Effect of Pre-Exercise Loading Diet in Different Digital Ratio Subject on Aerobic Level of Exercise Performance

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Abstract
This study 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 examine the effects of pre-exercise carbohydrate diet for untrained subjects on exercise performance. 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) and exercise performance (including: time, distance, calories and calculated calories expenditure). Participants were divided into three subgroups according to their digit ratio; 36 subject with (high D2:D4 1.036-0.980), 37 subject with (moderate D2:D4 0.979-0.954) and 27 subject with (Low D2:D4 0.950-0.912). The result showed that distance, time, calorie expenditure and calculated calorie expenditure were significantly higher after diet intake (150gm and 250gm respectively) in comparison with fasting state among participant during briskly walking on treadmill. As well as, the effect appear more obviously among low digit ratio group in comparison with that of moderate and high digit ratio group respectively.

تأثير التحميل الغذائي لما قبل الرياضة في أشخاص ذوي نسب إصبعية مختلفة على مستوى كفاءة الرياضة الهوائية

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الخلاصة
أجريت هذه الدراسة بالاعتماد على نموذج عشوائي من دراسة جماعة مستقبلية متضمنة 100 شاب متطوع وغير متدرب جميعهم أصحاء. هدف هذه الدراسة هو لاختبار تأثير الكربوهيدرات وزيادة الكربوهيدرات في طعام الشخص غير المتدرب قبل الرياضة على الانجاز الرياضي. 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، استهلاك السعر الحراري و السعر الحراري المحسوب). الأشخاص المشتركين قسموا إلى ثلاثة مجاميع حسب النسبة الإصبعية (عالية، متوسطة و منخفضة) حيث أظهرت النتائج أن الانجاز الرياضي يكون معنويا أعلى بعد تناول الطعام (150 غرام و 250 غرام على التوالي) بالمقارنة مع حالة الصيام للمشتركين على جهاز الرياضة الحركي أثناء المشي السريع ، والتأثير يكون أوضح لدى الأشخاص ذو النسب الإصبعية المنخفضة بالمقارنة مع الأشخاص ذو النسب الإصبعية المتوسطة والعالية على التوالي.

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]. The normal values of male 2D:4D ratio less than 1, whereas in female 2D:4D ratio equal or more than 1 across populations [3,4]. Aerobic exercise is generally defined as any activity which can be sustained continuously for periods of at least three minutes or longer [5]. Brisk walking, jogging, swimming and aerobic dancing are some popular forms of aerobic exercise [6,7]. Nutrition significantly influences physical performance. This relationship is even more clearly demonstrated during muscular exercise [8]. As a consequence in competitive sports disciplines, nutrition has become important for performance, to allow adequate time for digestion and prevent stomach discomfort, an athlete's final meal should be eaten two to three hours before exercise. This meal should be low in fat, moderate in protein, and high in complex carbohydrates [9]. There are three potential fuels which the body can use it during physical activity: glycogen, fat and protein. Under most circumstances, carbohydrate and fat are the fuels utilized during exercise [10]. When the subject first begin to do aerobic exercise, glycogen turns into glucose. However, the utilization of muscle glycogen is most rapid during the early stages of exercise and is exponentially related to exercise intensity [11]. Because the glycogen stores can become depleted so quickly, the concentration of muscle and liver glycogen prior to exercise plays an important role in endurance events [12]. If an subject can increase or supercompensate their glycogen stores before their event they may postpone fatigue and increase their performance on sport day [13,14]. The pre-event meal aims to top up carbohydrate reserves and fluid levels, while leaving the stomach feeling comfortable [15].

Aim of the Study

To examine the effects of pre-exercise carbohydrate diet and the increasing of carbohydrate content of untrained subjects' diet on exercise performance.

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). 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 [16]. 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). Digit 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.

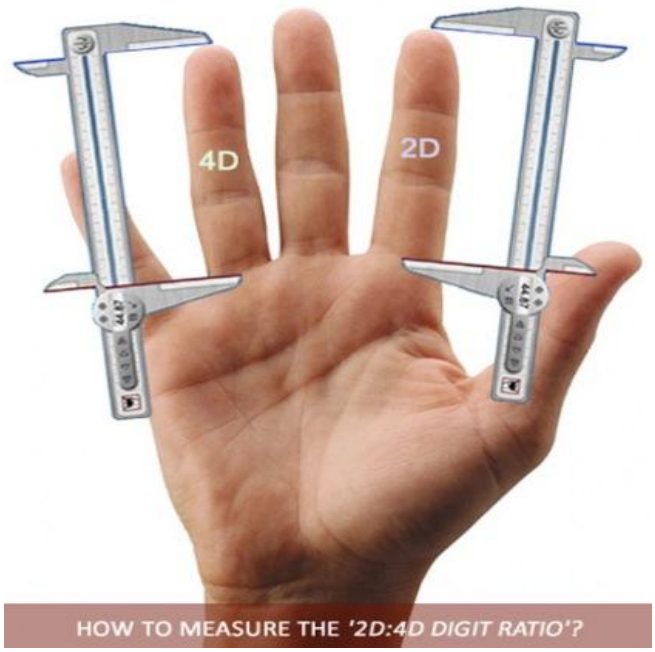

Figure (9):- How to measure the D2:D4 digit ratio.

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 first 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 each 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, distance and calories that appear on the screen of the treadmill, as well as, we measure calculated calories and power as following :

$$\text{Calclated calories} = \frac{\text{Distance(m.)*Body weight(kg)}}{426.8} \quad (\text{Kcal})$$

Power = Kcal/time(min.)

Then the exercise test conducted again with at least 3 days of rest between the trials by given diet (as a sandwiches of Zer Apricot Jam at first trial 150gm and 250 gm in the second trial) given within 2-3 hrs before exercise test. So we record the time, distance and calories that appear on the screen of the treadmill, as well as, we measure calculated calories and power at the end of the exercise test.

Diet includes:

1- Zer Apricot Jam, (each 100gm contain Energy 355Kcal, carbohydrate 66.2gm, Protein 0.9gm and fat 0.7gm).
2- Bread 50 gm.
3- Sport drink-beverage, You can make an excellent home-brewed 7.6 percent sports drink with reasonable sodium amounts. Add 6 tablespoons sugar and 1/3 teaspoon salt to each quart (960 ml) of water. Dissolve sugar and cool it. The salt translates into a sodium concentration of 650 mg/liter. This small amount is good for aerobic exercise which help to prevent dehydration and salt depletion.

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, ANOVA and Duncan test were used to compare results of exercise performance among the subjects of different digit ratio. The results were considered highly significant at $P \leq 0.001$; significant at $P \leq 0.05$ and non- significant at $P > 0.05$; Different letters vertically mean significant difference at $p \leq 0.001$ using Duncan test [17].

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 left digit ratio within the participants.

Left digit ratio	percent	Digit ratio groups
1.036-1.000	18%	High digit ratio 1.036-0.980
0.997-0.990	5%	
0.989-0.980	13%	
0.979-0.970	14%	Moderate digit ratio 0.979-0.954
0.969-0.960	13%	
0.959-0.950	10%	
0.949-0.940	11%	Low digit ratio 0.950-0.912
0.936-0.931	6%	
0.929-0.923	5%	
0.918-0.912	5%	

Table (3):- Comparison of exercise performance among the participants at fasting, 150gm diet and 250gm diet.

subject		Mean	± S.D.	P-Value
Distance	**Fasting**	6.950 c	2.852	< 0.001
	150gm	9.750 b	3.614	
	250gm	11.146 a	3.612	
Time	**Fasting**	59.440 c	24.377	< 0.001
	150gm	83.380 b	30.892	
	250gm	95.310 a	30.875	
Calorie expenditure	**Fasting**	112.600 c	46.388	< 0.001
	150gm	157.930 b	58.688	
	250gm	180.650 a	58.613	
Calculated calorie	**Fasting**	1088.3100 c	445.076	< 0.001
	150gm	1527.750 b	565.108	
	250gm	1745.140 a	564.543	

Table (4):- Comparison of exercise performance among high, moderate and low digit ratio participants at fasting state.

fasting		Mean	±S.D.	P-Value
Distance	1.036-0.980	3.814 c	1.175	< 0.001
	0.979-0.954	7.363 b	1.017	
	0.950-0.912	10.450 a	0.805	
Time	1.032-0.980	32.638 c	10.048	< 0.001
	0.979-0.954	62.972 b	8.696	
	0.950-0.912	89.357 a	6.886	
Calorie expenditure	1.032-0.980	61.611 c	19.068	< 0.001
	0.979-0.954	119.138 b	16.468	
	0.950-0.912	169.750 a	12.518	
Calculated calorie	1.032-0.980	612.944 c	208.339	< 0.001
	0.979-0.954	1167.500 b	197.941	
	0.950-0.912	1597.678 a	201.396	

Table (5):- Comparison of exercise performance among high, moderate and low digit ratio participants at 150gm diet.

150 gm diet		Mean	±S.D.	P-Value
Distance	1.032-0.980	5.744 c	1.311	< 0.001
	0.979-0.954	10.239 b	1.193	
	0.950-0.912	14.273 a	0.948	
Time	1.032-0.980	49.138 c	11.207	< 0.001
	0.979-0.954	87.555 b	10.190	
	0.950-0.912	122.035 a	8.107	
Calorie expenditure	1.032-0.980	92.861 c	21.295	< 0.001
	0.979-0.954	165.888 b	19.319	
	0.950-0.912	231.357 a	15.377	
Calculated Calorie	1.032-0.980	919.666 c	242.501	< 0.001
	0.979-0.954	1623.083 b	243.705	
	0.950-0.912	2187.000 a	248.748	

Table (6):- Comparison of exercise performance among high, moderate and low digit ratio participants at 250gm diet.

250 gm diet		Mean	±S.D.	P-Value
Distance	1.032-0.980	7.146 c	1.303	< 0.001
	0.979-0.954	11.626 b	1.188	
	0.950-0.912	15.673 a	0.953	
Time	1.032-0.980	61.111 c	11.145	< 0.001
	0.979-0.954	99.416 b	10.154	
	0.950-0.912	134.000 a	8.146	
Calorie expenditure	1.032-0.980	115.722 c	21.164	< 0.001
	0.979-0.954	188.444 b	19.240	
	0.950-0.912	254.107 a	15.459	
Calculated Calorie	1.032-0.980	1143.000 c	252.989	< 0.001
	0.979-0.954	1845.138 b	257.883	
	0.950-0.912	2390.750 a	265.348	

Discussion

Our human body is an amazing machine, in which perfectly coordinated events will occur simultaneously. If any one performs any activity like walking, he will be successfully shifting his body system from rest to active state. If he continues this activity several times, then his body gets adapted to that particular activity in a better way. The activity thus carried out is called as 'Physical-Activity'. There is no doubt that the type, amount, composition, and timing of food intake can dramatically affect exercise performance [(18)]. The systematic study of the link between carbohydrate intake and exercise capacity began over sixty years ago. Christiansen and Hansen were the first to explore systematically the link between diet and exercise capacity. Their study clearly showed the benefits of utilizing a high carbohydrate diet before prolonged exercise and was the first to establish the importance of carbohydrate content in diets of athletes preparing for competition [(19)]. Our result showed that distance, time, calorie expenditure and calculated calorie expenditure were significantly higher after diet intake (150gm and 250gm respectively) in comparison with fasting state among participant. As well as, the effect appear more obviously among low D2:D4 ratio group in comparison with that of moderate and high D2:D4 ratio group respectively (Tables 3,4,5 and 6). This observation of increased exercise performance after diet intake is probably due to that liver glycogen stores can be emptied after an overnight fasting. Liver glycogen levels are lowered as liver furnishes glucose to the body during the sleeping hours. On the other hand, muscle glycogen content decreased during exercise and was almost completely depleted when the individual was not able to continue the exercise [(20)]. The pre-exercise meal assists in replenishing muscles and liver glycogen and stocks the body with additional carbohydrate. This helps prevent or delay fatigue during exercise; so enhancing exercise performance. Our finding are in agreement with (Jacobs and Sherman, 1999 [(11)] ; Casey et al, 2000 [(21)] ; Febbraio et al, 2000 [(22)] ; Jentjens et al, 2003 [(23)] ; Moseley et al, 2003 [(14)]). In a series of studies examining the link between diet and sub-maximal endurance cycling capacity showed that time to exhaustion is increased when a high carbohydrate diet is consumed for about three days before exercise. In contrast, time to exhaustion (endurance capacity) was shorter when the diet was low in carbohydrate,

though adequate in fat and protein. These times to exhaustion were compared with the performance times of their subjects when they had consumed their normal mixed diets in the days before exercise [23]. Brewer et al, 1988 [24] showed that endurance capacity during treadmill run to exhaustion with lower exercise intensity at 70% VO2max can be improved by pre-exercise meal, eaten no later than 2 to 3 hours before exercise, which should be easy to digest and high in carbohydrates. Adopting this dietary recommendation improves endurance capacity during cycling and running when compared with fasting before exercise. Romijn et al, 1993 [25] suggested that the performance in subsequent prolonged exercise was related to the pre-exercise carbohydrate availability. It has been suggested that muscle glycogen is the primary fuel utilized early in exercise, but as exercise duration increases and muscle glycogen is depleted there is a gradual shift toward blood glucose as the predominant carbohydrate energy source. Hargreaves et al, 2004 [26] found that ingestion of a carbohydrate rich (about 200–300 g carbohydrate) meal after an overnight fast and 2–4 h before exercise can replenish endogenous carbohydrate reserves and is associated with improved performance.

Conclusions

1- Different D2:D4 ratio subjects have a significantly difference effect on the distance, time, calorie expenditure and calculated calorie expenditure at fasting state and as much as this ratio decrease there is increase in subject performance ability.

2- Diet intake has a significantly effect on distance, time, calorie expenditure and calculated calorie expenditure were higher in comparison with fasting state among participants. As well as, the effect appear more obviously among low digit ratio group in comparison with that of moderate and high digit ratio group respectively.

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- Churchchill AJG, Manning JT and Peters M, The effects of sex, ethnicity, and sexual orientation on self-measured digit ratio (2D:4D). Archives of Sexual Behavior 2007; 36(2) : 251-260.

4- Csatho A, Osvath A, Bicsak E, Karadi K, Manning JT and Kallai J, Sex role identity related to the ratio of second to fourth digit length in women. Biological Psychology 2003; 62: 147–156.

5- Fatima R, Aerobic exercises: Their cardiovascular and other benefits. Pak. J. Med. Sci. 2004; 20 (3) : 259-265.

6- Morris JN and Hardman AE, Walking to Health. Sport Medicine 1997; 23(5) : 307-332.

7- Ekkekakis P, Backhouse SH, Gray C and Lind E, 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. 2008; 9 : 246–264.

8- Rodriguez NR, Di-Marco NM and Langley S, Position of the American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and athletic performance. J. Am. Diet Assoc. 2009; 109:509-527.

9- Chryssanthopoulos C and Williams C, Pre-exercise carbohydrate meal and endurance running capacity when carbohydrates are ingested during exercise. Int. J. Sports Med. 1997; 18: 543-548.

10- Coyle EF, Substrate utilization during exercise in active people. Am. J. Clin. Nutr. 1995; 61(l): 968S-979S.

11- Jacobs KA and Sherman WM, The efficacy of carbohydrate supplementation and chronic high carbohydrate diets for improving endurance performance. Int. J. Sport Nutr. 1999; 9:92-115.

12- Balsom PD, Gaitanos GC, So¨derlund K and Ekblom B, High-intensity exercise and muscle glycogen availability in humans. Acta. Physiologica. Scandinavica. 1999; 165 : 337–345.

13- Volek JS, Influence of nutrition on responses to resistance training. Med. Sci. Sports Exerc. 2004; 36:689-696.

14- Moseley L, Lancaster GI and Jeukendrup AE, Effects of timing of pre-exercise ingestion of carbohydrate on subsequent metabolism and cycling performance. European Journal of Applied Physiology 2003; 88 : 453–458.

15- Coyle EF, Fluid and fuel intake during exercise. Journal of Sports Sciences 2004; 22, 39-55.

16- 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.

17- Einspruch EL, An Introductory Guide to SPSS for Windows. Sage Publications _ 2nd ed. 2005; pp. 60-75.

18- Quinn E, Nutrition and Athletic Performance. Canadian Journal of Dietetic Practice and Research 2000; 61(4):176-192.

19- Sullo A, Monda M, Brizzi G, Meninno V, Papa A, Lombardi P and Fabbri B, The effect of a carbohydrate loading on running performance during a 25-km treadmill time trial by level of aerobic capacity in athletes. European Review for Medical and Pharmacological Sciences 1998; 2: 195-202.

20- Hargreaves M, Finn JP, Withers RT, Halbert JA, Scroop GC, Mackay M, Snow RJ and Carey MF, Effect of muscle glycogen availability on maximal exercise performance. European Journal of Applied Physiology 1997; 75 : 188–192.

21- Casey A, Mann R, Banister K, Fox J, Morris PG, MacDonald IA and Greenhaff PL, Effect of carbohydrate ingestion on glycogen resynthesis in human liver and skeletal muscle, measured by 13C MRS. American Journal of Physiology 2000; 278 : E65–E75.

22- Febbraio MA, Chiu A, Angus DJ, Arkinstall MJ and Hawley JA, Effects of carbohydrate ingestion before and during exercise on glucose kinetics and performance. Journal of Applied Physiology 2000; 89 : 2220–2226.

23- Jentjens RLPG, Cale C, Gutch C and Jeukendrup AE, Effects of pre-exercise ingestion of differing amounts of carbohydrate on subsequent metabolism and cycling performance. European Journal of Applied Physiology 2003; 88 : 444–452.

24- Brewer J, Williams C and Patton A, The influence of high carbohydrate diets on endurance running performance. Eur. J. Appl. Physiol. 1988; 57: 698- 706.

25- Romijn JA, Coyle EF, Sidossis LS, Gastaldelli A, Horowitz JF, Endert E, et al., Regulation of endogenous fat and carbohydrate metabolism in relation to exercise intensity and duration. Am. J. Physiol. 1993; 265: E380-E391.

26- Hargreaves M, Hawley JA and Jeukendrup A, Pre-exercise carbohydrate and fat ingestion: effects on metabolism and performance. Journal of Sports Sciences 2004; 22 (1), 31-38.