

## Relationship between Motor Skills and Intellectual Functioning in Learners with Cerebral Palsy: Insights from the Adapted Pictorial Test of Intelligence

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### Abstract

This study examined how motor skills relate to verbal abstraction, form discrimination, and quantitative concepts in learners with cerebral palsy. The Gross Motor Function Classification System – Expanded and Revised (GMFCS-E&R), the Manual Ability Classification System (MACS), and an adapted version of the Pictorial Test of Intelligence – Second Edition were applied in assessing the gross motor skills, fine motor skills and the different components of intellectual functioning respectively. A sample size of 32 participants (21 males; 11 females) selected through simple random sampling were involved in the study. The findings of motor skill assessment revealed more than half of participants scored in the upper echelons (level I and II) of the Gross Motor Function Classification System–Expanded and Revised as well as the Manual Ability Classification System. Spearman's rank correlation analysis revealed statistically significant ( $P < 0.05$ ) positive relationships between gross motor skills and verbal abstraction ( $r = 0.71$ ), form discrimination ( $r = 0.62$ ), and quantitative reasoning ( $r = 0.54$ ). In a similar vein, fine motor skills demonstrated significant associations with verbal abstraction ( $r = 0.70$ ), form discrimination ( $r = 0.68$ ), and quantitative reasoning ( $r = 0.57$ ). The findings have practical implications for inclusive education policy and interventions, particularly in low-resource settings such as Ghana, where context-specific assessment tools and targeted strategies are essential.

**Keywords:** Cerebral Palsy, Motor Skills, Intellectual Ability, Verbal Abstraction, Form Discrimination, Quantitative Concept.

### Introduction

Motor disabilities are the hallmarks of cerebral palsy, often manifesting as difficulties in executing gross and fine motor skills (Rosenbaum et al., 2017). Gross motor skills involve large-muscle activities such as walking and sitting, while fine motor skills refer to precise hand and finger movements required for tasks like writing, grasping, and dressing (Beach et al., 2023). Several studies have documented the gross motor skills of children with cerebral palsy. Eseigbe et al. (2014) examined the gross motor skills of 235 children with cerebral palsy under 12 years old and found that over half could not walk independently or with assistive devices. Boyd et al., (2021) found gross motor skills to be generally impaired in children with cerebral palsy, with better skills observed in those with less limb involvement. In contrast, studies from other regions reveal better motor outcomes. Twum and Hayford (2019) established that majority of learners with cerebral palsy (approximately

80%) in special schools in Ghana could independently execute most gross motor activities (GMFCS-E&R levels I and II). However, the methodologies in the aforementioned studies vary considerably. As an example, Esegbe et al.'s study involved a large clinical sample in Nigeria, while Twum and Hayford (2019) focused on a smaller, school-based population in Ghana, potentially accounting for the differences in observed motor abilities. Again, this discrepancy may reflect differences in environmental factors, assessment settings, or support systems.

Research on fine motor skills in children with cerebral palsy reveals both consistencies and contextual variations. Twum and Hayford (2019), focusing on Ghanaian special schools, reported that over 60% of learners were able to perform fine motor activities with relative efficiency. This contrasts with findings by Kim et al. (2020), who identified significant deficits in hand-eye coordination and grip strength among children with cerebral palsy, likely contributing to fine motor difficulties. Gorter et al. (2022) further nuanced this understanding by showing that children with unilateral cerebral palsy exhibited better fine motor abilities than those with bilateral involvement, highlighting the role of CP subtype in motor outcomes. Notably, while Twum and Hayford's context-specific study suggests more optimistic fine motor performance, it differs from the others in population and setting, raising questions about the influence of educational environment, intervention exposure, and assessment tools. Such variations point to the need for culturally grounded research using locally adapted instruments.

Intellectual disabilities are prevalent across the cerebral palsy spectrum, with nearly 50% of individuals affected and approximately 28% presenting with severe forms (Olusanya et al., 2022). These impairments often encompass attention, memory, and executive function deficits (Rosenbaum et al., 2007). While these associations are well-documented within the CP population, much of the foundational understanding of motor–cognitive interplay stems from studies on typically developing children. For instance, research by Rigoli et al. (2012) links motor and cognitive functions through shared neural substrates—particularly the prefrontal cortex and cerebellum—suggesting that the two domains are neurologically intertwined. Cameron et al. (2022) reinforce this by showing parallel developmental trajectories for motor and cognitive skills, especially during the critical early years (ages 5–10). However, in the case of children with cerebral palsy, motor impairments may limit physical exploration and environmental engagement, potentially constraining cognitive development. This interplay underscores the importance of context-specific investigations into how motor deficits may shape intellectual functioning, particularly in settings where early intervention and inclusive learning opportunities may be limited.

The concept of embodied cognition serves as the theoretical foundation for this study. Embodied cognition posits that cognitive processes are deeply rooted in the body's interactions with the physical environment (Wilson & Golonka, 2013). In this context, motor activities such as walking, grasping, or manipulating objects are not merely physical tasks but are integral to developing cognitive functions like reasoning, problem-solving, and abstract thinking. This framework directly supports the current study's objective of

examining the relationship between motor skills (gross and fine) and specific components of intellectual functioning—verbal abstraction, form discrimination, and quantitative concept. By viewing movement and cognition as interdependent systems, the embodied cognition perspective provides a rationale for exploring whether enhancing motor skills can also promote intellectual development in learners with cerebral palsy.

The majority of research exploring the link between motor abilities and various aspects of intellectual functioning in individuals with cerebral palsy has primarily concentrated on gross motor skills. Al-Nemr and Abdelazeim (2017) investigated the relationship between gross motor skills on one hand and attention and executive function on the other hand in children with cerebral palsy. The study's findings revealed significant positive associations between gross motor skills and the aforementioned facets of intellectual functioning. Consistent with the aforementioned finding, Song (2013) established that intellectual ability was positively correlated to gross motor abilities in children with different sub-types of cerebral palsy. With respect to fine motor skills, Van Rooijen, Verhoeven, and Steenbergen, (2015) found that fine motor abilities could predict early numeracy outcomes in children with cerebral palsy aged between 6 and 8 years.

Currently, there remains a significant gap in studies exploring the specific connections between motor skills (gross and fine) and components of intellectual functioning such as verbal abstraction, form discrimination, and quantitative concept. These specific components of intellectual functioning are absolutely critical to learners relative to their critical thinking and overall understanding of the world around them. Verbal abstraction refers to the ability to understand and interpret relationships between concepts. Form Discrimination, on the other hand, involves recognizing and differentiating shapes, patterns, and visual details. Quantitative concept pertains to understanding and applying numerical relationships and mathematical principles. Existing research tend to focus on broader constructs like academic achievement, executive function, or general intelligence. Furthermore, studies on this topic rarely account for the unique experiences of learners with cerebral palsy, especially within African contexts where access to culturally adapted and normed assessment tools are limited. Thus, this research does not only addresses these specific gaps but also leverages the Pictorial Test of Intelligence, Second Edition, adapted for a Ghanaian population to provide contextually relevant insights. The study contributes to a deeper understanding of how motor skills interplay with intellectual functioning with the potential to inform targeted interventions for learners with cerebral palsy.

Children with cerebral palsy often face challenges that go beyond physical disabilities, with emerging evidence suggesting a link between motor function and cognitive development. Yet, in many low-resource settings including Ghana, there is limited empirical data on how specific aspects of intellectual functioning, such as verbal abstraction, form discrimination, and quantitative concept, relate to both gross and fine motor skills. This lack of context-relevant evidence constrains the development of targeted educational and therapeutic interventions.

To address this gap, the present study seeks to:

1. Examine the relationship between gross motor skills and the intellectual components of verbal abstraction, form discrimination, and quantitative concept.
2. Examine the relationship between fine motor skills and these same components of intellectual functioning.

## Materials and Methods

### Study Design

The present study employed a cross-sectional correlational approach in which data was gathered at a single time point through assessments of motor skills, verbal abstraction, form discrimination, and quantitative reasoning. The aforementioned study design was deemed suitable as it allowed the different variables in the study to be captured at a particular point in time without following up on participants.

### Sample Size Determination

The sample size in this current study was influenced by the accessible population of learners with cerebral palsy, which was 61. Out of the 61 learners, 42 met the inclusion criteria of this current study. The inclusion criteria were an age range of 5 to 12 years and the absence of blindness or deafness. Furthermore, the sample size was guided by the central limit theorem. The theorem asserts that for a sufficiently large sample size, the sampling distribution of the sample mean approximates a normal distribution as the sample size increases. As a rule of thumb, a sample size of 30 or more is often considered adequate for relevant inferential statistical techniques on the condition that the population is not highly skewed. Consistent with the central limit theorem, a sample size of 32 was applied in this study.

### Sampling Technique

A simple random sampling method was used to select 32 learners with cerebral palsy from a total study population of 42. The use of the aforementioned probability sampling technique ensured the sample was highly representative of the study population while allowing for the application of the inferential statistics.

### Research Instruments

The Gross Motor Function Classification System, Revised and Expanded (GMFCS-E&R) is a five level ordinal scale based on self-initiated movement and the need for assistive devices for mobility. The scoring system of the GMFCS, E&R is based on usual motor performance in school, home or community setting of persons with cerebral palsy. The title for each level is a reflection of the gross motor skill that is most characteristic of their performance and does not represent all aspects of their gross motor abilities. Level I typically includes persons able to walk independently with level IV and V occupied by those dependent on others for transfers.

The Manual Ability Classification System (MACS) is complementary to the GMFCS-E&R, and designed to assess the fine motor skills of persons with cerebral palsy in daily activities. Children with minor fine motor limitations are included in level 1 while those with severe limitations will usually fall in levels IV and V.

In adapting the Pictorial Test of Intelligence-2 (PTI-2), the researcher first replaced text instructions in the picture book that demanded answers not familiar in the Ghanaian culture. Item analysis in the form of item difficulty index and item discrimination index were applied in selecting these items to ensure consistency with the original items as the items on the PTI-2 are generally progressively more difficult. The researcher also expanded the items on the PTI-2 to include suitable items for upper primary learners in Ghana (9-12 years). Ten age-appropriate items were added to the three different subtests of the PTI-2. Each item added to the adapted PTI-2 had an item difficulty index of 0.6 or below in a sample of learners aged 9 to 12 years. Point-biserial correlation was applied to test item discrimination index. Subsequently, only items with positive and relatively higher point-biserial correlation were included. This was essential because PTI-2 was designed for learners with upper age limit of 8 years 11 months.

Prior to administering the adapted PTI-2, the instrument was normed on a population of 920 (515 males; 405 females) typically developing Ghanaians who were aged 9-12 years. The normative population was sub-grouped into 5, 6, 7, 8, 9, 10, 11 and 12-year olds, forming 8 sub-groups. It was necessary to norm the PTI-2 using typically developing learners in order to have standard scores that reflect the general population of 5-12-year olds in Ghana. Scoring for the adapted PTI-2 was structured to yield standardized, interpretable results across its three subtests: verbal abstraction (VA), form discrimination (FD), and quantitative concept (QC). Each subtest consisted of pictorial, multiple-choice items, with one correct response per item. Learners earned one point for each correct answer, and raw scores for each subtest were calculated by summing these points.

To contextualize these scores within a Ghanaian population, raw scores were converted into percentile ranks, based on performance distributions from a norming sample of 920 typically developing children aged 5–12. These percentile ranks were subsequently transformed into standard scores using a normal distribution with a mean of 10 and a standard deviation of 3, allowing for meaningful comparisons across age groups and subtests.

Each subtest targeted distinct aspects of cognitive functioning. Verbal abstraction items assessed the ability to recognize abstract relationships between pictured concepts (e.g., selecting a related object or concept from a set of four options). Form discrimination items required the identification of visual patterns, similarities, or differences in form or spatial arrangement. Quantitative concept items, on the other hand, evaluated understanding of quantity and numerical relationships through visual comparisons or symbolic reasoning. Scoring was done manually by a trained assessor (researcher) using a pre-established answer key. This structured scoring approach enabled consistent interpretation of intellectual functioning across the three domains.

**Validity and Reliability of Research Instruments**

The GMFCS-E&R and MACS are internationally validated classification systems for assessing gross and fine motor skills respectively in children with cerebral palsy. The GMFCS-E&R demonstrates strong content validity and inter-rater reliability ranging from 0.75 to 0.93 (Palisano et al., 2008), while the MACS exhibits excellent inter-rater reliability with intra-class correlation coefficients between 0.96 and 0.97 (Eliasson et al., 2006). These tools are widely accepted in both clinical and research contexts.

The adapted Pictorial Test of Intelligence – Second Edition (PTI-2) underwent cultural and linguistic modifications, followed by expert review for content validation. Construct validity of the adapted PTI-2 was supported through item difficulty and discrimination analyses, with only items exhibiting acceptable point-biserial correlations retained. The adapted tool was normed on a Ghanaian population of 920 typically developing children aged 5–12 years, and scoring norms were established accordingly. While originally developed for typically developing children, the PTI-2's nonverbal format and administration flexibility make it suitable for children with cerebral palsy. Pilot testing with learners with similar profiles confirmed clarity, accessibility, and appropriate response variability, indicating acceptable functional validity for this population.

**Field Data Collection**

A special school in the Bono East Region of Ghana was the site of data collection in this current study. Assessment of gross motor skills began with careful observation of the gait of learners as they made their way to the assessment desk. Further, their ability to support their bodies on the chair and move from sitting to standing were observed. Finally, the ability of learners with cerebral palsy to move up and down a mobile staircase was examined. Learners were accordingly scored on the GMFCS-E&R. Relative to fine motor skills assessment, learners sat comfortably in the chair across the examiner with a broad desk between the two. Learners were given simple and clear instructions on how to handle specific age-appropriate objects displayed on the desk. Age-appropriate objects applied in the fine motor assessment included toys, crayons, pencils and bottles. Additionally, the examiner demonstrated the handling of the objects to ensure learners were absolutely clear on what was expected of them. Learners generally applied their dominant hands in executing the fine motor skills but some tasks demanded the use of both hands. Learners were accordingly scored on the MACS. The adapted PTI-2 was applied right after the motor skill assessment as learners sat facing the examiner. Learners were taken through the examples of the different subtests before they proceeded to answer the different items and were scored accordingly.

**Data Management Analysis**

Data was stored and analyzed using Stata version 12 and backed up on Google Drive. Generally, continuous numeric variables were summarized using mean values and related standard deviations. Categorical variables were summarized using frequencies and

corresponding percentages. Spearman rank correlation was applied in ascertaining the relationship between motor skills (gross and fine motor skills) and the different components of intellectual functioning in the form of verbal abstraction, form discrimination and quantitative concept. The choice of spearman rank correlation was influenced by the fact that the GMFCS-E&R and the MACS represent ordinal scales while the adapted PTI-2 is on a continuous numeric scale. There were no significant outliers or skewed distributions were observed that would invalidate the spearman rank correlation analysis. While the correlation analysis revealed statistically significant associations between motor skills and intellectual functioning, this method does not imply causation or predictive direction.

### **Ethical Considerations**

The researcher involved in this study prioritized obtaining informed consent from all parents and legal guardians of children in this research. The informed consent form emphasized the procedures involved in the study as well as the fact that participation of their children was entirely voluntary. The right of children to withdraw from the study at any point without facing any penalty was also emphasized in the informed consent document. Parents were assured that the anticipated risks associated with the study were minimal, and the potential benefit lies in contributing to a deeper understanding of the relationship between motor skills and intellectual functioning. Beyond seeking informed consent from parents, the researcher obtained the assent of all children involved in the study. Seeking assent from the children involved in this study involved explaining the study procedures using age-appropriate communication and emphasizing that they could withdraw from the study even if their parents or legal guardians had granted consent.

### **Results**

Table 1 presents demographic characteristics of learners with cerebral palsy.

**Table 1**

*Demographic Characteristics of Learners with Cerebral Palsy*

| Demographic                     | Male f (%) | Female f (%) | Total n (%) |
|---------------------------------|------------|--------------|-------------|
| <u>Age (years)</u>              |            |              |             |
| 5                               | 1 (4.8)    | -            | 1 (3.1)     |
| 6                               | -          | -            | -           |
| 7                               | 1 (4.8)    | -            | 1 (3.1)     |
| 8                               | 1 (4.8)    | 2 (18.2)     | 3 (9.4)     |
| 9                               | 4 (17.4)   | 1 (9.1)      | 5 (15.6)    |
| 10                              | 3 (14.3)   | -            | 3 (9.4)     |
| 11                              | 2 (9.5)    | 2 (9.5)      | 4 (12.5)    |
| 12                              | 9 (42.9)   | 6 (54.6)     | 15 (46.9)   |
| <u>Class</u>                    |            |              |             |
| Upper primary                   | 14 (66.7)  | 3 (27.3)     | 17 (53.1)   |
| Lower primary                   | 7 (33.3)   | 8 (72.7)     | 15 (48.4)   |
| <u>Assistive walking device</u> |            |              |             |
| Yes                             | 1 (4.8)    | 1 (9.1)      | 2 (6.3)     |
| No                              | 20 (95.2)  | 10 (90.9)    | 30 (93.8)   |
| <u>Limb distribution</u>        |            |              |             |
| Monoplegia                      | 2 (9.5)    | 1 (9.1)      | 3 (9.4)     |
| Diplegia                        | 8 (38.1)   | 5 (45.5)     | 13 (40.6)   |
| Hemiplegia                      | 11 (52.4)  | 5 (45.5)     | 16 (50)     |
| Tetraplegia                     | -          | -            | -           |

Note. f = frequency, n = number of units

A total of 21 males and 11 females completed this current study. The modal age was 12 years (mean age 10.4 years; SD=1.8) while majority of learners with cerebral palsy were in upper primary school. Half of all learners with cerebral palsy presented with hemiplegic cerebral palsy with the rest distributed between monoplegia and diplegia. The vast majority did not utilize assistive walking device.

#### **Motor skills of learners with cerebral palsy**

Table 2 presents the gross and fine motor skills of learners with cerebral palsy involved in the study.

**Table 2**

*GMFCS-E&R and MACS Scores of Learners with Cerebral Palsy*

| Motor Skill          | Male f (%) | Female f (%) | Total n (%) |
|----------------------|------------|--------------|-------------|
| <u>GMFCS-E&amp;R</u> |            |              |             |
| Level I              | 12 (57.1)  | 7 (63.6)     | 19 (59.4)   |
| Level II             | 4 (19.05)  | 2 (18.2)     | 6 (18.8)    |
| Level III            | 2 (9.5)    | 2 (18.2)     | 4 (12.5)    |
| Level IV             | 3 (14.3)   | -            | 3 (9.4)     |
| Level V              | -          | -            | -           |
| <u>MACS</u>          |            |              |             |
| Level I              | 12 (57.1)  | 7 (63.6)     | 19 (59.4)   |
| Level II             | 1 (4.8)    | -            | 1 (3.1)     |
| Level III            | 5 (23.8)   | 3 (27.3)     | 8 (25)      |
| Level IV             | 3 (14.3)   | 1 (9.1)      | 4 (12.5)    |
| Level V              | -          | -            | -           |

*Note.* GMFCS-E&R = Gross Motor Function Classification System-Expanded and Revised  
MACS = Manual Ability Classification System, f = frequency, n = number of units

Over half of learners with cerebral palsy scored in the highest level of the GMFCS-E&R, level I. Generally, learners on level I executed gross motor skills including walking, sitting and moving out of chair with ease. There were nearly identical percentages between the percentage of males and females on level II of GMFCS-E&R. This group of learners were able to execute most of the gross motor skills but required some level of adaptive intervention on some few occasions. Learners with cerebral palsy on level III of the aforementioned scale generally required a hand held device to walk while needing trunk support during sitting. The less than 10% of learners with cerebral palsy on level IV of the GMFCS-E&R generally required physical assistance to walk. Similarly, they needed trunk and pelvic support to sit.

Relative to fine motor skills, over half of all learners with cerebral palsy scored on level I of the MACS, similar to the results on gross. These learners generally handled the different objects used in the fine motor skills assessment with ease. A single male scored on level II of the MACS. This pupil generally handled the different objects applied in the MACS with a greater degree of success but was tardy compared to learners on level I. A quarter of all learners with cerebral palsy in the study scored on level III of the MACS. Generally, this group of learners exhibited difficulties in handling the objects applied in the fine motor activities. They generally achieved limited success with the different fine motor tasks with reduced quality and quantity. Learners with cerebral palsy rated on level IV of the MACS could handle relatively fewer items in the fine motor assessment with little to no success.

### **Relationship between motor skills and intellectual ability**

Table 3 presents gross and fine motor levels against the scores related to the components of intellectual ability of learners with cerebral palsy.

**Table 3**

*Motor Skill scores against Scores on Components of Intellectual Ability*

Motor Skill Components of Intellectual Ability (mean  $\pm$  SD)

| GMFCS-E&R   | VA             | FD             | QC             |
|-------------|----------------|----------------|----------------|
| Level I     | 15.0 $\pm$ 4.3 | 13.1 $\pm$ 3.2 | 11.1 $\pm$ 3.0 |
| Level II    | 6.5 $\pm$ 6.3  | 7.8 $\pm$ 4.9  | 6.0 $\pm$ 3.2  |
| Level III   | 7.3 $\pm$ 4.3  | 8.3 $\pm$ 4.3  | 9.5 $\pm$ 4.7  |
| Level IV    | 1.7 $\pm$ 1.2  | 3.0 $\pm$ 1.0  | 2.3 $\pm$ 0.6  |
| Level V     | -              | -              | -              |
| <u>MACS</u> |                |                |                |
| Level I     | 15 $\pm$ 4.3   | 13.1 $\pm$ 3.2 | 11.1 $\pm$ 3.0 |
| Level II    | -              | -              | -              |
| Level III   | 7.25 $\pm$ 5.9 | 8.3 $\pm$ 5.0  | 7.6 $\pm$ 4.5  |
| Level IV    | 2.8 $\pm$ 2.4  | 4 $\pm$ 2.2    | 3.8 $\pm$ 2.9  |
| Level V     | -              | -              | -              |

*Note.* GMFCS-E&R = Gross Motor Function Classification System-Expanded and Revised  
MACS = Manual Ability Classification System, VA= Verbal Abstraction, FD = Form Discrimination, QC = Quantitative Concept

Generally, learners with cerebral palsy who were rated at higher levels on the GMFCS-E&R generally performed better on the PTI-2 subtests. A similar trend was observed between fine motor skill levels, as measured by the MACS, and scores related to the different components of intellectual functioning.

It is interesting to note the implications of the standard deviations (SD) against the respective mean values in the table. While most of the mean values had relatively lower SD, the mean VA value for GMFCS-E&R level II had relatively higher SD which implies the individual VA scores are widely dispersed from the mean value. A similar trend is seen with the SD associated with the mean values of the different subtests of MACS levels III and IV.

#### **Relationship between Motor Skills and Components of Intellectual Ability**

Table 4 presents the findings of the spearman rank correlation analysis.

**Table 4**

*Spearman Rank Correlation of Gross Motor Skills against the different Subtests related to Intellectual Ability*

| Subtests             | Number of paired scores | Correlation coefficient | P-value |
|----------------------|-------------------------|-------------------------|---------|
| Verbal Abstraction   | 32                      | 0.71                    | 0.00    |
| Form Discrimination  | 32                      | 0.62                    | 0.00    |
| Quantitative Concept | 32                      | 0.54                    | 0.00    |

*Note.* Significant at the  $p < 0.05$  level.

As evident in Table 4, gross motor skills had positive and statistically significant relationship with all the three components of intellectual ability as measured by the subtests of the adapted PTI-2. Among the components, verbal abstraction had the strongest correlation with gross motor followed by form discrimination, then quantitative concept.

The relationship between fine motor skills and the three components of intellectual ability are depicted in Table 5.

**Table 5**

*Spearman Rank Correlation of Fine Motor Skills against the different Subtests related to Intellectual Ability*

| Subtests             | Number of paired scores | Correlation coefficient | P-value |
|----------------------|-------------------------|-------------------------|---------|
| Verbal Abstraction   | 32                      | 0.70                    | 0.00    |
| Form Discrimination  | 32                      | 0.68                    | 0.00    |
| Quantitative Concept | 32                      | 0.57                    | 0.00    |

Note. Significant at the  $p < 0.05$  level.

Consistent with that of the relationship between gross motor skills, all the three components had positive and statistically significant correlation with fine motor skills. Again, verbal abstraction had the strongest correlation co-efficient with fine motor skills, followed by form discrimination and then quantitative concept.

## Discussion

The analysis of motor skills revealed variability in gross and fine motor skill proficiency among learners with cerebral palsy. Over half of the learners achieved Level I in the GMFCS-E&R and MACS. These learners demonstrated proficiency in executing gross motor tasks such as walking and sitting with ease as well as well as fine motor tasks involving object manipulation. These findings are consistent with that of Twum and Hayford (2019) as well as that of Smit et al. (2013) who documented majority of persons with cerebral palsy were proficient in motor skill activities. However, the remaining learners exhibited varying degrees of impairment relative to gross motor skills and fine motor skills. These learners were generally slower and less efficient with motor skill activities. Learners observed at Level IV of the GMFCS-E&R and MACS highlight the need for physical assistance and adaptive equipment in facilitating mobility and dexterity. These difficulties in motor skills have been extensively reported by Boyd et al. (2021) as well as Esegbe et al. (2014). The findings emphasize the importance of early and targeted interventions that address these motor skill deficits.

The findings reveal statistically significant positive correlations between gross motor skills and components of intellectual ability. This suggests that learners with cerebral palsy with better gross motor skills demonstrate enhanced verbal reasoning, form discrimination abilities, and quantitative thinking. These findings are consistent with that of Al-Nemr and Abdelazeim (2017), as well as Song (2013). The correlation between fine motor skills and

the three components of intellectual functioning in this current study align closely with the findings for gross motor skills. The positive and statistically significant correlation between fine motor skills and verbal abstraction, form discrimination, and quantitative concept are largely consistent with findings of Van Rooijen, Verhoeven, and Steenbergen, (2015). Verbal abstraction exhibiting a stronger correlation compared to form discrimination and quantitative concept could be down to the fact that it entails a greater level of executive functioning skills such as planning and working memory. As an example, gross motor activities such as navigating complex environments and participating in physical play are dependent on executive functioning skills. Thus, this shared reliance on executive functioning could result in a stronger correlation between gross motor skills and verbal abstraction. These positive and statistically significant correlations reinforce the embodied cognition theory that emphasizes the role of physical interactions in cognitive development (Wilson & Golonka, 2013). Engagement in physical tasks like walking or maintaining balance might activate brain regions linked to reasoning and cognitive flexibility. Likewise, detailed hand movements that involve control and forethought could bolster mental processes such as spatial interpretation and logical analysis.

Overall, the results of the study suggest that integrating motor skill development into educational curricula can have cascading benefits for cognitive functioning for learners with cerebral palsy. Combining movement activities with intellectual tasks could have the potential to boost the two domains. Interventions targeting these two domains are critical to learners with cerebral palsy in primary school as these learners are in the critical stage of developing their motor skills and intellectual functioning.

It is important to emphasize that the correlational nature of this study does not allow for causal conclusions. While significant positive associations were found between gross and fine motor skills and components of intellectual functioning, these relationships do not imply that motor proficiency directly causes improvements in cognitive performance. Other unmeasured factors, such as educational exposure, socioeconomic background, or type and severity of cerebral palsy, may mediate or moderate these associations. Therefore, interpretations should be viewed as indicative of patterns rather than deterministic effects. Again, it is important to acknowledge that the sample size of 32 participants in this current study presents some limitation. The findings may not be representative of the broader population of learners with cerebral palsy, particularly across different regions or educational settings in Ghana or beyond.

### **Conclusion and Recommendations**

In this current study, both gross and fine motor skills of learners with cerebral palsy statistically significantly correlated to verbal abstraction, form discrimination and quantitative concept. In light of these findings, it is recommended primary schools integrate age-appropriate activities that enhance both gross and fine motor skills into their daily classroom routines. These activities could include play-based learning activities such as dancing, relay activities, and painting intricate patterns. As much as possible, these

motor skill activities should be incorporated in classroom activities as well as outdoor occasions.

Based on the findings that some learners with cerebral palsy were on Level III and IV of the GMFCS-E&R, as well as MACS, it is recommended these learners are provided with adaptive devices, such as hand-held mobility aids and customized seating supports so as to enhance participation in both academic and extracurricular activities. Again, teachers should develop inclusive classroom practices that address the motor and cognitive needs of learners with cerebral palsy. As an example, teachers should be trained in differentiating instruction and individualized instruction to accommodate varying levels of motor and cognitive abilities.

School authorities, teachers and parents should collaborate to provide resources that promote early intervention programs that target motor skill development in children with cerebral palsy. These resources could mobility aids such as walkers for gross motor skill development as well as specialized seating systems to provide postural support during fine motor tasks. Again, the provision of multisensory toys that combine touch, sound, and visual stimuli to engage motor and cognitive functions will go a long way in improving the motor skills and intellectual functioning of learners with cerebral palsy.

However, some limitations must be acknowledged. The sample size of 32, though guided by the central limit theorem, limits the statistical power and generalizability of findings. Additionally, data were drawn from a single geographic region, which may not reflect the full diversity of learners with cerebral palsy in Ghana or other low-resource settings. The cross-sectional and correlational nature of the study also precludes any inference of causality.

Future research should explore these relationships using larger, more diverse samples, and consider longitudinal or experimental designs to examine how motor skill interventions may influence cognitive development over time. Such approaches would provide a stronger basis for informing intervention programs and inclusive education policy.

#### **Data Availability**

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

#### **Conflicts of Interest**

The author declares that there are no conflicts of interest or competing financial or personal relationships that could have influenced the work reported in this paper.

#### **Ethics Statement**

This study was approved by the Institutional Review Board (IRB) of the University of Education, Winneba with certificate number 2020/IRB/167.

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