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**Diet and Drugs but not Stenting Profoundly Increase Aerobic Exercise Capacity in Middle-Aged Athlete
with Obstructive Coronary Artery Stenosis- A Case Report**

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ABSTRACT:

A 55-year-old elite competitive cyclist noticed an abrupt 14% reduction in cycling power within a two-year period. Asymptomatic, he sought a cardiac evaluation utilizing maximal exercise testing. The patient demonstrated horizontal ST segment depression at 90% of his maximal oxygen uptake, indicating cardiac ischemia. Upon angiography, three non-obstructive (<50%) and two obstructive (>60%) stenoses were characterized and the right coronary artery was stented. His three-month post-stent maximal oxygen uptake declined 5%. After an aggressive plant-based diet and lipid therapy, three-year follow-up testing showed no cardiac ischemia and a dramatic 20% increase in maximal oxygen uptake.

INTRODUCTION:

Atherosclerotic cardiovascular disease characterized by fatty plaques narrowing coronary arteries is the leading cause of mortality worldwide[1]. Endurance athletes are known to have atherosclerotic cardiovascular disease at rates similar to non-athletes. However, myocardial infarction and subsequent death may be substantially lower[2, 3]. Aerobic functional capacity of an athlete with moderate to severe disease can far exceed that of an aged-matched non-diseased sedentary counterpart[4]. Although it is understood that the aging process will ultimately reduce a person's maximal oxygen uptake and therefore athletic performance, it is difficult to distinguish between simple age-related decline and disease-induced decline[5].

It is important to note that population studies for both masters athletes and the general population demonstrate an expected linear aerobic decline of approximately 0.5 to 1.0% per year from the mid-20's [5-7]. For this reason, if an athlete, as illustrated herein, notices a persistent, unrecoverable and steep performance decline, there may be cause for concern - even in the absence of symptomatology. Several recent investigations have highlighted the fact that individuals with seemingly normal cholesterol and other risk-factors may have not only subclinical disease but also potentially life-threatening stenosis[4, 8, 9]. Highly trained older athletes might have an abnormal electrocardiogram without symptoms which may or may not be benign[10]. In fact, the only symptom an older athlete may experience might be a reduction in aerobic performance[11]. This decline might be attributed to the aging process and thus the dangers of atherosclerotic cardiovascular disease progression might be inadvertently missed or ignored. Because an athlete may feel "inoculated" from atherosclerotic cardiovascular disease though an active lifestyle, they may never seek cardiac screening, however evidence supports they are at similar risk to the general population[2, 4].

CASE PRESENTATION:

This 55-year-old competitive road cyclist noticed a sharp 14% decline in his cycling performance as quantified by a rear wheel hub power meter (PowerTap®) measuring power in watts. His reduced aerobic power occurred rapidly within a two-year window and persisted for three more years (Figure 1).

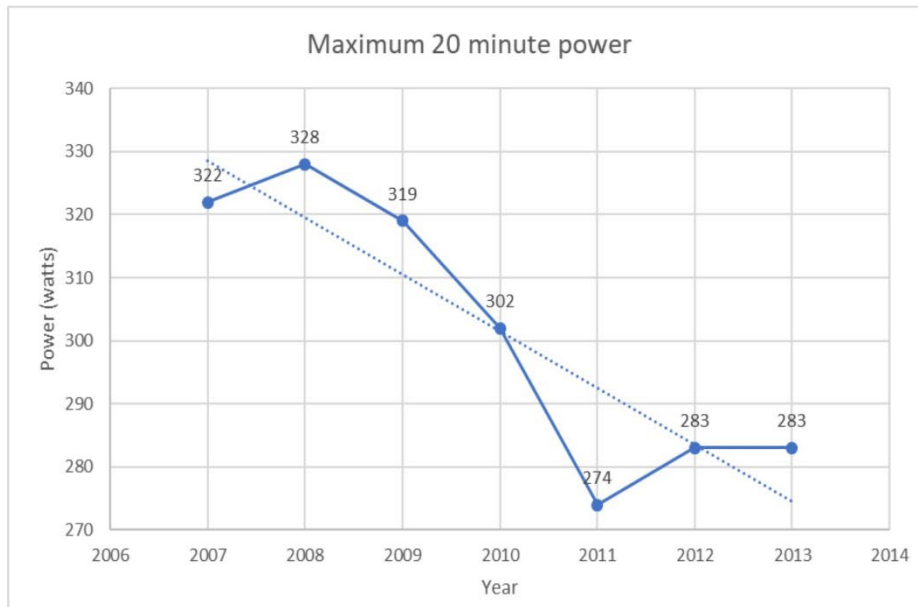


Figure 1. Cycling 20-minute power output curves. The patient reported this dramatic decline in cycling performance between the year 2009 and 2011. This 14% drop in power output far exceeds the expected 0.5% decline per year[6, 7].

The patient sought a cardiac evaluation including lipid levels and stress testing because he felt that his power decline was unusual, particularly after subsequently optimizing his cycling training for three years with no rebound or improvement in performance. Electrocardiograms, (Figure 2), illustrate a majority of horizontal depressed ST segments from September 2014 (baseline), December 2014 post stent), October 2016) indicating ischemia while up-sloping ST segments on August 2015 and September 2017.

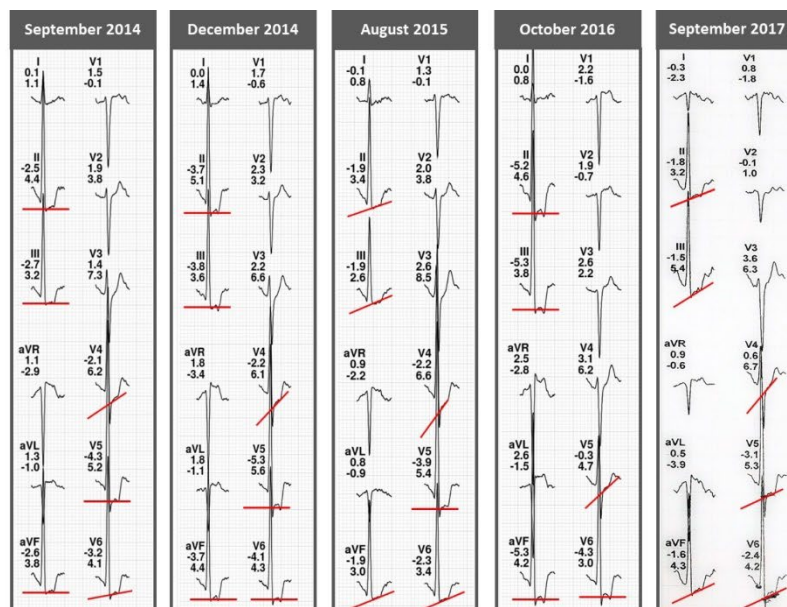


Figure 2. Sequential electrocardiograms. These 5 electrocardiograms illustrate ST-segment depressions (red lines indicate slope) in the final minute (HR exceeding 170) of the maximal bicycle ergometer exercise test. Each one resolved after only 30 seconds of rest (not shown). Note that horizontal ST segments indicate possible cardiac ischemia due to stenosis. The September 2014, December 2014 and October 2016 had only two up-sloping depressed ST segment (lead V6-September 2014 and lead V4-December 2014) indicating cardiac ischemia. The August 2015 and September 2017 had up-sloping ST segments (except lead V- August 2015) indicating no cardiac ischemia. The very late onset of the ST depression at near maximal exertion along with rapid resolution might indicate false positives. However, the angiographic studies clearly demonstrated that the patient had hemodynamically significant lesions inducing cardiac ischemia.

Generally, there was an improvement in the electrocardiogram with more up-sloping depressions through time indicating reduced ischemia coinciding with his improved maximal oxygen uptake. (Table 1) data show an increase of 16.2% in maximal oxygen uptake after 3 years of treatment with a low fat whole-food plant based diet, pravastatin, niacin, and evolocumab. LDL-C dropped from 139 mg/dL to a low of 21mg/dL. For the previous several years, the patient had what is generally regarded to be normal total cholesterol of 180 (mg/dL); low density lipoprotein, LDL-C of 120 (mg/dL); high density lipoprotein and HDL-C of 50 (mg/dL), and plasma glucose of 85 (mg/dL), (Table 1).

Date	weight (lb)	Percent body fat	Heart Rate Maximum	BMI (kg/mL)	V02max (mL/kg/min)	Percent delta	V02max (L/min)	Percent of predicted maximum oxygen uptake	Electrocardiogram	Carotid Ultrasound	TC (mg/dL)	HDL-C (mg/dL)	LDL-C (mg/dL)	Triglycerides (mg/dL)	Total/HDL-C (mg/dL)	Blood Pressure	Treatment
Sept. 2014	158	15	180	23	54.8	baseline	3.92	173	2 to 3 mm horizontal ST segment depression in the inferior apical leads- cardiac ischemia	Minimal Heterogenous plaque-normal 0-19% stenosis	193	48	139	49	4	140/90	none/baseline; Standard American Diet
Dec. 2014	160	15	180	23	52	-0.5	3.76	165	4-5 mm horizontal ST segment depression in the inferior and apical leads- cardiac ischemia	Minimal Heterogenous plaque-normal 0-19% stenosis	167	64	104	50	3.3	130/80	80 (mg) pravachol; Losartan; Standard American Diet
Aug. 2015	150	9	182	22	62.5	+12.3	4.24	196	up-sloping ST segment depressions in the inferior apical leads except V5 which displayed 3-4 mm horizontal ST segment depression no cardiac ischemia	Minimal Heterogenous plaque-normal 0-19% stenosis	153	53	91	51	3.0	115/60	low-fat whole food, plant-based diet; losartan;1000 (mg) instant release niacin
Oct. 2016	150	9	179	22	59.7	+8.2	4.05	187	4-5 mm horizontal ST segment depression in the inferior and apical leads- cardiac ischemia	Minimal Heterogenous plaque-normal 0-19% stenosis	76	47	21	41	1.8	120/65	low-fat whole food, plant-based diet; 1000 (mg) instant release niacin; losartan; 240 (mg) evolucumab
Sept. 2017	148	8	179	21	65.4	+16.2	4.38	202	1-1.5 mm up-sloping ST segment depression in the inferior leads and 2.5 mm up-sloping in the apical leads-no cardiac ischemia	Minimal Heterogenous plaque-normal 0-19% stenosis	134	42	74	92	3.1	112/55	low-fat whole food, plant-based diet;1000 (mg) instant release niacin; losartan; 240 (mg) evolucumab

Table 1. Patient characteristics. This 55-year-old patient's weight fell throughout the study period with rising maximal oxygen uptake to 65.4 mL/kg/min. The 80(mg) pravastatin dose of was discontinued due to intolerance but resulted in a LDL-C of 104 (mg/dL). However, the patient found comparable LDL-C lowering effects following a low fat whole-food plant-based diet with add-on 1000mg instant release niacin, LDL-C of 91(mg/dL). Although cardiac ischemia was noted again in 2016, maximal oxygen uptake continued to rise, and no ischemia was recorded in 2017.

DIAGNOSIS:

Cycling power meter measurements:

The patient's self-reported decline in cycling power output was measured in watts and was recorded via the PowerTap® power meter. The PowerTap® is a rear wheel hub based device utilizing an internal strain gauge that electronically transmits real-time power data to a head unit when the bicycle is pedaled. It is accurate within $\pm 2\%$ [12]. There are considerable advantages of this type of measurement and recording: the device is portable, lightweight and can store several workouts. In addition, the data can be exported to various software packages for analysis which include weekly, monthly and yearly trends for power of different durations allowing for a full catalog of physical energy output for multiple interpretations. In this case, 20-minute average maximal power was used since the patient regularly competed in time-trial events of this duration. This provides an excellent aerobic test comparable to laboratory maximal oxygen uptake testing in terms of duration and power output.

Maximal oxygen uptake stress test:

The patient underwent a maximum oxygen stress test using a cycling ergometer with resistance increasing at a rate of 1 watt/2 seconds. A full-face mask was used, and gas exchange ratio was recorded to determine oxygen uptake. The exercise tests lasted approximately 15 minutes with an ending power of over 400 watts. This protocol matched the patient's preferred sport of cycling closely and was therefore ideal because of his very high level of cycling fitness[13].

TREATMENT:

Angiogram and Stenting:

An angiogram was performed to confirm the stress test findings of cardiac ischemia. Utilizing the percutaneous trans-ulnar artery approach the proximal left anterior descending artery had a 30% stenosis at the first diagonal branch, and the mid-portion had a 50% stenosis after the second diagonal branch. The first diagonal had a 50% stenosis at its ostium. The ostium of the second diagonal also had a 60% stenosis. A tandem 65% and 30% stenosis was characterized in the proximal to mid right coronary artery. A Medtronic Launcher JR4 guiding catheter of 6-French was inserted over a guidewire and engaged into the right coronary ostium. A Boston Scientific Promus Premier RX stent of 4.00 mm by 38 mm long was inserted over the wire under fluoroscopic guidance. The stent was placed across both lesions of the proximal and mid right coronary artery. The diagonal branches were not stented due to inaccessibility. Post-intervention imaging of the right coronary artery revealed a residual 5% stenosis.

Diet:

The therapeutic diet consisted of a low fat whole food plant-based fare including legumes, whole grains (bread, pasta, oatmeal), dark green and color-rich vegetables, and a complete assortment of fruits, similar to the diet investigated by Dean Ornish, Caldwell Esselstyn, and Colin Campbell[14-16]. No milk, meat or fish were consumed, and high fat foods such as olives, avocado, and nuts were seldom eaten.

No added oils were used to cook or flavor food. The approximate macronutrient content was 12% total fat (95% unsaturated and monounsaturated, 5% saturated), 75% carbohydrate and 13% protein, 0%

cholesterol. The diet was well tolerated and maintained throughout the study. Pre-intervention diet was the Standard American Diet, SAD, which was typical in the United States with high dairy, meat, salt and refined sugar consumption. The macronutrient energy composition was approximately 40% fat; 15% protein and 45% carbohydrates.

Drugs:

To control lipids the patient was prescribed pravastatin, instant release niacin and evolocumab. Losartan was used to lower blood pressure (table 1).

Discussion:

This elite older cyclist profoundly improved his exercise capacity putatively through a low fat whole food plant-based diet, niacin, evolocumab (add in the final year) and his regular high-intensity cycling training. (Table 1) Although no follow up angiogram was obtained, and the carotid artery ultrasounds were inconclusive for atherosclerotic regression (this type of testing may not be sensitive enough to resolve small changes), it is possible to infer that the treatment protocol could have regressed hemodynamically significant stenoses in the culprit epicardial arteries and increased luminal diameter, thereby increasing exercise capacity[17]. The notion of plaque regressing is corroborated by the recent GLAGOV trial demonstrating most patients with the lowest LDL-C, had significant plaque regression in epicardial arteries after only one year of treatment with evolocumab [18]. It is important to note that an increase nitric oxide could be responsible for the increase in exercise capacity and the elimination of ischemia as demonstrated during stress testing since the low fat whole food plant-based diet purportedly leads to nitric oxide improvements, but this is unlikely since the patient undertook varying doses of isobromide dinitrate without an increase in exercise capacity[19]. The patient improved beyond his pre-diagnosis physical performance to win his first ever regional cycling championship along with a silver medal at a national championship.

Aging athletes can possess extraordinarily high exercise capacity with concomitant ischemic cardiac pathology[4]. There are potentially millions of older athletic competitors that could be put at risk if physicians are not mindful of this fact. In this case, a national caliber athlete determined to train hard and perform at an elite level identified early but significant disease. The patient was stented and first prescribed a maximum statin dose but was found to be statin intolerant with muscle aches and fatigue. The notion of reducing this patient's LDL-C through diet and medication to stabilize and possibly reverse plaque progression was derived from several studies that demonstrated that reversing atherosclerosis is possible[14, 20]. With the most recent study corroborating that there are no advantages for exercise tolerance with the use of stents, this patient achieved remarkable exercise capacity and elimination of cardiac ischemia through lifestyle changes and optimal medical therapy. Strictly whole food plant-based diets have demonstrated cholesterol lowering comparable to statins[21]. Decades of data on the efficacy of immediate-release niacin are robust and demonstrate reduced total cholesterol, increase HDL-C, and decrease LDL-C. Despite recent reports downplaying niacin efficacy, some studies used niacin either paired with a statin or with the prostaglandin inhibitor laropiprant which may have interfered with niacin's mechanism of action[22, 23].

Current data do not support the use of stents for increased survival in patients with stable coronary artery disease, most likely because the underlying disease is not sufficiently treated[24]. That is to say, atherosclerotic disease is a lifestyle disease and should be treated as such. Statin therapy can be useful in reducing future acute coronary syndromes as compared to placebo but has limited efficacy particularly given many patients discontinue statin therapy after a year due to intolerance or other reasons[25].

With many aging athletes at risk atherosclerotic heart disease, perhaps it is necessary for physicians to rethink options for both identifying and treating this chronic disease synergistically with sustainable lifestyle modifications and effective medicines as supported by the body of medical evidence.

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Key Words: Low fat whole-food plant based diet, maximal oxygen uptake, ST segment depression, stent, atherosclerosis, ischemia, cycle ergometry, athlete

Abbreviations: LDL-C, low-density lipoprotein; HDL-C, high-density lipoprotein; V02max, maximal oxygen uptake; Standard American Diet, SAD