79)	2.97(6.64)	-12.83(-19.51;-6.14)	-1.53
	Shoulder flexion	86.34(11.66)	95.82(9.90)	9.49(0.96;18.01)	0.88
	Elbow flexion	12.65(10.06)	8.74(13.59)	-3.90(-13.85;6.05)	-0.33
Fast Velocity	Scapular Internal rotation	5.75(15.72)	18.98(7.87)	13.23(3.52;22.95)	1.06
	Scapular upward rotation	35.92(5.40)	37.34(7.90)	1.41(-7.62;10.46)	0.21
	Scapular posterior tilt	15.93(10.18)	4.46(6.61)	-11.46(-18.15;-4.78)	-1.34
	Shoulder flexion	86.27(11.07)	95.82(10.01)	9.54(1.02;18.06)	0.90
	Elbow flexion	11.89(13.13)	10.27(13.36)	-1.61(-11.56;8.34)	-0.12

NBPPG: neonatal brachial plexus palsy group; UCG: unaffected control group; SD: standard deviation; 95%CI: 95% Confidence interval. ES: effect size.

Table 3- Comparison of range of motion during the hand on the back poket task in different velocity execution between neonatal brachial plexus palsy group (n=9) and unaffected control group (n=9).

		NBPPG Mean(SD)	**UCG Mean(SD)**	**Difference of mean (95% CI)**	**ES**
Auto-selected Velocity	Scapular external rotation	-4.86(3.84)	-9.81(2.25)	-4.94(-8.12;-1.77)	-1.31
	Scapular Upward rotation	-0.95(2.53)	0.45(2.74)	1.40(-1.02;3.82)	0.53
	Scapular anterior tilt	-6.81(3.35)	-8.64(2.51)	-1.83(-4.61;0.94)	-0.62
	Shoulder extension	-15.91(5.93)	-34.35(6.15)	-18.44(-24.31;-12.57)	-3.05
	Elbow flexion	9.01(11.24)	37.37(14.44)	28.35(16.14;40.57)	2.19
Fast Velocity	Scapular external rotation	-4.74(4.06)	-11.15(2.71)	-6.41(-9.58;-3.23)	-1.86
	Scapular Upward rotation	-0.89(2.37)	-0.18(2.42)	0.71(-1.71;3.13)	0.30
	Scapular anterior tilt	-7.00(3.02)	-9.65(2.60)	-2.65(-5.43;0.12)	-0.94
	Shoulder extension	-16.59(6.59)	-36.14(5.76)	-19.55(-25.42;-13.68)	-3.16
	Elbow flexion	9.65(10.93)	38.96(13.88)	29.31(17.09;41.52)	2.35

NBPPG: neonatal brachial plexus palsy group; UCG: unaffected control group; SD: standard deviation; 95%CI: 95% Confidence interval. ES: effect size.

Table 4- Comparison of range of motion during the hand on the head task in different velocity execution between neonatal brachial plexus palsy group (n=13) and unaffected control group (n=13).

		NBPPG Mean (SD)	UCG Mean (SD)	Difference of mean (95% CI)	ES
Auto-selected Velocity	Scapular external rotation	-8.14(15.29)	-2.71(7.66)	5.43(-3.58;14.41)	0.83
	Scapular Upward rotation	43.31(8.42)	41.26(7.51)	-2.05(-8.52;4.42)	-0.26
	Scapular posterior tilt	19.96(14.75)	11.41(6.30)	-8.55(-16.99;-0.11)	-0.75
	Shoulder flexion	110.69(28.77)	110.07(13.66)	-0.62(-17.64;16.39)	-0.03
	Elbow flexion	71.15(19.05)	83.34(13.05)	12.18(-1.06;25.43)	0.75
	Head flexion	-23.92(12.28)	-6.84(5.16)	17.07(9.24;24.90)	1.81
	Head tilt	11.04(6.54)	10.77(2.84)	-0.26(-4.62;4.09)	-0.05
Fast Velocity	Scapular external rotation	-6.18(13.81)	-1.29(5.92)	4.89(-4.09;13.87)	0.46
	Scapular Upward rotation	43.04(8.70)	40.15(8.14)	-2.90(-9.36;3.58)	-0.34
	Scapular posterior tilt	18.67(13.13)	10.35(5.34)	-8.32(-16.76;0.12)	-0.83
	Shoulder flexion	107.58(24.88)	108.76(15.11)	1.18(-15.83;18.20)	0.06
	Elbow flexion	72.29(21.66)	85.80(11.23)	13.50(0.26;26.75)	0.78
	Head flexion	-22.54(13.04)	-7.24(6.83)	15.29(7.46;23.12)	1.47
	Head tilt	10.25(7.63)	11.27(3.56)	1.02(-3.32;5.32)	0.17

NBPPG: neonatal brachial plexus palsy group; UCG: unaffected control group; SD: standard deviation; 95%CI: 95% Confidence interval. ES: effect size.

There was a group effect on the coordination modes of the shoulder-elbow coupling angle on the hand on ball task (Wilks Lambda $F_{4,45}$=4.0 p=0.007). The in-phase and anti-phase were different between the groups (F>5.2, p<0.03). The NBPP group had higher relative frequency for in-phase coordination and lower for the anti-phase mode when compared to the UC group (Table 5).

Table 5 - Comparison between neonatal brachial plexus palsy group (n=13) and unaffected control group (n=13) of the relative frequency of coordination modes obtained during the hand on ball task to the shoulder flexion-elbow flexion coupling angle.

		NBPPG Mean (SD)	**UCG Mean (SD)**	**Difference of mean (95% CI)**	**ES**
Auto-selected Velocity	In-phase	51.38(26.73)	38.85(20.68)	12.54(-6.75;31.83)	0.52
	Anti-phase	5.92(6.55)	22.31(10.37)	-16.38(7.40;25.36)	-1.89
	Shoulder phase	27.31(23.56)	19.00(10.50)	8.31(-4.93;21.55)	0.46
	Elbow phase	15.38(11.49)	19.85(15.92)	-4.46(-16.68;7.76)	-0.32
Fast Velocity	In-phase	56.69(24.37)	38.92(25.64)	17.76(-37.06;1.52)	0.71
	Anti-phase	11.38(14.44)	19.69(12.64)	-8.31(-17.28;0.67)	-0.61
	Shoulder phase	21.54(17.75)	15.00(12.13)	6.53(-6.70;19.78)	0.43
	Elbow phase	10.38(12.21)	18.69(20.64)	-8.31(-20.53;3.91)	-0.49

NBPPG: neonatal brachial plexus palsy group; UCG: unaffected control group; SD: standard deviation; 95%CI: 95% Confidence interval. ES: effect size.

In contrast, there was no group effect for the coordination modes of the shoulder-head coupling angle in the hand to head task (Wilks Lambda $F_{4,.45}$=1.2, p=0.29) (Table 6). For both tasks there were no main velocity (F>2.3, p<0.26) and interaction effects between group and velocity condition (F>1.3, p<0.53) for all modes of coordination.

Tabela 6 - Comparison between neonatal brachial plexus palsy group (n=13) and unaffected control group (n=13) of the relative frequency of coordination modes obtained during the hand on the head task to the shoulder flexion-head flexion coupling angle.

		NBPPG Mean (SD)	**UCG Mean (SD)**	**Difference of mean (95% CI)**	**ES**
Auto-selected Velocity	In-phase	12.08(7.14)	8.23(6.63)	3.85(-3.54;11.23)	0.56
	Anti-phase	39.15(22.89)	43.15(15.85)	-4.00(-19.59;11.59)	-0.20
	Shoulder phase	31.31(18.23)	33.08(15.42)	-1.77(-13.17;9.63)	-0.10
	Head phase	17.46(11.27)	15.54(10.03)	-1.92(-10.58;6.73)	0.18
Fast Velocity	In-phase	15.69(10.03)	11.08(12.46)	-4.61(-12.00;2.77)	0.41
	Anti-phase	47.69(19.72)	47.38(19.97)	0.31(-15.28;15.90)	0.02
	Shoulder phase	21.69(8.98)	22.23(13.61)	0.54(-10.87;11.94)	-0.05
	Head phase	14.92(13.28)	11.62(8.81)	3.31(-5.35;11.96)	0.29

NBPPG: neonatal brachial plexus palsy group; UCG: unaffected control group; SD: standard deviation; 95%CI: 95% Confidence interval. ES: effect size.

The self-selected velocity and the fast velocity were different within groups in the hand on ball ($F=28.3$, $p<0.001$) and hand to head tasks ($F=77.5$, $p<0.001$). In the hand to back pocket task there was no difference within groups ($F=3.9$ $p=0.06$). The NBPP group presented lower velocity than the UC group on the hand on ball task ($F=9.9$, $p<0.01$) and hand to head task ($F=7.3$, $p<0.05$) (Table 7).

Table 7 - Means, standard deviations (SD), confidence intervals (95% CI) and effect size of average speed of hand on the ball task, hand on the back pocket task and hand to head task of neonatal brachial plexus palsy group and unaffected control group

		NBPPG Mean (SD)	**UCG Mean (SD)**	**Difference of mean (95% CI)**	**ES**
Hand on ball	**Auto-selected Velocity**	49.34(22.64)	74.44(15.74)	-25.21(-40.99;-9.42)	1.29
	Fast Velocity	59.51(28.38)	90.09(23.72)	-30.57(-52.18;-8.96)	1.17
Hand on the back pocket	**Auto-selected Velocity**	6.02(4.74)	8.93(4.56)	-7.10(-7.10;1.29)	0.53
	Fast Velocity	6.91(4.72)	10.97(6.37)	-4.06(-9.28;1.15)	0.72
Hand to head	**Auto-selected Velocity**	61.46(24.11)	80.17(11.27)	-18.72(-33.96;-3.48)	0.99
	Fast Velocity	82.16(27.74)	105.14(15.45)	-22.98(-41.16;-4.80)	1.02

NBPPG: neonatal brachial plexus palsy group; UCG: unaffected control group; SD: standard deviation; 95%CI: 95% Confidence interval. ES: effect size

3.4. Discussion

The aim of this study was to investigate the upper limb function and intersegmental coordination in NBPP children and unaffected controls during reaching tasks at different execution speeds. The results of the study show that: The NBPP children presented lower ROM of the shoulder, wrist and elbow evaluated through AMS when compared the UC children, and showed reduction of ROM in all positions evaluated by the MMS. (reseach question 1); NBPP children used different scapulothoracic, shoulder, elbow and head kinematic movement patterns when compared to unaffected controls (reseach question 2); in the external reach task the NBPP group used different modes coordination when compared the UC group and in the hand to head task both groups used similar coordination to perform the movement (reseach question 3); And how fast children move the upper limb does not change their movement pattern or coordination strategies (reseach question 4).

4.1 Does NBPP affect the ROM at individual joints and segments of children's upper limb?

The NBPP children presented lower ROM of the shoulder, wrist and elbow evaluated through AMS when compared the UC children. The shoulder external rotation movement was more affected, since the ROM was less than 50% of the complete ROM against gravity. The forearm pronation, finger and thumb movements presented good functionality. Akel et al. (2013) also used the AMS to quantify the ROM of the upper limb and stratified the group with NBPP in total injury and upper trunk injury, and found that for both groups the upper limb ROM was reduced, however in the total injury group the scores were lower than upper trunk injury. Those children with total injury were excluded from the analysis, since they had severe restrictions in range of motion and did not reach the end point of the reaching tasks evaluated by kinematic analysis.

The NBPP children of the present study presented similar performance to NBPP teenagers (Squitieri, Larson, Chang, Yang, & Chung, 2013) when evaluated with the MMS. The NBPP group showed a reduction of ROM in all positions evaluated through the MMS, with larger effect size to perform the external rotation movement and the task hand to spine. The restriction of these movements was also observed by Holst et al. (2015). The shoulder external rotation movement is usually combined with some shoulder abduction/flexion in daily activities (Holst, Vliet, Meesters, & Bekkering, 2015). Russo et al. (2014) found that the restriction for shoulder extension is a limiting factor for the successful accomplishment of the task of hand to spine. The restriction of the range of motion of the glenohumeral joint results initially from nerve damage and abnormal muscle development, and results in altered motor planning and movement patterns (Gharbaoui, Gogola, Aaron, & Scott, 2015). The active range of movement is a composite that will determine overall functionality and thus quality of life of the child (Holst et al., 2015).

4.2 What scapula, shoulder, elbow and head kinematic patterns NBPP children use to perform reach task?

In reaching tasks, NBPP children used different scapulothoracic contributions when compared to unaffected controls, such as lower scapular internal and greater scapular posterior tilt (hand on ball), lower scapular anterior tilt and scapular external rotation (hand on the back pocket) and greater scapular posterior tilt (hand to head). Although the literature shows that NBPP children have different scapulothoracic contributions when compared to unaffected controls (Russo et al. 2014; Duff et al. 2007; Russo et al. 2015), these contributions are not described in reaching tasks. In addition to the different scapulothoracic contributions, we found that NBPP children use smaller shoulder range of motion to perform hand on ball and hand on the back pocket tasks when compared to unaffected controls. These children used lower elbow flexion in the hand on the back pocket and hand to head tasks, and presented compensatory patterns of head flexion in the hand to head task when compared to unaffected controls. These patterns of restriction of shoulder, elbow and greater head flexion had already been evidenced in the study by Mosqueda et al. 2004. However, the NBPP children in our study had less shoulder flexion than NBPP children of Mosqueda et al. (2004). The shoulder flexion range of motion and other joints of the upper limb are affected by the height of the target, thus, movements with similar relative height (head height) tend to present similar results in unaffected controls. In NBPP children this is not necessarily true, since the level of restriction caused by the nerve injury is dependent on the level and extent of the injury. Mosqueda et al. (2004) do not explain how the height of the high reach task was determined, and we speculate that the differences mentioned to accomplish the high reach task of hand on ball may be due to the difference in the relative distance that the hand shifted to accomplish the task.

In the hand on the back-pocket task, our NBPP children showed less elbow flexion than the NBPP children in the Mosqueda et al. (2004). In the present study, only the children who managed to reach the back pocket and had control of the movement were analyzed. This is different from Mosqueda et al. (2004) who also considered children who pushed the limb to approach the desired site, and the observed differences of range of motion may be related to this condition.

In the hand to head task were observed similar movement patterns compared to Mosqueda et al. (2004). The use of compensatory patterns with the head flexion during the hand to head task may be related to compensation due to the limited ROM of the shoulder observed by significative difference between unaffected controls during the task.

4.3 How is the intersegmental coordination affected in NBPP children?

When it was necessary to understand the orientation of the body and body location in relation to the environment, in the external reach task (touching a ball) the NBPP children and unaffected controls did not use the same coordination strategy. However. when it was necessary only to recognize the body posture and orientation, both groups of children used the same coordination strategy in the hand to head task.

The NBPP children showed different patterns of coordination between shoulder and elbow when they moved their hand to external reach task (touching a ball) compared to unaffected controls. The NBPP children presented predominance in more than 50% of the task using the in-phase mode, when the shoulder and elbow move in the same direction, in flexion, and used antiphase coordination less frequently when compared to unaffected controls. In anti-phase coordination, the direction of movement of the joints is opposite, shoulder flexion with elbow extension, which is more common in typical children. In this way, NBPP children choose the coordination strategy that allows for a maximum reach within their limitations. This is necessary because these children showed lower range of motion of shoulder flexion to reach the ball. Therefore, to compensate for the lower range of motion, NBPP children need to spend most of the task using in-phase coordination. However, the predominance of in-phase coordination is detrimental with respect to task accuracy and reduces the range of the reach.

The motor coordination pattern of head and shoulder movements was the same in moving the hand to the head in NBPP children compared to unaffected controls. In about 40% of the total movement time, children from both groups moved the head and shoulder in opposite directions (anti-phase coordination), while in about 30% of the total time, they only moved the shoulder. This suggests that the strategy of reaching the head with the hand involves parallel coordination of the movements of the head and the shoulder and the isolated movement of the shoulder. Moving the shoulder to bring the hand to the head was facilitated in the NBPP group by the greater flexion of the head. In this way, the choice of coordination strategy may be influenced by reference systems used to move the body in space. In addition, when we observe the amplitudes of movement between the shoulder and head segments, there is a difference between groups. However, the range normalization resulted in that less head flexions performed by unaffected controls were classified in the same coordination mode as NBPP children. An adaptation of the vector coding analysis is required for upper limb tasks that present different ranges of motion.

4.4 Does increasing speed influence the strategy of movement and coordination during reaching tasks?

In all reaching tasks evaluated the kinematic patterns did not change when the task was done as quickly as possible compared to the self-selected speed. In addition, coordination strategies for performing reach tasks did not change when speed was altered. These results suggest that the basic kinematic features of the movement and the coordination are stable when it is necessary move the hand at different speeds.

The UCG was faster than UC group to perform the hand on ball and hand to head task. Children with NBPP have the perception that limited range of motion and reduced strength affects their performance of certain movements in sports or school activities (K. W. Chang et al., 2017; Kirjavainen, Remes, Peltonen, Helenius, & Po, 1998; Sarac et al., 2015). These children related difficulties to perform the movement putting their arm above their head or they find it hard to reach for something (Sarac et al., 2015). The speed difference between groups is possibly related to these difficulties and limited range of movement.

The coordination strategies of external reach task (touching a ball) and hand to head task were similar for both speeds. This result suggests that coordination strategy might remain invariant across different movement speeds for both NBPP and unaffected children. The invariance is a basic principle from dynamical system theory, the stable coordination patterns are called attractors (Van Emmerik et al., 2013). These stable states are revealed by stability of atractor coordination modes in the reach task independent of execution speed.

4.5 Implications for clinical practice and limitation

Our results have implications for clinical practice. The NBPP children presented different coordination in the task in which the target was in the external environment when compared to controls. The therapist should include reaching tasks that require this. In this way, tasks such as placing a ball in a basketball hamper, reaching a ball or other objects in a lower place and placing them on a shelf with height above the head. Futhermore, encouraging the parents of the child with NBPP to perform movements in the fullest range of motion as early as possible would be beneficial. Emphasizing the use of the affected limb by children in reaching tasks can aid in maintaining muscle balance, preventing joint contractures, possibly avoiding permanent secondary musculoskeletal abnormalities and use of different coordination strategies.

One limitation of the current study was the small sample size, since it does not allow the generalization of the results. Therefore, similar studies with larger samples are needed in the future.

3.5 Conclusion

We conclude that the NBPP children presented lower ROM of the shoulder, wrist and elbow when compared to unaffected controls. The NBPP children and controls used different scapulothoracic, shoulder, elbow and head kinematic movement patterns. The coordination of NBPP children was different compared to unaffected controls when performing arm movements in the external environment (hand on ball task), and presented similar coordination when movements were made to their own body, as in the hand to head task in which it was only necessary to recognize the orientation of the body. The velocity variation did not change the kinematic patterns and coordination strategies of the children.

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{Bibliography

4 STUDY 3

Article 3 - In preparation

Movement patterns and intersegmental coordination of children with neonatal brachial plexus palsy during movement of arm elevation and lowering

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Running Title: intersegmental coordination of NBPP children

Abstract

The aim of this study was to compare the motor patterns and intersegmental coordination of scapula and humerus in neonatal brachial plexus palsy (NBPP) children and matched controls during arm elevation and lowering in the frontal plane. Ten children with neonatal brachial plexus palsy (6 had upper Erb's palsy and 4 had extended Erb's palsy) and 10 unaffected controls were evaluated. Discrete angles were analyzed and coordination analysis using vector coding was applied to assess coupling between scapula and shoulder during the task. The statistical comparison of discrete angles of scapula during elevation and lowering of the arm does not show evidence of difference between groups. However, the coordination strategy of scapula protraction during the arm lowering was different. In the NBPP group, there was greater use of the antiphase coordination mode, as the lowering of the arm occurs, the protraction movement of the scapula is reduced, different from the coordination strategy used by the unaffected controls that the protraction of the scapula increases. We conclude that NBPP children present similar scapular motor patterns to execute the arm elevation and lowering in the frontal plane, but the coordination strategy of scapula protraction during the lowering arm was different between the groups.

Keywords: shoulder, scapula, kinematics, abduction, biomechanics

4.1 Introduction

Traditional methods in biomechanics focus on the analysis of discrete motion variables or linear relations in the times series of the system, since the dynamic system approach, evaluates behavior over the entire time series[1]. Although assessment of discrete scapular angles (position at a specific point in time) during humerus elevation allows to describe in the motion, this approach is considered failure to not cover more movement characteristics, such as the coordination between two segments throughout the movement[2]. The analysis of the movement from the dynamic systems approach instead, provides a comprehensive study of the movement coordination[2].

The movement of the humerus is possible due to coordination between the scapulothoracic and glenohumeral joints that are anatomically and biomechanically involved[3,4]. One way to assess changes in coordination or segment coupling of two anatomical structures is relative motion and can be quantified by the coupling angle using vector coding analysis[5]. This analysis has been used during walking [6] and in walking and grasping tasks [7]. We propose to evaluate intersegmental coordination between scapula and shoulder during elevation and lowering of the arm in the frontal plane in neonatal brachial plexus palsy (NBPP)[5–7].

The arm Abduction/flexion movements combined with others, such as arm external rotation, are often used in activities of daily living[8]. Children with NBPP may to present a restriction of the upper limb range of motion, weakness of the deltoid muscles and shoulder external rotators, and they often develop deformities in shoulder internal rotation, shoulder adduction[9,10], and dysplasia of the glenohumeral joint[11]. In this condition, these children present restrictions to perform reaching tasks[12,13]. Each lesion has its peculiarities due to the extension of the lesion and the variety of possibilities of injury of the elements of the brachial plexus (roots, trunks, subdivisions)[14].

Accordingly, previous kinematic studies of children with NBPP using the analysis of discrete motion variables demonstrated a less of active shoulder motion in the impaired limb[12], different contributions of scapulothoracic and glenohumeral joint in the impaired limb when compared to the non-affected limb[15–17] and unaffected controls[18,19]. Recently, Mayfield et al. analyzed the coordination of NBPP children and adolescents during reach-to-grasp task by analyzes that consider the entire time series (Arm Profile Score and Multi-joint Coordination) and found changes in the movement coordination of scapula, wrist and glenohumeral plane of elevation joint trajectories. However, in the Mayfield et al. study the target was placed on a table at elbow height, so it was not necessary to raise the arm to perform the task, thus were included the participants with ability to flex and abduct the impaired arm at least 30°.

Given the impairments imposed to NBPP and the different approaches of kinematic analysis, it is important to know the patterns of movements and coordination between scapula and shoulder in NBPP in task that require greater range of motion of the shoulder with different perspective of analysis.

The purpose of this study was to compare the movement patterns and intersegmental coordination of scapula and humerus in NBPP children and matched controls during elevation and lowering of the arm. The hypothesis of this study is that NBPP children will present similar shoulder complex kinematic to controls not affected, because in this study, the NBPP children had at least 90 degrees of arm elevation. However, it is believed that different strategies of coordination between groups will be used.

4.2 Methods

4.2.1 Participants

This was a cross-sectional, comparative, and descriptive study. Parents or guardians of the children were informed about the study objective and procedures and provided signed written informed consent. The children also signed the assent agreement terms approved by the local Ethics Research Committee (protocol 16172/2015).

For this study, the children were classified into two groups based on their condition: the NBPP group and the unaffected control (UC) group. The NBPP group comprised of 10 children and the UC group included ten healthy children matched for sex and age.

The inclusion criteria for the NBPP group were a diagnosis of NBPP and age between 5 and 14 years. The exclusion criteria were bilateral plexus lesion, difficulty in communicating with the evaluator, auditory and visual disorders, present complete recovery and present glenohumeral joint range of motion (ROM) less than 90 degrees during arm elevation detected by the 3D Liberty tracking system (Polhemus. Inc, Colchester, VT).

Nineteen NBPP children were excluded 14 because they did not reach the minimum required ROM and 5 because they had a complete recovery from the injury.

The upper limb function was evaluated through Modified Mallet Scale (MMS) and Active Movement Scale (AMS). For MMS, children were asked to perform the following movements: global abduction, external and internal rotation; hand to neck, hand to spine, and hand to mouth movements. Each movement was classified from 1 (no movement) to 5 (ROM symmetrical to the unaffected side), with a maximum total of 25. Lower scores (5) indicate more limited range of motion.[20]

The performance of following upper limb movements was assessed using AMS: flexion, abduction, adduction, internal and external rotation of the shoulder, elbow flexion and extension, forearm pronation and supination, wrist flexion and extension, finger flexion and extension, thumb flexion and extension.[21] This scale evaluated movements without the influence of gravity on a scale ranging from 0 (no muscle contraction) to 4 (complete and/or full movement without gravity), as well as movements against gravity; 5 (ROM < 50%, 6 (ROM > 50%), and 7 (ROM completely against gravity), with a maximum total of 105. [21] The UCG presented full active ROM and perfect function of upper limb, these children will hit the maximum scores.

4.2.2 Procediments

Medical history form was used to collect information regarding the child's age, anthropometric measurements (height and body mass), and all data related to the exclusion criteria. Body mass was measured using a digital scale (Filizola, accurate to within 100 g), and height with a stadiometer (precise to within 1 mm).

The motion analysis was done with *The Motion Monitor (Chicago, MI, EUA),* which is a biomechanical interface program and the 3D tracking system *Liberty* (*Polhemus. Inc, Colchester, VT*). This electromagnetic device has a root mean square accuracy of 0.076 cm for sensor position and 0.15 for sensor orientation. The transmitter was fixed 110 cm above the floor and emitted an electromagnetic signal to the sensors attached to the participant. The sensors were attached to the sternum, to the flat surface of the acromion process, just below the insertion of the deltoid muscle, which was fixed with adhesive tape. Another sensor was attached to a pointer to manually digitize the bony landmarks to create local coordinate systems on the thorax (suprasternal notch, xiphoid process, spinal processes of C7 and T8), scapula (acromial angle, the root of the spine, inferior angle), humerus (medial and lateral epicondyle)[22].

Before the beginning of the data collection, the movement was shown, and the experience of the movement was propitiated for familiarization with the procedure. Three attempts were made during the arm elevation and lowering in the frontal plane. Typical children performed tasks with dominant limb and children with POPB with the compromised limb.

4.2.3 Data processing

The three-dimensional coordinates were preprocessed and exported by the program *The MotionMonitor (Innsport Inc.)*. For the scapulothoracic movement (protraction/retraction, anterior/posterior tilt and lateral/medial rotation) was used the YX’Z’’ sequence[22] and for the glenohumeral (plane of elevation, axial rotation, and elevation) was used the XZ’Y’’ sequence[23]. The Butterworth low-pass filter of the fourth order, with cutoff frequency at 6 Hz and zero-shift was used to attenuate noise. All the data were segmented for values between 30 and 90 degrees and reduced for 30, 60 and 90 of the glenohumeral plane of elevation for vector coding analysis and discrete analysis respectively. It was done for arm elevation and lowering in both analyses.

The following scapular variables were analyzed: protraction/retraction, lateral/medial rotation and anterior/posterior tilt.

We performed the coding analysis of the vector of the coupling angles: glenohumeral elevation-scapular protraction/retraction (GE-SPR), lowering glenohumeral - scapular protraction/retraction (GL-SPR), glenohumeral elevation - scapular anterior/posterior tilt (GE-APT), lowering glenohumeral-scapular anterior/posterior tilt (GL-APT), glenohumeral elevation – scapular lateral/medial rotation (GE-LMR), lowering glenohumeral - scapular lateral/medial rotation (GL-LMR)[5]. This analysis provides information on the coordination between two segments. The x-axis comprises the proximal segment, in this example, the angular displacement of the scapula during the arm elevation in the frontal plane. The angular values of the movement of the head and the humerus are projected on a graph; each point has an x and y coordinate. A coupling angle is the angle of the vector formed between two adjacent data points relative to the right horizontal (Figure 1). The coupling angle (θ) was calculated during the whole movement, using the slope defined by the pair of variables X and Y in relation to the horizontal, according to equation 1.

$$\theta = \tan^{-1}\left(\frac{Y_{i+1} - Y_i}{X_{i+1} - X_i}\right) \tag{2}$$

Where tan-1 is the inverse tangent of the vertical variation of segment X relative to the horizontal variation of segment Y.

Angular results have polar distribution (0-360°) and are divided into four sectors that correspond to the four coordination modes. In-phase: $22.5^\circ<\theta<67.5^\circ$ e $202.5^\circ<\theta<247.5^\circ$; Anti-phase: $112.5^\circ<\theta<157.5^\circ$ and $292.5^\circ<\theta<337.5^\circ$; Proximal phase: $337.5^\circ<\theta<22.5^\circ$ e $157.5^\circ<\theta<202.5^\circ$; and Distal phase: $67.5^\circ<\theta<112.5^\circ$ e $247.5^\circ<\theta<292.5^\circ$[5–7]. In-phase coordination is the positive diagonal (45° and 225°) when both segments move in the same direction, such as shoulder abduction (+) and scapula posterior tilt (+) (both the shoulder and scapula angulations increase or decrease in the coordinates y and x). Anti-phase coordination occurs when the movements have opposite direction, such as shoulder abduction (+) and scapula anterior tilt (-), that is, an increase in the y coordinate and a decrease in the x coordinate). Proximal phase occurs when there is a predominance of shoulder abduction, that is, an angular increase only in the y coordinate. Finally, distal phase occurs when the angular increase is only in the x coordinate, such as with the predominance of scapula posterior tilt. The angular amplitude of one of the segments can be much bigger, what as the formula (1) can cause a predominance of this segment phase. In order to avoid this predominance of angular displacement of the shoulder, the scapula angles were normalized by dividing by its maximum range, so they are now the same range, from -1 to 1.

4.2.4 Statistical analysis

Descriptive statistics of the variables were performed using mean, the standard deviation of the mean, as well as the mean differences between the groups with 95% confidence intervals and standard error to discrete data.

The normality of the data was verified using the Shapiro-Wilk test. The ANOVA two way mixed linear model was performed for the scapula movements (protraction/retraction, anterior/posterior tilt and lateral/medial rotation) to verify the group effect (UC and NBPP group) and humeral degrees during elevation (30, 60 and 90) and lowering (90, 60 and 30) of the arm in the frontal plane.

The coordination modes did not present normal distribution of the data; the Mann-Whitney U test was used to verify the difference between the groups in coordination modes in the coupling angles (GE-SPR, GL-SPR, GE-APT, GL-APT, GE-LMR, GL-LMR).

The magnitude of effect size was classified as 0.2, 0.5, and 0.8 for small, moderate, and large effects, respectively[24].

Statistical analyses were performed with Statistical Package for the Social Sciences (SPSS, version 20.0, USA).

4.3 Results

The characterization of the sample is showed in the Table 1.

Table 1. Characteristics of 10 children with Neonatal brachial plexus palsy (NBPP) and a summary of unaffected control group (UCG).

Subject number	Age (Years)	Sex	Diagnosis	Mallet Score	AMS
NBPP 1	8	F	Erb's	21	95
NBPP 2	8	F	Erb's	26	100
NBPP 3	12	F	Erb's	22	100
NBPP 4	12	F	Erb's	30	105
NBPP 5	14	F	Erb's	23	99
NBPP 6	10	F	Erb's	22	-
NBPP 7	14	M	Extended	20	97
NBPP 8	9	M	Extended	21	94
NBPP 9	10	F	Extended	23	97
NBPP10	7	F	Extended	17	79
NBPPG	10±4	8F, 2M	-	22.5±3.5	86.6±31.2
UCG	10±4	8F, 2M	-	25	105

AMS: Active Movement Scale, F: female, M: male.

No difference was found between the groups for the scapular protraction/retraction (F = 0.95 p = 0.34) during arm elevation and lowering (Figure 1). There was no difference between groups for scapular anterior/posterior tilt (F=0.45 p=0.51) and (F=1.80 p=0.19) (Figure 2) and lateral/medial rotation of the scapula (F=2.57 p= 0.13) and (F=1.05 p=0.32) (Figure 3) during arm elevation and lowering, respectively. There was the effect of glenohumeral angulation for the scapular anterior tilt/posterior (F=11.63 p=0.003) and (F=29.49 p<0.001) and lateral/medial rotation of the scapula (F 441.93 p<0.001) and (F=407.14 p<0.001) during arm elevation and lowering the arm, respectively. The scapular anterior/posterior tilt, lateral/medial rotation of the scapula was different between angles 30 and 60, 30 and 90, and 60 and 90 (p <0.05) during elevation and lowering of the arm.

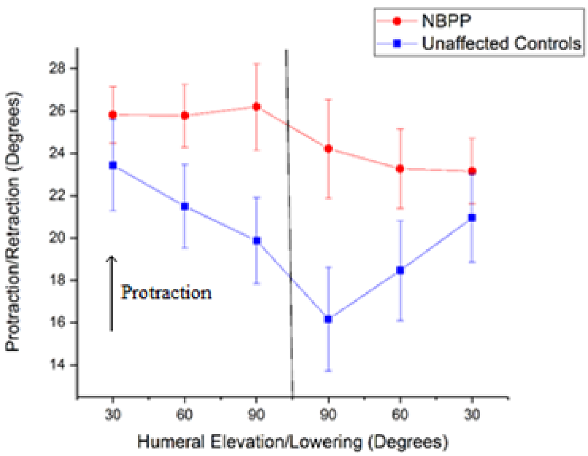

Figure 1. The mean and standard error of scapular protraction during arm elevation and lowering in the frontal plane of children with neonatal brachial plexus palsy (NBPP) (n = 10) and unaffected controls (n = 10).

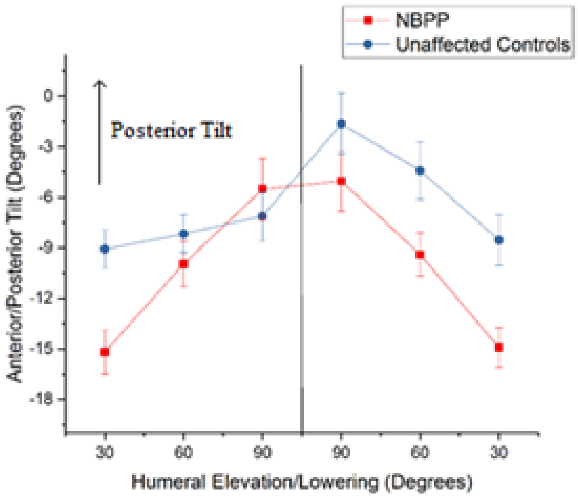

Figure 2. The mean and standard error of scapular anterior/posterior tilt during arm elevation and lowering in the frontal plane of children with neonatal brachial plexus palsy (NBPP) (n = 10) and unaffected controls (n = 10).

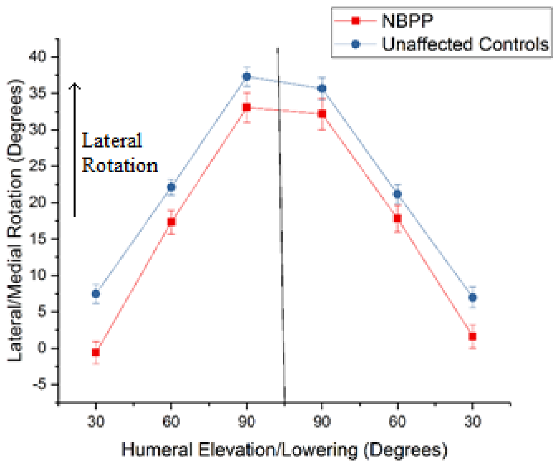

Figure 3. The mean and standard error of lateral/medial rotation of the scapula during arm elevation and lowering in the frontal plane of children with neonatal brachial plexus palsy (NBPP) (n = 10) and unaffected controls (n = 10).

There was a difference between the groups for coordination modes of phase and antiphase in scapular protraction in the lowering of the arm (Table 1). In addition, there were differences in the coordination modes of phase and glenohumeral phase in scapular anterior tilt during the elevation of the arm (Table 2). There was no difference in the coordination of the lateral rotation of the scapula (Table 3).

Table 1 - Comparison between neonatal brachial plexus palsy group (n=10) and unaffected control group (n=10) of the relative frequency of coordination modes obtained during the arm elevation and lowering in the frontal plane to glenohumeral elevation -scapular protraction, lowering glenohumeral - scapular protraction coupling angle.

		NBPPG Mean (SD)	**UCG Mean (SD)**	**Difference of mean (95% CI)**	**p**	**ES**
Elevation	In-phase	44.17(38.32)	52.60(34.57)	-8.43(-27.29;10.42)	0.24	-0.23
	Anti-phase	28.70(32.16)	26.47(30.02)	-2.23(-13.84;18.31)	0.82	0.07
	Shoulder phase	18.50(12.45)	12.47(8.82)	6.03(0.46;11.61)	0.06	0.56
	Scapula phase	8.63(10.48)	8.47(10.57)	0.16(-5.27;5.60)	0.93	0.02
Lowering	In-phase	38.13(39.94)	64.73(31.85)	-26.60(-45.27;-7.93)	0.01	-0.74
	Anti-phase	40.00(28.46)	16.50(27.05)	23.50(6.32;40.68)	0.02	1.11
	Shoulder phase	14.20(13.94)	12.33(10.21)	1.86(-4.48;8.18)	0.78	0.15
	Scapula phase	7.67(12.35)	6.43(11.70)	1.23(-4.98;7.45)	0.54	0.10

NBPPG: neonatal brachial plexus palsy group; UCG: unaffected control group; SD: standard deviation; 95%CI: 95% Confidence interval. ES: effect size.

Table 2 - Comparison between neonatal brachial plexus palsy group (n=10) and unaffected control group (n=10) of the relative frequency of coordination modes obtained during the arm elevation and lowering in the frontal plane to glenohumeral elevation -scapular anterior tilt, lowering glenohumeral - scapular anterior tilt coupling angle.

		NBPPG Mean (SD)	**UCG Mean (SD)**	**Difference of mean (95% CI)**	**p**	**ES**
Elevation	In-phase	79.20(36.34)	58.50(43.64)	20.70(-0.05;51.46)	0.02	0.52
	Anti-phase	13.73(29.91)	27.57(38.55)	-13.83(-31.67;4.00)	0.21	-0.40
	Shoulder phase	4.27(8.86)	10.63(12.04)	-6.37(-11.83;-0.90)	0.02	-0.60
	Scapula phase	7.88(2.80)	3.30(6.55)	0.50(-3.25;4.25)	0.40	0.91
Lowering	In-phase	77.10(36.88)	58.50(43.64)	18.60(-2.28;39.48)	0.06	0.46
	Anti-phase	11.57(25.42)	27.57(38.55)	-16.00(-32.88;0.88)	0.15	-0.49
	Shoulder phase	6.63(10.45)	10.63(12.04)	-4.00(-9.82;1.82)	0.16	-0.35
	Scapula Phase	4.70(11.35)	3.30(6.55)	1.40(-6.19;3.39)	0.40	0.15

NBPPG: neonatal brachial plexus palsy group; UCG: unaffected control group; SD: standard deviation; 95%CI: 95% Confidence interval. ES: effect size.

Table 3 - Comparison between neonatal brachial plexus palsy group (n=10) and unaffected control group (n=10) of the relative frequency of coordination modes obtained during the arm elevation and lowering in the frontal plane to glenohumeral elevation -scapular lateral rotation, lowering glenohumeral - lateral rotation coupling angle.

		NBPPG Mean (SD)	**UCG Mean (SD)**	**Difference of mean (95% CI)**	**p**	**ES**
Elevation	In-phase	99,63(1,32)	99,67(1,82)	-0,03(-0,86;0,79)	0,18	-0,03
	Anti-phase	0,00(0,00)	0,00(0,00)	-	1,0	-
	Shoulder phase	0,37(1,33)	0,00(0,00)	0,36(-0,85;0,11)	0,06	0,39
	Scapula phase	0,00(0,00)	0,33(1,83)	-0,33(-1,00;0,33)	0,31	-0.26
Lowering	In-phase	98,00(8,58)	99,67(1,83)	-1,67(-4,87;1,54)	0,09	-0,27
	Anti-phase	0,03(0,18)	0,00(0,00)	0,03(-0,03;0,10)	0,31	0,24
	Shoulder phase	0,43(2,37)	0,00(0,00)	0,43(-0,43;1,30)	0,32	0,26
	Scapula phase	1,53(6,06)	0,33(1,83)	1,20(-1,11;3,51)	0,09	0,27

NBPPG: neonatal brachial plexus palsy group; UCG: unaffected control group; SD: standard deviation; 95%CI: 95% Confidence interval. ES: effect size.

4.4 Discussion

This study aimed to compare the movement patterns and intersegmental coordination of scapula and humerus in NBPP children and matched controls during elevation and lowering of the arm.

The statistical comparison of discrete angles of scapula during elevation and lowering of the arm does not show evidence of difference between groups. However, the coordination between the scapular and glenohumeral movements analyzed through the vector coding analysis are different between the groups, agreeing with the initial hypothesis. Although the NBPP group present similar ROM to execute the same movement, the coordination strategy used is different. Duff et al. 2007 verified that NBPP children with arm elevation ROM greater than 75° present glenohumeral and scapulothoracic contribution similar to typical children evaluated in the study of Dayanidhi et al. 2005. Furthermore, Herisson et al. 2017 did not observe differences in the kinematics patterns of the scapula during elevation of the arm between the injury limb and non-involved limb, both studies supported the initial hypothesis. The activities of daily living depend on concurrent movement of many joints, thus, kinematic methods that take into account multiple joint angles in their analysis may have greater clinical utility[26].

The coordination pattern of protraction movement during the lowering arm is different between the groups. In the NBPP group, there was greater use of the antiphase coordination mode, as the lowering of the arm occurs, the protraction movement of the scapula is reduced, different from the coordination strategy used by the unaffected controls that the protraction of the scapula increases. In the analysis of the discrete angles, it was observed that the NBPP group showed greater protraction of the scapula throughout the ROM and less variation of the ROM compared to other movements of the scapula, however, this difference was not significant. This lower variability of ROM may be related to neurological pathology or orthopedic injury [27]. The greater contribution of serratus anterior could explain this coordination strategy in the NBPP children as a result of brachial plexus injury[17]. Due to injury, NBPP children may show a predominance of the anterior serratus in relation to the trapezius in the arm lowering. Herisson et al. 2017 observed greater scapulothoracic protraction/glenohumeral elevation ratio in the injured limb of NBPP children during the elevation arm in the scapular plane.

The coordination between scapula posterior tilt and arm elevation was different than expected for unaffected controls, there was a lot of variation of the data, which may be justified by the moderate effect size. A greater scapula posterior tilt was expected during arm elevation as observed in the Habechian et al. 2014 study comparing healthy children and adults during arm elevation. The NBPP group presented a higher glenohumeral phase coordination mode when compared to the unaffected controls, which can be explained by the tendency of the controls to maintain the same scapula posterior tilt ROM during arm elevation. On the other hand, the NBPP group presented a predominance of phase coordination mode compared to unaffected controls during arm elevation. This mode of coordination indicates that as the shoulder angulation has increased, the posterior tilt inclination of the scapula also increased throughout the movement, which was expected for unaffected controls.

The lateral rotation movement of the scapula was the most consistent and with greater variation of the ROM during the elevation and lowering of the arm in both groups. Although the unaffected controls show a tendency to do more lateral rotation throughout the ROM, this difference was not significant between the groups and there was no difference in the coordination strategy used. Lempereur et al. 2012 observed similar pattern of lateral rotation of the scapula to the present study, both in typical children as well as in children with cerebral palsy.

In the present study we limited the analysis to 90 degrees, since most of the NBPP children not exceed this ROM. Russo et al. 2015 observed that NBPP children present scapular dyskinesis, and this is an adaptation to compensate for the reduced movement of glenohumeral. Infraspinatus and lower round muscle contraction as well as posterior compression of the joint capsule of NBPP children may limit glenohumeral ability to perform shoulder movement[30]. However, scapular dyskinesis was not assessed in the present study.

One limitation of the current study was the small sample size, since it does not allow the generalization of the results. There is still the difficulty of recruiting homogenous samples of larger size due variety of nerves injuries which is a potentially confounding factor. The NBPP is a relatively rare condition, the most children were excluded because presented severe limitation of shoulder abduction ROM.

We conclude that NBPP children present similar scapular movement patterns to execute the arm elevation and lowering in the frontal plane, but the coordination strategy of scapula protraction movement during the lowering arm was different between the groups.

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5 Concluding Remarks

Taking our results together, we can conclude that the NBPP children presented a lower function of the shoulder, elbow, and wrist when compared to unaffected controls. These children presented good functionality of the forearm pronation, finger and thumb movements. The Parents consider NBPP has a negative influence on the QOL of their children, mainly concerning upper limb function, overall health, basic mobility, physical function, happiness, pain, behaviour, mental health, and the emotional impact on their parents, as well as psychosocial summary score.

The scapulothoracic, shoulder, elbow and head kinematic movement patterns were different between the groups in the reaching task, and similar to execute the arm elevation and lowering in the frontal plane. In hand on ball task, the NBPP children presented less shoulder flexion, less scapular internal rotation and greater scapular posterior tilt. In hand on the back-pocket task, the NBPP children used lower shoulder extension, elbow flexion, scapular external rotation, and scapular anterior tilt. In the hand to head task, the NBPP group used greater scapular posterior tilt, greater head flexion, and lower elbow flexion when compared to the UC group.

Although the NBPP presented different movement patterns when compared the UC in the all reaching tasks evaluated, the coordination of NBPP children was different when performing arm movements in the external environment (hand on ball task). The UC children presented predominance in more than 50% of the task using the in-phase mode, when the shoulder and elbow move in the same direction, in flexion, and used lower relative frequency of the anti-phase mode when compared to UC. In anti-phase coordination, the direction of movement of the joints is opposite, shoulder flexion with elbow extension, which was more common in UC. The coordination strategy of scapula protraction movement during the lowering arm was different between the groups. There was more significant use of the antiphase coordination mode, as the lowering of the arm occurs, the protraction movement of the scapula is reduced, different from the coordination strategy used by the UC that the protraction of the scapula increases.

Future studies are encouraged to be performed with a larger sample and with subdivision by types of injury.

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ATTACHMENTS

ATTACHMENT A – Ethics committee approval

HOSPITAL DAS CLÍNICAS DA FACULDADE DE MEDICINA
DE RIBEIRÃO PRETO DA UNIVERSIDADE DE SÃO PAULO

HC FMRP-USP RIBEIRÃO PRETO

Ribeirão Preto, 02 de março de 2016

Ofício nº 708/2016
CEP/MGV

Prezadas Senhoras,

O trabalho intitulado **"CONTRIBUIÇÕES ARTICULARES DO COMPLEXO DO OMBRO E COLUNA CERVICAL DE CRIANÇAS COM PARALISIA OBSTÉTRICA DO PLEXO BRAQUIAL DURANTE TAREFAS DE ALCANCE" – versão 2, de 10/12/2015,** foi analisado pelo Comitê de Ética em Pesquisa em sua 422ª Reunião Ordinária, realizada em 29/02/2016 e enquadrado na categoria: **APROVADO,** bem como o **Termo de Consentimento Livre e Esclarecido – Grupo POPB - versão 2, de 10/12/2015, o Termo de Consentimento Livre e Esclarecido – Controle - versão 2, de 10/12/2015, o Termo de Consentimento Livre e Esclarecido/Assentimento – Grupo POPB – versão 3, de 15/02/2016 e o Termo de Consentimento Livre e Esclarecido/Assentimento – Grupo Controle- versão 3, de 15/02/2016,** de acordo com o Processo HCRP nº 16172/2015.

De acordo com Carta Circular nº 003/2011/CONEP/CNS, datada de 21/03/2011, o sujeito de pesquisa ou seu representante, quando for o caso, deverá rubricar todas as folhas do Termo de Consentimento Livre e Esclarecido – TCLE – apondo sua assinatura na última do referido Termo; o pesquisador responsável deverá da mesma forma, rubricar todas as folhas do Termo de Consentimento Livre e Esclarecido – TCLE – apondo sua assinatura na última página do referido Termo.

Este Comitê segue integralmente a Conferência Internacional de Harmonização de Boas Práticas Clínicas (IGH-GCP), bem como a Resolução nº 466/12 CNS/MS.

Lembramos que devem ser apresentados a este CEP, o Relatório Parcial e o Relatório Final da pesquisa.

Atenciosamente.

Marcia Villanova

DRª. MARCIA GUIMARÃES VILLANOVA
Coordenadora do Comitê de Ética em
Pesquisa do HCRP e da FMRP-USP

Ilustríssimas Senhoras
DAIANE LAZZERI DE MEDEIROS
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ATTACHMENT B- Child Health Questionnaire

CHILD HEALTH QUESTIONNAIRE (CHQ-PF28)

QUESTIONÁRIO DE SAÚDE DA CRIANÇA - RELATÓRIO DOS PAIS

PARENT FORM – 28 PORTUGUESE (BRASIL)

DATA DE HOJE

☐☐☐☐☐☐☐☐☐☐☐☐   ☐☐ / ☐☐ / ☐☐

NÚMERO DE IDENTIFICAÇÃO   DIA   MÊS   ANO

INSTRUÇÕES: As questões que se seguem referem-se à saúde e bem estar do seu/sua filho(a). As suas respostas serão tratadas de forma confidencial. Não há respostas certas ou erradas. Se não tem a certeza de como responder a uma questão, dê a melhor resposta que puder. É muito importante que responda a cada questão. Por favor use caneta de cor azul ou preta.

Marcação correcta: ■ ☒ ☑ ⊟

SEÇÃO 1: A SAÚDE GLOBAL DE SEU/SUA FILHO(A)

		Excelente	Muito Boa	Boa	Razoável	Má
1.1	Em geral, você diria que a saúde de seu/sua filho(a) é:	☐	☐	☐	☐	☐

SEÇÃO 2: ATIVIDADES FÍSICAS DE SEU/SUA FILHO(A)

As perguntas seguintes indagam sobre as atividades físicas que seu/sua filho(a) poderia fazer durante um dia.

2.1	Durante as últimas 4 semanas, seu/sua filho(a) ficou limitado(a) em qualquer uma das atividades seguintes devido a problemas de saúde?	Sim, muito limitado(a)	Sim, um tanto limitado(a)	Sim, um pouco limitado(a)	Não, não limitado(a)
	a. Fazer coisas que requerem muita energia, como jogar futebol ou correr?	☐	☐	☐	☐
	b. Fazer coisas que requerem alguma energia, como andar de bicicleta ou de patins?	☐	☐	☐	☐
	c. Dobrar-se, levantar-se ou debruçar-se?	☐	☐	☐	☐

SEÇÃO 3: AS ATIVIDADES DIÁRIAS DE SEU/SUA FILHO(A)

3.1 Durante as últimas 4 semanas, o seu/sua filho(a) ficou limitado(a) na QUANTIDADE de tempo que ele/ela utilizou para fazer os trabalhos escolares ou atividades com amigos devido a dificuldades EMOCIONAIS ou problemas de COMPORTAMENTO?

Sim, muito limitado(a)	Sim um tanto limitado(a)	Sim, um pouco limitado(a)	Não, não limitado(a)
☐	☐	☐	☐

3.2 Durante as últimas 4 semanas, seu/sua filho(a) esteve limitado(a) no TIPO de trabalho escolar ou atividades que ele/ela poderia realizar com amigos devido a problemas com seu/sua saúde FÍSICA?

Sim, muito limitado(a)	Sim, um tanto limitado(a)	Sim, um pouco limitado(a)	Não, não limitado(a)
☐	☐	☐	☐

SEÇÃO 4: DOR

4.1 Durante as últimas 4 semanas, com que freqüência seu/sua filho(a) teve dor ou desconforto no corpo?

Nenhuma vez	Uma ou duas vezes	Algumas vezes	Com bastante freqüência	Com muita freqüência	Todos / quase todos os dias
☐	☐	☐	☐	☐	☐

SEÇÃO 5: COMPORTAMENTO

Abaixo estão descritos comportamentos ou problemas que as crianças têm às vezes.

5.1 Com que freqüência, nas últimas 4 semanas, cada uma das afirmações abaixo descreve seu/sua filho(a)?	Muito freqüentemente	Freqüentemente	Às vezes	Quase nunca	Nunca
a. Discutiu muito	☐	☐	☐	☐	☐
b. Teve dificuldade em se concentrar ou prestar atenção	☐	☐	☐	☐	☐
c. Mentiu ou enganou	☐	☐	☐	☐	☐

5.2 Comparado(a) a outras crianças da sua idade, como diria que é o comportamento, em geral, de seu/sua filho(a) :

Excelente	Muito bom	Bom	Razoável	Mau
☐	☐	☐	☐	☐

SEÇÃO 6: BEM-ESTAR
As frases seguintes são sobre o estado de humor das crianças.

6.1 Durante as últimas 4 semanas, quanto de tempo você acha que seu/sua filho(a):	Todo o tempo	A maior parte do tempo	Algum tempo	Um pouco do tempo	Nem um pouco do tempo
a. Sentiu-se só?	☐	☐	☐	☐	☐
b. Agiu de modo nervoso?	☐	☐	☐	☐	☐
c. Agiu de modo incomodado ou chateado?	☐	☐	☐	☐	☐

SEÇÃO 7: AUTO-ESTIMA
As questões seguintes dizem respeito à satisfação do seu filho(a) consigo próprio, com a escola, e com os outros. Poderá ser útil ter presente o que outras crianças da idade do seu filho(a) sentem sobre os mesmos assuntos.

7.1 Durante as últimas 4 semanas, o quão satisfeito(a) você acha que seu/sua filho(a) se sentiu em relação a:	Muito satisfeito(a)	Um pouco satisfeito(a)	Nem satisfeito, nem insatisfeito(a)	Um tanto insatisfeito(a)	Muito insatisfeito(a)
a. Sua capacidade na escola?	☐	☐	☐	☐	☐
b. Suas amizades?	☐	☐	☐	☐	☐
c. Sua vida como um todo?	☐	☐	☐	☐	☐

SEÇÃO 8: A SAÚDE DE SEU/SUA FILHO(A)
As afirmações seguintes são sobre a saúde em geral.

8.1 Quão verdadeiras ou falsas são cada uma dessas afirmativas em relação a seu/sua filho(a)?	Certamente Verdadeira	Verdadeira na maior parte das vezes	Não sei	Falsa na maior parte das vezes	Certamente Falso
a. Meu/minha filho(a) parece ser menos saudável que outras crianças que conheço.	☐	☐	☐	☐	☐
b. Meu/minha filho(a) nunca esteve gravemente doente.	☐	☐	☐	☐	☐
c. Eu preocupo-me mais com a saúde do meu/minha filho(a) do que outras pessoas se preocupam com a saúde dos seus filhos.	☐	☐	☐	☐	☐

8.2 Comparada a um ano atrás, como classificaria a saúde de seu/sua filho(a) agora:

Muito melhor agora do que há um ano	Um pouco melhor do que há um ano	Quase a mesma agora do que há um ano	Um pouco pior do que há um ano	Muito pior agora do que há um ano
☐	☐	☐	☐	☐

SEÇÃO 9: VOCÊ E SUA FAMÍLIA

9.1 Durante as últimas 4 semanas, quanta preocupação e apreensão emocional cada um dos seguintes aspectos causou em VOCÊ?	Nenhuma	Pouca	Alguma	Bastante	Muita
a. A saúde física de seu/sua filho(a)	☐	☐	☐	☐	☐
b. O bem-estar emocional ou o comportamento de seu/sua filho(a)	☐	☐	☐	☐	☐

9.2 Durante as últimas 4 semanas você esteve LIMITADO(A) na quantidade de tempo para SUAS atividades devido a:	Sim, muito limitado(a)	Sim, limitado(a) em parte	Sim, um pouco limitado(a)	Não, não limitado(a)
a. A saúde física de seu/sua filho(a)	☐	☐	☐	☐
b. O bem-estar emocional ou o comportamento de seu/sua filho(a)	☐	☐	☐	☐

9.3 Durante as últimas 4 semanas, com que freqüência a saúde ou comportamento de seu/sua filho(a):	Muito freqüentemente	Freqüente-mente	Às vezes	Quase nunca	Nunca
a. Limitou os tipos de atividades que você poderia fazer em família?	☐	☐	☐	☐	☐
b. Interrompeu várias atividades diárias da família (fazer refeições, assistir TV)?	☐	☐	☐	☐	☐

9.4 Por vezes as famílias têm dificuldade em dar-se bem uns com outros. Nem sempre concordam com os mesmos pontos de vista e podem-se zangar. Em geral, como classificaria a capacidade da sua família em dar-se bem?

Excelente	Muito boa	Boa	Razoável	Má
☐	☐	☐	☐	☐

ATTACHMENT C- Pediatric Outcome Data Collection Questionnaire - Pediatric

AVALIAÇÃO DE SAÚDE DA CRIANÇA (RELATO DOS PAIS)

PODCI/Pediátrico

(preenchido pelos pais)

Questionário de resultados

Desenvolvido por:

American Academy of Orthopaedic Surgeons®
Pediatric Orthopaedic Society of North America
American Academy of Pediatrics
Shriner's Hospitals

Para ser respondido pelos pais de crianças de 2 a 10 anos.

AVALIAÇÃO DE SAÚDE DA CRIANÇA (RELATO DOS PAIS)

Data de hoje: / /

Obrigado por responder a este questionário.

Este questionário nos ajudará a compreender melhor saúde geral do seu filho/ da sua filha e quaisquer problemas que eles tenham relacionados com ossos e músculos.

Responder este questionário é completamente voluntário e suas respostas serão estritamente confidenciais.

Por favor, responda todas as questões. Algumas questões podem parecer semelhantes, mas cada uma é diferente.

Não existe resposta certa nem errada. Se você não tiver certeza de como responder uma pergunta, apenas dê a melhor resposta possível. Você pode fazer algum comentário na margem. Lemos realmente todos os seus comentários. Portanto, sinta-se à vontade para fazê-los, quantos você desejar.

Data de nascimento do seu filho/ da sua filho: / /

CPF da criança: ________________

Seu CPF: ________________

AVALIAÇÃO DE SAÚDE DA CRIANÇA (RELATO DOS PAIS)

Alguns tipos de problema podem dificultar a realização de muitas atividades, tais como comer, tomar banho, fazer tarefa escolar e brincar com amigos. Queremos saber como seu filho/ a sua filha está se saindo. (Circule uma resposta em cada linha.)

Nos **últimos 7 dias,** foi fácil ou difícil para o seu filho/ a sua filha:

	Fácil	Um pouco difícil	Muito difícil	Não consegue	Muito jovem para essa atividade
1. Levantar livros pesados?	1	2	3	4	5
2. Despejar leite de uma embalagem de 1 litro?	1	2	3	4	5
3. Abrir um frasco que já tinha sido aberto antes?	1	2	3	4	5
4. Usar garfo e colher?	1	2	3	4	5
5. Pentear o cabelo?	1	2	3	4	5
6. Abotoar botões?	1	2	3	4	5
7. Vestir o casaco?	1	2	3	4	5
8. Escrever com lápis?	1	2	3	4	5

9. SEM VALIDADE

Nos últimos 7 dias, como foi o nível de satisfação do seu filho/ a sua filha com:
(Circule uma resposta em cada linha.)

	Muito satisfeito	Pouco satisfeito	Não sei	Pouco insatisfeito	Muito insatisfeito	A criança é pequena
10. A sua aparência?	1	2	3	4	5	6
11. O seu corpo?	1	2	3	4	5	6
12. As roupas e sapatos que pode usar?	1	2	3	4	5	6
13. A sua capacidade de fazer as mesmas coisas que seus amigos ?	1	2	3	4	5	6
14. Saúde em geral?	1	2	3	4	5	6

AVALIAÇÃO DE SAÚDE DA CRIANÇA (RELATO DOS PAIS)

Nos **últimos 7 dias**, com que freqüência o seu filho/ a sua filha:
(Circule uma resposta por linha.)

	Maior parte do tempo	Algum tempo	Pouco tempo	Tempo nenhum
15. SEM VALIDADE				
16. SEM VALIDADE				
17. Dor ou desconforto chegaram a interferir nas atividades do seu filho(a)?	1	2	3	4

Nos **últimos 7 dias**, foi fácil ou difícil para o seu filho/ a sua filha:
(Circule uma resposta por linha.)

	Fácil	Um pouco difícil	Muito difícil	Não conseguiu fazer	Novo demais para esta atividade
18. Correr pequenas distâncias?	1	2	3	4	5
19. Andar de bicicleta ou triciclo?	1	2	3	4	5
20. Subir três lances de escada?	1	2	3	4	5
21. Subir um lance de escada?	1	2	3	4	5
22. Andar mais de 1,5 Km?	1	2	3	4	5
23. Andar três quarteirões?	1	2	3	4	5
24. Andar um quarteirão?	1	2	3	4	5
25. Subir e descer do ônibus?	1	2	3	4	5

26. Com que frequência o seu filho/ a sua filha precisa da ajuda de outra pessoa para caminhadas e subidas? (Circule uma resposta em cada linha.)
    1. Nunca 2. Às vezes 3. Mais ou menos metade do tempo 4. Frequentemente 5. Todo o tempo

27. Com que frequência o seu filho/ a sua filha utiliza apoios (tais como aparelho ortopédico, muleta, cadeira de roda) para caminhadas e subidas? (Circule uma resposta em cada linha)
    1. Nunca 2. Às vezes 3. Mais ou menos metade do tempo 4. Frequentemente 5. Todo o tempo

AVALIAÇÃO DE SAÚDE DA CRIANÇA (RELATO DOS PAIS)

Nos **últimos 7 dias**, tem sido fácil ou difícil para o seu filho/ a sua filha:
(Circule uma resposta em cada linha.)

	Fácil	Um pouco difícil	Muito difícil	Não conseguiu fazer	Novo demais para esta atividade
28. Manter-se de pé enquanto lava as mãos e o rosto na pia?	1	2	3	4	5
29. Sentar-se numa cadeira comum sem se segurar?	1	2	3	4	5
30. Sentar-se em um aparelho sanitário ou em uma cadeira e levantar-se dele?	1	2	3	4	5
31. Deitar –se e levantar-se da cama?	1	2	3	4	5
32. Girar maçanetas?	1	2	3	4	5
33. Estando de pé, curvar-se para pegar alguma coisa no chão?	1	2	3	4	5

34. Com que frequência o seu filho/ a sua filha precisa de ajuda de alguém para sentar-se ou ficar de pé? (Circule uma resposta.)
   1. Nunca 2. Às vezes 3. Mais ou menos metade do tempo 4. Frequentemente 5. Todo o tempo

35. Com que frequência o seu filho/ a sua filha utiliza apoios (tais como aparelho ortopédico, muleta, ou cadeira de roda) para sentar-se e levantar-se? (Circule uma resposta.)
   1. Nunca 2. Às vezes 3. Mais ou menos metade do tempo 4. Frequentemente 5. Todo o tempo

36. O seu filho/ a sua filha consegue participar de **atividades recreativas ao ar livre** com outras crianças da mesma idade?(exemplo: andar de bicicleta, andar de skate, correr, jogar futebol).
   (Circule uma resposta.)
   1. Sim, facilmente 2. Sim, mas um pouco dificuldade 3. Sim, mas com muita dificuldade 4. Não

Se você respondeu "não" à questão 36 acima, a atividade de seu filho/ a sua filha foi limitada por:
(circule **sim** para todas que se aplicam) .

		SIM
37.	Dor?	1
38.	Saúde geral?	1
39.	Por orientação médica ou dos pais?	1
40.	Medo das outras crianças não gostarem dele(a)?	1
41.	Por não gostar de atividades recreativas ao ar livre?	1
42.	Por seu muito novo para realizar estas atividades?	1
43.	Atividades não disponíveis nesse período?	1

AVALIAÇÃO DE SAÚDE DA CRIANÇA (RELATO DOS PAIS)

44. Seu filho/ a sua filha consegue participar de **jogos ou esportes (não competitivos)** com outras crianças da mesma idade? (Por exemplo: pega-pega, queimada, basquete, futebol, pular corda, amarelinha). (Circule uma resposta)

1. Sim, facilmente   2. Sim, mas um pouco dificuldade   3. Sim, mas com muita dificuldade   4. Não

Se você respondeu "não" à questão 44 acima, a atividade de seu filho/ a sua filha foi limitada por: (circule **sim** para todas que se aplicam)

	SIM
45. Dor?	1
46. Saúde geral?	1
47. Por orientação médica ou dos pais?	1
48. Medo das outras crianças não gostarem dele/a?	1
49. Por não gostar de atividades recreativas ao ar livre?	1
50. Por seu muito novo para realizar estas atividades?	1
51. Atividades não disponíveis nesse período?	1

52. O seu filho/ a sua filha consegue participar de **competições esportivas** com outras crianças da mesma idade (Por exemplo: basquete, futebol , natação, corridas, ginástica, ou dança). (Circule uma resposta)

1. Sim, facilmente   2. Sim, mas um pouco dificuldade   3. Sim, mas com muita dificuldade   4. Não

Se você respondeu "não" à questão 52 acima, a atividade do seu filho/ da sua filha foi limitada por: (circule **sim** para todas que se aplicam)

	SIM
53. Dor?	1
54. Saúde geral?	1
55. Por orientação médica ou dos pais?	1
56. Medo das outras crianças não gostarem dele/a?	1
57. Por não gostar de atividades recreativas ao ar livre?	1
58. Por ser muito novo para realizar estas atividades?	1
59. Atividades não disponíveis nesse período	1

60. Com que freqüência, **nos últimos 7 dias**, seu filho/ sua filha se reuniu com seus amigos para fazer alguma atividade? (Circule uma resposta)

1. Com freqüência   2. Algumas vezes   3. Nunca ou raramente

Se você respondeu "algumas vezes" ou "nunca ou raramente" para a pergunta 60 acima, a atividade foi limitada por: (Circule **sim** para todas que se aplicam)

	SIM
61. Dor?	1
62. Saúde geral?	1
63. Por orientação médica ou dos pais?	1
64. Medo das outras crianças não gostarem dele(a)?	1
65. Sem amigos por perto?	1

AVALIAÇÃO DE SAÚDE DA CRIANÇA (RELATO DOS PAIS)

66. Quantas vezes, nos últimos 7 dias, seu filho/ sua filha participou das aulas de educação física e das brincadeiras do recreio? (circule uma resposta)

1.Frequentemente 2. Algumas vezes 3. Nunca ou raramente 4. Sem aulas ou recreio

Se você respondeu "algumas vezes" ou "nunca ou raramente" para a pergunta 63 acima, a atividade foi limitada por: (Circule **sim** para todas que se aplicam).

	SIM
67. Dor?	1
68. Saúde geral?	1
69. Por orientação médica ou dos pais?	1
70. Medo das outras crianças não gostarem dele(a)?	1
71. Por não gostar de aulas de educação física/recreio?	1
72. Recesso escolar?	1
73. Não freqüentar aulas?	1

74. **SEM VALIDADE**

75. Quanta dor seu filho/ sua filha teve **nos últimos 7 dias**? (circule uma resposta)

1. Nenhuma 2. Muito leve 3. Leve 4. Moderada 5. Forte 6. Muito forte

76. Nos **últimos 7 dias**, como a dor interferiu nas atividades normais do seu filho/ da sua filha (incluindo em casa, fora de casa e na escola)? (circule uma resposta)

1. Nunca 2.Um pouco 3. Moderadamente 4. Bastante 5. Extremamente

ATTACHMENT D- Pediatric Outcome Data Collection Questionnaire - Teenagers

AVALIAÇÃO DE SAÚDE DO ADOLESCENTE (RELATO DOS PAIS)

PODCI/Adolescentes

(relato dos pais)

Questionário de resultados

Desenvolvido por:

American Academy of Orthopaedic Surgeons®
Pediatric Orthopaedic Society of North America
American Academy of Pediatrics
Shriner's Hospitals

Para ser completado pelos pais de adolescentes de 11 a 18 anos

AVALIAÇÃO DE SAÚDE DO ADOLESCENTE (RELATO DOS PAIS)

Data de hoje: / /

Obrigado por responder a este questionário.

Este questionário nos ajudará a compreender melhor saúde geral de seu filho/ sua filha e quaisquer problemas que eles tenham relacionados com ossos e músculos.

Responder este questionário é completamente voluntário e suas respostas serão estritamente confidenciais.

Por favor, responda todas as questões. Algumas questões podem parecer semelhantes, mas cada uma é diferente.

Não existe resposta certa nem errada. Se você não tiver certeza de como responder uma pergunta, apenas dê a melhor resposta possível. Você pode fazer algum comentário na margem. Lemos realmente todos os seus comentários. Portanto, sinta-se à vontade para fazê-los, quantos você desejar.

Data de nascimento do seu filho/a: / /

CPF da criança: ________________

Seu CPF: _________________

AVALIAÇÃO DE SAÚDE DO ADOLESCENTE (RELATO DOS PAIS)

Alguns tipos de problema podem dificultar a realização de muitas atividades, tais como comer, tomar banho, fazer tarefa escolar e brincar com amigos. Queremos saber como seu filho/ sua filha está se saindo. (Circule uma resposta em cada linha.)

Nos **últimos 7 dias**, foi fácil ou difícil para seu filho(a):

	Fácil	Um pouco difícil	Muito difícil	Não consegue
1. Levantar livros pesados?	1	2	3	4
2. Despejar leite de uma embalagem de 1 litro?	1	2	3	4
3. Abrir um frasco que já tinha sido aberto antes?	1	2	3	4
4. Usar garfo e colher?	1	2	3	4
5. Pentear o cabelo?	1	2	3	4
6. Abotoar botões?	1	2	3	4
7. Vestir o casaco?	1	2	3	4
8. Escrever com lápis?	1	2	3	4

9. **SEM VALIDADE**

Nos últimos 7 dias, como foi o nível de satisfação do seu filho/ sua filha com: (Circule uma resposta em cada linha.)

	Muito satisfeito	Pouco satisfeito	Não sei	Pouco insatisfeito	Muito insatisfeito
10. A sua aparência?	1	2	3	4	5
11. O seu corpo?	1	2	3	4	5
12. As roupas e sapatos que pode usar?	1	2	3	4	5
13. A sua capacidade de fazer as mesmas coisas que seus amigos?	1	2	3	4	5
14. Saúde em geral?	1	2	3	4	5

AVALIAÇÃO DE SAÚDE DO ADOLESCENTE (RELATO DOS PAIS)

Nos <u>últimos 7 dias</u>, com que frequência o seu filho/ a sua filha:
(**Circule** uma resposta por linha.)

	Maior parte do tempo	Algum tempo	Pouco tempo	Tempo nenhum
15. SEM VALIDADE				
16. SEM VALIDADE	1	2	3	4
17. Dor ou desconforto chegaram a interferir nas atividades de seu filho(a)?	1	2	3	4

Nos **<u>últimos 7 dias</u>**, foi fácil ou difícil para o seu filho/ a sua filha:
(Circule uma resposta por linha.)

	Fácil	Um pouco difícil	Muito difícil	Não conseguiu fazer
18. Correr pequenas distâncias?	1	2	3	4
19. Andar de bicicleta ou triciclo?	1	2	3	4
20. Subir três lances de escada?	1	2	3	4
21. Subir um lance de escada?	1	2	3	4
22. Andar mais de 1,5 Km?	1	2	3	4
23. Andar três quarteirões?	1	2	3	4
24. Andar um quarteirão?	1	2	3	4
25. Subir e descer do ônibus?	1	2	3	4

26. Com que frequência o seu filho/ a sua filha precisa da ajuda de outra pessoa para caminhadas e subidas? (Circule uma resposta em cada linha.)
    1. Nunca 2. Às vezes 3. Mais ou menos metade do tempo 4. Frequentemente 5. Todo o tempo

27. Com que frequência o seu filho/ a sua filha utiliza apoios (tais como aparelho ortopédico, muleta, cadeira de roda) para caminhadas e subidas? (Circule uma resposta em cada linha.)
    1. Nunca 2. Às vezes 3. Mais ou menos metade do tempo 4. Frequentemente 5. Todo o tempo

AVALIAÇÃO DE SAÚDE DO ADOLESCENTE (RELATO DOS PAIS)

Nos **últimos 7 dias**, tem sido fácil ou difícil para o seu filho/ a sua filha:
(Circule uma resposta em cada linha.)

	Fácil	Um pouco difícil	Muito difícil	Não conseguiu fazer
28. Manter-se de pé enquanto lava as mãos e o rosto na pia?	1	2	3	4
29. Sentar-se numa cadeira comum sem se segurar?	1	2	3	4
30. Sentar-se em um aparelho sanitário ou em uma cadeira e levantar-se dele?	1	2	3	4
31. Deitar –se e levantar-se da cama?	1	2	3	4
32. Girar maçanetas?	1	2	3	4
33. Estando de pé, curvar-se para pegar alguma coisa no chão?	1	2	3	4

34. Com que frequência o seu filho/ a sua filha precisa de ajuda de alguém para sentar-se ou ficar de pé? (Circule uma resposta)
   1. Nunca 2. Às vezes 3. Mais ou menos metade do tempo 4. Frequentemente 5. Todo o tempo

35. Com que frequência o seu filho/ a sua filha utiliza apoios (tais como aparelho ortopédico, muleta, ou cadeira de roda) para sentar-se e levantar-se? (Circule uma resposta)
   1. Nunca 2. Às vezes 3. Mais ou menos metade do tempo 4. Frequentemente 5. Todo o tempo

36. O seu filho/ a sua filha consegue participar de **atividades recreativas ao ar livre** com outros adolescentes da mesma idade? (Por exemplo: andar de bicicleta, andar de skate, correr, jogar futebol). (Circule uma resposta)
   1. Sim, facilmente 2. Sim, mas um pouco dificuldade 3. Sim, mas com muita dificuldade 4. Não

Se você respondeu "não" à questão 36 acima, a atividade de seu filho/ a sua filha foi limitada por:
(circule sim para todas que se apliquem)

	SIM
37. Dor?	1
38. Saúde geral?	1
39. Por orientação médica ou dos pais?	1
40. Medo das outras crianças não gostarem dele(a)?	1
41. Por não gostar de atividades recreativas ao ar livre?	1
42. Por ser muito novo para realizar estas atividades?	1
43. Atividades não disponíveis nesse período?	1

AVALIAÇÃO DE SAÚDE DO ADOLESCENTE (RELATO DOS PAIS)

44. Seu filho/ a sua filha consegue participar de **jogos ou esportes** com outros adolescentes da mesma idade? (Por exemplo: pega-pega, queimado, basquete, futebol, pular corda, amarelinha).
(Circule uma resposta)
1. Sim, facilmente 2. Sim, mas um pouco dificuldade 3. Sim, mas com muita dificuldade 4. Não

Se você respondeu "não" à questão 44 acima, a atividade de seu filho/ a sua filha foi limitada por:
(circule sim para todas que se aplicam.)

	SIM
45. Dor?	1
46. Saúde geral?	1
47. Por orientação médica ou dos pais?	1
48. Medo das outras crianças não gostarem dele(a)?	1
49. Por não gostar de participar de jogos ou esportes?	1
50. Por ser muito novo para realizar estas atividades?	1
51. Atividades não disponíveis nesse período?	1

52. Seu filho/ a sua filha consegue participar de **competições esportivas** com outros adolescentes da mesma idade (Por exemplo: basquete, futebol , natação, corridas, ginástica, ou dança).
(Circule uma resposta)
1. Sim, facilmente 2. Sim, mas um pouco dificuldade 3. Sim, mas com muita dificuldade 4. Não

Se você respondeu "não" à questão 52 acima, a atividade do seu filho/ a sua filha foi limitada por:
(circule **sim** para todas que se aplicam.)

	SIM
53. Dor?	1
54. Saúde geral?	1
55. Por orientação médica ou dos pais?	1
56. Medo das outras crianças não gostarem dele/a?	1
57. Por não gostar de participar de jogos ou esportes?	1
58. Por ser muito novo para realizar estas atividades?	1
59. Atividades não disponíveis nesse período	1

AVALIAÇÃO DE SAÚDE DO ADOLESCENTE (RELATO DOS PAIS)

60. Com que frequência **nos últimos 7 dias** seu filho/ a sua filha se reuniu com seus amigos para fazer alguma atividade? (Circule uma resposta)
   1. Com frequência   2. Algumas vezes   3. Nunca ou raramente

Se você respondeu "algumas vezes" ou "nunca ou raramente" para a pergunta 60 acima, a atividade foi limitada por: (Circule **sim** para todas que se aplicam.)

	SIM
61. Dor?	1
62. Saúde geral?	1
63. Por orientação médica ou dos pais?	1
64. Medo das outras crianças não gostarem dele/a?	1
65. Sem amigos por perto?	1

66. Quantas vezes, **nos últimos 7 dias**, seu filho/ a sua filha participou das aulas de educação física e das brincadeiras do recreio? (circule uma resposta)
   1. Frequentemente   2. Algumas vezes   3. Nunca ou raramente   4. Sem aulas ou recreio

Se você respondeu "algumas vezes" ou "nunca ou raramente" para a pergunta 66 acima, a atividade foi limitada por: (Circule sim para todas que se aplicam.)

	SIM
67. Dor?	1
68. Saúde geral?	1
69. Por orientação médica ou dos pais?	1
70. Medo das outras crianças não gostarem dele(a)?	1
71. Não gostar de aulas de educação física/recreio?	1
72. Recesso escolar?	1
73. Não freqüentar aulas?	1

74. **SEM VALIDADE**

75. Quanta dor seu filho/ a sua filha teve **nos últimos 7 dias**? (circule uma resposta.)
   1. Nenhuma   2. Muito leve   3. Leve   4. Moderada   5. Forte   6. Muito forte

76. **Nos últimos 7 dias**, como a dor interferiu nas atividades normais do seu filho/ a sua filha (incluindo em casa, fora de casa e na escola)? (circule uma resposta.)
   1. Nunca   2.Um pouco   3. Moderadamente   4. Bastante   5. Extremamente

ATTACHMENT E- Modified Mallet Scale

Modified Mallet classification
(grade I = no function, Grade V = normal function)

		Grade I	Grade II	Grade III	Grade IV	Grade V
Global abduction	Not testable	No function	<30°	30° to 90°	>90°	Normal
Global external rotation	Not testable	No function	<0°	0° to 20°	>20°	Normal
Hand to neck	Not testable	No function	Not possible	Difficult	Easy	Normal
Hand on spine	Not testable	No function	Not possible	S1	T12	Normal
Hand to mouth	Not testable	No function	Marked trumpet sign	Partial trumpet sign	<40° of abduction	Normal
Internal rotation	Not testable	No function	Cannot touch	Can touch with wrist flexion	Palm on belly, no wrist flexion	

ATTACHMENT F- Active Movement Scale

ACTIVE MOVEMENT SCALE

Sem gravidade	
Sem contração	**0**
Contração, sem movimento	**1**
<50% da ADM	**2**
>50% da ADM	**3**
Movimento completo	**4**
Contra a gravidade	
<50% da ADM	**5**
>50% da ADM	**6**
Movimento completo	**7**

Flexão do ombro -

Abdução do ombro -

Adução do ombro -

Rotação interna -

Rotação externa -

Flexão do cotovelo -

Extensão do cotovelo -

Pronação -

Supinação -

Flexão de punho -

Extensão de punho -

Flexão dos dedos -

Extensão dos dedos -

Flexão do polegar -

Extensão do polegar -

APPENDICES

APPENDIX A – Anamnesis file

FICHA DE ANAMNESE

Nome:____ Idade:______

Responsável:____

Endereço: ____

Telefone:____

Tipo da lesão ( ) Paralisia de Erb ( ) Paralisia de Erb estendida ( ) Sem lesão (Controle)

Data de Nascimento:

Sexo ( ) Masculino ( ) Feminino

Peso: ___________ Altura:____________

Apresentou intercorrências durante o nascimento?

( ) sim ( ) não O que?____

Passou por cirurgias de correção?

( ) sim ( ) não Quais?____

Apresenta desordem visual e/ou auditiva?

( )sim ( ) não

Informações importantes:

APPENDIX B - Control Group Assent Term

TERMO DE ASSENTIMENTO

Você está sendo convidado a participar, como voluntário, da pesquisa chamada "**Contribuições articulares do complexo do ombro e coluna cervical de crianças com paralisia obstétrica do plexo braquial durante tarefas de alcance**".

Essa pesquisa estudará os movimentos dos braços de crianças que tem doença de paralisia obstétrica do plexo braquial. **Você não tem essa doença**. Mas, está sendo convidado para que os seus resultados possam ser comparados com os de crianças que têm a doença.

Se você concordar em participar desta pesquisa você fará os seguintes testes: colocar a mão na cabeça, alcançar a bola no plano acima da cabeça, colocar a mão no bolso traseiro da calça, colocar a mão na nuca, colocar a mão no mais alto possível sobre a coluna vertebral e colocar a mão na boca.

Durante os testes não é esperado você sentir desconforto. Esta pesquisa poderá nos ajudar a entender melhor quais mudanças nos movimentos dos braços à doença provoca nas crianças com paralisia obstétrica do plexo braquial e, assim, poderá ajudar os terapeutas a pensar em melhores formas de tratamento de fisioterapia.

Caso você concorde em participar desta pesquisa, favor assinar abaixo.

Ribeirão Preto, ___ de ____________ de ______.

_________________________________ _________________________________

Nome do voluntário Assinatura do voluntário

APPENDIX C – Neonatal brachial plexus palsy Group Assent Term

TERMO DE ASSENTIMENTO

Você está sendo convidado a participar, como voluntário, da pesquisa chamada "**Contribuições articulares do complexo do ombro e coluna cervical de crianças com paralisia obstétrica do plexo braquial durante tarefas de alcance**".

Essa pesquisa estudará possíveis alterações nos membros superiores de crianças que tiveram paralisia obstétrica do plexo braquial. Se você concordar em participar desta pesquisa, você responderá um questionário sobre atividades do seu dia-a-dia, qualidade de vida e grau de satisfação e fará os seguintes testes: colocar a mão na cabeça, alcançar a bola no plano acima da cabeça, colocar a mão no bolso traseiro da calça, colocar a mão na nuca, colocar a mão no mais alto possível sobre a coluna vertebral e colocar a mão na boca.

Durante os testes, não é esperado que você sinta desconforto. Esta pesquisa poderá ajudar os fisioterapeutas a entender melhor quais mudanças à paralisia obstétrica do plexo braquial provoca no seu braço e assim, ajudar a pensar em melhores formas de tratamento.

Caso você concorde em participar desta pesquisa, favor assinar abaixo.

Ribeirão Preto, ___ de ____________ de ______.

Nome do voluntário	Assinatura do voluntário

APPENDIX D – Free informed consent form for those responsible for children with Neonatal brachial plexus palsy

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

O seu filho está sendo convidado a participar, como voluntário, do estudo **"Contribuições articulares do complexo do ombro e coluna cervical de crianças com paralisia obstétrica do plexo braquial durante tarefas de alcance"** que será realizada na cidade de Ribeirão Preto – SP, tendo como responsáveis a Profa. Dra. Anamaria Siriani de Oliveira e a fisioterapeuta Daiane Lazzeri de Medeiros, ambas da Faculdade de Medicina de Ribeirão Preto - USP.

Esclarecimento geral e objetivo do estudo:
O objetivo geral desse estudo é comparar as contribuições do complexo articular do ombro e coluna cervical durante tarefas de alcance entre crianças com paralisia obstétrica do plexo braquial e saudáveis. Estes dados irão esclarecer os padrões de movimento utilizados por essa população, de modo que a avaliação e intervenção fisioterapêutica possa ser aprimorada visando maior independência funcional.

Explicação do procedimento:
Se você e seu filho aceitarem participar deste estudo, será avaliado a função do braço por meio de uma escala (Escala Mallet Modificada), será aplicado um questionário (Peadiatric Outcomes Data Collection) para avaliar atividades funcionais e qualidade de vida e outro (Child Health Questionnaire*)* para avaliar grau de saúde, satisfação e bem estar. Serão avaliados também os movimento do seu filho durante as seguintes tarefas: colocar a mão na cabeça, alcançar a bola no plano acima da cabeça, colocar a mão no bolso traseiro da calça, colocar a mão na nuca, colocar a mão no mais alto possível sobre a coluna vertebral e colocar a mão na boca. Para essa avaliação serão necessários à colocação de sensores eletromagnéticos que serão fixados com fita adesiva.

Possíveis benefícios:
Seu filho passará por avaliações funcionais do ombro e da coluna cervical, avaliação da qualidade de vida e grau de satisfação e bem estar e ao final dessas o (a) Sr (a) e a criança sob sua responsabilidade saberão sobre o seu desempenho. E após analisado a avaliação da análise do movimento durante tarefas de alcance do membro superior necessárias para desempenhar tarefas funcionais, será encaminhado ao responsável o desempenho da criança de sua responsabilidade, e conforme o resultado será realizado orientações visando maior independência funcional da criança.

Desconforto e risco:
Este estudo não trará desconforto ao participante. A equipe da pesquisa esclarecerá as dúvidas e explicará anteriormente cada avaliação que será realizada. Os riscos destes procedimentos serão mínimos por envolver somente medições não-invasivas.

Sigilo de identidade:

A identidade do seu filho será mantida em sigilo absoluto, as informações obtidas nesta pesquisa serão de maneira alguma associadas a sua identidade e não poderão ser consultadas por pessoas leigas sem sua autorização oficial. Estas informações poderão ser utilizadas para fins estatísticos ou científicos, desde que fiquem guardados a sua identidade e seu anonimato.

Ressarcimento de despesa e indenização:

Pela a participação do seu filho, o Sr.(a) não receberá nenhum tipo de seguro de vida ou saúde que possa beneficiá-lo. Caso sinta-se prejudicado(a) ou lesado(a) por participar da pesquisa, o Sr.(a) deverá buscar indenização nas Leis vigentes no Brasil.

Liberdade de participação:

A sua participação do seu filho neste estudo é voluntária. É seu direito interromper sua participação a qualquer momento, sem que isso cause qualquer penalidade ou prejuízo à sua pessoa, comprometendo-se somente a comunicar pelo menos um dos responsáveis da pesquisa.

Para questões relacionadas a este estudo, contate:

Comitê de Ética do CSE-Cuiabá: (16) 3315-0009

Daiane Lazzeri de Medeiros, telefone (45)98100304/(16) 3315-4413
daialazzeri@hotmail.com

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Declaro que fui informado sobre todos os procedimentos da pesquisa e, que recebi de forma clara e objetiva todas as explicações pertinentes ao projeto e, que todos os dados a meu respeito e da criança sob minha responsabilidade serão sigilosos. Declaro que fui informado que posso me retirar do estudo a qualquer momento.

Nome por extenso____

Assinatura do responsável____

Ribeirão Preto,___/___/___.

Nome Pesquisador:____

Assinatura Pesquisador: ____

Ribeirão Preto,___/___/___.

APPENDIX E – Free informed consent form for those responsible for control group

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO DIRIGIDO ÀS CRIANÇAS DO GRUPO CONTROLE (SEM A DOENÇA)

O seu filho está sendo convidado a participar, como voluntário, do estudo "**Contribuições articulares do complexo do ombro e coluna cervical de crianças com paralisia obstétrica do plexo braquial durante tarefas de alcance**" que será realizada na cidade de Ribeirão Preto – SP, tendo como responsáveis a Profa. Dra. Anamaria Siriani de Oliveira e a fisioterapeuta Daiane Lazzeri de Medeiros, ambas da Faculdade de Medicina de Ribeirão Preto - USP.

O seu filho **não** tem essa doença. Então vamos comparar crianças saudáveis (sem a doença) com crianças que tem a doença.

Esclarecimento geral e objetivo do estudo:

O objetivo desse estudo é comparar as contribuições do complexo articular do ombro e coluna cervical durante tarefas de alcance entre crianças com paralisia obstétrica do plexo braquial e saudáveis. Estes dados irão esclarecer os padrões de movimento utilizados por essa população, de modo que a avaliação e intervenção fisioterapêutica possa ser aprimorada visando maior independência funcional.

Explicação do procedimento:

Se você e seu filho aceitarem participar deste estudo, serão avaliados os movimentos do seu filho durante as seguintes tarefas: colocar a mão na cabeça, alcançar a bola no plano acima da cabeça, colocar a mão no bolso traseiro da calça, colocar a mão na nuca, colocar a mão no mais alto possível sobre a coluna vertebral e colocar a mão na boca. Para essa avaliação serão necessários à colocação de sensores eletromagnéticos que serão fixados com fita adesiva.

Possíveis benefícios:

Seu filho passará por avaliações funcionais do ombro e ao final dessas o (a) Sr (a) e a criança sob sua responsabilidade saberão sobre o seu desempenho. Os dados obtidos neste estudo auxiliarão no maior conhecimento sobre os padrões de movimento de crianças com lesão de plexo braquial pela comparação com os resultados de crianças saudáveis.

Desconforto e risco:

Este estudo não trará desconforto ao participante. A equipe da pesquisa esclarecerá as dúvidas e explicará anteriormente cada avaliação que será realizada. Os riscos destes procedimentos serão mínimos por envolver somente medições não-invasivas.

Sigilo de identidade:

A identidade do seu filho será mantida em sigilo absoluto, as informações obtidas nesta pesquisa serão de maneira alguma associadas a sua identidade e não poderão ser consultadas por pessoas leigas sem sua autorização oficial. Estas informações poderão ser utilizadas para fins estatísticos ou científicos, desde que fiquem guardados a sua identidade e seu anonimato.

Ressarcimento de despesa e indenização:

Pela a participação do seu filho, o Sr.(a) não receberá nenhum tipo de seguro de vida ou saúde que possa beneficiá-lo. Caso sinta-se prejudicado(a) ou lesado(a) por participar da pesquisa, o Sr.(a) deverá buscar indenização nas Leis vigentes no Brasil.

Liberdade de participação:

A sua participação do seu filho neste estudo é voluntária. É seu direito interromper sua participação a qualquer momento, sem que isso cause qualquer penalidade ou prejuízo à sua pessoa, comprometendo-se somente a comunicar pelo menos um dos responsáveis da pesquisa.

Para questões relacionadas a este estudo, contate:

Comitê de Ética do CSE-Cuiabá: (16) 3315-0009

Daiane Lazzeri de Medeiros, telefone (45)98100304/(16) 3315-4413 daialazzeri@hotmail.com

TERMO DE CONSENTIMENTO

Declaro que fui informado sobre todos os procedimentos da pesquisa e, que recebi de forma clara e objetiva todas as explicações pertinentes ao projeto e, que todos os dados a meu respeito e da criança sob minha responsabilidade serão sigilosos. Declaro que fui informado que posso me retirar do estudo a qualquer momento.

Nome por extenso____

Assinatura do responsável____

Ribeirão Preto,___/___/___.

Nome Pesquisador:____

Assinatura Pesquisador: ____

Ribeirão Preto,___/___/___.