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Gross motor function, surgical intervention, and academic performance in children with cerebral palsy receiving physiotherapy at a special needs school

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Declaration: Student's contribution to article(s) and agreement of co-author(s)

Declaration

I, Nicole Comninellis, declare that this Dissertation is my own, unaided work. It is being submitted for the degree Master of Science in Medicine Child Health: Neurodevelopment at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

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Name of candidate


Signature of candidate

11th day of **August 2024** in **Cape Town**

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Abstract

Background: Cerebral palsy (CP) is the most common cause of childhood disability globally. Children with CP often undergo surgical intervention. Academic performance and possible functional associations in children with CP in South Africa has not been described.

Objectives: To describe and compare the gross motor and academic performance of children with CP who received physiotherapy. To describe the surgical interventions performed, and to investigate associations between gross motor function, surgical intervention and academic performance.

Methods: This five-year retrospective descriptive cohort study, is from a single centre. Records for 67 participants across all GMFCS levels were reviewed. Ethical clearance and informed consent were obtained as appropriate. Data, including demographics, clinical history, Gross Motor Function Measure and academic scores were collected for the time period 2015-2019. Descriptive statistics were used to summarise the data. T-tests were used to determine changes over time. Pearson's correlation was used to investigate associations. ANOVA was used to assess change over time.

Results: Sixty-four percent of participants were male; half were born preterm. The predominant subtype was spastic (57%), with bilateral involvement in three-quarters of participants (40% diplegia; 34.5% quadriplegia). There was no statistical significance between the occurrence of surgical intervention on gross motor performance, ($p=0.474$), nor between GMFCS levels and academic performance. There was a positive effect of statistical significance noted in year five for academic performance vs surgery ($p=0.016$).

Conclusion: There was no correlation between surgical intervention, gross motor function and academic performance determined in this study. Further research is recommended to evaluate these relationships.

(Word count: 250)

Introduction

Cerebral palsy (CP) is an umbrella term for individuals who may experience various impairments of posture and movement, and other co-morbidities which impact activity and participation; attributable to non-progressive but permanent neurological changes that occurred in their developing brain. Children with CP may also experience impairments in sensation, perception, cognition, communication and behaviour (e.g. ADHD), as well as epilepsy, chronic pain, sleep disorders, and secondary musculoskeletal problems.[1,2] CP remains one of the most common neurodevelopmental disabilities of childhood globally. Internationally, the prevalence of CP is an average of 2 -2.5 per 1000 children in high-income countries (HICs)[3] and in Africa, this prevalence is reported to be between 2-10 per 1000 children[4]. A 2024 scoping review of CP in Africa described a prevalence of 0.8 to 10 cases per 1000 across seventeen African countries[5]. Functional CP registers exist in HICs[6], however there is no known register for CP in South Africa[7].

Academic performance requires complex cognitive functions such as attention and executive skills, memory, visual-perception and auditory processing skills, and speech and language, and body co-ordination. A study conducted in Sweden[19] described children with CP as performing substantially lower in school than those without CP, including those with a gross motor function classification scale (GMFCS) level I.

The GMFCS is a widely-used five-level scale describing functional ability of children with CP. It has five levels ranging from Level I: minimal motor impairment to level V: full dependence on others for participation and wheelchair mobility.[8] While functional limitations can be a direct cause of limitations of activity and participation in the context of schooling, communicative ability and intellectual impairment were more strongly associated with academic outcomes, and access to communication tools are strongly recommended. [19,20]

Public special schools assist children with CP to access mainstream Curriculum Assessment Policy Statements (CAPS) education, by providing modified learning and assessment accommodations, use of augmentative and alternative communication (AAC), facilitators, scribes and readers, and therapy. Referral pathways allow placement of a child into a suitable school following a holistic assessment. Learners who achieve grade twelve receive the National Senior Certificate.

The Gross Motor Function Measure (GMFM) is a comprehensive, standardised and validated assessment tool used by physiotherapists, to compare functional change over time, especially

before and after interventions. It comprises 88 functional items, across five domains: Lying and rolling, sitting, crawling and kneeling, standing, and walking, running and jumping.[9] This provides an opportunity to monitor and describe small yet important changes in variability of gross motor function.[10,11] Physiotherapists are essential role players in the holistic management of a child with CP in the special needs school setting. They consult with doctors, parents, therapists and teachers to monitor function, prescribe orthotics and mobility aids and consider referral for well-timed neuro-musculoskeletal intervention.[12][13] Pre and post-surgical rehabilitation is essential, especially in the case of complex surgery such as selective dorsal rhizotomy or multi-level orthopaedic surgery.[14,15]

Orthopaedic intervention is common in the management of children with cerebral palsy in order to manage secondary musculoskeletal problems. The timing and type of intervention is important to consider in terms of access to regular rehabilitation. Conservative orthopaedic management includes stretch-casts and orthotics. [16,17] Surgical intervention in the context of this study is considered an umbrella term for procedures performed in-hospital under general anaesthesia that puncture the skin and disrupt the function of the nerves, muscles, connective tissue, bones or joints. Botulinum Toxin type-A (Botox) is used commonly in CP and is often injected with the guidance of electromyography (EMG); it can be used alone or grouped with other procedures.[18]

Many studies exist that describe function and interventions in CP, but there is no research available that investigates the possible relationships between gross motor function, surgical intervention, and academic performance in the same population group.

Methods

Location: This five-year single-centre retrospective longitudinal descriptive cohort study was conducted at a single English-medium public special needs school in Cape Town, which enrols learners from pre-primary level through to grade twelve, teaching CAPS.[21] The learners may also receive occupational therapy (OT), and speech therapy (SLT). Learners received physiotherapy for one hour per week during school terms.

Participants: Historical records of learners of any age and grade, with clinically diagnosed CP across all GMFCS levels, were considered for inclusion if they were receiving physiotherapy during any part of the five study period (2015-2019) as a sample of convenience. They were not required to be in attendance of all five years to be included, nor have had surgical

intervention. This study presumed that learners placed at this special school were deemed intellectually capable to cope academically with the support provided.

Ethics: Ethics approval was obtained from the ethics committee of the University of the Witwatersrand (M210507) (Appendix A) and approval was granted by the Western Cape Department of Education (WCED) to conduct the study. Consent was obtained from parents and assent from learners still attending the school at the time of data collection, for use of anonymous secondary data (Appendix B). Each participant was allocated a number in order to anonymise the data set.

Aim: The aim of this study was to retrospectively describe and compare the gross motor function, academic performance and any surgical intervention of children with CP across all GMFCS levels, who received physiotherapy at a Special School, over a five-year study period, and determine if there were any relationships between these components.

Objectives:

1. To describe the gross motor function, classification, relevant history and co-morbidities of the population of children with CP who attended this school and received physiotherapy during the study period.
2. To determine gross motor performance changes over time in children with CP who attended this school and received physiotherapy during the study period.
3. To describe and compare the yearly academic average scores and subject-specific scores of children with different sub-types of CP who attended this school and received physiotherapy during the study period.
4. To describe the type and frequency of neuro-musculoskeletal surgical intervention undergone by children with CP who attended this school and received physiotherapy during the study period.
5. To determine if there is an association between surgical intervention, gross motor function and academic performance in learners with CP, who attended this school and received physiotherapy during the study period.

Procedure:

Seventy-six study participants were identified using the WCED learner database and checked against the physiotherapy database and historical archive for inclusion. Data collection was split into two parts: 01 July 2021 – 30 September 2021, and 24 May 2022 – 30 September 2022. Thirty-three participants no longer attending the school were identified for automatic inclusion. Forty-three learners still attending the school were invited to participate. Thirty-four learners returned signed consent forms. The total number of records reviewed was 67.

Data was extracted from archived files and entered into a data collection sheet (Appendix C) with anonymous coding and transcribed into an excel spreadsheet. GMFM-88 and academic scores as well as surgical history were collected. Academic scores were captured per subject per term per year from report cards and converted to the *scale of achievement* code system (1-7) for uniformity (Appendix D). Medical history including diagnosis, medication, radiological findings, classification of CP, assistive devices, therapy attended; and comments regarding academic potential (IQ) were collected. Anonymised coded data was then analysed.

Statistical analysis:

Microsoft Excel and STATA version 17 (StataCorp.USA) were used for analysis of the data. The data is presented as means, frequencies and percentages, with supporting tables or graphs. T-tests were used to determine changes over time, and Pearson correlation was used to determine if there were any correlations between the data components. Anova was used to compared birth history variables to GMFCS levels.

Results:

Sixty-seven participant records were reviewed. Table 1 describes demographics and functional classification of CP by GMFCS level, subtype and topography. Nearly two-thirds of the participants were male (64%). Over half of the participants with reported gestational age were born preterm (33/63), and a large proportion of those were born between 28 to 32 weeks (42%; 14/33). The predominant subtype was spastic (57%), followed by mixed spastic-dyskinetic (31%). Diplegia (40%) was the most frequently described topography. Of those with unilateral CP, nearly 60% (10/17) had right hemiplegia. Nearly two-thirds of the participants had ‘mild’ impairment designated by GMFCS level I (36%), and II (28%).

Table 1: General Demographics and functional classification of CP

Sex	**Total N=67 (%)**
Male	43 (64)
Female	24 (36)
Gestational Age at birth	Total N=63 (%) **Mean:** 34.5 weeks**;** **Range:** 26-42 weeks
Extreme Preterm <28 weeks	10 (6)
Very Preterm 28-32 weeks	14 (22)
Moderate Preterm 32-34 weeks	4 (6)
Late Preterm 34-37 weeks	5 (8)
37-42 weeks	30 (48)
Birth Weight (g)	Total N=54 (%) Mean: 2229g Range: 540g-4460g
ELWB <1000g	10 (19)
VLBW <1500g	11 (20)
LBW <2500g	10 (19)
2500 – 3500g	16 (30)
3500 – 4500g	7 (12)
GMFCS levels	N=67 (%)
level I	24 (36)
Level II	19 (28)
Level III	13 (19)
Level IV	6 (9)
Level V	5 (7)
CP Subtype	N=67 (%)
Spastic	38 (57)
Mixed	21 (31)
Dyskinetic	5 (7)
Ataxic	3 (4)
Topography	N=67 (%)
Bilateral - Diplegia	27 (40)
Bilateral - Quadriplegia	23 (34.5)
Unilateral	17 (25.5)
Unilateral - left	7 (10)
Unilateral - right	10 (15)

Risk factors and co-morbidities:

Over 80 variables grouped between antenatal, perinatal and post-natal events were described across all records (Appendix E). There was no statistical significance between gestational age at birth (p=0.6591) or birth weight (p= 0.3519) and GMFCS level. **Epilepsy** was diagnosed in 18% (12/67) and sodium valproate was the most frequently used medication to treat this (50%). Methylphenidate was used for ADHD (15%) and oral baclofen for spasticity (5%). **Hearing impairment** occurred in 6% as a result of auditory neuropathy or hearing loss. One participant had **impairment of speech** due to vocal-cord palsy.

Assistive devices: Two-thirds of participants used a mobility aid, of which 9% were dependent on assistance of others for mobility, 6% used independent powered mobility, and 21% were able to self-propel. Thirty percent of participants walked with an assistive device. Nearly 70% of participants made use of an ankle-foot orthosis. Two participants used hearing-aids and one participant received a cochlear implant. Spectacles were used by 18% of participants.

Academic potential

Less than half (32/67) of the participants had data pertaining to academic potential. The data was not comparable in this study between participants due to use of incomplete data, different tests, or large discrepancies in performance. Of the available data, more than one-third (12/32) had *average* or better performance, with a frequency of 75% for GMFCS level I. Fifty percent (16/32) had a performance of *below-average* or less, and the remainder were described as *borderline* (3/16) or *intellectually disabled* (5/16).

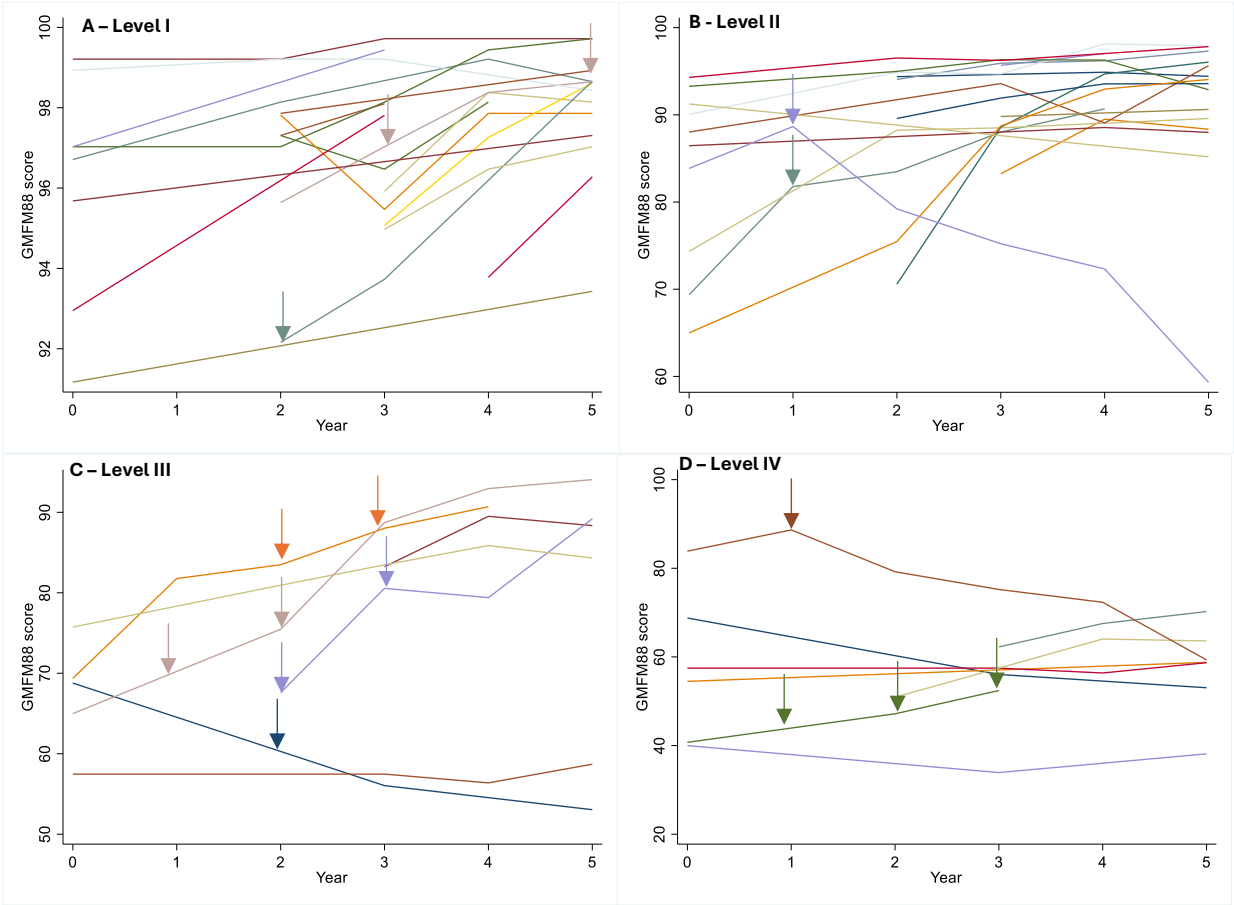
Gross motor function

Mean baseline and interval scores for the GMFM-88 were recorded per participant and compared across all GMFCS levels for change over time. A large proportion (79%, 53/67) had data, of which 85% had two or more comparable data sets (45/53). Fourteen participants had no GMFM data during the study period. GMFM-88 assessment data for year one of the study was poorly recorded (2/46) in comparison to the years before the study. The remaining years of the study showed fluctuations in assessments: Year two 59% (26/44); Year three 82% (37/45); Year four 61% (28/46) and Year five 81% (38/47). Figure 1 provides an opportunity for individual participant trajectories over time and intervention inflection points to be appreciated. There is limited data for GMFM-88 GMFCS level V, therefore it has not been represented graphically.

GMFCS levels are known to remain stable with age in up to 75% of children with CP, with the least likelihood of change occurring in levels I and V.[8] In this study, seven participants changed GMFCS level. Three level III participants changed to level IV, though one participant was still completing acute rehabilitation following surgery. Three others improved from level III to level II - one of these participants had no received surgery in the study period but received physiotherapy regularly. One participant had a significant reduction in GMFCS from level II to IV following surgery despite rehabilitation, which remained long-term. These significant changes in GMFM-88 scores are observable on Figure 1.

Figure 1: *GMFM-88 scores represented as percentages across the study period for individual trajectories for A: level I GMFCS; Figure B: GMFCS level II; C: GMFCS level III; D: GMFCS level IV.*

Arrows that correspond to line colour provide inflection points for participants indicate examples of when intervention occurred in relation to their gross motor function trajectory across the time period. Note the changing values of the y-axis which describes ability from higher function at level I to lower function at level IV.



A combined total of 98 instances of neuro-musculoskeletal surgical interventions were performed for 46 children over the five-year period, with the majority (69%) occurring in the public sector. Nearly one-third of participants had no intervention during the study period (21/67).

The mean age of intervention increased from 8.6 years to 9.4 years of age from year one to year five, with an overall mean of 8.7 years across all five years, and a range of 3 to 18 years.

Orthopaedic intervention categories were split into Botox, soft-tissue and bony surgery. At times these three interventions were combined.

Botox was used in 18 different anatomical areas, with a total frequency of 180 over the study period. It was used in combination with conservative measures such as stretch casts as well as combined with soft-tissue and bony surgeries where appropriate. The most frequently occurring anatomical area of Botox administration was to the calf muscle (27%, 49/180), followed by the hamstrings (13%, 24/180), wrist flexors (12%, 22/180), thumb adductors (11%, 20/180) and forearm pronator teres (15/180).

Soft-tissue surgery was described in fourteen anatomical areas, with a combined frequency of 77. The most frequent were lengthening of the Achilles tendon (22%, 17/77), and the gastrocnemius muscle (18%, 14/77). Followed by Hamstrings (14%, 11/77).

Bony surgery comprised of eleven different procedures with a combined frequency of 27, with the most frequent being subtalar arthrodesis (30%, 8/27) followed by hallux valgus repair (18.5%, 5/27) and femoral derotation osteotomy (15%, 4/27).

Neurosurgical intervention by Selective dorsal rhizotomy was performed for two participants; and these participants also underwent orthopaedic bony and soft-tissue surgeries during the time period.

There was no statistical significance between the occurrence of surgical intervention on gross motor performance (GMFM-88), ($p=0.474$). Over one-quarter had one procedure, while one-fifth had two procedures during the study period. The remaining participants had between three (13%), four (7.5%) and five (1.5%) instances of intervention in the study period. There was a progressive decrease in surgical intervention frequency from year one ($n=27$) to year five ($n=8$).

Academic performance

Table 2 shows the grade distribution over the study period, and provides comparison of academic performance with GMFCS level, sub-type and topography.

The ataxic group had a higher average rounded code rating (5) than the other groups, denoting ‘substantial achievement’ (i.e. 60-69%). The dyskinetic group had mathematics in their top three performing subjects, while every other group had mathematics in their lowest three subjects. In reference to topography, participants with right-hemiplegia had a higher average rounded code rating (5) than other groups. The group with the lowest average code rating was

the group with bilateral quadriplegia; however there is no statistical significance between these scores.

Art was the subject with the highest average performance while mathematics was the lowest across all GMFCS levels. Of the four core subjects which are consistent across all grades, Afrikaans second additional language was the highest with an average code of 4.7, followed by Life Orientation (4.2), English (3.6) and Mathematics/Maths Literacy combined (3.4).

There was no statistically significant difference between GMFCS levels and academic performance scores. The overall academic code across all GMFCS levels is code 4, which is described as 'adequate achievement' and denotes a percentage range of 50-59%.

Fourteen learners left the school prematurely during the study period: one child passed away from illness, five learners transferred to other mainstream or CAPS-aligned special schools; eight learners transferred to schools with a less demanding curriculum because they were not coping. Year four had the highest number of repeating learners in the foundation phase than any other year (n=10). Eleven participants achieved grade twelve level in the five-year period.

The academic performance of the eight learners who left this school during the study period for a more adapted curriculum had a mean academic code 2, which denotes elementary achievement (i.e. 30-39%). Two of these learners had academic potential described as intellectually disabled. Removing these eight participants' mean academic scores from the total of this cohort showed no significant change in mean code rating, as the overall code remained four. Their data was not excluded from overall analysis.

Pearson's correlation between gross motor performance and academic scores over time (Ta2, 2.2.1) showed no significance; however there was a positive trend for improving academic scores with improving gross motor scores.

In comparing average academic performance with incidence of surgery, there was a positive effect of statistical significance noted in year five, ($p=0.016$), and though not significant, a positive effect was noted in gross motor performance with incidence of surgery in year five, ($p=0.072$). Overall, there was no statistically significant correlation between surgical intervention, gross motor function and academic performance determined in this study.

Table 2:

2.1 Grade distributions, and Comparison of CP GMFCS, sub-type and Topography vs Academics

2.1.1. Grades distribution Per Year

	Total	MG	PP	R	1	2	3	4	5	6	7	8	9	10	11	12
Year 1	46	1	6	9	7	2	2	1	5	-	2	5	1	-	3	2
Year 2	44	1	6	5	8	6	2	2	1	4	-	1	4	1	-	3
Year 3	45	2	4	6	7	7	5	2	1	1	4	-	1	4	1	-
Year 4	46	2	2	5	6	10	2	5	2	1	1	4	-	1	4	1
Year 5	47	2	2	4	6	7	7	1	3	2	1	1	5	-	1	5
(MEAN) of participants N=	(45)		(4) 20	(6) 29	(7) 34	(6) 32	(3.6) 18	(2) 11	(2) 12	(2) 8	(2) 8	(2) 11	(2) 11	(1) 6	(2) 9	(2) 11

2.1.2. GMFCS vs Subject codes

ENG: English; AFR: Afrikaans; MA: Maths; ML: Maths Literacy; LO: Life Orientation; NST: Natural Science & Technology; NS: Natural Science; SS: Social Sciences; EMS: Economic Management Science; TEC: Technology; CAT: Computer Applications Technology; CON: Consumer Studies; TOU: Tourism; LS: Life Sciences

Code Totals	AVG	ENG	AFR	MA	ML	LO	NST	NS	SS	EMS	TEC	Art	CAT	CON	TOU	LS
GMFCS I	4.2	4	4	4	3	5	6	4	4	4	4	5	4	5	3	4
GMFCS II	4.4	4	5	4	4	5	5	4	4	4	5	5	4	5	4	4
GMFCS III	4.2	4	4	3	4	4	2	5	4	6	4	5	4	5	5	4
GMFCS IV	4.3	3	4	3	-	4	5	5	4	5	5	5	-	-	-	-
GMFCS V	3.5	3	6	2	-	3	-	-	-	-	-	-	-	-	-	-
MEAN	4.2	3.6	4.6	3.2	3.7	4.2	4.5	4.5	4.0	4.8	4.5	5.0	4.0	5.0	4.0	4.0

2.1.3. CP Sub-type vs Subject codes

	AVG	ENG	AFR	MA	ML	LO	NST	NS	SS	EMS	TEC	ART	CAT	CON	TOU	LS
Dyskinetic	4.0	4	4	4	-	4	5	4	4	3	3	5	-	-	-	-
Ataxic	4.8	4	5	4	-	6	5	-	-	-	-	-	-	-	-	-
Spastic	4.2	4	5	3	4	5	4	4	4	5	4	5	4	4	4	4
Mixed	4.2	4	4	4	3	4	5	5	5	5	5	5	2	5	3	-
MEAN	4.2	4	4.5	3.8	3.5	4.5	5.0	4.3	4.5	4.3	4.0	5.0	3.0	4.5	3.5	4.0

2.1.4. CP Topography vs Subject codes

	AVG	ENG	AFR	MA	ML	LO	NST	NS	SS	EMS	TEC	ART	CAT	CON	TOU	LS
Diplegia	4.3	4	4	3	4	5	4	4	4	5	4	5	5	5	4	4
Quadriplegia	4.0	4	4	4	3	4	5	5	4	4	4	5	2	4	4	-
Left-uni	4.4	4	5	3	4	4	6	4	4	5	4	5	4	5	4	-
Right-uni	4.8	4	5	4	-	5	6	4	5	4	5	6	5	6	-	4
MEAN	4.3	4.0	4.5	3.5	3.7	4.5	5.3	4.3	4.3	4.5	4.3	5.3	4.0	5.0	4.0	4.0

2.2. Comparisons between gross motor function, academic performance and surgical intervention

2.2.1. Academic Performance (Average) vs Gross Motor Function (GMFM)

GMFM Year	Year 1	Year 2	Year 3	Year 4	Year 5
Academic Year					
Year 1	-----				
Year 2		0.3869			
Year 3			0.3078		
Year 4				-0.0418	
Year 5					0.0917
P-value	-----	P=0.0682	P=0.0639	P=0.8328	P=0.5839

2.2.2. Academic Performance vs No Surgery / Surgery

Academic Year	Year 1	Year 2	Year 3	Year 4	Year 5
No Surgery (SD)	4.22 (1.34)	3.94 (0.86)	4.5 (1.14)	4.24 (1.27)	4.37 (0.97)
Surgery (SD)	4.05 (1.43)	4.13 (1.35)	3.94 (1.47)	4.19 (1.22)	3.33 (1.58)
P-value	0.6929	0.5931	0.1602	0.891	0.0167

2.2.3. Gross Motor Function (GMFM) vs No Surgery / Surgery

GMFM Year	Year 1	Year 2	Year 3	Year 4	Year 5
No Surgery (SD)	-	83.96(22.8)	85.73(21.42)	88.23(19.0)	89.91(13.3)
Surgery (SD)	-	84.94(17.9)	78.02(23.46)	85.43(15.06)	78.2(22.29)
P-value	-	0.9035	0.3085	0.7024	0.0722

Discussion

Learning difficulties experienced by children of preterm or term gestational age are known to differ, and the implication of prematurity in academic performance is complex, affecting different cognitive domains, even in the absence of motor impairment.[2] Impairments in visual-perception, reading, sensory-processing, difficulties with activities of daily living and fine motor function are common in CP.[20] Lower gestational age impacts neuronal organisation and overall brain volume, as well as intracranial pathology and white matter changes are linked to decreased visual-spatial-perceptual abilities and sensory-processing difficulties which impact learning greatly.[20]

In greater gestational age, cortical sparing in brain injury is linked to improved cognitive potential. It is encouraging to see that despite some participants enduring multiple risk factors they are achieving adequately at school. This is important as educational achievement provides later opportunity for income generation in adulthood.[19]

In this study there was no relationship between gestational age and birth weight compared to academic performance; this is likely due to the cohort being of reasonably similar academic potential as assessed for acceptance into this school.

There was a large reduction in GMFM-88 assessments from baseline to the first year of the study. There had been a reduction in the number of physiotherapists working at this special school from four to three, resulting in increased caseload. Children with SLD diagnoses were then less likely to receive physiotherapy, placed on a waiting list. Subsequent to this study being concluded, a further reduction to two physiotherapists has occurred.

Many of the learners at this school rely on the school transport system for travel. It is of great benefit to have access to regular physiotherapy input at school, accessing healthcare within the education domain, which allows a multidisciplinary opportunity to support a learner holistically. It is essential that gross motor function and surgical intervention monitoring continue, to determine long term impact as a result of lack of recommended individualised therapeutic input.

Conclusion

There was no statistically significant correlation between surgical intervention, gross motor function and academic performance determined in this study. Further research is recommended to evaluate these relationships with more detail, in particular to determine the differences between preterm and term-born groups. It is encouraging to observe an average

positive change in gross motor function scores over time, and this finding can be helpful to motivate for the continuation of physiotherapy services.

Study limitations

This study was a record-review of a small sample size. Due to the nature of obtaining information from historical records, some data was missing or inconsistently described, which can impact processing and analysis. Information obtained in medical records was assumed as correctly disclosed and there was no way to verify this information. It may have been more effective to exclude school-leavers from the academic performance correlation analysis on the presumption that they were not placed correctly.

Future considerations

The years of the COVID-19 pandemic occurred following this study. The school learners had a long-term lack of physiotherapy during this time. It is unknown whether the confines of the pandemic resulted in significant deteriorating function and associated secondary impairments. It would be an opportunity to evaluate any changes in GMFM from this study timepoint to the resumption of physiotherapy.

Further research is recommended to evaluate the relationships between academic performance and relevant variables in the Special School setting, particularly in relation to individual function as well as on a participation level.

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Appendix A: Ethics Approval

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R49 Ms N Comninellis

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M210507

NAME: (Principal Investigator)	Ms N Comninellis
DEPARTMENT:	School of Clinical Medicine Department of Paediatrics and Child Health Medical School University
PROJECT TITLE:	*Gross motor function, surgical intervention and academic performance in children with cerebral palsy receiving physiotherapy at a special needs school*
DATE CONSIDERED:	2021/05/28
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Professor J Potterton
APPROVED BY:	CB Penny Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2021/07/26

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office secretariat on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **May** and therefore reports and re-certification will be due in the month of **May** each year. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

Signature of Principal Investigator	Date
	26/07/2021

Appendix B – Consent and assent forms



PARTICIPANT ASSENT SHEET FOR MINORS

UNDER 18 YEARS OF AGE

I _____ agree that Nicole Comninellis may look at my school and physiotherapy records for her study: "*Gross motor function, surgical intervention, and academic performance in children with cerebral palsy receiving physiotherapy at a special needs school.*"

1. **I have read the information page, or someone read it to me _____**
2. **I understand what will happen if I take part _____**
3. **I was given time to ask any questions I wanted to and was happy with the answers I was given _____**
4. **I have been given a phone number to call if I have any questions _____**
5. **I understand that even if I say yes now, I can change my mind later and then my information won't be used _____**
6. **My parent/s know that I have been invited to take part in the project and they have said that I am allowed to _____**

Name of Participant (child):			
Date:		**Place:**	
Signature or Mark			

Name of Parent / Guardian:			
Date:		**Place:**	
Signature			

Witness Name:			
Date:		**Place:**	
Signature			

Contact details:

Nicole Comninellis, Principal Investigator, telephone no. 0714617122, or by e-mail at nicolecomninellis@gmail.com,

Professor Joanne Potterton, Supervisor, on telephone no. 0117173718, or by e-mail at joanne.potterton@wits.ac.za

Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za.

Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Appendix C – Data collection sheet

Participant code:			**Sex:**	**Race:**	
Gestational age at birth:			**Birth weight:**		
Birth history / perinatal events: e.g., jaundice, HIE, preterm, meningitis					
IQ:	Above average	Average	Below average	Intel. disability	
Home Language:	English	Afrikaans	isiXhosa	Other:	Not Recorded
Epilepsy:	Yes	No			
CP subtype:	Dyskinesia	**Spastic bilateral:**	Diplegia (LL)	Quadriplegia	
	Dystonia	Ataxia	**Spastic unilateral**	Left	Right
GMFCS level/s:	I	II	III	IV	V
Assistive devices:					
Medication:					
Speech Therapy	Year 1	Year 2	Year 3	Year 4	Year 5
Occupational Therapy	Year 1	Year 2	Year 3	Year 4	Year 5

Gross motor function measure (GMFM) scores in %

Time Period of Ax	Age at Ax	GMFM-66	GMFM-88	Notes

Surgical History

Time period of surgery	Age at surgery	Intervention description	Public	Private

Academic record – subject % per term, per grade, subjects listed & additional subjects described

Year	Grade	Subjects	Term 1	Term 2	Term 3	Term 4
1		English HL				
		Afrikaans FAL				
		Maths/Maths literacy				
		Life Skills/Orientation				
		Average:				

Year	Grade	Subjects	Term 1	Term 2	Term 3	Term 4
2		English HL				
		Afrikaans FAL				
		Maths/Maths literacy				
		Life Skills/Orientation				
		Average:				

Year	Grade	Subjects	Term 1	Term 2	Term 3	Term 4
3		English HL				
		Afrikaans FAL				
		Maths/Maths literacy				
		Life Skills/Orientation				

		Average:				

Year	Grade	Subjects	Term 1	Term 2	Term 3	Term 4
4		**English HL**				
		Afrikaans FAL				
		Maths/Maths literacy				
		Life Skills/Orientation				
		Average:				

Year	Grade	Subjects	Term 1	Term 2	Term 3	Term 4
5		**English HL**				
		Afrikaans FAL				
		Maths/Maths literacy				
		Life Skills/Orientation				
		Average:				

Appendix D - Scale of academic achievement

Achievement level (Rating code)	Achievement description	Percentage %
7	Outstanding achievement	80 – 100
6	Meritorious achievement	70 – 79
5	Substantial achievement	60 – 69
4	Adequate achievement	50 – 59
3	Moderate achievement	40 – 49
2	Elementary achievement	30 – 39
1	Not achieved	0 – 29

Appendix E – Aetiological risk factors for CP

Antenatal Risk factors

	Total (N=67) n(%)
Features of foetal distress	**11 (16%)**
Foetal distress	7 (10%)
Decreased foetal movement	1 (1%)
Bradycardia	1 (1%)
Meconium Liquor	2 (3%)
Complications of Multiples	**7 (10)**
Multiples	5 (7)
Twin-twin transfusion	1 (1)
intrapartum Twin demise	1 (1)
History of IVF	**1 (1)**
Congenital brain malformations	**4 (6)**
Maternal hypertension	**12 (18)**
Maternal hypertension	4 (6)
Pre-eclampsia	4 (6)
Eclampsia	1 (1)
HELLP syndrome	3 (4)
Rhesus incompatibility	1 (1%)
Intrauterine Growth Restriction	1 (1%)
Maternal infections	**8 (12%)**
Maternal asphyxia: Asthma	**1 (1%)**
Maternal diabetes / hypoglycaemia	**4 (6%)**
Maternal drug use	**1 (1%)**

Perinatal Risk Factors

	Total (N=67) n (%)
Need for resuscitation / ventilation	**24 (36)**
Resuscitation	9 (13)
Ventilation	15 (22)
Complications of Labour	**13 (19)**
Premature rupture of membranes	2 (3)
Spontaneous preterm labour	4 (6)
Cervical incompetence	1 (1)
Prolonged labour	6 (9)
HIE / Asphyxia / Hypoxia	**11 (16)**
Meconium Aspiration	**2 (3)**
Breech Presentation	**4 (6)**
Placental / Uterine / Cord	**4 (6)**
Placental abruption	2 (3)
Uterine rupture	1 (1)
Snapped cord	1 (1)
Other birth trauma	**2 (3)**
Brachial plexus injury	1 (1)
Cephalohematoma	1 (1)
Intracranial pathology	**24 (35)**
Haemorrhage	8 (33)
Infarct	7 (29)
PVL	5 (20)
hydrocephalus	4 (17)
Low APGAR	N=35
Score 0-3 at 1 minute	**9 (26)**
Score <6 at 5 minutes	**8 (23)**

Post-natal Risk Factors

	Total (N=67) n (%)
Respiratory	**38 (57)**
Respiratory distress syndrome	13 (19)
CPAP/HHFNC	9 (13)
Hyaline Membrane Disease	9 (13)
Bronchopulmonary Dysplasia	1 (1)
Apnoea	6 (9)
Cardiovascular	**8 (12)**
Persistent Pulmonary Hypertension	1 (1)
Neonatal hypertension	1 (1)
Patent Ductus Arteriosus	5 (7)
Hypertrophic Cardiomyopathy	1 (1)
Neonatal Jaundice	**20 (30)**
Kernicterus	1 (1)
Neonatal Seizures	**9 (13)**
Infections	**12 (18)**
Sepsis	8 (12)
Meningitis	2 (3)
Tuberculosis	1 (1)
Gastroenteritis	1 (1)
Miscellaneous	**24 (36)**
Anaemia of prematurity	5 (7)
Blood transfusion	5 (7)
Medullary Nephro-calcinosis	1 (1)
Acute Tubular Necrosis	1 (1)
Acute Renal Failure	2 (3)
Metabolic Acidosis	1 (1)
Hypoglycaemia	3 (4)
Hypopituitism	1 (1)
Hypotonia	3 (4)
Microcephaly	2 (3)
Intracranial pathology	**9 (13)**
hydrocephalus	4 (6)
PVL	5 (7)
Surgery	**8 (10)**
Bowel / NEC	2 (3)
Craniotomy	1 (1)
PDA ligation	1 (1)
Gastrostomy (PEG)	1 (1)
VP Shunt	3 (4)
Feeding, hearing & Speech system	**8 (12)**
Vocal cord palsy	1 (1)
Feeding difficulties	3 (4)
Auditory Neuropathy	1 (1)
Hearing Loss	3 (4)
Visual system	**5 (7.5)**
Retinopathy of prematurity	1 (1)
Septo-optic dysplasia	1 (1)
Cortico-visual impairment	1 (1)
Unilateral Strabismus	1 (1)
Congenital Ptosis	1 (1)
Delayed milestones reported	15 (22)
Epilepsy	12 (18)

Appendix F – WCED and School Approval

Western Cape Government
Education

Directorate: Research

meshack.kanzi@westerncape.gov.za
Tel: +27 021 467 2350
Fax: 086 590 2282
Private Bag x9114, Cape Town, 8000
wced.wcape.gov.za

REFERENCE: 20210428-2567
ENQUIRIES: Mr M Kanzi

Mrs Nicole Comninellis
38 Cogill Road
Wynberg
7800

Dear Mrs Nicole Comninellis,

RESEARCH PROPOSAL: GROSS MOTOR FUNCTION, SURGICAL INTERVENTION AND ACADEMIC PERFORMANCE IN CHILDREN WITH CEREBRAL PALSY RECEIVING PHYSIOTHERAPY AT A SPECIAL NEEDS SCHOOL

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **01 July 2021 till 30 September 2021.**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Mr M Kanzi at the contact numbers above quoting the reference number.
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:

The Director: Research Services
Western Cape Education Department
Private Bag X9114
CAPE TOWN
8000

We wish you success in your research.

Kind regards,
Meshack Kanzi
Directorate: Research
DATE: 1 July 2021



Western Cape Government
Education

Directorate: Research

meshack.kanzi@westerncape.gov.za
Tel: +27 021 467 2350
Fax: 086 590 2282
Private Bag x9114, Cape Town, 8000
wced.wcape.gov.za

REFERENCE: 20210428-2567
ENQUIRIES: Mr M Kanzi

Mrs Nicole Comninellis
38 Cogill Road
Wynberg
7800

Dear Nicole Comninellis,

RESEARCH PROPOSAL: RESEARCH PROPOSAL: GROSS MOTOR FUNCTION, SURGICAL INTERVENTION AND ACADEMIC PERFORMANCE IN CHILDREN WITH CEREBRAL PALSY RECEIVING PHYSIOTHERAPY AT A SPECIAL NEEDS SCHOOL.

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **24 May 2022 till 30 September 2022.**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Mr M Kanzi at the contact numbers above quoting the reference number.
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:

The Director: Research Services
Western Cape Education Department
Private Bag X9114
CAPE TOWN
8000

We wish you success in your research.

Kind regards,
Meshack Kanzi
Directorate: Research
DATE: 24 May 2022



VISTA NOVA SCHOOL

Primary Campus: 11 MILNER ROAD RONDEBOSCH ☎ (021) 689 5323 FAX (021) 685 2402
High School Campus: LOERIE AVENUE PINELANDS ☎ (021) 531 7192 FAX (021) 531 1151
Postal Address: P.O. BOX 193 RONDEBOSCH 7700

Mrs Nicole Comninellis
38 Cogill Road
Wynberg
7800

Dear Mrs Nicole Comninellis

RESEARCH PROPOSAL: GROSS MOTOR FUNCTION, SURGICAL INTERVENTION AND ACADEMIC PERFORMANCE IN CHILDREN WITH CEREBRAL PALSY RECEIVING PHYSIOTHERAPY AT VISTA NOVA SCHOOL

Your application to conduct the above-mentioned research at Vista Nova School in the Western Cape has been approved subject to the following conditions:

1. The staff and learners are under no obligation to assist you in your investigation.
2. Staff, learners and the school should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **01 July 2021 till 30 September 2021.**
6. No research is to be conducted during the fourth term as the school will be preparing and for examinations (October to December).

Wishing you success in your research.

Yours sincerely

R WARD
Principal

Appendix G - Turnitin Report

Turnitin Originality Report

- Processed on: 13-Aug-2024 8:03 AM SAST
- ID: 2431407375
- Word Count: 4150
- Submitted: 1

Submissible-N.Comninellis 441790 - 08.2024 co... By Nicole Comninellis

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Christopher M. Hayre, Dave J. Muller, Marcia J. Scherer. "Virtual Reality in Health and Rehabilitation", CRC Press, 2020

Gross motor function, surgical intervention, and academic performance in children with cerebral palsy receiving physiotherapy at a special needs school Introduction Cerebral palsy (CP) is an umbrella term for individuals who may experience various impairments of posture and movement, and other co-morbidities which impact activity and participation; attributable to non-progressive but permanent neurological changes that occurred in their developing brain. Children with CP may also experience impairments in sensation, perception, cognition, communication and behaviour (e.g. ADHD), as well as epilepsy, chronic pain, sleep disorders, and secondary musculoskeletal problems.(1,2) CP remains one of the most common neurodevelopmental disabilities of childhood globally. Internationally, the prevalence of CP is an average of 2 -2.5 per 1000 children in high-income countries (HICs)(3) and in Africa, this prevalence is reported to be between 2-10 per 1000 children(4). A 2024 scoping review of CP in Africa described a prevalence of 0.8 to 10 cases per 1000 across seventeen African countries(5). Functional CP registers exist in HICs(6), however there is no known register for CP in South Africa(7). Academic performance requires complex cognitive functions such as attention and executive skills, memory, visual-perception and auditory processing skills, and speech and language, and body co-ordination. A study conducted in Sweden(19) described children with CP as performing substantially lower in school than those without CP, including those with a gross motor function classification scale (GMFCS) level I. The GMFCS is a widely-used five-level scale describing functional ability of children with CP. It has five levels ranging from Level I: minimal motor impairment to level V: full dependence on others for participation and wheelchair mobility.(8) While functional limitations can be a direct cause of limitations of activity and participation in the context of schooling, communicative ability and intellectual impairment were more strongly associated with academic outcomes, and access to communication tools are strongly recommended. (19,20) Public special schools assist children with CP to access mainstream Curriculum Assessment Policy Statements (CAPS) education, by providing modified learning and assessment accommodations, use of augmentative and alternative communication (AAC), facilitators, scribes and readers, and therapy. Referral pathways allow placement of a

child into a suitable school following a holistic assessment. Learners who achieve grade twelve receive the National Senior Certificate. The Gross Motor Function Measure (GMFM) is a comprehensive, standardised and validated assessment tool used by physiotherapists, to compare functional change over time, especially before and after interventions. It comprises 88 functional items, across five domains: Lying and rolling, sitting, crawling and kneeling, standing, and walking, running and jumping.(9) This provides an opportunity to monitor and describe small yet important changes in variability of gross motor function.(10,11) Physiotherapists are essential role players in the holistic management of a child with CP in the special needs school setting. They consult with doctors, parents, therapists and teachers to monitor function, prescribe orthotics and mobility aids and consider referral for well-timed neuro-musculoskeletal intervention.(12)(13) Pre and post-surgical rehabilitation is essential, especially in the case of complex surgery such as selective dorsal rhizotomy or multi-level orthopaedic surgery.(14,15) Orthopaedic intervention is common in the management of children with cerebral palsy in order to manage secondary musculoskeletal problems. The timing and type of intervention is important to consider in terms of access to regular rehabilitation. Conservative orthopaedic management includes stretch-casts and orthotics. (16,17) Surgical intervention in the context of this study is considered an umbrella term for procedures performed in-hospital under general anaesthesia that puncture the skin and disrupt the function of the nerves, muscles, connective tissue, bones or joints. Botulinum Toxin type-A (Botox) is used commonly in CP and is often injected with the guidance of electromyography (EMG); it can be used alone or grouped with other procedures.(18) Many studies exist that describe function and interventions in CP, but there is no research available that investigates the possible relationships between gross motor function, surgical intervention, and academic performance in the same population group. Methods Location: This five-year single-centre retrospective longitudinal descriptive cohort study was conducted at a single English-medium public special needs school in Cape Town, which enrols learners from pre-primary level through to grade twelve, teaching CAPS.(21) The learners may also receive occupational therapy (OT), and speech therapy (SLT). Learners received physiotherapy for one hour per week during school terms. Participants: Historical records of learners of any age and grade, with clinically diagnosed CP across all GMFCS levels, were considered for inclusion if they were receiving physiotherapy during any part of the five study period (2015-2019) as a sample of convenience. They were not required to be in attendance of all five years to be included, nor have had surgical intervention. This study presumed that learners placed at this special school were deemed intellectually capable to cope academically with the support provided. Ethics: Ethics approval was obtained from the ethics committee of the University of the Witwatersrand (M210507) (Appendix A) and approval was granted by the Western Cape Department of Education (WCED) to conduct the study. Consent was obtained from parents and assent from learners still attending the school at the time of data collection, for use of anonymous secondary data (Appendix B). Each participant was allocated a number in order to anonymise the data set. Aim: The aim of this study was to retrospectively describe and compare the gross motor function, academic performance and any surgical intervention of children with CP across all GMFCS levels, who received physiotherapy at a Special School, over a five-year study period, and determine if there were any relationships between these components. Objectives: 1. To describe the gross motor function, classification, relevant history and co-morbidities of the population of

children with CP who attended this school and received physiotherapy during the study period. 2. To determine gross motor performance changes over time in children with CP who attended this school and received physiotherapy during the study period. 3. To describe and compare the yearly academic average scores and subject-specific scores of children with different sub-types of CP who attended this school and received physiotherapy during the study period. 4. To describe the type and frequency of neuro-musculoskeletal surgical intervention undergone by children with CP who attended this school and received physiotherapy during the study period. 5. To determine if there is an association between surgical intervention, gross motor function and academic performance in learners with CP, who attended this school and received physiotherapy during the study period.. Procedure: Seventy-six study participants were identified using the WCED learner database and checked against the physiotherapy database and historical archive for inclusion. Data collection was split into two parts: 01 July 2021 – 30 September 2021, and 24 May 2022 – 30 September 2022. Thirty-three participants no longer attending the school were identified for automatic inclusion. Forty-three learners still attending the school were invited to participate. Thirty-four learners returned signed consent forms. The total number of records reviewed was 67. Data was extracted from archived files and entered into a data collection sheet (Appendix C) with anonymous coding and transcribed into an excel spreadsheet. GMFM-88 and academic scores as well as surgical history were collected. Academic scores were captured per subject per term per year from report cards and converted to the scale of achievement code system (1- 7) for uniformity (Appendix D). Medical history including diagnosis, medication, radiological findings, classification of CP, assistive devices, therapy attended; and comments regarding academic potential (IQ) were collected. Anonymised coded data was then analysed. Statistical analysis: Microsoft Excel and STATA version 17 (StataCorp. USA) were used for analysis of the data. The data is presented as means, frequencies and percentages, with supporting tables or graphs. T-tests were used to determine changes over time, and Pearson correlation was used to determine if there were any correlations between the data components. Anova was used to compared birth history variables to GMFCS levels. Results: Sixty-seven participant records were reviewed. Table 1 describes demographics and functional classification of CP by GMFCS level, subtype and topography. Nearly two-thirds of the participants were male (64%). Over half of the participants with reported gestational age were born preterm (33/63), and a large proportion of those were born between 28 to 32 weeks (42%; 14/33). The predominant subtype was spastic (57%), followed by mixed spastic-dyskinetic (31%). Diplegia (40%) was the most frequently described topography. Of those with unilateral CP, nearly 60% (10/17) had right hemiplegia. Nearly two-thirds of the participants had 'mild' impairment designated by GMFCS level I (36%), and II (28%). Table 1: General Demographics and functional classification of CP Sex Male Female Gestational Age at birth Extreme Preterm <28 weeks Very Preterm 28-32 weeks Moderate Preterm 32-34 weeks Late Preterm 34-37 weeks 37-42 weeks Birth Weight (g) ELWB <1000g VLBW <1500g LBW <2500g 2500 – 3500g 3500 – 4500g GMFCS levels level I Level II Level III Level IV Level V CP Subtype Spastic Mixed Dyskinetic Ataxic Topography Bilateral - Diplegia Bilateral - Quadriplegia Unilateral Unilateral - left Unilateral - right Total N=67 (%) 43 (64) 24 (36) Total N=63 (%) Mean: 34.5 weeks; Range: 26-42 weeks 10 (6) 14 (22) 4 (6) 5 (8) 30 (48) Total N=54 (%) Mean: 2229g Range: 540g-4460g 10 (19) 11 (20) 10 (19) 16 (30) 7 (12) N=67 (%) 24 (36) 19 (28) 13 (19) 6 (9) 5 (7) N=67 (%) 38 (57) 21 (31) 5 (7) 3 (4) N=67

(%) 27 (40) 23 (34.5) 17 (25.5) 7 (10) 10 (15) Risk factors and co-morbidities: Over 80 variables grouped between antenatal, perinatal and post-natal events were described across all records (Appendix E). There was no statistical significance between gestational age at birth (p=0.6591) or birth weight (p= 0.3519) and GMFCS level. Epilepsy was diagnosed in 18% (12/67) and sodium valproate was the most frequently used medication to treat this (50%). Methylphenidate was used for ADHD (15%) and oral baclofen for spasticity (5%). Hearing impairment occurred in 6% as a result of auditory neuropathy or hearing loss. One participant had impairment of speech due to vocal-cord palsy. Assistive devices: Two-thirds of participants used a mobility aid, of which 9% were dependent on assistance of others for mobility, 6% used independent powered mobility, and 21% were able to self-propel. Thirty percent of participants walked with an assistive device. Nearly 70% of participants made use of an ankle-foot orthosis. Two participants used hearing-aids and one participant received a cochlear implant. Spectacles were used by 18% of participants. Academic potential Less than half (32/67) of the participants had data pertaining to academic potential. The data was not comparable in this study between participants due to use of incomplete data, different tests, or large discrepancies in performance. Of the available data, more than one-third (12/32) had average or better performance, with a frequency of 75% for GMFCS level I. Fifty percent (16/32) had a performance of below-average or less, and the remainder were described as borderline (3/16) or intellectually disabled (5/16). Gross motor function Mean baseline and interval scores for the GMFM-88 were recorded per participant and compared across all GMFCS levels for change over time. A large proportion (79%, 53/67) had data, of which 85% had two or more comparable data sets (45/53). Fourteen participants had no GMFM data during the study period. GMFM-88 assessment data for year one of the study was poorly recorded (2/46) in comparison to the years before the study. The remaining years of the study showed fluctuations in assessments: Year two 59% (26/44); Year three 82% (37/45); Year four 61% (28/46) and Year five 81% (38/47). Figure 1 provides an opportunity for individual participant trajectories over time and intervention inflection points to be appreciated. There is limited data for GMFM-88 GMFCS level V, therefore it has not been represented graphically. GMFCS levels are known to remain stable with age in up to 75% of children with CP, with the least likelihood of change occurring in levels I and V.(8) In this study, seven participants changed GMFCS level. Three level III participants changed to level IV, though one participant was still completing acute rehabilitation following surgery. Three others improved from level III to level II - one of these participants had no received surgery in the study period but received physiotherapy regularly. One participant had a significant reduction in GMFCS from level II to IV following surgery despite rehabilitation, which remained long-term. These significant changes in GMFM-88 scores are observable on Figure 1. Figure 1: GMFM-88 scores represented as percentages across the study period for individual trajectories for A: level I GMFCS; Figure B: GMFCS level II; C: GMFCS level III; D: GMFCS level IV. Arrows that correspond to line colour provide inflection points for participants indicate examples of when intervention occurred in relation to their gross motor function trajectory across the time period. Note the changing values of the y-axis which describes ability from higher function at level I to lower function at level IV. A – Level I B - Level II C – Level III D – Level IV Surgical intervention A combined total of 98 instances of neuro-musculoskeletal surgical interventions were performed for 46 children over the five-year period, with the majority (69%) occurring in the public sector.

Nearly one-third of participants had no intervention during the study period (21/67). The mean age of intervention increased from 8.6 years to 9.4 years of age from year one to year five, with an overall mean of 8.7 years across all five years, and a range of 3 to 18 years. Orthopaedic intervention categories were split into Botox, soft-tissue and bony surgery. At times these three interventions were combined. Botox was used in 18 different anatomical areas, with a total frequency of 180 over the study period. It was used in combination with conservative measures such as stretch casts as well as combined with soft-tissue and bony surgeries where appropriate. The most frequently occurring anatomical area of Botox administration was to the calf muscle (27%, 49/180), followed by the hamstrings (13%, 24/180), wrist flexors (12%, 22/180), thumb adductors (11%, 20/180) and forearm pronator teres (15/180). Soft-tissue surgery was described in fourteen anatomical areas, with a combined frequency of 77. The most frequent were lengthening of the Achilles tendon (22%, 17/77), and the gastrocnemius muscle (18%, 14/77). Followed by Hamstrings (14%, 11/77). Bony surgery comprised of eleven different procedures with a combined frequency of 27, with the most frequent being subtalar arthrodesis (30%, 8/27) followed by hallux valgus repair (18.5%, 5/27) and femoral derotation osteotomy (15%, 4/27). Neurosurgical intervention by Selective dorsal rhizotomy was performed for two participants; and these participants also underwent orthopaedic bony and soft-tissue surgeries during the time period. There was no statistical significance between the occurrence of surgical intervention on gross motor performance (GMFM-88), ($p=0.474$). Over one-quarter had one procedure, while one- fifth had two procedures during the study period. The remaining participants had between three (13%), four (7.5%) and five (1.5%) instances of intervention in the study period. There was a progressive decrease in surgical intervention frequency from year one ($n=27$) to year five ($n=8$). Academic performance Table 2 shows the grade distribution over the study period, and provides comparison of academic performance with GMFCS level, sub-type and topography. The ataxic group had a higher average rounded code rating (5) than the other groups, denoting 'substantial achievement' (i.e. 60-69%). The dyskinetic group had mathematics in their top three performing subjects, while every other group had mathematics in their lowest three subjects. In reference to topography, participants with right-hemiplegia had a higher average rounded code rating (5) than other groups. The group with the lowest average code rating was the group with bilateral quadriplegia; however there is no statistical significance between these scores. Art was the subject with the highest average performance while mathematics was the lowest across all GMFCS levels. Of the four core subjects which are consistent across all grades, Afrikaans second additional language was the highest with an average code of 4.7, followed by Life Orientation (4.2), English (3.6) and Mathematics/Maths Literacy combined (3.4). There was no statistically significant difference between GMFCS levels and academic performance scores. The overall academic code across all GMFCS levels is code 4, which is described as 'adequate achievement' and denotes a percentage range of 50-59%. Fourteen learners left the school prematurely during the study period: one child passed away from illness, five learners transferred to other mainstream or CAPS-aligned special schools; eight learners transferred to schools with a less demanding curriculum because they were not coping. Year four had the highest number of repeating learners in the foundation phase than any other year ($n=10$). Eleven participants achieved grade twelve level in the five-year period. The academic performance of the eight learners who left this school during the study period for a more adapted

curriculum had a mean academic code 2, which denotes elementary achievement (i.e. 30-39%). Two of these learners had academic potential described as intellectually disabled. Removing these eight participants' mean academic scores from the total of this cohort showed no significant change in mean code rating, as the overall code remained four. Their data was not excluded from overall analysis. Pearson's correlation between gross motor performance and academic scores over time (Ta2, 2.2.1) showed no significance; however there was a positive trend for improving academic scores with improving gross motor scores. In comparing average academic performance with incidence of surgery, there was a positive effect of statistical significance noted in year five, (p=0.016), and though not significant, a positive effect was noted in gross motor performance with incidence of surgery in year five, (p=0.072). Overall, there was no statistically significant correlation between surgical intervention, gross motor function and academic performance determined in this study. Table 2: 2.1 Grade distributions, and Comparison of CP GMFCS, sub-type and Topography vs Academics 2.1.1. Grades distribution Per Year Total MG PP R 1 2 3 4 5 6 7 8 9 10 11 12 Year 1 46 1 6 9 7 2 2 1 5 - 2 5 1 - 3 2 Year 2 44 1 6 5 8 6 2 2 1 4 - 1 4 1 - 3 Year 3 45 2 4 6 7 7 5 2 1 1 4 - 1 4 1 - Year 4 46 2 2 5 6 10 2 5 2 1 1 4 - 1 4 1 Year 5 47 2 2 4 6 7 7 1 3 2 1 1 5 - 1 5 (MEAN) of participants N= (45) (4) 20 (6) 29 (7) 34 (6) (3.6) (2) 32 18 11 (2) 12 (2) 8 (2) 8 (2) 11 (2) 11 (1) 6 (2) 9 (2) 11 2.1.2. GMFCS vs Subject codes ENG: English; AFR: Afrikaans; MA: Maths; ML: Maths Literacy; LO: Life Orientation; NST: Natural Science & Technology; NS: Natural Science; SS: Social Sciences; EMS: Economic Management Science; TEC: Technology; CAT: Computer Applications Technology; CON: Consumer Studies; TOU: Tourism; LS: Life Sciences Code Totals AVG ENG AFR MA ML LO NST NS SS EMS TEC Art CAT CON TOU LS GMFCS I 4.2 4 4 4 3 5 6 4 4 4 4 5 4 5 3 4 GMFCS II 4.4 4 5 4 4 5 5 4 4 4 5 5 4 5 4 4 GMFCS III 4.2 4 4 3 4 4 2 5 4 6 4 5 4 5 5 4 GMFCS IV 4.3 3 4 3 - 4 5 5 4 5 5 5 - - - - GMFCS V 3.5 3 6 2 - 3 - - - - - - - - - - MEAN 4.2 3.6 4.6 3.2 3.7 4.2 4.5 4.5 4.0 4.8 4.5 5.0 4.0 5.0 4.0 4.0 2.1.3. CP Sub-type vs Subject codes AVG ENG AFR MA ML LO NST NS SS EMS TEC ART CAT CON TOU LS Dyskinetic 4.0 4 4 4 - 4 5 4 4 3 3 5 - - - - Ataxic 4.8 4 5 4 - 6 5 - - - - - - - - - Spastic 4.2 4 5 3 4 5 4 4 4 5 4 5 4 4 4 4 4 Mixed 4.2 4 4 4 3 4 5 5 5 5 5 5 2 5 3 - MEAN 4.2 4 4.5 3.8 3.5 4.5 5.0 4.3 4.5 4.3 4.0 5.0 3.0 4.5 3.5 4.0 2.1.4. CP Topography vs Subject codes AVG ENG AFR MA ML LO NST NS SS EMS TEC ART CAT CON TOU LS Diplegia 4.3 4 4 3 4 5 4 4 4 5 4 5 5 5 4 4 Quadriplegia 4.0 4 4 4 3 4 5 5 4 4 4 5 2 4 4 - Left-uni 4.4 4 5 3 4 4 6 4 4 5 4 5 4 5 4 - Right-uni 4.8 4 5 4 - 5 6 4 5 4 5 6 5 6 - 4 MEAN 4.3 4.0 4.5 3.5 3.7 4.5 5.3 4.3 4.3 4.5 4.3 5.3 4.0 5.0 4.0 4.0 2.2. Comparisons between gross motor function, academic performance and surgical intervention 2.2.1. Academic Performance (Average) vs Gross Motor Function (GMFM) GMFM Year Year 1 Year 2 Year 3 Academic Year Year 1 ---- - Year 2 0.3869 Year 3 0.3078 Year 4 Year 5 Year 4 -0.0418 Year 5 0.0917 P-value ----- P=0.0682 P=0.0639 P=0.8328 P=0.5839 2.2.2. Academic Performance vs No Surgery / Surgery Academic Year Year 1 Year 2 No Surgery (SD) 4.22 (1.34) 3.94 (0.86) Surgery (SD) 4.05 (1.43) 4.13 (1.35) Year 3 4.5 (1.14) 3.94 (1.47) Year 4 4.24 (1.27) 4.19 (1.22) Year 5 4.37 (0.97) 3.33 (1.58) P-value 0.6929 0.5931 0.1602 0.891 0.0167 2.2.3. Gross Motor Function (GMFM) vs No Surgery / Surgery GMFM Year No Surgery (SD) Surgery (SD) Year 1 Year 2 - 83.96(22.8) - 84.94(17.9) Year 3 85.73(21.42) 78.02(23.46) Year 4 88.23(19.0) 85.43(15.06) Year 5 89.91(13.3) 78.2(22.29) P-value - 0.9035 0.3085 0.7024 0.0722 Discussion Learning difficulties experienced by children of preterm or term gestational age are known to differ, and the implication of prematurity in academic

performance is complex, affecting different cognitive domains, even in the absence of motor impairment.(2) Impairments in visual-perception, reading, sensory-processing, difficulties with activities of daily living and fine motor function are common in CP.(20) Lower gestational age impacts neuronal organisation and overall brain volume, as well as intracranial pathology and white matter changes are linked to decreased visual-spatial-perceptual abilities and sensory-processing difficulties which impact learning greatly.(20) In greater gestational age, cortical sparing in brain injury is linked to improved cognitive potential. It is encouraging to see that despite some participants enduring multiple risk factors they are achieving adequately at school. This is important as educational achievement provides later opportunity for income generation in adulthood.(19) In this study there was no relationship between gestational age and birth weight compared to academic performance; this is likely due to the cohort being of reasonably similar academic potential as assessed for acceptance into this school. There was a large reduction in GMFM-88 assessments from baseline to the first year of the study. There had been a reduction in the number of physiotherapists working at this special school from four to three, resulting in increased caseload. Children with SLD diagnoses were then less likely to receive physiotherapy, placed on a waiting list. Subsequent to this study being concluded, a further reduction to two physiotherapists has occurred. Many of the learners at this school rely on the school transport system for travel. It is of great benefit to have access to regular physiotherapy input at school, accessing healthcare within the education domain, which allows a multidisciplinary opportunity to support a learner holistically. It is essential that gross motor function and surgical intervention monitoring continue, to determine long term impact as a result of lack of recommended individualised therapeutic input. Conclusion There was no statistically significant correlation between surgical intervention, gross motor function and academic performance determined in this study. Further research is recommended to evaluate these relationships with more detail, in particular to determine the differences between preterm and term-born groups. It is encouraging to observe an average positive change in gross motor function scores over time, and this finding can be helpful to motivate for the continuation of physiotherapy services. Study limitations This study was a record-review of a small sample size. Due to the nature of obtaining information from historical records, some data was missing or inconsistently described, which can impact processing and analysis. Information obtained in medical records was assumed as correctly disclosed and there was no way to verify this information. It may have been more effective to exclude school-leavers from the academic performance correlation analysis on the presumption that they were not placed correctly. Future considerations The years of the COVID-19 pandemic occurred following this study. The school learners had a long-term lack of physiotherapy during this time. It is unknown whether the confines of the pandemic resulted in significant deteriorating function and associated secondary impairments. It would be an opportunity to evaluate any changes in GMFM from this study timepoint to the resumption of physiotherapy. Further research is recommended to evaluate the relationships between academic performance and relevant variables in the Special School setting, particularly in relation to individual function as well as on a participation level.

Appendix H – South African Journal of Child Health Guidelines for Submission

South African Journal of Child Health

Preparation notes by article type

Research

Guideline word limit: 3 000 words (excluding abstract and bibliography)

Research articles describe the background, methods, results and conclusions of an original research study. The article should contain the following sections: introduction, methods, results, discussion and conclusion, and should include a structured abstract (see below). The introduction should be concise – no more than three paragraphs – on the background to the research question, and must include references to other relevant published studies that clearly lay out the rationale for conducting the study. Some common reasons for conducting a study are: to fill a gap in the literature, a logical extension of previous work, or to answer an important clinical question. If other papers related to the same study have been published previously, please make sure to refer to them specifically. Describe the study methods in as much detail as possible so that others would be able to replicate the study should they need to. Where appropriate, sample size calculations should be included to demonstrate that the study is not underpowered. Results should describe the study sample as well as the findings from the study itself, but all interpretation of findings must be kept in the discussion section, which should consider primary outcomes first before any secondary or tertiary findings or post-hoc analyses. The conclusion should briefly summarise the main message of the paper and provide recommendations for further study.

- May include up to 3 illustrations or tables.
- A max of 20 - 25references

Structured abstract

- This should be no more than 250words, with the following recommended headings:
    - **Background:** why the study is being done and how it relates to other published work.
    - **Objectives:** what the study intends to find out
    - **Methods:** must include study design, number of participants, description of the intervention, primary and secondary outcomes, any specific analyses that were done on the data.
    - **Results:** first sentence must be brief population and sample description; outline the results according to the methods described. Primary outcomes must be described first, even if they are not the most significant findings of the study.
    - **Conclusion:** must be supported by the data, include recommendations for further study/actions.
    - Please ensure that the structured abstract is complete, accurate and clear and has been approved by all authors. It should be able to be intelligible to the reader without referral to the main body of the article.
    - Do not include any references in the abstracts.