Nigerian Journal of Social Psychology

Published by
Nigerian Association of Social Psychologists
www.nigerianjsp.com

NIGERIAN JOURNAL OF SOCIAL PSYCHOLOGY

Volume 2, Issue 3
Online ISSN: 2682-6151
Print ISSN: 2682-6143
2019

Age and Gender- related Fluctuations in Associated Movement Among Igbo Children of Southeastern Nigeria

Leonard Onwukwe
Imo State University Owerri
leonardonwukwe@imsu.edu.ng, leonabraham1975@gmail.com

ABSTRACT

Associated Movement (AM) is a spontaneous propensity in humans to generate ipsilateral and contralateral movements while performing motor functions. The study investigated age and gender-related fluctuations in AM among Igbo children of Southeastern Nigeria. It utilized 224 children within the age range of 1 to 16 years (mean=8.50, 8D=4.620 who were selected from two schools in Imo State, Nigeria. AM was measured with clip pinching, finger spreading, and finger lifting tests. The study utilized 2x3 factorial (experimental) design and data generated was analyzed using chi square analysis and spearman's correlation. Results indicate that age has significant effect on finger spreading but no effect on clip pinching and finger lifting. Also gender had significant effect on finger lifting but none on clip pinching and finger spreading. The superiority in AM performance in early ages, and both gender and age-related fluxes suggests earlier maturity of brain-related processes of motor control among Igbo (African) children as opposed to their Caucasian counterparts. Further studies using stringent methods is suggested.

Keywords: *Associated Movement, Fluctuations, Gender, Igbo Children.*

INTRODUCTION

Associated movements (AM) comprises simultaneous involuntary movement of homologous muscles on the contralateral side of the body that accompany voluntary movement (Kim, Park & Park, 2020). It is also described as superfluous or unintended movements accompanying motor function (Connolly & Stratton, 1968). It is spontaneous propensity in humans to generate ipsilateral and/or contralateral movements while performing a motor action; as well as 'involuntary movements in ipsilateral muscles that can accompany intended movement' (Beaule, Tremblay & Theoret, 2012). It has been variously described as mirror movements (Kim , Park & Park, 2020; Beaule, Tremblay & Theoret, 2012; Armattas, Summers & Bradshaw, 1994); decoupling movements (Tallet, Albaret & Barral, 2013); synkinetic movement (Connolly & Stratton, 1968; Cambier & Dehen, 1977); motor overflows (Soska, Galeon & Adolph, 2011; Addamo, Farrow, Bradshaw & Georgiou-karistianis, 2010; Stern, Gold, Hoin & Barocas 1976; Yensen , 1965) and associated reactions (Kim, Park &Park, 2020) and motor primitives (Mirranda, Daneault, Veegara-Diaz, Torres, Quixada Fonseca, *et al.*,2018).

Researchers have attempted over the years to explain the neural origin of associated movements. Fog and Fog (1965) explained it as arising from the absence of or structural underdevelopment of mechanisms of inhibitory neural control in children. Early in life, infants are clumsy and incapable of coordinated manual actions (Soska, Galeon & Adolph 2011; Thelen, Corbetta & Spencer, 1996) but the acquisition of coordination and autonomous control of their two arms takes place roughly in the first year of life (Goldfield & Michel 1986; Thelen, Corbetta & Spencer, 1996) and this endows them with the ability to manipulate many objects at a time and perform diverse actions involving both hands (kotwica, Ferre & Michel, 2008). According to a number of authors, one hurdle of successfully performing manual actions is the inhibition of symmetry all through the body to enable the separate control of each limb (Tallet, Albaret & Barral, 2013; Fagard & Jacquet, 1986; Michel & Harkins 1986) and this tends to support the argument of an innate spatio- temporal connection between the limbs as the default condition of the motor system (Soska *et al*., 2011; Duque *et al*., 2007; Goldfield & Wolff, 2004). It is the motor cortices of the brain that brings about this inhibition of symmetry that enable individuals to perform manual tasks but motor overflows emerges when such manual tasks are strenuous and attention demanding and hence obstructing the inhibitory signals of the motor system (Aranyi & Roster, 2002).

Apart from the cortex, studies of neurological dysfunction has implicated the roles of corpus callosum (Duque, Murase, Celnik, Hummel *et al*., 2007) and the ipsilateral corticospinal tracts (Mayston, Harrison & Stephans, 1999) in associated movements. The above studies noticed that associated movements occur amongst the elderly and those with neurological impairment due to deficits in these brain areas (Soska Galeon & Adolph, 2011). Assessment of AMs is deemed to be vital in determining mild to moderate motor dysfunction (Gasser, Rousson, Caflisch, Jenni, 2009).

A host of studies have found a developmental and age- related trend in associated movements among normal children (Fog & Fog 1963; Stratton & Connolly 1968; Lazarus & Todor 1987; Gasser, Rousson, Caflisch, Jenni, 2009; Tallet, Albbaret & Barral, 2013); and AMs have been noticed among newly born infants especially as evidenced in eye-mouth over flow movements (Futagi, Ozaki, Futagi, Suzuki & kitajima, 2016). However conflicting outcomes exist as concerns this age related trend in AMs (Pansy, Marschik & Einspieler, 2008).

Stratton and Connolly (1968) found gender variances in associated movements with girls showing lesser degree of such movements. This position was confirmed for contralateral AMs for females at all ages (Gasser, Rousson, Caflisch, Jenni, 2009) However, Abercrombie (1964) did not notice gender differences in AM.

There seem to be paucity of research in this area of interest in Nigeria. One remarkable study conducted by Ashton, (1973) in Yorubaland of South Western Nigeria found considerable differences in the frequency of associated movements between his African participants and their Caucasian counterparts studied by Connolly and Stratton (1968).

The objectives of this study is therefore to investigate whether AMs decreases with increasing age as claimed by previous researchers ; and to find out if there are gender variances in AMs.

METHOD

Participants

Participants comprise 224 pupils and students with ages ranging from one (1) to sixteen (16) years (mean = 8.50 years, SD = 4.620). Fourteen (14) participants consisting 6.3% of the sample were chosen from each age level. Also equal number of males (112) and females (112) were selected to guide against bias that could originate from unequal sample size for gender. The children were selected from Stella Maris Nursery and Primary School Orodo, Imo State, Nigeria and St John Leonardi Model Nursery, Primary/ Secondary School, Amakohia Extension Owerri, Imo State, Nigeria. Descriptive statistics revealed the number of children of different developmental stages: infancy (28), preschool (42), school (70) and adolescence (84). The sample was selected using simple random sampling technique which involved the use of the nth term in a sequence which involved the choice of every third person in a row of a class involving children of similar ages and gender. Each class contained children of similar ages with only slight variations so 300 participants in all were selected from the two schools (at different points in time) and this made it possible for the assignment of 14 children at each age level to be involved in the study.

Procedure

The researcher acquired a written permission from the schools to be able to carry out the study and the permission was granted. The two schools involved comprise Stella Maris Nursery and Primary School Orodo and St John Leonardi Nursery/Primary and model Secondary School Amakohia Owerrri. Three tests of associated movement was used comprising *clip pinching test, finger spreading* and *index finger lifting test*. In the three tests, "1" was assigned as a score for "fail" which indicated presence of associated movement whereas "0" was assigned for absence of associated movement. The researcher was accompanied by four confederates who were trained on how to apply the test to the children. All the participants were selected for the study through a random process, from different classrooms and brought to a hall where the study was carried out. This is because of the need to select children of different age groups. Upon arrival in each classroom, the researcher took permission from the teacher who allowed the study to be carried out. The participants was selected through a random process in which the nth term was used in a sequential other in which the third person from each roll of seat was chosen, until all the participants were recruited. Since the researcher needed equal number of the sexes. The males and females were made to stay in separate sides of the classroom in order to make randomization possible.

Clip Pinching Test: For clip pinching, each child was asked to place both hands on the table, then, a child was directed to hold a bulldog clip between the thumb and other corner of the first finger of the dominant hand. Then, the child was asked to open the clip. Any movement of the thumb and other fingers of the non-dominant hand is counted as associated movement. However, if there is no movement on the non-dominant hand, then no associated movement was recorded. Children of younger ages (1-3 years) were asked to work with a smaller less strenuous rubber clip, the one usually used to clip children's cloths.

Finger spreading test: The child was asked to place both hands on the table and spread the third finger from the fourth finger of the dominant hand. If the fingers are spread without the movement of any other finger of the dominant hand or that of the non-dominant then no associated movement is recorded and vice versa.

Finger lifting test: Each child was asked to place their two hands on the table and to lift the third finger of the dominant hand which was pointed at by the researcher or his confederate. If the finger was successfully lifted without the movement of other fingers then no associated movement was assigned. However, any movement of other fingers of the dominant or non- dominant hands is recorded as associated movement. The descriptions or procedure of these three tests followed that given by Connolly and Stratton (1968: 50-51). However clip-pinching test was earlier used by fog and fog (1963).

Design

The design involved a 2 X 3 experimental design (factorial design) with two levels of the factors: age and gender and three levels of the response variable: clip pinching, finger lifting and finger spreading. This design is adequate because it allows for the observation of variability at the different levels of each independent variable as the response variable is measured. Owing to the nominal nature of the data gathered chi square analysis as well as Spearman's correlation was used in analyzing the data generated.

RESULTS

Table I. Percentage values of presence and absence of associated movement by gender

Source		DV	Absence	Presence	Total
Gender	Male	Clip Pinching	21.0	29.0	50
	Female	Clip Pinching	19.2	30.8	50
	Male	Finger Spreading	17.4	32.6	50
	Female	Finger Spreading	21.9	28.1	50
	Male	Finger Lifting	33.3	17.0	50
	Female	Finger Lifting	25.0	25.0	50
	Total	Clip Pinching	40.2 (90)	59.8 (134)	100
		Finger Spreading	39.3 (88)	60.7 (136)	100
		Finger Lifting	58.0 (130)	42.0 (94)	100

Above are the percentage values indicating the presence or absence of associated movements for both male female children tested. The results indicated little difference between male (29%) and female (30.8%) participants in terms of clip pinching. For finger spreading, a greater number of male participants (32.6%) engaged in associated movements than the females (28.1%). In contrast, for finger lifting, a greater percentage of female children (25%) engaged in associated movements as opposed to male children (17%). Overall, 59% of all the children showed associated movements during clip pinching; and 60.7 during finger spreading. However, only 42% of the children showed superfluous movements during finger lifting.

Table II. Percentage values of presence and absence of associated movement by age

		Clip Pinching		Finger Spreading		Finger Lifting	
Source		presence	absence	presence	absence	presence	absence
Age	1	4.5	1.8	2.7	3.6	1.8	4.5
	2	3.1	3.1	1.3	4.9	1.8	4.5
	3	2.2	4.0	1.8	4.5	1.3	8.5
	4	4.5	1.8	4.9	1.3	3.6	8.5
	5	4.9	1.3	4.9	1.3	2.7	3.6
	6	3.1	3.1	4.5	1.8	2.2	4.0
	7	4.0	2.2	2.7	3.6	2.7	3.6
	8	4.0	2.2	4.5	1.8	2.7	3.6
	9	3.6	2.7	4.5	1.8	3.1	3.1
	10	4.0	2.2	4.0	2.2	3.1	3.1
	11	2.7	3.6	3.1	3.1	2.2	4.0
	12	4.5	1.8	4.5	1.8	2.7	3.6
	13	4.5	1.8	4.5	1.8	2.7	3.6
	14	4.5	1.8	5.4	0.9	3.1	3.1
	15	5.4	0.9	3.6	2.7	2.2	4.0
	16	3.1	3.1	4.0	2.2	4.0	2.2
	Total	59.8(134)	40.2(90)	60.7(136)	88(39.3)	42.0(94)	58.0(130)

Table II indicates percentage values for the presence and absence of associated movements in Clip Pinching, finger spreading and finger lifting across all ages (age 1 to 16). Generally, the results indicate fluctuations across ages. The scores does not indicate sequential decrease in associated movement with increasing age. For example, at age 1 the participants got 4.5% scores in clip pinching showing presence of AM whereas at 2 they scored 3.1% and 2.2% in age 3. The scores increased to 4.5% at age 4 and 4.9% at age 5 only to decrease to 3.1 % at age 6. Generally, children at age 1 showed more AM than those in age 2 and 3. There were fluctuations in ages 6 (3.1%), 9 (3.6%) and 11 (2.7%). The rest age levels showed increased AMs, with people at age 15 showing higher AM than the rest.

For finger spreading infants from age 1 to 3 showed reduced AMs even though infants at age 1 showed higher AM than those in ages 2-3. However, from age 4 to 6 there was an increase in AMs represented by 4.9%, 4.9% and 4.5% scores for ages 4, 5 and 6 respectively. A fall in AM was noticed at age 7 (2.7%). However from age 8 to 16, a consistent increase in AM was witnessed. In all, the increase or decrease in AM is far from linear.

For finger lifting, children from ages 1 to 3 showed reduced AM as compared to children at age 4 (3.6%). From age 5 there was a decrease in AM till age 8. Children at age 16 showed more AM than children of other age levels.

A pictorial representation of these staggered outcomes is shown for clip pinching, finger spreading and finger lifting in the bar charts below: bars with star sign on top of it indicate presence of AM.

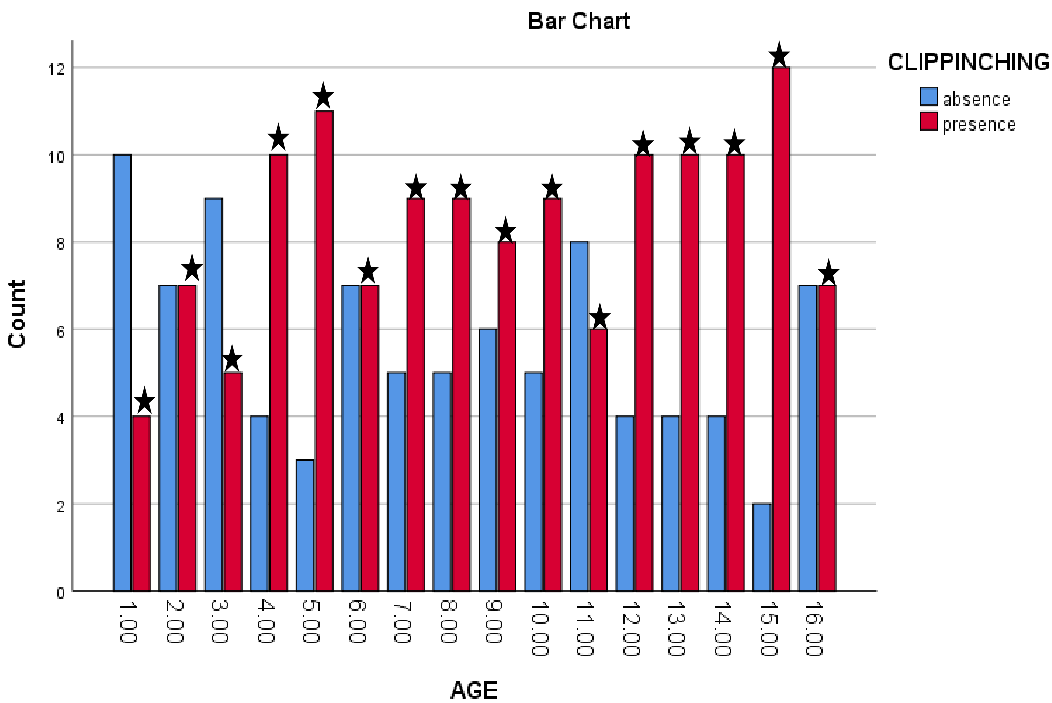

Fig I. Bar chart of age and clip pinching

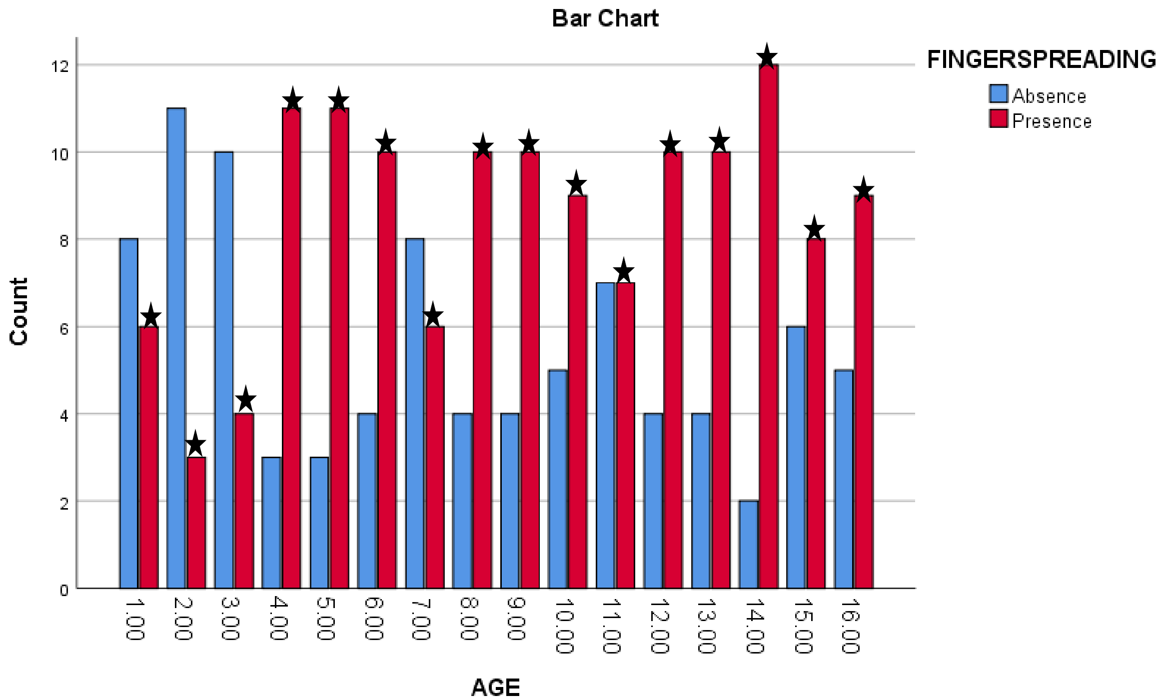

Fig. II: Bar Chart of age and finger spreading

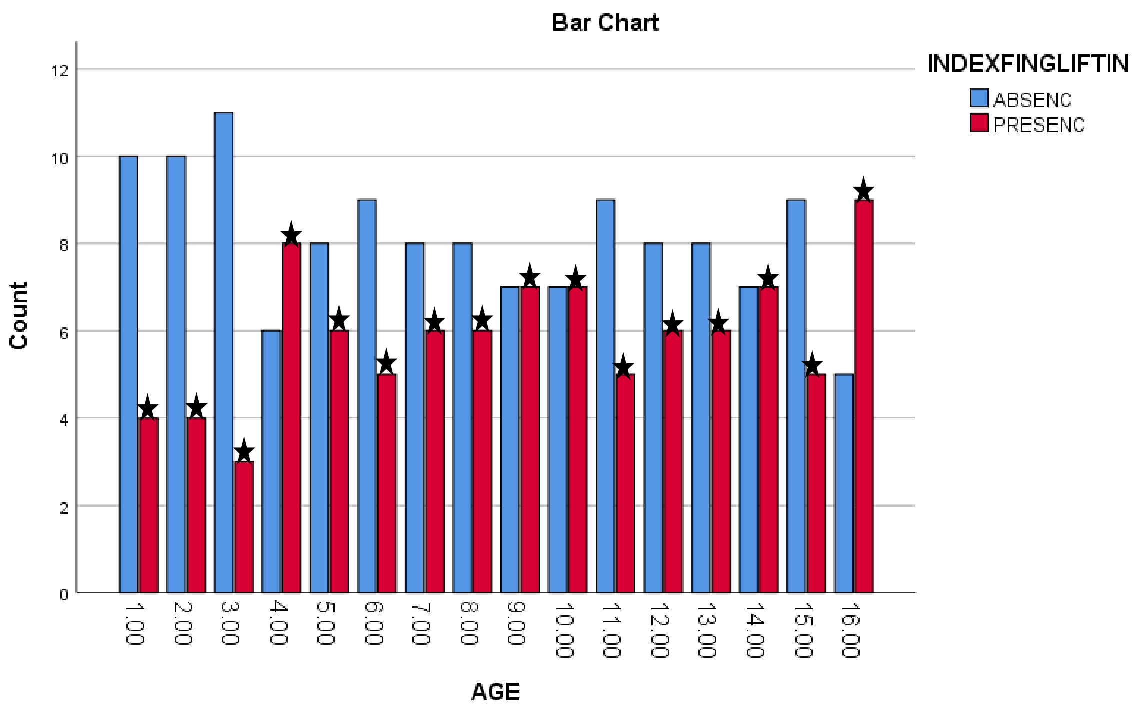

Fig III: Bar chart of age and finger lifting

As can be seen from above, there was no linear decrease of associated movement with increasing age. What is indicated is nothing but fluctuations across different ages in terms of AMs.

Table III: Chi Square and Spearman Coefficients of Age and Gender on AM.

	X^2 values	Sig.	Spearman RHO	Sig.
Gender				
Clip Pinching	.279	6.83#	-.036	.588#
Finger Spreading	1.872	.218#	.091	.173#
Finger lifting	5.939	.021*	-.163	.015*
Age				
Clip Pinching	21.917	.110#	.150	.025*
Finger Spreading	30.545	.010*	.174	.009*
Finger lifting	10.718	.758#	.116	.084#

P< .0   Key: * significant; # Not significant

Above are the results of the chi square analysis and Spearman's RHO (correlation) for the three methods used to measure AM. The result showed no significant difference between males and females in terms of clip pinching (X^2 = .279 p>.05). Also, there was no significant correlation between gender and clip pinching. The same was found for gender and finger spreading (X^2 = 1.872 p > .05). However, a significant difference was found between males and females in terms of finger lifting (X^2 = 5.939, p >.05). Also, there was a significant negative correlation between gender and index finger lifting. The percentage values indicated that males showed significantly lower presence of AM (17%) than females (25%).

Also, Table III above showed results relating to age and AM. The outcome indicated no significant effect of age on clip pinching using chi square analysis (X^2 = 21.917, p >.05). However, there was a significant correlation between age and clip pinching (R = .150, p < .05). In contrast, there was significant effect of age on finger spreading (X^2 = 30.545) as well as significant correlation between the two variables (R = .174, p < .05). In terms of finger spreading 60.7 % of the scores of Participants of all ages showed the presence of AM as opposed to 39.3% that did not. Finally, in terms of finger lifting, age did not have any significant effect on finger lifting (X^2 = 10.718 p > .05) and also there was no significant correlation between the variables (R = .116, p > .05).

DISCUSSION

The first result showed that males and females did not differ significantly in their overflow movements during clip pinching. Though insignificant, females showed greater presence of associated movements than males when this method was used. This is in line with the work of Carlier, Dumont, Beau & Michel (1993) who found that French male children were faster than the females in finger tapping task. This finding is opposed to the finding by Grasser, Rousson, Caflisch & Jenni (2010) who found that females showed lesser AMs in most of the measure of AM. The authors noticed that females showed significantly more over flow movement in repetitive hand, alternating hand, repetitive finger and sequential finger which are part of the Zurich Neuromotor Assessment Battery used by the authors to measure AM. However females did not show greater advantage in the repetitive foot movement by the authors. Also Stratton & Connolly (1968) observed a significant gender difference in AM with females showing greater absence of AM except for age 10 when males scored higher in terms of absence of AM in their feet to hands test.

Similarly, for finger spreading there is no significant gender difference noticed. However, contrary to the results found in clip pinching, female participants showed more absence of AM (21.9%) than their male counterpoints (17.4%) and this is consistent with a host of research findings (Gasser *et. al.,* 2010., Largo Catflisch, Hug, Muggli, Molnar, Molina, Molinari, 2001 & Larson, Mostofsky, Goldberg Cutting, Denckla, Mahone 2007, Stratton & Connolly 1968). These authors found gender differences in AM with female children showing superiority in motor development. However, Abercrombie *et al.,* (1964) found no gender differences in AM. Even though, they observed that females showed superiority in AM in most of the tests they used like clip pinching and feet-to-hands tests.

As opposed to these other methods, males and females showed significant difference in terms Finger Lifting. However, like clip pinching females showed greater presence of AM than males. This finding is opposed to a host of research outcomes (Gasser *et al*., 2010; Larson *et al*., 2007; Largo *et al*., 2001; Stratton & Connolly 1968). It appears African participants do not respond the same way like their Caucasian counterparts as regards Associated movements. The idea that females show superiority than males in terms of AM is disconfirmed by our results. The argument by Gasser *et al*., (2010) that females show earlier reduction in AM is disconfirmed by our results as regards finger lifting.

Also, results show that age is correlated with clip pinching, implying that a relationship exist between age and AM. However, age has no significant effect on clip pinching. Also, age did not correlate with neither does it have significant effect on finger lifting. These outcomes support the observation of a non- linear relationship between age and decrease in AM. The findings are opposed to many studies in this area which utilized Caucasian children, because they observed that AM decreases with increasing age (Fog & Fog., 1963; Stratton & Connolly 1968; Gasser *et al*., 2009; Gasser *et al*., 2010) and even among patients with other conditions including cerebral palsy (kim, Park & Park, 2020) and developmental coordination disorder (Tallet *et al*., 2013). Consistent to our finding is the study by Ashton (1973). The above study used 162 children from Yoruba ethnic group in Nigeria to whom three tests of AM including finger spreading and clip pinching were administered. The study noticed no "developmental trends" in AM explaining it as related to the early development of inhibitory motor control in African Children. Consistent with Ashton, our study did not show evidence of a linear decrease in AMs with age among Igbo children in Nigeria. The study also confirmed successes in motor control among children below the age of four indicating greater maturity of the ipsilateral cortical motor areas responsible for inhibitory motor control.

One limitation of our study especially it relates to clip pinching was that it did not take care of individual differences in the application of volitional force. Todor and Lazarus (1986) and later Lazarus and Todor (1987: 726) found that AMs is affected by "the failure to control for individual differences in the exertion level of the primary or intended act". They argued that variability exist in terms of volitional force exerted by individuals depending on their strength. In other to control for this situation, the authors devised a modified test of clip pinching which involved an apparatus that could transmit the exertion level of each participant at every trial, enabling the experimenter to reject trials that did not tally with a predetermined exertion level.

Also, it was found that age has significant effect on finger spreading. From the bar chart (fig11) it was noticed that children as early as one to three years showed higher percentage scores in terms of absence of AM. However, increased AM was noticed from the 4^{th} to the 7^{th} year. This superiority by African children in the early years in terms of the development of the nervous system over their Caucasian counterparts have been confirmed in early research in AM (Ashton, 1973; Marshal 1968 cited in Ashton 1973; Geber & Dean 1957). However evidence from the bar chart representation and the percentage scores (table II) shows that the effect of age on overflow movements is far from linear and this is consistent with the work of Koerte, Eftimov, Laubender *et. al*.,(2010) who found a robust non- linear nexus between age and AM. An interesting difference between the present study and that of the above authors is that while the present study focused on children from age 1 to 16, Koerte, *et al* (2010) studied normal humans from age 3 to 96 years. However, the finding that age is significantly related to AM has received support from a host of studies (Fog & Fog., 1963; Stratton & Connolly 1968; Gasser *et al*., 2009; Gasser *et al*., 2010).

In Conclusion, it is clear from the results that a great degree of fluctuations and variance exist in AM across different successive ages. Our Igbo (Nigerian) participants did not show linear decrease in AM with increasing age. Apart from in Index finger lifting where females showed significantly more superiority in AM, males indicated more reductions in AM than their female counterparts. The implication of these findings is that African children appear to have more developed nervous processes of inhibitory motor control than their counterparts in other climes. However, given the limitation of the study especially in terms of controlling exertion levels, further studies imploring stringent methods is suggested.

REFERENCES

Abercrombie, M. L. J., Lindon, R. L., Tyson, M. G. (1964) 'Associated movements in physically handicapped children.' *Developmental Medicine and Child Neurology*, 6, 573-580.

Addamo, P.K, Farrow. M., Bradshaw, J.L., Moss, S. & Georgiou- karishanis, N. (2010). The effect of attending to motor over flow on us voluntary inhibition in Young and older adults. *Brain and Cognition*, 74 (3) 358-364.

Aranyi Z, Ro¨ sler K .M. (2002) Effort-induced mirror movements. *Experimental Brain Research*, 45: 76–82.

Armatas CA, Summers JJ, Bradshaw JL. (1994) Mirror movements in normal adult subjects. *Journal of Clinical and Experimental Neuropsychology*. 16(3):405–413.

Ashton, R. (1973). Associated movements in Yoruba school children. *Developmental Medicine and Child Neurology*, 15 (1), 3-6.

Beaule, v., Tremblay, S., & Theoret, H (2012) Interhemispheric control of unilateral movement. *Neural Plasticity*. Published online. do1: 1.1155/2012/627816.

Boudrias, M., Gonclaves, C. S., Penny, W. D., Park., C., Rossiter, H. E., Tallelli, P., Ward, H.s. (2012). Age related changes in causal interactions between cortical motor regions during handgrip. *Neuro Image* 59, 3398- 3405

Cambier, J., Dehen, H. (1977) 'Imitation synkinesia and sensory control of movement.' *Neurology 27, 646-649.*

Carlier M, Dumont, A.M., Beau, J., & Michel, F. (1993). Hand performance of French children on a finger-tapping test in relation to handedness, sex and age. *Perception and Motor Skills*, 931-940.

Connolly, K.J. & Stratton, P (1968). Developmental changes in associated movements. *Developmental Medicine and child neurology*, 10, 49-50.

Dugue, J, Murase, N, Celnik p., Hummel, F, Harris-love, & M, et al., (2007). Intermanual differences in movement-related interhemispheric inhibition. *Journal of cognitive neuroscience,* 19(2), 204-213

Fagard, J. & Jacquet A.Y. (1996). Changes in reaching and grasping objects of different sizes between 7 and 13 months of age. *British Journal of Developmental Psychology*, 14, 65-78.

Fog, E. & Fog, M. (1963) 'Cerebral inhibition examined by associated movements.' *In* Bax, M., Mac Keith, R. C. (Eds.) *Minimal Cerebral Dysfunction, Clinics in Developmental Medicine No. 10.* London: Spastics Society with Heinemann. pp. 52-57.

Futagi, Y., Ozaki, N., Matsubara, T., Futagi, M., Suzuki, Y. & Kitajima, H. (2016) Eye-mouth Associated Movement in the human newborn and very young infant. *Pediatric Neurology*, 58, 75-82 doi: 10.1016/J.pediatrneurol.2016.01.006.epub 2016. Jan 15.

Gasser, T., Rousson, V., Caflisch, J., & Jenni, O.G (2009). Development of motor speed and associated movements from 5 to 18 years. *Developmental Medicine and Child Neurology*, 256-263. D01: 10. 1111/J. 469-8749. 2009. 033391x.

Gasser, T., Rousson, V., Caflisch, J., & Jenni, O.G (2010). Development of motor speed and associated movements from 5 to 18 years. *Developmental Medicine & child Neurology* 52 (3), 256-263.

Geber, M, Dean, R.F.S. (1957). The state of development of new-born African children. Loncet, 1, 12-16

Gidley Larson J. C., Mostofsky S .H, Goldberg M.C, Cutting LE, Denckla MB,Mahone EM. (2007) Effects of gender and age on motor exam in typically developing children. *Developmental Neuropsychology*, 32: 543–62.

Gidley, L.J.C., Mostofsky, S.H., Goldberg, M.C., L.E., Denckla, M.B., Mahone, E.M. (2007). Effects of gender and age on motor exam in typically developing children. *Developmental Neuropsychology* 32, 543-562.

Goldfield, E. C., & Michel, G. F. (1986). The ontogeny of infant bimanual reaching during the first year. *Infant Behavior & Development*, *9*(1), 81–89. https://doi.org/10.1016/0163-6383(86)90040-8

Goldfield, E. C., & Wolff, P. H. (2004). A dynamical systems perspective on infant action and its development. In G. Bremner & A. Slater (Eds.), *Theories of infant development* (pp. 3–29). Blackwell Publishing. https://doi.org/10.1002/9780470752180.ch1

Kim, S. K., park, H. k., park, E. S. (2020). Contralateral unintended upper arm movement during unimanual tasks in children with cerebral palsy. *Yonsei Medical Journal*, 61 (3) 235-242.

Koerte I, Eftimov L, Laubender RP, et al.(2010) Mirror movements in healthy humans across the life-span – development and aging. *Developmental Medicine & Child Neurology*, 52: 1106–12. DOI:10.1111/j.1469-8749.2010.03766.x.

Kotwica, K. A., Ferre, C. L., & Michel, G. F. (2008). Relation of stable hand-use preferences to the development of skill for managing multiple objects from 7 to 13 months of age. *Developmental Psychobiology*, *50*(5), 519–529. https://doi.org/10.1002/dev.20311

Largo, R., Caflisch, J., Hug, F., Muggli, K., & Molinari, L. (2001). Neuromotor development from 5 to 18 years parts 2: associated movements. *Developmental Medicine & Child Neurology*, 43, 444-453.

Mayston M. J, Harrison L. M, & Stephens J. A. (1999) A neurophysiological study of mirror movements in adults and children. Annals of Neurol 45: 583–94.

Michel, G. F., & Harkins, D. A. (1986). Postural and lateral asymmetries in the ontogeny of handedness during infancy. *Developmental Psychobiology*, *19*(3), 247–258. https://doi.org/10.1002/dev.420190310

Miranda, J.G.V., Daneault, JF., Vergara-Diaz, G. *et al.* (2018). Complex Upper-Limb Movements Are Generated by Combining Motor Primitives that Scale with the Movement Size. *Scientific Reports* 8, 12918 https://doi.org/10.1038/s41598-018-29470-y (Published online).

Pansy, J., Marschik, P. B., & Einspieler, C. (2008). Associated movements in 5 to 10-year-old infants. *Neuropediatrics*, 39 retrieved from *https://www.thieme-connect.com/products/ejournals/issue/10.1055/s-00216101/grouping/016037/10.1055/s00000041?device=desktop&lang=de*

Soska, K.C., Galeon, M.A. & Adolph, K.E., (2012). On the other hand: overflow movements of infants' hands and legs during uni-manual object exploration. *Developmental Psychobiology*, 54(4)372-382.

Stern, J. A,, Gold, S., Hoin, H., Barocas, V. S. (1976) 'Towards a more refined analysis of the "overflow" or "associated movement" phenomenon.' *In* Sankar, D. V. S. (Ed.) *Mental Health in Children.* Westbury, NY: PJD Publications.

Tallet. J, Albaret, J.M. & Barral (2013). Age- related alonges in left or right selective inhibition in children with and without developmental coordination disorder. *Brazilian Journal of Motor Behaviour*, 7. (Supplement) 62…

Thelen, E., Corbetta, D., & Spencer, J. P. (1996). Development of reaching during the first year: Role of movement speed. *Journal of Experimental Psychology: Human Perception and Performance, 22*(5), 1059–1076. https://doi.org/10.1037/0096-1523.22.5.1059

Todor, J. I., Lazarus, J. C. (1986) 'Exertion level and the intensity of associated movements. *Developmental Medicine and Child Neurology,* 28**,** 205-212.

Yensen, R., (1965) 'A factor influencing motor overflow. *Perceptual and Motor Skills,* 20, 967-968.