Original Article

Gender and environmental influence on laterality functions among preclinical students of the University of Benin, Benin City

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Abstract

Background: A semi-structured questionnaire was designed to ascertain laterality functions in randomly sampled population of 400 preclinical students of the University of Benin, Benin City, Edo State, Nigeria. **Methodology:** Frequency in use of limbs in physical activities categorized as: Always if (>80%), usually if (>50–80%), or equally if (50%) of cases was used in grading this perception. Three hundred and sixty-three questionnaires with well-generated data were analyzed using Statistical Package for Social Sciences (version 16.0, Chicago IL, USA). **Results:** Results revealed significant difference ($P < 0.05$) in the choice of limbs, but there was no significant ($P > 0.05$) influence from gender, physical disability, or indoctrination on the choice. 43.86% males, 33.86% females claimed to use the right-hand always; 1.38% males, 0.83% females use the left-hand always; 0.55% males, 0.84% females use the left-hand usually; 8.54% males, 5.23% females use the right-hand usually; and 3.84% males, 2.75% females use both hands equally. On use of the foot, 26.45% males, 19.83% females initiate staircase climbing with the right foot always; 6.34% males, 4.13% females do the same with the left foot always; 14.69% males, 11.30% females use their right foot usually; 4.13% males, 4.96% females use the left foot first usually; and 5.79% males, 0.03% females use the right and left foot equally. **Conclusion:** The majority of the respondents were right-handed and right-footed, thus suggesting left cerebral hemispheric laterality in the population.

Key words: Environmental influence, gender, laterality functions, preclinical students

INTRODUCTION

Observing foot and hand use in every society reveals that while some people are left-handed or left-footed, some are similarly right-handed or right-footed. Others are considered ambidextrous, that is, they can use both the left and the right limbs equally. Another small segment of the entire population may as well be considered awkward or poorly skilled in the use of either the left or the right limb. The cerebrum, otherwise known as the forebrain, exercises control over body activities such as footedness,

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handedness, and eyedness. This reflects either on the contralateral side of the body or the ipsilateral side of the body (McManus and Bryden, 1991). Being the seat of consciousness, memory, intelligence, as well as voluntary and involuntary actions, it has correlated localized structures and functions. The control that the cerebrum has on limb movements is determined by the dominant hemisphere. This is because of the functional asymmetry between the two halves of the brain. Kertesz *et al.,* 1992 remarked that anatomical and functional asymmetries are linked with individual differences in cerebral organization (Hardyck and Petrinovich, 1977). Even single-celled organisms are commonly asymmetric (Cooke, 1995; Beddington, 1996). Vertebrate embryos are said to have a symmetrical arrangement of tissues or cells which is subsequently broken down such that the consequent asymmetrical development of vertebrate's anatomical structures is a product of symmetric disruptions (White *et al.,* 1994; Levin, 2005). The more specialization of function, the more complex the asymmetry of the structure and functional organization as exemplified with the human brain which is different (Ecles, 1977; Deacon, 1997; Heinz *et al.,* 1988). Thus, humans' with asymmetric brains (Corballis and Morgan, 1978; Beaton, 1997) exhibit lateralized behavior (Purves *et al.*, 1994; Hepper *et al.,* 1998). Several factors have actually been propounded to influence laterality, among which are ultrasonography (McManus, 1993; Salvesen *et al*., 1993; Kieler *et al*., 1998), the genetic theory (McCartney and Hepper, 1999; Francks *et al.*, 2007; McManus *et al.,* 2009), culture and environment (Liederman and Coryell, 1981; Lenroot and Giedd, 2008; Yoon *et al*., 2010), and hormones which determines phenotypic sex or gender (Moffat *et al.,* 1998; Frederikse *et al.,* 1999). On hormonal basis, previous researchers claimed that exposure to the higher rate of testosterone before birth can lead to a suppressed right-handedness such that a left-handed child is born (Geschwind and Galaburda, 1985). This theory, known as the Geschwind theory, states that variation in the level of testosterone during pregnancy will shape the development of the fetal brain, such that neurons in the left cerebral hemisphere are suppressed in growth and those in the right cerebral hemisphere being well-developed, take over the predominant cerebral functions thus making the individual to become left-handed. This implies that there is a strong evidence that prenatal testosterone contribute to brain organization (Geschwind and Galaburda, 1985), a subject for further investigation.

It is a known fact that motor decussation from the contralateral hemisphere influences the functional capacity and use of the extremities (White *et al.,* 1997; Nielson *et al*., 2002). MacNeilage, 1991 proposed that the first evolutionary step in hemispheric specialization was a left-hand, right hemispheric visuospatial specialization of unimanual predation. Furthermore, author also claimed that "postural control element" of footedness predicts cerebral lateralization. Although preferred handedness has actually been widely researched as the most popular predictor of cerebral lateralization, it alone, is not considered a reliable predictor (Day and MacNeilage, 1996; Rasmussen and Milner, 1977). Hence, suitable predictor of cerebral lateralization is still being researched.

This study investigates the relationship between gender and the degree of footedness/handedness of the sampled population of preclinical students of the University of Benin, Benin City. Can the degree of footedness/handedness really be a possible way of predicting the dominant cerebral hemisphere of the population? To this end, two "Hypotheses" were canvassed for the study:

"There is a significant association between gender and handedness/footedness. The gender handedness/footedness is influenced by environmentally-induced factors such as injury and indoctrination."

METHODOLOGY

This study was carried out on 200 level and 300 level preclinical medical students of both sexes of the University of Benin, Benin City. It included male and female students' resident on campus and off – campus. This population was chosen for the ease of sample collection irrespective of marital status, religious, ethnic background, occupation, and the length of stay of the respondents in the university or locality.

A total of 1000 students made up this number. On different lecture days for each class, samples were drawn using every alternate student by administering questionnaires to those who were willing. In all, about 200 students either declined consent or were absent during sampling. Out of about the 800 students present from both classes, alternate student sampling gave us the sample size of 400. Of the administered 400 questionnaires, 363 were well-completed and submitted for analysis. The study, therefore, was drawn from youth population of school age. The sample size was chosen bearing in mind the time, finance, and feasibility of the study. Samples were obtained by simple random sampling technique, wholly in the class when all the students were fully seated in between lecture hours. Each of the classes used was oriented with seats patterned in rows of about 7–9 students. In each row, 4–5 students were randomly selected. The exclusion criteria were those who were either unwilling or absent.

The questionnaire comprised three parts. Part I, II, and III. Part I contained the socioeconomic background of respondents. Part II comprised questions on handedness and Part III on footedness. Questions were drawn taking the cognizance of the possibility of cross handedness or footedness and use of the limbs in finer and contextual movements. Information gathered from the questionnaire were coded and recorded in spreadsheets. From here, they were fielded into the computer for statistical analysis using Statistical Package for Social Sciences(SPSS) Inc. Released 2007. SPSS for Windows, Version 16.0. Chicago, SPSS Inc. In all, percentages were used for data interpretation and Chi-square test for a test of hypothesis.

RESULTS

To ascertain the number of persons and use of which hand, the following question was asked. Which hand do you use for writing? Left always, left usually, equal use of both hands (equally), right usually, and right always?

Using Chi-square, at 5% probability, results of Table 1 were analyzed and $P > 0.05$. This implies that significant association does not exist between gender of the population and the preferred hand use. So, null hypothesis, which states that significant association exists between gender and handedness, was rejected. The study population was comprised of predominantly right-handed individuals.

To verify if physical assault or injury contributed to the choice and manner of use of the hand, the following question was asked: Is there any reason (injury) why you have changed your hand preference, yes or no?

At 5% probability, $P < 0.05$, hence null hypothesis was upheld [Table 2]. There is a significant association between gender and hand preference due to injury suffered. More females suffered from injury to the hand compared to their male counterparts which significantly informed their hand preference.

To ascertain if the use of the preferred left or right-hand was influenced by any training or indoctrination of the respondents, the following question was asked: Have you ever been given special training or encouragement by anyone to use a particular hand for certain activities, yes or no?

At 5% probability, the results of Table 3 were analyzed and $P > 0.05$. This implies that formal training or indoctrination did not significantly affect the choice use of the hands in both sexes.

To ascertain, which foot is more frequently used by the respondents, the following question was asked: If you had to step up onto a chair, which foot would you place on the chair first?

The result showed that at 5% probability, ($P > 0.05$) [Table 4]. Therefore, there is no significant association between gender and foot preference in the population. So, null hypothesis was rejected. However, most subjects of the sampled population use the right foot.

To verify if injury affected the choice of which foot to use, the following question was asked: Is there any reason (injury) why you have changed your foot preference, yes or no?

The results showed that at 5% probability, ($P > 0.05$) [Table 5]. This means that physical assault or injury did not contribute significantly to the choice use of foot, thus rejecting the null hypothesis.

Table 1: Association between use of the hand and gender

Use of the hand	Gender *n* (%)		Total	Statistics		
	Male	Female		χ^2	df	*P*
Left always	5 (62.5)	3 (37.5)	8	1.370	4	0.849
Left usually	2 (40.0)	3 (60.0)	5			
Equally	11 (52.4)	10 (47.6)	21			
Right usually	31 (62.0)	19 (38.0)	50			
Right always	159 (57.0)	120 (43.0)	279			
Total	208 (57.3)	155 (42.7)	363			

Table 2: Association between physical injury to the hand and gender

Physical injury to the hand	Gender *n* (%)		Total	Statistics		
	Male	Female		χ^2	df	*P*
No	185 (63.4)	107 (36.6)	292	22.377	1	<0.001
Yes	23 (32.4)	48 (67.6)	71			
Total	208 (57.3)	155 (42.7)	363			

Table 3: Association between indoctrination use of the hand and gender

Indoctrination use of the hand	Gender *n* (%)		Total	Statistics		
	Male	Female		χ^2	df	*P*
No	202 (58.0)	146 (42.0)	348	1.914	1	0.167
Yes	6 (40.0)	9 (60.0)	15			
Total	208 (57.3)	155 (42.7)	363			

Table 4: Association between use of the foot and gender

Use of the foot	Gender *n* (%)		Total	Statistics		
	Male	Female		χ^2	df	*P*
Left always	23 (60.5)	15 (39.5)	38	4.066	4	0.397
Left usually	15 (45.5)	18 (54.5)	33			
Equally	21 (70.0)	9 (30.0)	30			
Right usually	53 (56.4)	41 (43.6)	94			
Right always	96 (57.1)	72 (42.9)	168			
Total	208 (57.3)	155 (42.7)	363			

Table 5: Association between physical injury to the foot and gender

Physical injury to the foot	Gender *n* (%)		Total	Statistics		
	Male	Female		χ^2	df	*P*
No	200 (57.0)	151 (43.0)	351	0.445	1	0.505
Yes	8 (66.7)	4 (33.3)	12			
Total	208 (57.3)	155 (42.7)	363			

To ascertain if use of the preferred foot was influenced by any training or indoctrination, the following question was asked: Have you ever received any special training or encouragement to use a particular foot for certain activities, yes or no?

The results at 5% probability showed that ($P < 0.05$) [Table 6]. This implies that the preferred foot used by the respondents was significantly influenced by training. Hence, the null hypothesis was upheld.

DISCUSSION

The results from the study revealed that there is the preponderant use of the right limbs among respondents. This is significant and with underlying anatomic basis defined within the concept of human laterality (Melsbach *et al.,* 1996). There is no doubt that the human brain is unique both in its components and size (Heinz *et al.,* 1988), compared to primates. Deacon, (1997), already noted such marked difference in the human brain to be mostly due to superficial gross anatomical features. Furthermore, the recognition drawn from knowledge of the functional diversity of the brain as understood from the fields of neuroanatomy, developmental biology and genetics correlates with the morphology of the brain, and the topographical anatomy (McManus and Bryden, 1993; McManus *et al.,* 2009). Pyramidal decussation of corticospinal tract transmission is known to account for contralateral manifestations of brain's activities in the limbs (Nielsen *et al.,* 2002). The results obtained from this study as with previous documentation (Amunts *et al.,* 2000), showed no evidence of gender bias in this manifestation as there was no significant difference between the sex of respondents and choice use of the limbs, thus rejecting the null hypothesis. It was noted from study that there was a significant association between gender and physical injury to the hand, affecting the choice use of the hand. More females (13.22%) than males (6.34%) had the preferred hand use affected by injury while more males (50.96%) than females (29.48%) had their choice hand unaffected by injury. This is understandable because many of such female respondents actually alluded injuries sustained from household chores influenced the change from the otherwise preferred hand. The implication of, this is, that anatomic basis does not alone suffice in explaining preferred limb use in its entirety. Rather, there is a significant contribution by environmental factors. This observation is supported by results from previous studies (Lenroot and Giedd, 2008; Yoon *et al.*, 2010). Injury to the foot did not significantly influence foot preference, and report from this study also showed no significant association between gender and preferred foot. Most of the respondents were right-footed. However, the influence of indoctrination on gender foot preference was statistically significant ($P < 0.05$). It was remarkable that (51.51%) male and (41.87%) female respondents were not indoctrinated on foot preference. Among those indoctrinated, more males (5.79%) compared to females (0.83%) were influenced to change their preferred foot. This was noticeable when mainly the male respondents claimed that for certain tasks, such as playing footballs or picking objects with the foot, they were trained from childhood to adopt the use of the right foot. The implication of these environmental and indoctrination influences on handedness/footedness is that none of them can be suitably used as sole predictors of human laterality. In support of this view is report from Elias *et al.,* (1998), disputing footedness as a purer predictor of sidedness than handedness. Although authors further posited that footedness may be less culturally influenced than is handedness, this is, however, not exactly consistent with the results of this study. Worth remarking, however, is that culture and other environmental factors do not alone suffice for the explanation of the observations from this study. What must not be ignored are the other variables that influence the anatomic arrangement in the brain even early in life (Hepper *et al.,* 1998), as possible explanations for human laterality. An example is the concept of hormonal influence. Previous researchers (Geschwind and Galaburda, 1985) claimed that exposure to a higher rate of testosterone before birth can lead to a suppressed right-handedness such that a left-handed child is born. This theory is known as the Geschwind theory which states that variation in the level of testosterone during pregnancy will shape the development of the fetal brain such that neurons in the left cerebral hemisphere are suppressed in growth and those in the right cerebral hemisphere being well-developed, take over the predominant cerebral functions; thus making the individual to become left-handed (Geschwind and Galaburda, 1985). This implies that prenatal testosterone contribute to brain organization (Elkadi *et al.*, 1999). Does this also imply that right-handedness might be a possible outcome of low prenatal testosterone exposure? This is an issue for further studies.

Table 6: Association between indoctrination use of the foot and gender

Indoctrination use of the foot	Gender *n* (%)		Total	Statistics		
	Male	Female		χ^2	df	*P*
No	187 (55.2)	152 (44.8)	339	9.579	1	0.002
Yes	21 (87.5)	3 (12.5)	24			
Total	208 (57.3)	155 (42.7)	363			

CONCLUSION

It is obvious from previous work that handedness/footedness are means by which the dominant cerebral hemisphere may be predicted. The opinion from this study is that why gender may not necessarily affect lateralization, prediction of the dominant cerebral hemisphere will be more precise, taking cognizance of other variables such as culture, environmental influence, anatomic arrangement, and structuring of the brain, hormonal factor inclusive.

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Conflicts of Interest

There are no conflicts of interest.

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