Second to Fourth Digit Ratio and Exercise Performance in Untrained Adult Males

***Mohammed A-K. Younes, **Shakir M. Sulaiman**
***,** Department of Physiology, Collage of medicine, University of Mosul, Mosul, Iraq**

Received 9/5/2012 Accepted 20/5/2012

Abstract
This study was based on a random sample from a Prospective Cohort study including one hundred healthy young untrained male volunteers, with mean age ± standard deviation (SD) of 22.820 ± 2.271 years. The aim of this study was to evaluate the role of the digit ratio as an indicator for the performance of untrained adult males in endurance sports. The parameters that have been measured were: Index and ring fingers length of both right and left hand, body weight, height, waist and hip circumferences, body composition (including: fat, muscle and water percents) and exercise performance (including: distance and time). The descriptive analyses of this study showed that normative values of male 2D:4D ratio vary between 0.912-1.036. and it also revealed that there is a strong inverse relation-ship between digit ratio of the subjects and exercise performance according to the distance and time; as the subject briskly walked on the treadmill at fasting state.

نسبة طول الإصبع الثاني إلى الرابع والكفاءة الرياضية لدى الشباب البالغين غير المتدربين

محمد عبد الكريم يونس شاكر محمود سليمان

الملخص
أجريت هذه الدراسة بالاعتماد على نموذج عشوائي من دراسة جماعة مستقبلية متضمنة 100 شاب متطوع وغير متدرب جميعهم أصحاء. هدف هذه الدراسة هو اعتماد النسبة الإصبعية كدليل لأداء الأشخاص البالغين غير المتدربين في رياضة المطاولة. المتغيرات التي تم قياسها :- طول الإصبع الثاني و الرابع لليد اليمنى واليسرى ، وزن وطول الجسم ومحيط الخصر والورك، مكونات الجسم (وتتضمن نسبة الدهون، العضلات والماء) والانجاز الرياضي (ويتضمن الزمن ، المسافة). النتائج في هذه الدراسة أظهرت أن توزيع النسبة الإصبعية للمشاركين تتراوح بين 0.912-1.036 . كما وتظهر النتائج أن هنالك علاقة عكسية قوية بين النسبة الإصبعية و الانجاز الرياضي وفقا للزمن و المسافة المنجزة للشخص على جهاز الرياضة الحركي أثناء المشي السريع في حالة الصيام.

Introduction

The digit ratio is the ratio of the lengths of different digits, fingers or toes, typically as measured from the bottom crease where the finger joins the hand to the tip of the finger [1,2]. length of the index finger divided by the length of the ring finger (2D:4D) has been proposed as a marker of prenatal androgen action [3]. The investigation of 2D:4D ratio as a possible marker of androgen action in early life began with the long-recognized observation that, compared with women, adult males tend to have longer ring fingers relative to other fingers [4,5]. According to Manning higher levels of testosterone during a critical fetal development stage (later part of the first trimester) facilitates the growth of the ring finger, while higher levels of estrogen facilitates the growth of the index finger [6]. Fetal and adult testosterone may be important in establishing and maintaining sex-dependent abilities associated with male physical competitiveness [7,8]. There is an evidence that 2D:4D ratio is a negatively correlate with prenatal and adult testosterone [9]. Dr John Manning reported in many studies that one simple physical feature offers an accurate means for predicting future footballing ability. It kicks in the womb and can be seen from birth [10]. Physical activity is a complicated process in which a trainer should closely watch all the minute changes in the subject during activity. Noticeable physiological changes take place in the body, when it is subjected to continuous physical or sports training program [11]. In general, the best exercise for a specific sport is the sport itself. Additional exercises should condition the particular components of fitness specific to the sport. The specific muscles involved, type of muscular contraction, intensity, duration, recovery time, and motor skill must be considered [12]. However the relationship between D2:D4 ratio and exercise performance seems to be stronger for endurance sport and weaker for sprint, power and strength sport, although walking is much more preferable than running or jogging because it creates less stress on joints, including hips, knees, and ankles [13].

Aim of the Study

To evaluate the role of the digit ratio as an indicator for the performance of untrained adult males in endurance sports.

Subjects, Apparatus and Methods

This study was conducted during the period from November 2010 to March 2012 at the Researches Laboratory in the Collage of Pharmacy / University of Mosul. This study was based on a random sample from a Prospective Cohort Study, 100 healthy untrained male volunteers took part in this study (Table 1 and 2). Any subjects who had history of diabetes, cardiovascular, respiratory, renal diseases, smoking and taken any anabolic drugs, also any subject who reported injuries to the second or fourth digits were excluded from the study.

Apparatus

Sport Treadmill 2008; made in Germany, Vernier Caliper, Beurer Body Fat Analyzer, model GmbH, 89077 UIm, BG 39; made in Germany and Tape measure.

Methods

1. Familiarization

During their first visit to the laboratory, participants were familiarized with the equipment and exercise protocol in order to be cooperative during conducting the exercise test.

2. Baseline appointment

Participant body weight was determined by measuring weight to the nearest 0.1 kg using an electronic scale. Subject in light clothing without shoes was asked to stand erect on the scale with both arms at the sides. Participant height was determined by measuring height to the nearest 0.1 cm using a standard tape measure. BMI was derived by Quetelet's index from body weight/(height)^2 . Participant waist circumference and hip circumference were measured in centimeters (cm) at a standing position with a standard tape measure within ±1 cm. The waist to hip ratio (WHR) was calculated as the waist measurement divided by the hip measurement. Participant body composition (body fat %, body muscle% and body water%) were assessed using the leg-to-leg

bioelectrical impedance method [Beurer Body Fat Analyzer, model GmbH, 89077 UIm, BG 39; Germany].

3. Digit Length Measurement

Second- and fourth-digit lengths for each hand were recorded with a Vernier Caliper using the methodology described by Manning [14]. Digit length was measured on the ventral surface of the hand from the most proximal crease when there was a band of creases at the base of the digit to the finger tip, to the nearest 0.01 mm. The digit was held extended throughout and care was taken not to compress the fingertip (Figure 1). Digits lengths were easily and reliably measured, and they were readily accessible. To minimize measurement error, each measurement was done twice and the mean value calculated for each finger of the right and left hand. The length of the index finger divided by the length of the ring finger giving D2:D4 ratio.

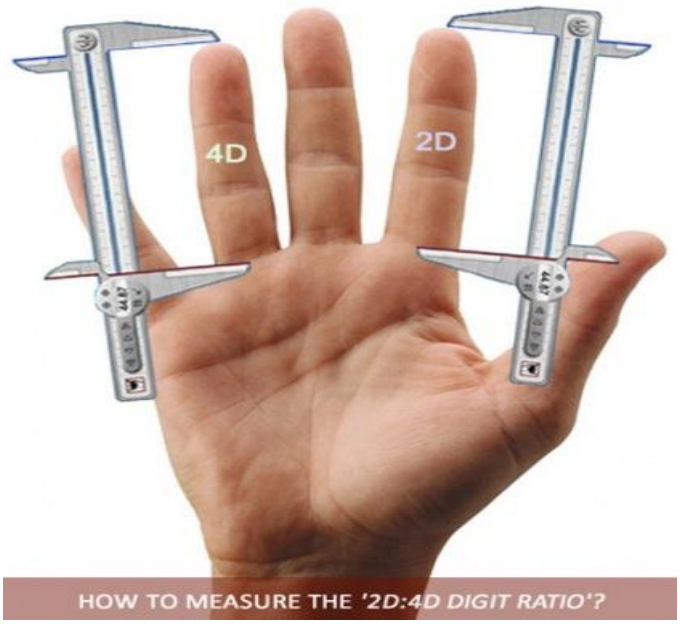

Figure (1):- How to measure the D2:D4 digit ratio.

5. Exercise Testing

The test done on a motorized treadmill during the same morning hour to prevent individual diurnal variation between exercise tests. On the morning of the exercise trial, subjects reported to the laboratory after an 8 to12 hour overnight fasting. Each subject was asked to refrain from vigorous exercise 24 h prior to the test and consume his usual family diet. No food or fluid was allowed during either laboratory treadmill exercise test. Laboratory temperature (20–25◦C) and relative humidity was maintained constant over all the trials by an air conditioner. The subject had a 5-minute warm-up period before doing the exercise test. Then allowed to briskly walking on the treadmill with speed held constant at 7 km/hr with zero inclination; until volitional exhaustion, or the subject could no longer keep pace with the treadmill speed. At this moment we stop the treadmill and record the time and distance that appear on the screen of the treadmill.

Statistical Analysis

The SPSS statistical package (version 19) was used for statistical analysis. Standard statistical methods were used to determine the mean, standard deviation (SD), minimum, maximum and range, Pearson correlation between digit ratio and exercise performance and Regression equation for digit ratio and exercise performance. The results were considered highly significant at $P \leq 0.001$; significant at $P \leq 0.05$ and non- significant at $P > 0.05$ [15].

Results

1. Descriptive Statistics of the Subjects

Table (1):- Anthropometric measurements and body composition analysis of the participants.

	Age(year)	Wt (kg)	Height (cm)	BMI	Waist (cm)	Hip (cm)	WHR
Mean	22.8	67.1	172.9	22.4	77.9	96.9	0.80
S.D.	2.2	6.2	5.5	1.4	5	4.9	0.028
Min	19	54	161	19.3	67	81	0.75
Max	26	83	186	24.4	90	109	0.87
Range	7	29	25	5.1	23	28	0.12

	Body Fat %	Body Water %	Body Muscle%
Mean	17.28	59.8	46.8
S.D.	2.65	1.9	1.6
Min	12.5	56.2	42.1
Max	20.7	64	50.8
Range	8.2	7.8	8.7

	Right D2 (cm)	Right D4 (cm)	Right D2:D4 ratio	Left D2 (cm)	left D4 (cm)	Left D2:D4 ratio
Mean	7.316	7.538	0.970	7.330	7.561	0.970
S.D.	0.843	0.447	0.029	0.445	0.460	0.030
Min	6.190	6.600	0.912	6.000	6.410	0.912
Max	8.600	8.730	1.032	8.710	8.810	1.036
Range	2.410	2.130	0.120	2.710	2.400	0.124

Table (2):- Distribution of the digit ratio within participants

Left digit ratio	percent
1.036-1.000	18%
0.997-0.990	5%
0.989-0.980	13%
0.979-0.970	14%
0.969-0.960	13%
0.959-0.950	10%
0.949-0.940	11%
0.936-0.931	6%
0.929-0.923	5%
0.918-0.912	5%

Right digit ratio	percent
1.032-1.000	17 %
0.997-0.990	4 %
0.989-0.980	14 %
0.979-0.970	17 %
0.969-0.960	13 %
0.959-0.950	12 %
0.949-0.940	5 %
0.936-0.931	9 %
0.929-0.923	5 %
0.918-0.912	4 %

2. Correlations of Digit Ratio with Exercise Performance

Table (3):Pearson correlation between digit ratio and exercise performance.

A- for Right Digit Ratio

		Distance at Fasting	Time at Fasting
Right D2:D4 ratio	Pearson Correlation	-.985**	-.985**
	P value	< 0.001	< 0.001
**. Correlation is significant at the 0.01 level (2-tailed).			

Correlation value r= -98.5% indicate a strong inverse relation-ship between right D2:D4 ratio and exercise performance according to the distance and time.

B- for Left Digit Ratio

		Distance at Fasting	Time at Fasting
Left D2:D4 ratio	Pearson Correlation	-.985**	-.985**
	P value	< 0.001	< 0.001
**. Correlation is significant at the 0.01 level (2-tailed).			

Correlation value r= -98.5% indicate a strong inverse relation-ship between left D2:D4 ratio and exercise performance according to the distance and time.

3. Regression of Digit Ratio with Exercise Performance

1. Regression Equation for Right Hand

A- Distance at fasting = 100.604 - 96.517 * (Right D2:D4 ratio)

This indicating that distance at fasting = 100.604 when the right D2:D4 ratio = zero and any increase in this ratio by about 0.01 leading to decrease the distance at fasting by about 0.96517 .

For example:

If right D2:D4 = 1, then

Distance at fasting = 100.604 - 96.517 * (1)

= 4.087 kilometers

If right D2:D4 = 0.91, then

Distance at fasting = 100.604 - 96.517 * (0.91)

= 12.774 kilometers

Model Summary		
r	R Square	Adjusted R Square
-.985	.971	.971
The independent variable is Right D2:D4 ratio.		

Adjusted R Square (0.971) indicating the percent effect of right D2:D4 ratio = 97.1% on distance at fasting with significance at p value < 0.001 .

Distance at fasting

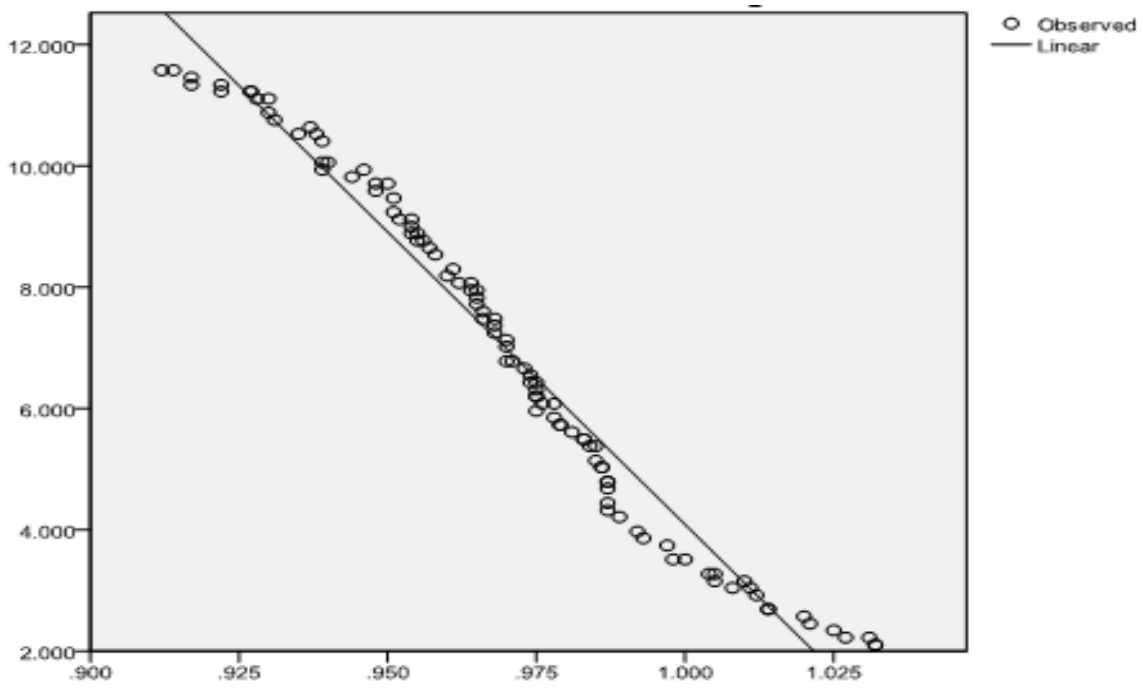

Figure (2):- Regression curve for right hand D2:D4 ratio with distance at fasting.

B- Time at fasting = 859.902 - 824.930 * (Right D2:D4 ratio)

This indicating that time at fasting = 859.902 when the right D2:D4 ratio = zero and any increase in this ratio by about 0.01 leading to decrease the distance at fasting by about 0.824930 .

For example:

If right D2:D4 = 1, then

Time at fasting = 859.902 - 824.930 * (1)

= 34.972 minutes

If right D2:D4 = 0.91, then

Time at fasting = 859.902 - 824.930 * (0.91)

= 109.215 minutes

Model Summary		
r	R Square	Adjusted R Square
-.985	.971	.971
The independent variable is Right D2:D4 ratio.		

Adjusted R Square (0.971) indicating the percent effect of right D2:D4 ratio = 97.1% on time at fasting with significancy at p value < 0.001 .

Time at fasting

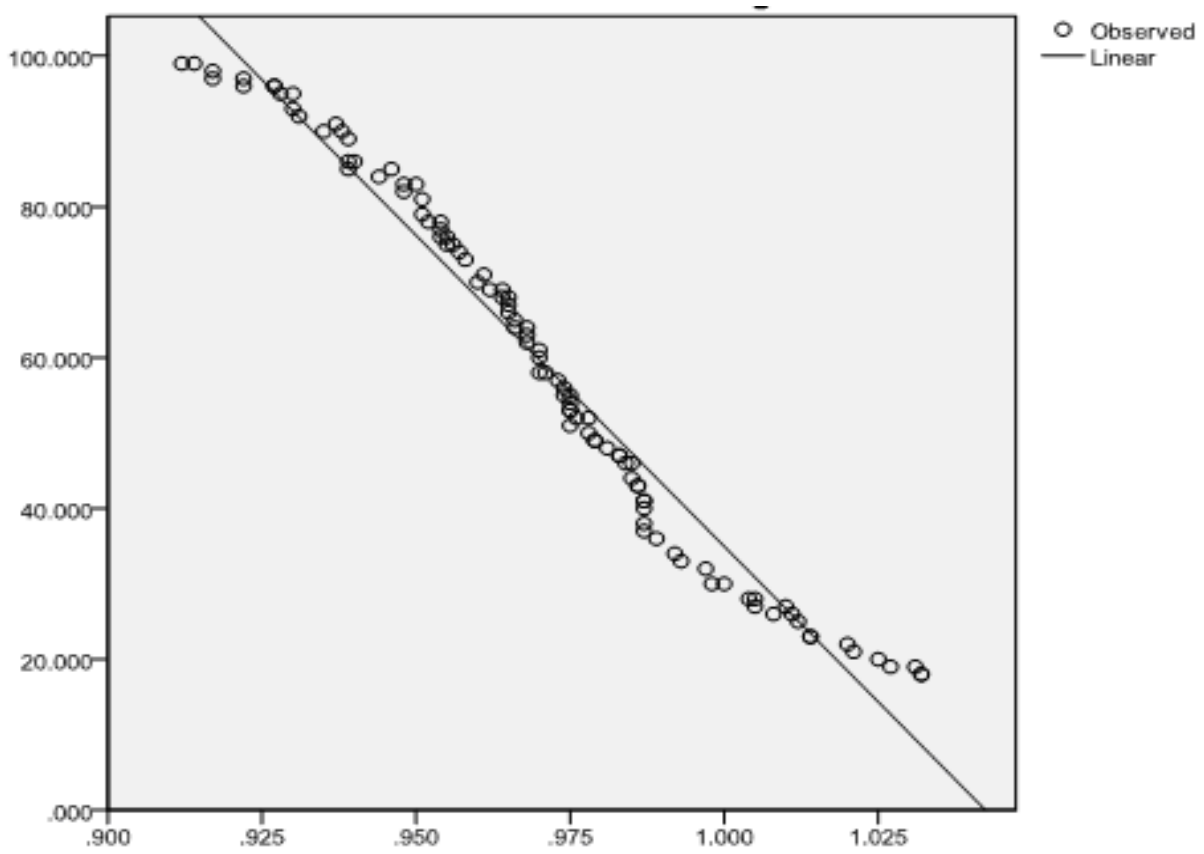

Figure (3):- Regression curve for right hand D2:D4 ratio with time at fasting.

2. Regression Equation for Left Hand

A- Distance at fasting = 98.012 - 93.912 * (left D2:D4 ratio)

This indicating that distance at fasting = 98.012 when the left D2:D4 ratio = zero and any increase in this ratio by about 0.01 leading to decrease the distance at fasting by about 0.93912 .

For example:

If left D2:D4 = 1, then

Distance at fasting = 98.012 - 93.912 * (1)

= 4.10 kilometers

If left D2:D4 = 0.91, then

Distance at fasting = 98.012 - 93.912 * (0.91)

= 12.55 kilometers

Model Summary		
r	R Square	Adjusted R Square
-.985	.970	.970
The independent variable is Left D2:D4 ratio.		

Adjusted R Square (0.970) indicating the percent effect of left D2:D4 ratio = 97 % on distance at fasting with significancy at p value < 0.001 .

Distance at fasting

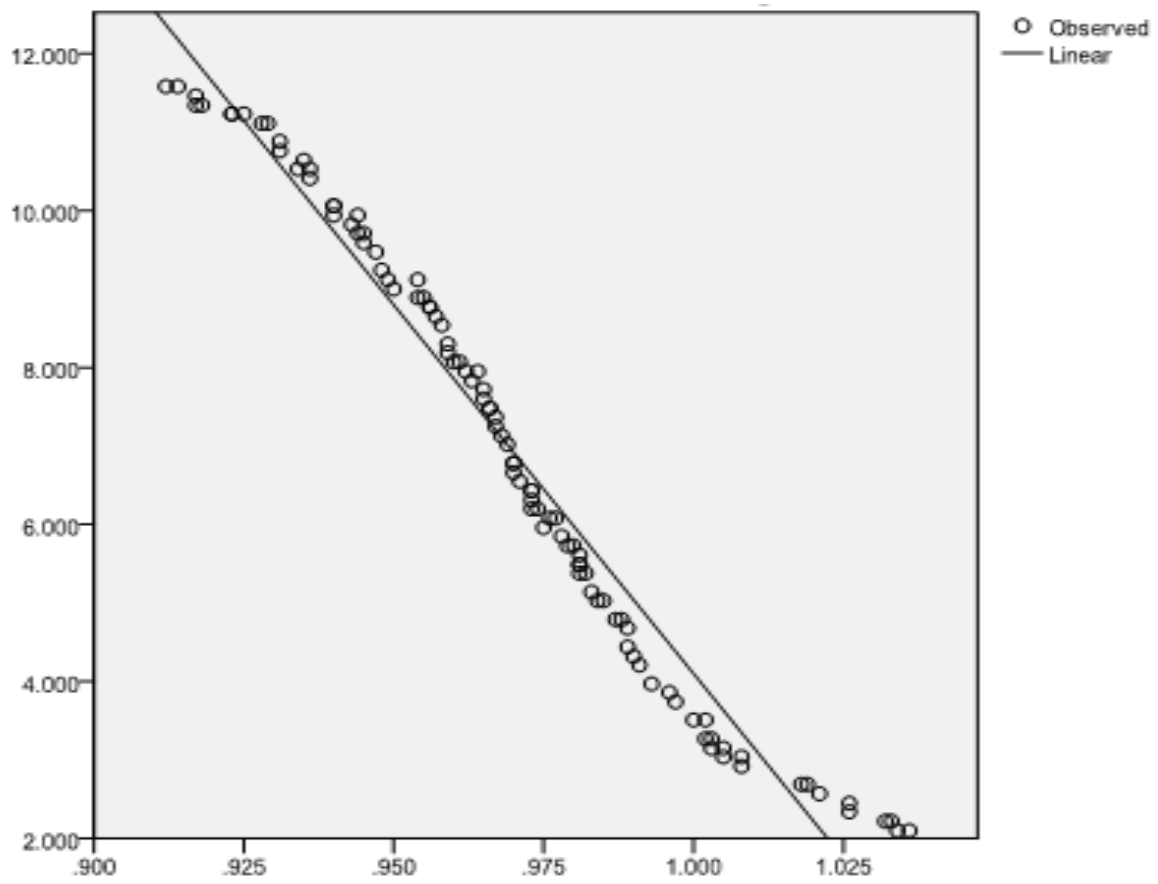

Figure (4):- Regression curve for left hand D2:D4 ratio with distance at fasting.

B- Time at fasting = 837.758 - 802.671 * (left D2:D4 ratio)

This indicating that time at fasting = 837.758 when the left D2:D4 ratio = zero and any increase in this ratio by about 0.01 leading to decrease the distance at fasting by about 0.802671 .

For example:

If left D2:D4 = 1, then

Time at fasting = 837.758 - 802.671 * (1)
= 35.087 minutes

If left D2:D4 = 0.91, then

Time at fasting = 837.758 - 802.671 * (0.91)
= 107.327 minutes

Model Summary		
r	R Square	Adjusted R Square
-.985	.971	.970
The independent variable is Left D2:D4 ratio.		

Adjusted R Square (0.970) indicating the percent effect of left D2:D4 ratio = 97 % on time at fasting with significance at p value < 0.001 .

Time at fasting

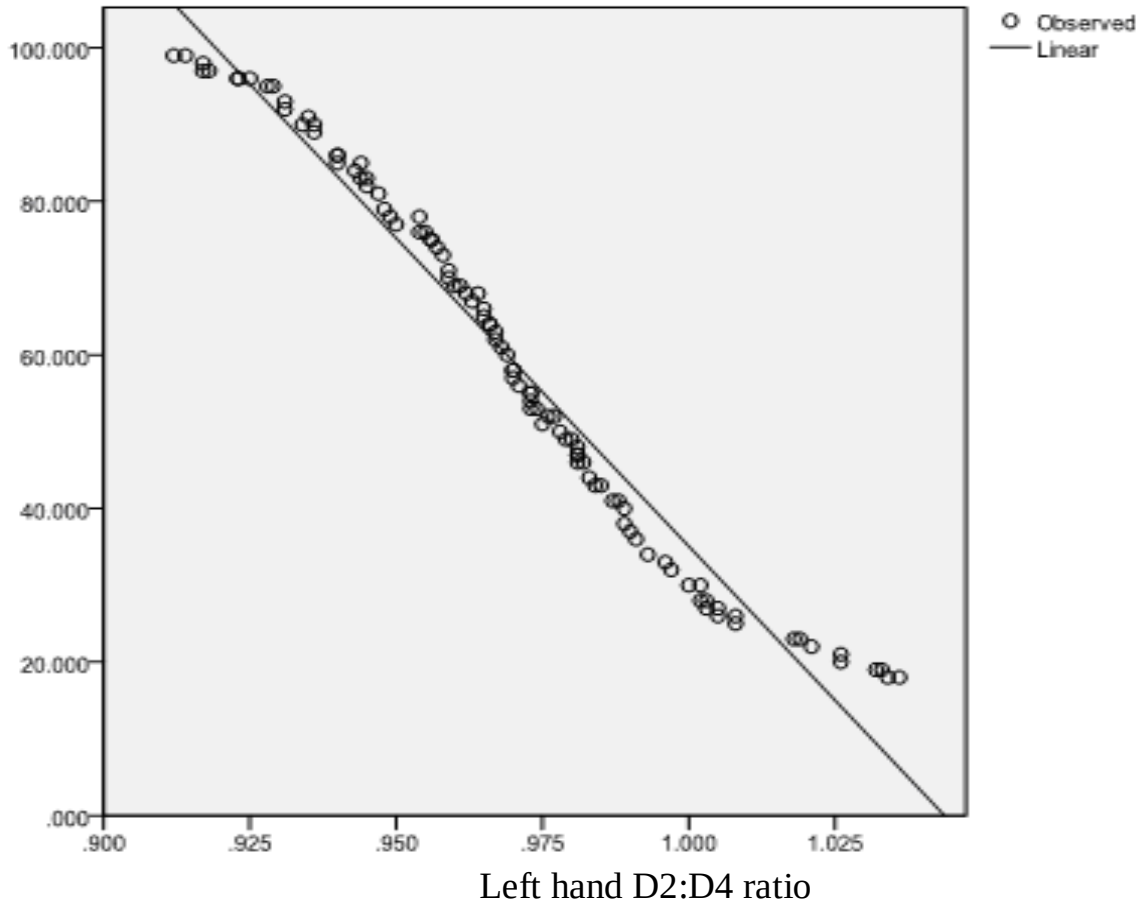

Figure (5):- Regression curve for left hand D2:D4 ratio with time at fasting.

Discussion

Sporting achievement is certainly related to several factors apart from personality. These include age of the subject, BMI,WHR, body composition (including body fat %, body muscle %. and body water %), training program (trained or untrained), health status, and nutrition before doing exercise test [16,17]. These factors was measured in the present study in order to evaluate the role of 2D:4D ratio as an indicator for sports achievement when other influencing factors are controlled (Table 1). The descriptive analyses of our study showed that normative values of male 2D:4D ratio vary between 0.912-1.036 which distributed within the participants (Table 2). Variation in finger length ratio is thought to reflect the influence of prenatal exposure to the sex hormones like testosterone and estrogen during fetal development [18]; There are two causes have been suggested for this variation:- First, is that common genes (Hox a and Hox d) underlie development of both fingers and gonads. Second, is that allelic variation in androgen receptor sensitivity influences digit ratio [19]. The androgen receptor gene contains a polymorphic trinucleotide repeat in the terminal domain region that codes for a polyglutamine chain [6]. Increased number of such repeats produces receptors with lower androgen sensitivity [20,21]. In other word, when polyglutamine chain is low, transactivation of the androgen receptor gene is high and is associated with higher sensitivity to androgens leading to more masculine finger ratio (low D2:D4) [6]. There is evidence in humans that the length ratio of the index and ring finger (D2:D4) is negatively correlated with prenatal testosterone and higher genetic sensitivity to androgen. Prenatal testosterone and androgen receptor gene are both known to vary between human population [22]. The results of our study show that a strong inverse relation-ship between 2D:4D ratio of the subjects and exercise performance according to the distance and time; as the subject briskly walked on the treadmill (Table 3, Figures

2,3,4 and 5). This observation of increased exercise performance as much as decreasing the digit ratio is probably due to a higher prenatal androgen exposure that relatively causing longer fourth finger than second finger indicating a lower D2:D4 ratio. Our finding revealed that D2:D4 ratio significantly affect performance in endurance sports. On going with our results many studies also showed that D2:D4 ratio could affect exercise performance in various types of sports as (Manning and Taylor, 2001 [23] ; Pokrywka et al, 2005 [24] ; Paul et al, 2006 [25] ; Voracek et al, 2006 [26] ; Van den Bergh and Dewitte, 2006 [8]). In many study [27] [28] researchers found that males achievement in sports and athletics is correlated with the 2nd to 4th digit ratio (2D:4D) as a putative measure of prenatal testosterone. Thus, 2D:4D ratio in males may show negative correlation with frequent exercise which then predict success in highly competitive sports. Manning and his coworkers in 2007 [29] showed that individuals with smaller 2D:4D ratios tend to have greater athletic abilities. That is, those with longer ring fingers are more often the better athletes. The relationship seems to be stronger for endurance athletes and weaker for sprint, power and strength athletes. For example, the 2D:4D correlates better with 10km race performance than with 50m sprint time. Voracek et al, 2010 [30] suggested that second-to-fourth digit ratio (2D:4D), a widely studied putative marker for masculinization through prenatal androgen exposure, is lower (more masculinized) in athletes than in general population controls, and athletes with lower 2D:4D have higher sporting success.

Conclusions

1- The normative values of male 2D:4D ratio vary between 0.912-1.036 which distributed within the participants.

2- There is a strong inverse relation-ship between digit ratio of the subjects and exercise performance according to the distance and time; as the subject briskly walked on the treadmill.

References

1- Manning JT and Quinton S, Association of Digit Ratio (2D:4D) with Self-Reported Attractiveness in Men and Women. Journal of Individual Differences 2007; 28(2): 73–77.

2- Millet K and Dewitte S, Second to fourth digit ratio and cooperative behavior. Biological Psychology 2006; 71: 111–115.

3- Bull R and Benson PJ, Digit ratio (2D:4D) and the spatial representation of magnitude. Hormones and Behavior 2006; 50 : 194–199.

4- Muller DC, Giles GG, Bassett J, Morris HA, Manning JT, Hopper JL, English DR and Severi G, Second to fourth digit ratio (2D:4D) and concentrations of circulating sex hormones in Adulthood. Reproductive Biology and Endocrinology 2011; 9(57) : 1-12.

5- McIntyre MH, Ellison PT, Lieberman DE, Demerath E and Towne B, The development of sex differences in digital formula from infancy in the Fels Longitudinal Study. Proc. R. Soc. Lond. B. 2005; 272 : 1473–1479.

6- Manning JT, Bundred PE, Newton DJ and Flanagan BF, The second to fourth digit ratio and variation in the androgen receptor gene. Evolution and Human Behavior 2003; 24 : 399–405.

7- Fink B, Neave N and Manning JT, Second to fourth digit ratio, body mass index, waist-to-hip ratio, and waist-to-chest ratio: their relationships in heterosexual men and women. Ann. Hum. Biol. 2003; 30(6):728-738.

8- Van den Bergh B and Dewitte S, Digit ratio (2D:4D) moderates the impact of sexual cues on men's decisions in ultimatum games. Proceedings of the Royal Society of London B. 2006; 273 : 2091–2095.

9- Manning JT and Robinson SJ, 2nd to 4th digit ratio and a universal mean for prenatal testosterone in homosexual men. Med. Hypotheses 2003; 61(2):303-306.

10- Manning JT, The ratio of 2nd to 4th digit length and performance in skiing. J. Sports Med. Phys. Fitness 2002; 42(4) : 446-450.

11- Blair SN, Cheng Y and Holder JC, Is physical activity or physical fitness more important in defining health benefits? Med. Sci. Sports Exerc. 2001; 33 : S379- S399.

12- Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, Macera CA, Heath GW, Thompson PD, and Bauman A, Physical activity and public health: Updated recommendation for adults from the American College of Sports Medicine and the

American Heart Association. Circulation 2007; 116: 1081–1093.
13- Ekkekakis P, Backhouse SH, Gray C and Lind E (2008) Walking is popular among adults but is it pleasant? A framework for clarifying the link between walking and affect as illustrated in two studies. Psychol. Sport Exerc. 9: 246–264.
14- Manning JT, Barley L, Walton J, Lewis-Jones DI, Trivers RL, Singh D, et al., The 2nd:4th digit ratio, sexual dimorphism, population differences, and reproductive success: Evidence for sexually antagonistic genes? Evolution and Human Behavior 2000; 21: 163–183.
15- Einspruch EL, An Introductory Guide to SPSS for Windows. Sage Publications _ 2nd ed. 2005; pp. 60-75.
16- Austin EJ, Manning JT, McInroy K and Mathews E, A preliminary investigation of the association between personality, cognitive ability and digit ratio. Personality and Individual Differences 2002; 33 : 1115–1124.
17- Shields M, Tremblay MS, Laviolette M, Craig CL, Janssen I and Gorber SC, Fitness of Canadian adults: Results from the 2007-2009 Canadian Health Measures Survey. Health Reports 2010; 21(1) : 1-15.
18- Manning JT, Digit Ratio: A Pointer to Fertility, Behavior and Health. Human Nature Review 2002; 2 : 418-423.
19- Kondo T, Zakany J, Innis J and Duboule D, Of fingers, toes and penises. Nature 1997; 390: 185–198.
20- Chamberlain NL, Driver ED and Miesfeld RL, The length and location of cag trinucleotide repeats in the androgen receptor n-terminal domain affect transactional function. Nucleic Acids Research 1994; 15 : 3181–3186.
21- Kazemi-Esfarjani P, Trifiro MA and Pinski L, Evidence for a repressive function of the long polyglutamine tract in the human androgen receptor: possible pathogenic relevance for the (cag)n-exppanded neuropathies. Human Molecular Genetics 1995; 4 : 523–527.
22- Peters M, Tan U, Kang Y, Teixiera L and Mandal M, Sex-specific finger length patterns linked to behavioural variables: consistency across various human populations. Percept. Mot. Skills 2002; 94: 171-181.
23- Manning JT and Taylor RP, Second to fourth digit ratio and male ability in sport: implications for sexual selection in humans. Evol. Hum. Behav. 2001; 22 (1): 61–69.
24- Pokrywka L, Rachon D, Suchecka-Rachon K and Bitel L, The second to fourth digit ratio in elite and non-elite female athletes. American Journal of Human Biology 2005; 17 : 796-800.
25- Paul SN, Kato BS, Hunkin JL, Vivekanandan S and Spector TD, The Big Finger: the second to fourth digit ratio is a predictor of sporting ability in women. British Journal of Sports Medicine 2006; 40 : 981-983.
26- Voracek M, Reimer B, Ertl C and Dressler S, Digit ratio (2D:4D), lateral preferences, and performance in fencing. Perceptual and Motor Skills 2006; 103(2) : 427-446.
27- Hönekopp J, Manning JT and Müller C, Digit ratio (2D:4D) and physical fitness in males and females: Evidence for effects of prenatal androgens on sexually selected traits. Horm. Behav. 2006; 49(4):545-549.
28- Coates JM, Gurnell M and Rustichini A, Second-to-fourth digit ratio predicts success among high-frequency financial traders. Proceedings of the National Academy of Sciences 2009; 106 (2), 623–628.
29- Manning JT, Morris L and Caswell N, Endurance running and digit ratio (2D:4D): Implications for fetal testosterone effects on running speed and vascular health. American Journal of Human Biology 2007; 19 (3): 416-421.
30- Voracek M, Pum U and Dressler SG, Investigating digit ratio (2D:4D) in a highly male-dominated occupation: the case of firefighters. Scand. J. Psychol. 2010; 51(2): 146-156.