***Case study***

# A 3-year Physiotherapy Management of a case of spinal Poliomyelitis Referred at Three Months Post paralysis


## Abstract:

**Background:** Poliomyelitis is known to bring about huge complications that foist debilitating disabilities on a patient with poliomyelitis. Most post-polio survivors live with disabilities throughout a lifetime with an attendant social and economic consequence. **Objective:** Based on the findings from subjective assessment and physical examination, the objective of the current study focused on early physiotherapy intervention measures for preventing complications such as contracture, joint stiffness, muscle wasting, severe gait abnormality, vertebral mal-alignment, and unusual pain. **Case Description:**A 4-month-old patient referred for physiotherapy evaluation following an inability to functionally move the two lower limbs and lifting of the left upper limb. There was no history of previous treatment before referral to physiotherapy management. The physical therapists reviewed the available literature, consulted with medical and physical therapist experts and the patient, and elected to use an approach combining the use of low intensity, short duration, and intermittent activity or exercise performed within patient's limit of fatigue, weakness, and pain. **Intervention:** The child was on low-intensity exercises, electrical muscle stimulation and heat therapy 3 times per week for 12 months, 2 times per week for12 months, once a week, and once in two weeks for 6 months. **Outcomes:** Patient was able to achieve one-minute ambulation without walking aid in 33 months. Significantly, patient attained 5-minute ambulation in 36 months' time. Also, ranges of motion were intact with no records of contracture in any tendon. **Discussion:** The outcome of this study demonstrated that early

physiotherapy intervention and long-term follow-up are beneficial in preventing/reducing complications, thereby regaining of millstones and achieving functional independence in patients with acute flaccid paralysis such as polio.

**Keywords**: -Poliomyelitis, Physiotherapy, Early intervention, Follow up

## Background

The association between physiotherapy and poliomyelitis (polio) historically has always been close. Shepherd [1]described how before the 1950s, the practice of physiotherapy was to a great extent concerned with the treatment of people with polio. In fact,the growth of physiotherapy as a profession in the middle part of this century was largely due to the need to rehabilitate people with polio [1].Physiotherapy was rated as providing considerable or some relief by a relatively high proportion (80 percent) of clients but it also attracted criticism primarily due to vigorous exercise programs that increased fatigue and weakness [2].

Polio is a viral disease that can affect nerves and lead to partial or full paralysis. Paralytic polio attacks certain nerve cells (motor neuron) in the spinal cord and may cause paralysis of the muscles that control breathing and those in arms and legs. The muscles affected and extent of paralysis depends on the part of the spinal cord and the number of neurons involved [3]. Although paralysis can occur to any combination of limbs, for instance, both legs and one arm children under age 5 are most likely to become paralyzed in a single extremity, while in adults, paralysis of both arms and legs is more common [3].The degree of recovery is determined by the number of motor neurons that recovers from the infection and resumes normal functioning, the number that survives impaired and the number that develops terminal axon sprouts to reinnervate

muscle fibers orphaned by the death of their original neuron [3]. Axon sprouting enables uninvolved or recovered motor neurons to adopt up to five additional muscle fibers and is so effective that a muscle can regain normal strength even after 50 percents of its original motor neurons have been lost. It is usually some months before the extent of permanent paralysis resulting from the infection can be assessed [3].

In a community-based study byNarayan, et al., among the physical disabilities identified, the most common was post-polio residual paralysis. 35.65% (n = 41). Subjects had developed paralysis after administration of an intramuscular injection when they had acute viremia in childhood, indicating that (probably) muscle paralysis would be provoked by intramuscular injections, resulting in provocative poliomyelitis [4].

An understanding of the pathophysiology of poliomyelitis and its late sequelae in conjunction with contemporary principles of rehabilitation practice provides a basis of revising the principles of acute management to optimize function over the long term [5]. First, treatment is based on a definitive diagnosis and multi-system assessment given the systemic effects of the disease. After, it is suggested treatment should be implemented early and continued throughout the first year after onset when most recovery is likely to occur; rest, comfort, and the prevention of deformity with proper body positioning and range of motion exercises to remain priorities[6]. Heat may reduce pain, spasm, and stiffness, and optimize the effect of a range of motion exercises. Exercise needs to be prescribed in such a way that over-exertion, fatigue, pain and further muscle damage are minimized[6].Dynamic moderate resistive exercise can be supported for strength and endurance training. Heavy resistive exercise may contribute to muscle irritation, pain, and muscle damage. The frequency, duration and time course of treatment are based on the assessment [6].

Although recommended by the WHO [7], the effects of physiotherapy on muscle strength in the acute poliomyelitis phase remains poorly documented and the bibliography available on that subject is outdated. A few studies have addressed the potential role of physiotherapy on the course of polio disease and muscle strength and functioning [8-10], showing that physiotherapy is an effective treatment of polio-related problems and can improve muscle function. A study carried out on 70 polio cases treated between 1952 and1953 showed improvements in muscle strength after physiotherapy, for some patients, as long as 6 months after symptom onset [11]. In another study on poliomyelitis, the phase of potential recovery of muscle strength varied from a few weeks to a maximum of 2 years [12]. Targeted physiotherapy at different stages of the illness may, therefore, help to restore strength, to prevent deformity, and to rehabilitate patients [13].

As recently as 2012, Nigeria accounted for more than half of all polio cases worldwide, but the country has made significant strides, recently marking 2 years without a case on 24 July 2016. This progress has been the result of a concerted effort by all levels of government, civil society, religious leaders and dedicated health workers. Some steps included increased community involvement and establishment of emergency operations centers at the national and state level have been pivotal to Nigeria's capacity to respond to outbreaks [14]. Sequel to this positive development, the World Health Organization removes Nigeria from Polio-Endemic List in 2015 [15].Polio was sporadic in earlier centuries, but later became epidemic and later pandemic. The incidence peaked during the 1850s in many developed countries. The World Health Organization (WHO) had shown commitment to the eradication of polio since 1988 and polio cases have decreased by over 99 percent since that time [16]. Estimates place the number of polio survivors in the United States (US) at between 600,000 and 1,600,000 [16, 17]. Since 2014, only two

90 countries, Pakistan and Afghanistan, have reported polio cases caused by wild poliovirus types
91 1[18]. The highest record incidence of polio in Australia (39, 1 per 100,000 populations) was in
92 1938 [19]. The cause of the disease includes motor unit dysfunction-degenerative change within
93 motor units, muscle overuse, muscle underuse, loss of motor units due to age, growth or other
94 hormonal effects the combined effects of disuse, overuse, pain, weight gain or other illness[20].
95 The spread of the virus could be through direct person to person contact, contact with infected
96 mucus or phlegm from the nose or mouth, contact with infected feces. The virus enters through
97 the mouth and nose, multiplies in the throat and intestinal tract and then get absorbed and spread
98 through the blood and lymph system. The time for being infected with the virus to developing
99 symptoms of the disease (incubation) ranges from 5-35 days (average 7-14 days). However, most
100 people don't develop symptoms.

101 The objective of this study was to examine the importance of early physical therapy intervention
102 in preventing post-acute physical complications from polio such as contracture, stiffness, muscle
103 wasting, severe gait abnormality, vertebral mal-alignment that are usually associated with poorly
104 managed or late referral of polio conditions. This the author sees as novel especially in a
105 developing country like Nigeria where most cases of physiotherapy management of paralytic-
106 polio start when such complications had developed simply because of late referrals making
107 management and application of orthotic devices difficult.



108 **Case Description**

109 A 4-month old baby boy, weighing 7.4kg, referred to Landmark Physiotherapy Services
110 in Nnewi, Nigeria on the 23rd February, 2015 by a senior resident medical practitioner with a
111 complaint of 3-month history of inability to move the left lower limbs, difficulty in moving the

right lower limb and dropping of left shoulder joint one month after birth. The above complaint followed injection that was giving to the baby when he had a febrile illness in a community health center. This is in agreement with the findings that a history of intramuscular injections precedes paralytic poliomyelitis in about 50–60 % of patients with a patient presenting initially with fever and paralysis (provocation paralysis). Clinical characteristics of poliomyelitis include fever at onset, rapid progression of paralysis within 24–48 hours, asymmetric, proximal more than distal limb paralysis, preservation of sensory function often with severe myalgia (but in the current study there was no record of myalgia) and residual paralysis at 60 days [19]. At the point of presence in the current study baby had no subsisting fever. The physiotherapist immediately reported the case to the local health authority in Nnewi North Local, Anambra, Nigeria as no previous laboratory test had been done before referral for physiotherapy. The female personnel in charge of the polio control came and collected two sets of stool (≥24 h apart, each 8–10 g) and sent to Ibadan, southwest Nigeria, where the laboratory analysis was done. Because the window period (14 days after onset of paralysis) for dictating the virus had elapsed due to late presentation of the patient, the laboratory test was not positive [20].

However, clinical assessment and the differential diagnosis was used by the referring physician in accordance with the review study by Arthur et al 2000 on differential diagnosis of flaccid acute paralysis to make an impression of paralytic poliomyelitis at the post-acute stage [21].Some conditions ruled out in differential diagnosis using clinical signs and symptoms included: Guillain Barre syndrome, transverse myelitis, traumatic neuritis, infectious and toxic neuropathies, and insecticide poisoning. However, it must be noted that the differential diagnosis of AFP varies considerably with age. No single operational clinical case definition of AFP or paralytic poliomyelitis that combines both high sensitivity and high specificity has

emerged [22, 23, 24]. The currently used case definition increases sensitivity in detecting the existence of AFP but tends to decrease specificity in detecting paralytic poliomyelitis[22].

The baby is a foster and the only child of the parent. The parent lives in a bungalow apartment in a semi-urban settlement in Anambra South senatorial zone, Nigeria. The source of drinking water was a mixture of the stream (untreated) and borehole water. The toilet facility was a pit. The parent confirmed that the child did not receive anti-polio vaccination prior to receiving an anti-fever injection.

**Examination**

The patient presented to the clinic with a history of acute flaccid paresis of the bilateral lower limbs and subluxation of the left shoulder joint. The patient's baseline supine position, before assessment, were: the left lower limb was positioned in external rotation with the knee slightly flexed and the foot plantar flexed. Similarly, the right lower limb assumed the position similar to that of the left lower limb but slightly better muscle tone than that of the former. The baseline muscle power for the four limbs was shown in Tables 3 and 4 [25]. The muscle bulk was slightly more on the right limb than the left using anterior superior iliac spine and 2/3 of the thigh from patella as landmarks. The skin sensation test conducted with pin and cotton wools for superficial and deep sensation showed partial pain perception on the left lower limb. The limb length was the same for the two limbs at baseline measurement using anterior superior iliac spine and medial malleolias the landmark.Neurological assessment using reflex hammer showed depressed reflexes at the elbow and knee tendons. The radiological evidence showed depression atthe left shoulder joint and evidence of fracture. The patient could grip, supinate and pronate but could neither flex the left elbow nor lift the leftshoulder joint.Significantly, the muscles around the

shoulder joints look flabby and wasted. On the same supine position, the tummy drops to the right side (away from the midline) probably because of the weakness of the abdominals. The patient had achieved neck control on presentation but has not started sitting unsupported. The range of motion was full for all joints.After the assessment, the child was placed on 3 times per week management which was later reduced to 2 times per week, once a week and once in two weeks as improvement was recorded (Table 2). The treatment time was made flexible but average one hour per session. The parent resented the provisional polio diagnosis because of their belief the child was suffering from spiritual manipulation. They, however, were enthusiastic about their child being functionally active irrespective of the causative factor.

**Physiotherapist (PT) Diagnosis:** impaired function of the left upper limb and bilateral lower extremities sequel to post- poliomyelitis

**Prognosis:** The prognosis was good because of early intervention and cooperation from the parents

**Summary of findings:**

1. The skin sensation test was impaired more on the left lower limb than the right.
2. The range of motion was intact for all joints in the affected limbs
3. There was flabbiness of bilateral lower limb muscles and muscles of the left shoulder joint
4. There were discrepancies in the muscle strength between the left and right lower limbs.
5. There was no contracture in any of the contracture prone points such as tendon Achilles and hip flexors
6. The patient could not lift the left upper limb

**Treatment goals:**

**Short-term goal**

1. To maintain joint ROM of Motion
2. To prevent tendon shortening (contracture)
3. To limit muscle wasting
4. To improve tone
5. To enhance milestones
6. Advise on home program

**Long-term goal**

1. To achieve unsupported sitting
2. To achieve supported standing/independent standing
3. To achieve independent ambulation
4. Advice on orthotics application
5. Advice on a home program

**Material and Methods**

1. Standing box (measured to the child's chest region), 2 back slabs and two inches' crepe. The above combinationis used for standing exercises. This was from 4$^{th}$ month to enhance weight-bearing on the bilateral limbs3x per week one hour per session. The heights of back slabs and the standing box diameter was adjusted 3 times as the child

was growing up so as to make it comfortable for standing. The crêpe bandage was for tying the back slab [ Table 2]

2. Medicine ball to strengthen the back extensors and the abdominals.
3. Faradic current used to improve tone on the flabby muscles
4. Goniometer used for a range of motion measurement
5. Measuring tape for limb length measurement to track discrepancy and muscle atrophy
6. Pediatric toys to win the child's attention
7. Pin and wool for skin sensation test
8. Tactile stimulation
9. The Medical Research Council Grading (Table 1) (MRCG) was used as an outcome measure for determining muscle strength pre and post-intervention [25],

**Outcomes**

Table 2 shows the documentation of developmental milestone attained by the child between baseline and 36 months of exercises, and electrical muscle stimulation interventions. It was observed that after the initial 12 months of management patient was able to sit without support. Also by 24 months of intervention supported standing /walking was achieved. Standing without support was achieved by 30 months while I minute walk was achieved by 33 months. Significantly, by $36^{th}$ months 5 minutes' walk was achieved; patient walks with mild hyperextension of the left knee, high stepping gait because of foot drop and mild scoliosis in the back. There was no contracture in all contracture prone points with a range of motion remaining free in all the joints.

Tables 3 and 4 show changes in the muscle strength of the left upper limb and bilateral lower limbs pre and post interventions. After 36 months of interventions, the improvement in the muscles of the left upper limb was not enough to achieve any significant movement of the shoulder joint, the shoulder remains dropped with significant muscle wasting around the shoulder muscles. Tables 3 and 4 show muscle strength variations in both the right lower limb muscleand leftlower limb respectively. The muscle improvement in the lower limbs enhances the patient's standing and mobility abilities though with the hyperextended left knee. The foot-drop significantly reduced in the right foot, while no significant changes were recorded in the left foot; this makes the patient ambulate with high stepping gait.

## Discussions

Poliomyelitis is a very rear presentation in the contemporary medical facilities in Nigeria because of the enormity of resources being pumped into its eradication by the Nigerian government in collaboration with WHO and other donor agencies like Rotary International. The current study was an isolated occurrence as no official new case was reported in Nigeria by the Federal Ministry of Health since 2016 [14]. The author has known the potential disabilities of polio and the consequences of not taking pre-emptive rehabilitative measures to curtail it, have undertaken this study to explore not only the beneficial effects of early initiation of physiotherapy intervention but long-term follow-up study. The outcome of this study shows that both the short-term and long-term goals as stated above were substantially achieved after a 3-year follow-up. The authors were conscious of the implications of not initiating physiotherapy early in paralytic polio: contractures, joint stiffness, pain, muscle wasting, poor tone, delayed milestone, and have taking intervention measures that were in agreement with Dean et

al,findings that early intervention in paralytic polio alleviates disabilities, pain and later higher demand for orthotic appliances as the patient matures into adult life. The strength of this study lies in the parent who was not only compliant but also committed to management plan outlined for their child. This commitment made the case of absconding as seen in many follow-up studies not an issue in this current study.

Interestingly, after 3 years of physiotherapy intervention, the range of motion in various joints of the bilateral lower limbs and the left upper limb remain free, no form of stiffness in the affected joints because of the effect of passive joint mobilization in sustaining joints range of motion. The goal of preventing contractures was realized after 3 years because the patient has no contractures in all the contracture prone sites like tendon Achilles, hip flexors, knee flexors, and elbow and shoulder region. This is as a result of beneficial effects of muscle stretching exercises and full range joint mobilization in preventing contractures. Also, substantially, the goal set on lowering muscle wasting was achieved due to combined effects of strengthening exercises, galvanic current and sustained weight-bearing on the bilateral lower limbs using back slabs and standing box. Significantly, Table 4 detailed the milestone progressions cumulating in about 5 minutes' ambulation after 36 months' physiotherapy management. Preceding Table 4 were Tables 3 and 4 which comprised muscle assessment chart for the bilateral upper and lower limbs. It must be noted that the baseline measurements were approximate as indicated in the tables because the child at that age could not take instructions - so by provocation the baseline muscle power was determined. One remarkable point to note was that the left upper limb was affected especially at the shoulder region creating slight subluxation on that joint. Post-intervention, the recovery at the shoulder region was not significant to restore functionality to the shoulder region and the atrophy of the muscle still persists. This has greatly limited the deployment of the left

hand to the performance of functions especially ones involving or needing elevation of the upper limb. The muscle chart reveals significant improvement between the baseline muscle power and post-intervention (36 months) between the right and left lower limbs respectively. However, that the child could ambulate shows the gain in muscle power in the two limbs after 36 months' intervention was significant. The muscle chart (Table 3) reveals a continuation of lag in planter-flexors and Dorsi-flexors in the two lower limbs especially in the left lower limb which was the more affected. This might lead to contemplation of anti-foot drop orthotic device for the left foot in the planned second phase of rehabilitation. Finally, the last objective set under the short-term plan was achieved because the caregivers (parent) were constantly reminded of the importance of the home program. They had the standing box and back slabs they used to practice standing at home; this might have helped in sustaining the muscle bulk by not allowing significant disuse atrophy. The parent was advised on the need to sustain the home program, guard and guide the child as he navigates through rough terrains to avoid fall. The findings of this current study were consistent with the opinion of Dean et al,that treatment should be implemented early and continued throughout the first year after onset when most recovery is likely to occur. She also opined that rest, comfort, and the prevention of deformity with proper body positioning and range of motion exercise should remain priorities. [6]. The recommendation of the use of low intensity, short duration, and intermittent activity or exercise performed within patient's limit of fatigue, weakness and pain was consistent with what obtains in the current study [6]. It is important that treatment was based on a definitive diagnosis and multi-system assessment given the systemic effects of the disease. In the post-acute stage, however, the routine procedures that dominated management in the epidemic in the industrialized countries should be replaced with prescriptive physiologically based treatment. Heat may reduce pain, spasm and stiffness, and

optimize the effect of a range of motion exercise. Exercise needs to be prescribed in such a way that over-exertion, fatigue, pain and further muscle damage are minimized in patients. Dynamic moderate resistive exercise can be supported for strength and endurance training. Heavy resistive exercise may give muscle irritation, pain and muscle damage. The frequency, duration and time course of treatment depends on the assessment [6]. The findings of this study were in agreement with previous research studies which confirms the effectiveness of physiotherapy treatment in managing paralytic poliomyelitis: a few studies have addressed the potential role of physiotherapy on the course of polio disease and muscle strength and functioning [8,9,10], showing that physiotherapy is an effective treatment of polio-related problems and can improve muscle function; a study carried out on 70 polio cases treated in 1952–1953 showed improvements in muscle strength after physiotherapy, for some patients, as long as 6 months after symptom onset [11]; also in another study on poliomyelitis, the phase of potential recovery of muscle strength varied from a few weeks to a maximum of 2 years[12].

The authors also set long-term goals of achieving supported standing/walking, standing without support and independent walking which were achieved at 24 months, 30 and 33 months respectively. The boy has now achieved some good level of independence in walking after 3 years of physiotherapy intervention and has since enrolled in pre-primary school this September 2018. This should be seen as a preliminary outcome as more follow-ups and interventions will continue for the next 2 years with the hope of sustaining the gains achieved in the last three years and probably minimizing the chances of orthotic appliances. As the child grows up major consideration will be given to regular assessment of the child's need for orthotic device(s): an ankle-foot orthotics should be given if the foot drop in the left lower limb is sustained; a long brace of plastic or metal will be applied if there is weak knee, this may be with or without knee

joint that locks straight for walking and bend for sitting, and finally if a long leg brace attached to a body brace or body jacket will be required if there is weak trunk. There is an obvious need to continue physical therapy on an outpatient basis to help muscle re-education as specific exercise programs for strengthening lower extremities are helpful to avoid contracture and muscle atrophy [13]. The role of physiotherapy in the management of poliomyelitis has been highlighted since 1947 and should be administered at various stages of recovery though with different management plan [12].

## Conclusions

After the administration of the physiotherapy interventions that comprised electrical stimulation and an approach combining the use of low intensity, short duration, and intermittent activity or exercise performed within patient's limit of fatigue, weakness, and pain for 36 months, patient was able to achieve 5 minutes' walk. Also there was no contracture at the tendons, and the range of motion for various joints were full and pain free. Significantly, the muscle power in the right lower limb improved better than that of the left lower limb. However, the muscle wasting around the left shoulder joint persisted making the child unable to lift the left upper limb. The authors are of the opinion that the intervention procedures applied in this study could have helped to facilitate milestone development because adverse complications did not develop. This positive outcome will make extensive demand for orthotic devices for paralytic polio victims less, and ensure safe application where needed. This study was limited by a dearth of relevant literature to support the outcome especially as applied to rationale or evidence supporting clinical decisions about care. This may be adduced to significantly reduced prevalence of paralytic polio globally [15] hence researchers have shifted focus to other areas of global concern.

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**Table 1: Medical Research Council Grading (MRCG) of Muscle Strength**

| | |
|---|---|
| Grade 0 | No Movement is Observed |
| Grade 1 | Only a trace or flicker of movement is seen or felt in the muscle, or fasciculation is observed |
| Grade 2 | Movement is possible only if the resistance of gravity removed |
| Grade 3 | Movement against gravity is possible but not against resistance of the examiner |
| Grade 4 | Muscle strength is reduced but muscle contracture can move joint against gravity and resistance |
| Grade 5 | Muscle contracts normally against full resistance |

Summary of Table 1: The lowest muscle movement is grade 0 while the highest muscle movement in a normal muscle is grade 5. Other grades represent different levels of movement depending on the case in question.

395

396 **Table 2: Diary of Treatment, Expected and Attained Milestone**

| Number of session per Week(s) | Duration | Intervention type | Normal expected milestone | Attained Milestone |
|---|---|---|---|---|
| 3x per week one hour per session | 12 months | The following treatment regimen were applied the first 12 months: Passive mobilization and stretching of joints and ligaments, tactile stimulation, sitting reeducation, standing reeducation with back slabs using standing box, electrical muscle stimulation (EMS) and home program. The intervention timeline was 1hour. | A normal child should be walking at 12 months | Sitting without support was achieved |
| 2x per week one hour per | 12 months | The following | A normal | Supported |

| | | | | |
|---|---|---|---|---|
| session | | treatment regimen were applied the second 12 months: Passive mobilization and stretching of joints and ligaments, tactile stimulation, standing reeducation with back slabs using standing box, electrical muscle stimulation (EMS) and home program. | child should be walking | standing /walking was achieved |
| 1 per week one hour per session | 6months | The following treatment regimens were applied for 6 months: Passive mobilization and stretching of joints and ligaments, tactile stimulation, sitting reeducation, standing reeducation | | Standing without support was achieved |

| | | | | |
|---|---|---|---|---|
| | | with back slabs using standing box, walking reeducation with pediatric parallel bar. | | |
| 1 per two weeks one hour per session | 6 months | The following treatment regimens were applied 6 for months: Passive/active mobilization and stretching of joints and ligaments, tactile stimulation, standing reeducation without back slabs, walking reeducation with pediatric parallel bar. The intervention timeline was 1hour. | A normal child should be running and play around. | 1-minute walk was achieved |
| Total | 36 months | The following treatment regimens | | Over 5 minutes' |

| | | | | |
|---|---|---|---|---|
| | | were applied the first 12 months: Passive mobilization and stretching of joints and ligaments/tendon, tactile stimulation, standing reeducation without back slab and 5 minutes walking without support. The intervention timeline was 1hour. | | walk was achieved |

Summary of Table 2: After series of interventions, sitting without support was achieved in 12 months; supported standing /walking was achieved after 24 months of intervention; Standing without support was achieved after 30 months; 1-minute walk was achieved about 33 months while 5 minutes' walk was achieved after 36 months

**Table 3: Muscle assessment using MRC grading pre and post-intervention for bilateral lower limbs**

| Muscle group | Right lower limb (Approximate MRCG scores) | Left lower limb (Approximate MRCG scores) |
|---|---|---|

| | Baseline | 36 months | Baseline | 36 months |
|---|---|---|---|---|
| Hip flexors | 2+ | 3 + | 1 | 2+ |
| Hip extensors | 2+ | 3+ | 1 | 2+ |
| Hip Abductors | 2+ | 3+ | 1 | 2+ |
| Hip Adductors | 2 | 3 | 1+ | 2+ |
| Knee flexors | 2 | 3+ | 1+ | 2+ |
| Knee extensors | 1+ | 3+ | 1+ | 2+ |
| Dorsiflexors | 1+ | 3 | 1+ | 2+ |
| Plantar flexors | 1+ | 3 | 1 | 2 |

403

404 Summary of Table 3: the baseline muscle powers of the right lower limb were higher than that of the left lower limb.

405 After 36 months the muscle powers of the right lower limb were higher than that of the left lower limb

406 **Table 4: Muscle assessment using MRC grading pre and post-intervention for bilateral**

407 **upper limbs**

| Muscle group | Right upper limb (Approximate MRCG scores) Baseline | 36 months | Left upper limb (Approximate MRCG scores) Baseline | 36 months |
|---|---|---|---|---|
| Shoulder abductors | 5 | 5 | 1+ | 2+ |
| Shoulder adductors | 5 | 5 | 1+ | 2+ |
| Shoulder elevators | 5 | 5 | 1+ | 2 |
| Shoulder depressors | 5 | 5 | 1+ | 2 |
| Elbow flexors | 5 | 5 | 3 | 4 |

| | | | | |
|---|---|---|---|---|
| Elbow extensors | 5 | 5 | 3 | 4 |
| Wrist extensors | 5 | 5 | 4 | 4+ |
| Wrist flexors | 5 | 5 | 4 | 4+ |

Summary of Table 4: the baseline muscle powers of the right upper limb were normal and hence higher than that of the left upper limb. After 36 months the muscle powers of the right upper limb were higher than that of the left upper limb.