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Measuring Digit Ratio with Smart Phone to Unveil Health Conditions and Behavior

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Abstract - Finger lengths have fascinated scientific researchers for a long time and people hardly notice different underpinnings of the relation between the shape and size of our body to the scientific meanings. The idea behind the shape of the palm length of the fingers indicates something profound about people sexual proclivities and vulnerability to certain diseases. In order to investigate and intervene in this health concern we measure the digit ratio that is the ratio of the lengths of different digits. The index finger (2D) and ring finger (4D) for both the hands are typically measured from the midpoint of the bottom crease where the finger joins the hand to the tip of the finger. This study uses smart phone camera to take the hand image and then measure relative lengths of the second (2D) and the fourth (4D) fingers. Their ratio is calculated by dividing the length of the index finger by the length of the ring finger of the hand. This finger reading foretells information of an individual's psychology, motivations, health and social behavior such as homosexuality, cancers, musical ability, aggressive personality, passive personality traits, development disorder such as Dyslexia (which can be termed as literacy deficiencies), athletic ability and dexterity innate ability in key cognitive areas.

Keywords – digit ratio; human health and behaviour; smart phones.

I. INTRODUCTION

Over the past few years, digit ratio of the second to fourth finger (2D:4D), studies have become increasingly popular in human biological, medical and psychological research. The extensive past research has focused on whole hand digit ratio. Agreement levels are still complicated to permit conclusions on findings from different research groups based on these observations. Negotiations on the conclusion of earlier researches still occur. Earlier research and experiments used different tools, such as x-rays, digital scans, photocopies or the direct measures by calipers and some used different software with physical intervention for pinpointing of a person which can bring valuable information. This takes a lot of time and may even cause fluctuations in the quality of the measurements due to measurer's tiredness or automation.

In human, parental androgen exposure influences development of the fingers and leads to distinct differences in hand patterns among men and women. The digit ratio of the length of the second to fourth finger (2D:4D) has consistently been shown to be more sexually dimorphic on the right hand than the left hand, in which females have higher 2D:4D ratio than the males. The 2D:4D has been linked with parental

hormone exposure in human as well as other mammals and has been found to be related with diverse physical abilities in humans [1-2,20-31]. Exposure to high parental androgens, low parental androgens, or both may lead to lower digit ratio [3]. The ratio of lengths of the second and fourth hand digits 2D:4D has been suggested to be a proxy indicator of human exposure during the prenatal development. And 2D:4D has been postulated as a potential indicator of fetal hormone exposures leading to the adult diseases [4,17]. To decrease breast cancer risk and to increase prostate cancer risk [5], they may also influence eating disorder [6], alcohol dependency [7], social risk taking behaviors [8], personality disorders [9], depression, and anxiety [10]. Furthermore, a variety of behaviors that are either sexually dimorphic or ascribed to the actions of sex steroids also correlates with 2D:4D [11,32]. Previous study indicated that the androgenization affects the right hand more than the left. Digit ratio has been shown to correlate with psychological traits when the right hand and left hand digit ratios have been used to instigate relationships between the digit ratios. Psychological factors are found to have a stronger effects on the right hand of human body [12]. On a comparison between the two hands, stronger effects are found on the right hand of the body.

Having said that the main purpose in the present study is to introduce smart phone camera apps to measure the digit ratio which will enhance the procedure by decreasing the time-cost and increasing the quality. The parameters of measurement can provide information about the health status, functional ability, effectiveness of rehabilitation, falling risks and other potential clinical data of elderly people from different ethnics groups.

This paper is organized as follows. In section II the measurement of digit ratio is proposed. Results from measuring digit ratio are given in section III. Discussions on the discovered results are presented in section IV. Conclusions are made in the final section V.

II. MEASURING DIGIT RATIO

A. Study Subjects

The gender difference in 2D:4D digit ratio was studied on 102 people comprising of 61 men and 41 women. It was discovered that out of both females and males, 90% were right hand dominant and 10% were left hand dominant. Ages in the sample ranged from 20-75 years, with most of the participants being in their twenties from different countries, viz Taiwan,

India, Indonesia, and Swaziland. The digit ratio measurement of those people who are in their twenties were correlated with the 50's and above, to find out the relation of social behaviors, diseases, psychological change, personality and individual differences. The lengths of index (2D) and ring (4D) fingers were measured from the points on finger tips and bottom most proximal creases using a smart phone camera of different group ethnics. The difference in 2D:4D digit ratio and results were correlated with age, marital status, body weight, height, and body mass index (BMI) to draw a precise and concrete result. Life history of each individual and clinical records were recorded to standardize the loophole of any ailment.

B. Data Collection

To measure the relative length of the fingers, it is important to make sure they are extended vertically from the bottom of the palm. The average and standard measurement of hand reads the relative lengths of the fingers. The index and ring fingers are of the same length or the index finger is shorter by half a centimeter of ring finger (Fig. 1). To get the data more affirmed and accurate, volunteers and participants with a history of unintentional injury or physical disability affecting the hands or fingers were excluded from this study.

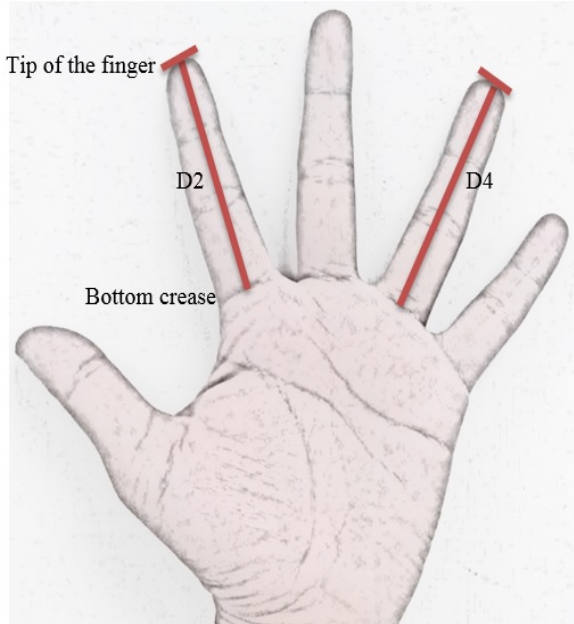


Figure 1. 2D and 4D image of hand.

During image acquisition, we request the users to position their hands on a flat table with the palm facing the smart phone camera. The users have to slightly stretch their fingers apart. There is no guidance peripheral to restraint the users hands. The users can place their hands naturally above the table or on any smooth surface. We do not restrict the users to place their hands at a particular position above the table nor limit them to pose the hands at a certain direction. Instead, we allow the users to stretch their hands while the images are being acquired. The optimal viewing region from the surface of the hand to the observer is approximately 33cm. The camera focus range is kept at 15.5cm above the hand to ensure flexibility for the users to interact with the device (Fig. 2).

Each participant's left index finger was gauged first, followed by the left ring, right index, and then right ring finger to ensure the proximal crease. This is a band of crease at the base of the digit and fingertip borders and these should be well visualized on the screen of the phone and their data recorded. The digit ratios for 2D:4D were then calculated based on the recorded data according to each individual measurement. Their clinical history are also recorded simultaneously to correlate with the results of digit ratio measurement.

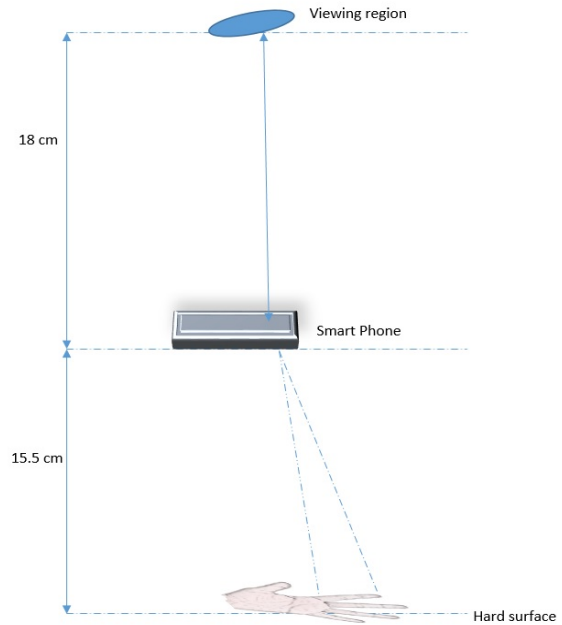


Figure 2. Framework to capture the 2D and 4D of hand.

III. RESULTS

Digit ratio study is related to a multitude of outcomes such as health, sexuality, sexual orientation, fertility and reproduction, attractiveness of perceptions, cognitive abilities, personality dimensions and performance in sports [10-11]. From the study it is found that reliable average range of 2D:4D ratio falls in between [0.979, 0.992] for male and [0.96, 1] for female. 2D:4D ratio was lower among males and this is associated with the height of their body. At some point, longer index finger results in a ratio greater than 1, while a longer ring finger results in a ratio of less than 1. And another fact reveals that the sexual orientation of an individual for those who has longer index finger is more likely to have feminine hand and men with lower 2D and 4D ratios rather pose stronger masculine features.

A. Digit Ratio with Respect to Age and Gender

There is evidence that sex and individual differences in 2D:4D are established and vary substantially according to the demographic of human origin. 90% of Indian females digit ratios fall in between [0.979, 1], while Swaziland, Taiwan, and Indonesia average digit ratios fall in between [.960, 1]. A multiple regression analysis was used to compare left and right digital ratios, taking into account factors that may

influence social characters such as gender, age, weight, height, BMI, race, and occupation. We found no significant correlation between age and 2D:4D for each gender. People with higher height have longer length of 2D and 4D and the digit ratio of these lengths falls at 1. Body mass index is used to assess weight status in adults but BMI is not a good measure for comparison of relative weight status among children of different ages. Therefore, we used the BMI just to monitor the health conditions to assess the association measure of individual behavior problems. The relative weight adjusted for age and sex may be with demographic details of their origins.

A linear regression model is used to relate 2D:4D ratio on left and right hands for each gender.

$$y=mx+b, \quad (1)$$

where x and y represent measured 2D and 4D values, respectively. m is the slope and b is the intercept for y . Based on 61 male subjects a regression equation for left hand is given as follows:

$$y=0.7607x+1.9961. \quad (2)$$

For male right hand the regression equation is found to be:

$$y=0.8819x+1.1067. \quad (3)$$

This study shows that for males the index finger is generally about 95% of the length of the ring finger, which gives an average digit ratio about [0.96, 0.99] in both right and left hands. The remaining 5% have the digit ratio of 1, which the ring and index fingers were of the same length (Fig. 3 and Fig. 4).

From 41 female subjects we found the regression equation for their left hand is:

$$y=0.8483x+1.1723. \quad (4)$$

For female right hand the regression equation is found to be:

$$y=0.7498x+1.7294. \quad (5)$$

Females typically have index and ring fingers of the same length, 90% of females have digit ratio of about 1 in both right and left hands, and the digit ratio of the remaining 10% of females lie between [0.97, 0.99] (Fig. 5 and Fig. 6). There were no significant differences noted in the left hand dominant group with those right handed. However, there were significant differences between the different genders in both hands.

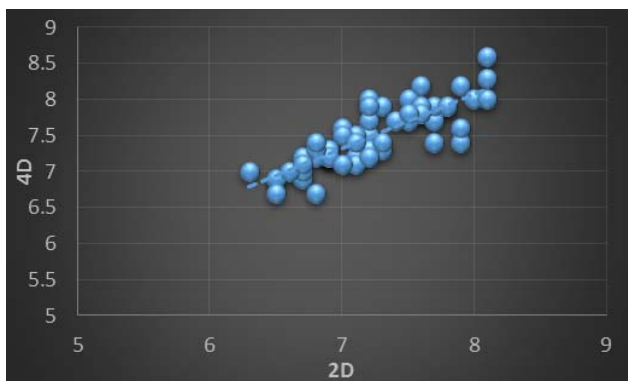


Figure 3. Scatter plots 2D:4D from male left hand.

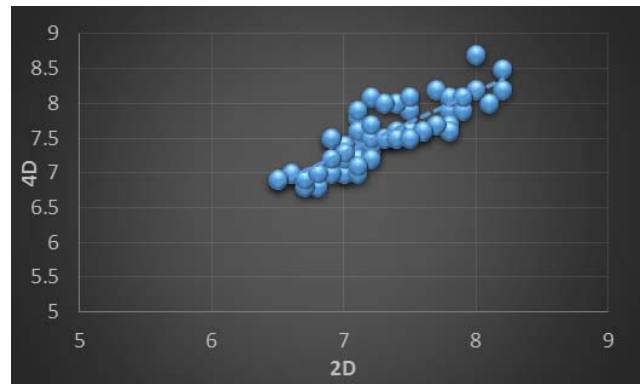


Figure 4. Scatter plots 2D:4D from male right hand.

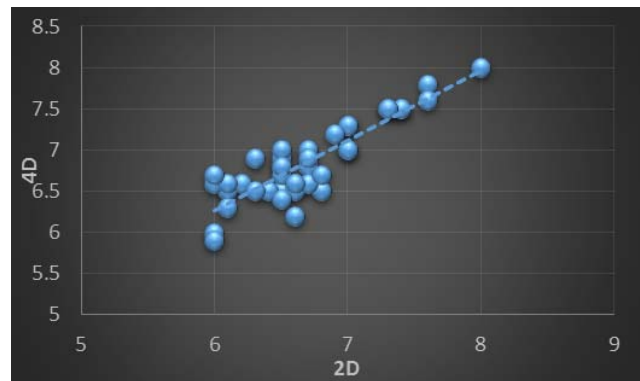


Figure 5. Scatter plots 2D:4D from female left hand.

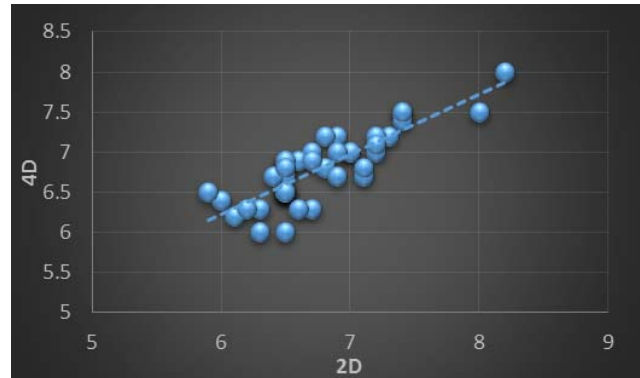


Figure 6. Scatter plots 2D:4D from female right hand.

B. Relationship Between Digit Ratio and Elderly Social Behaviors

There is well known fact that the proportion of people aged 65 and above is increasing quickly. Chronically ill patients have to deal with numerous problems in their day to day medication management. The lack of knowledge related to medication purpose and decrease adherence have been major issues faced by older people. To develop the efficient system using human activities such as gestures and body movements to communicate is a natural approach good to the human being. Based on the pre-identified problems and challenges faced by the elderly such as heart disease, stroke,

cancer, respiratory diseases and diabetes, we correlate with the digit ratio 2D:4D to find out possible ways to curb these health issues.

Having studied the filled multitude questionnaire from the participants and comparing the data recorded from 2D:4D from different individual, we found that digit ratio has consistently shown to be more dimorphic in the right than on the left hands. Sex difference on the digit ratio 2D:4D is generally fixed in uteri which then is presented in the new born babies. Exposure to parental androgens is essential of sexual differentiation and fetal sex hormonal is an important biological basis. Source of sex and individual differences in many human psychological traits, clinically and statistically significant behavioral differences were also found in this study.

For male right hand 2D and 4D values ranging from [6.7cm, 7.0cm] are more prone to diabetics. Men with digit ratio ≤ 1 and women digit ratio which lies between [0.94, 0.99] have complained more about blood pressure (BP) and arthritis. Men with lower digit ratio tends to be more aggressive. If the index finger of men is longer than ring finger it shows that they are more emotional and thus more likely to be affected by problems of depression. However, hyper androgenization of homosexual men might not fit some cultural expectations. Those participants with longer ring fingers were more likely to be affected by heart troubles. In females, anxiety disorders and depression are associated with higher weight and digit ratio. The static postural equilibrium is measured by the amount of body sway evident during the normal stance but some elderly people with digit ratio [0.99, 1] have complained about body balance. This may be impacted by Alzheimer or Parkinson's disease peer review that is needed for this part to ensure accountability of judgments.

IV. DISCUSSIONS

Different approaches have been proposed to extract various correlation with the digit ratio which can foretell some rules for obvious hand mark and configuration of fingers through the ages. Although there is a belief that the digit ratio is influenced by the sex hormones it has not yet proved with concrete experimental findings. Various techniques and opinions about the meaning of various markings was proposed, many researchers attempted to identify the relation between the finger ratio, personal habits, sex hormone status, sex roles and ability, etc. With our findings we are proved that one's prenatal androgen and estrogen activity are heavily influenced by the digit ratios.

It is very much an intriguing fact to study the relation between the digit ratios and sex dependent behaviors, homosexuality, cardiovascular disorders and diseases that affects our immune system, etc. Though different methods and approaches have been utilized to measure digit ratio, measurement precision and comparisons have not been systematically compared yet. However, relative technical error of measurement and intra class coefficient was acceptable for each method. Estimates for the caliper methods were somewhat lower followed by ruler method which shows lowest precision.

The perspective of this study is to examine and evaluate possible relationships between finger length ratios 2D:4D using a smart phone camera and to discover elderly health and social behavior both in male as well as female and to take

precaution. To ensure the reliability associated with 2D:4D measurement, we compare the various commonly used measurement methods like photocopies [13,18-19], printed scan images [14], digital photograph [15], and ink hand print [16] of both the hand orientations.

The measurement taken from the smart phone camera consistently demonstrates levels of more reliability and ease of access by any individual. Printed scanned images and photocopies have been of benefit by providing permanent record. Although it can be done at a low cost but very hectic and time consuming. The use of digital photograph or computer assisted analysis by other investigators may be reliable but time consuming. It also makes the individual to feel insecure when their biological data such as fingerprint are scanned.

Digit ratio obtained from the computer assisted analysis or photocopies are more costly and large memory is required to store their data. The accuracy of measurements and the reliability of the device used to take them crucial when associations with other variables are expected. Our study which involves the use of a smart phone camera ensures accuracy, reliability, portability, low cost and shorter time. With various promising features of the device used this technique contributes to an accurate identification of the finger crease. A smart phone is portable, making it easy to take measurements anywhere without the need for printed scanned images and photocopies. Considering also the fact that the whole implementation can be done through the use of a smart phone application, this approach makes it less costly and efficient. The use of smart phone measurements provided the most reliable method of determining 2D:4D as compared to other investigators.

From this study it is interesting to note that the sample measurements have provided some indication that the effect size of the digit ratio varies between different populations of origin and race which support considerable geographical variation seen in typical 2D:4D levels. Statistically the finger lengths are found to vary from country to country and found minimal change in their digit ratio. We also believe that the digit ratios could also be related to other human traits like spatial ability and physical potential. However we found the correlation weak in the course of our study. These effects need more empirical evidence to support many of the theories. The 2D:4D ratios tended to be smaller on average in males as compared with that in females but this theory does not apply to all the sections.

The relationship between biology and sexual orientation is a subject of research. Although a single determinant has not yet been proved regarding sexual orientation. All the studies in this area so far has its different versions and results. However the hypothesis developed by the researchers and scientists conclude on the same that a person's genetic hormone and social behavior determines their sexual orientation.

For example, if we take a case of addiction. Addiction is mostly understood to be either of drugs or alcohol. Most of the time people never get the idea of the cause and types or forms of addiction. People often put an individual who excessively uses something beyond normal under the category of addiction. And the point where an individual is differentiated from the peers is through the person's behavioral changes which is considered not normal.

In earlier studies researchers have come up with the case of video game addicts. They have claimed that people who frequently play violent games have higher digit ratio and often

shows high aggressive behavior and hostility. And also at the same time, they found that individuals who play non-violent games show no difference in their aggression and hostility. As human faces differs with respect to their sexual orientations, male faces differs from the female faces in shape, sizes, texture. It is possible that this dimorphism is determined by the sex steroids such as testosterone and estrogen. It is not clear why digit ratio ought to be influenced by prenatal hormones. There is evidence of similarity with other traits, for example arm to trunk length ratio which shows similar effects. As per the findings in our study, it is found that subjects from different parts of the geographical area are slightly different in the 2D:4D ratio.

A trait to sexually differentiate at puberty will likely not correlate well with 2D:4D ratio which differentiates early in prenatal development. Sexual orientation is perhaps influenced by androgens and is established in the early stages of development but for some it is established at the later stages and seem dependent on pubertal androgen. Finger length ratio is a sexually dimorphic trait. Men have relatively shorter index finger than ring finger. Smaller, more masculine, digits ratios are thought to be associated with either prenatal testosterone levels or greater sensitivity to androgens or both.

We made our hypothesis to find out that digit ratio is related with aggressive behavioral traits and hostility. We examined it by circulating a questionnaire for both men and women. Men with lower digit ratio had higher relation to aggressive traits but such result is not found in females during the study. These results are consistent with the hypothesis that we developed at the initial course of the study.

The coronary artery disease is rapidly increasing in prevalence across the world. So, it would be useful to identify a group of simplified indicators for the identification of the person at risk of coronary artery disease and other life threatening diseases in the earlier stage in order to enable appropriate health interventions. However through the analysis it is learnt that low 2D:4D somehow indicates less probability of certain illness like breast cancer and coronary heart diseases. This is important to incorporate into any discussion concerning 2D:4D ratio and population difference in disease predispositions and behavior. As gender differentiation is studied with reference to the digit ratios, the case of lower 2D:4D ratio in male can serve a modest way to study even among the female population.

V. CONCLUSIONS

Some elderly may live with their family members but some have to stay alone. Suitable path planning is very important to prevent the elderly from any possible obstacle and threat to their life. More and more elderly are living with chronic conditions that need long term and ongoing health care. In this work, knowledge based methods were evaluated and implemented to detect discrete activities with the elders that change the social behaviors and illness with respect to the digit ratio. The result from the study of within different sex associations and age group shows that digit ratios are relatively candidate biomarkers for their social behavior and the diseases. From the experiment it has also been proven that there are things which can be done to stay healthy and active at our age. Some changes perhaps are merely a part of normal aging, while others are warning effects of medical problem(s). It is very crucial to know the differences at the early stage and

consequences by reading the digit ratio, and therefore pre-planned path is required to prevent those consequences and obstacles that are faced by the elders.

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