

## Effect of a Match on Salaries for Medical Fellows

**To the Editor:** In their Research Letter, Drs Niederle and Roth<sup>1</sup> reported that fellowship markets without a match offered similar salaries as those that do. Although the authors acknowledged that “the market for fellowships is not the same as the market for residencies,” they nonetheless concluded that “eliminating the resident match would not necessarily increase residents’ wages.” Their underlying comparison between fellowship and residency, however, is misleading: an applicant for nephrology fellowship, for instance, in which there is no match, is not in the same market as an applicant for pulmonary/critical care, in which there is. The correct comparison from which one could draw conclusions about the effect of a match on fellowship salary would be between the salaries paid to fellows who obtain positions through the match and the salaries paid to fellows who are offered positions in the same fellowship program outside the match. I suspect that the salaries would be found to be identical in this circumstance. The very existence of a residency match allows all programs to pay lower salaries because the participating programs can operate as a cartel.

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1. Niederle M, Roth A. Relationship between wages and presence of a match in medical fellowships. *JAMA*. 2003;290:1153-1154.

**In Reply:** Dr Schlegel is dissatisfied that we compared different subspecialties with one another. To test the hypothesis that a match results in lower wages, we looked for a set of comparable markets, only some of which use a centralized match. We compared all internal medicine subspecialties, and found no systematic difference in wages between subspecialties that use a match and those that do not.

Schlegel proposes that the appropriate comparison would be between the wages paid to fellows in the same fellowship program, some of whom are recruited within the subspecialty match and some of whom are recruited outside it. He suspects this test would also fail to detect any wage differences. Without data we cannot tell. But even if wage differences were found, they would be difficult to interpret. If 2 fellows in the same program were hired by different means, there would likely be some difference between these individuals. This, rather than the difference in how they were hired, might account for their different wages. More important, such a test would not be informative about whether the presence of a match systematically raises or lowers wages across the subspecialty as a whole (eg, average wages), which is the question we addressed.

Nevertheless, it is sometimes possible to look at the effects of a match in a single market. For example, because the gastroenterology fellowship market had a match that was discontinued, some of the effects of a match can be inferred by examining that market before the adoption of the match, during

its operation, and afterwards.<sup>1</sup> Similarly, the market for residents can be examined before and after the adoption of the resident match.<sup>2,3</sup> Those comparisons suggest that the match benefits residents and fellows. Comparisons of related British medical markets also support that conclusion.<sup>4</sup>

Schlegel suggests that the match depresses wages and harms residents and fellows. To date there is no evidence to support this hypothesis. Rather, the wages of fellows and residents appear to be determined by features of the medical marketplace other than the presence or absence of a match.

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1. Niederle M, Roth AE. Unraveling reduces mobility in a labor market: gastroenterology with and without a centralized match. *J Polit Econ*. In press.
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3. Roth AE. The evolution of the labor market for medical interns and residents: a case study in game theory. *J Polit Econ*. 1984;92:991-1016.
4. Roth AE. New physicians: a natural experiment in market organization. *Science*. 1990;250:1524-1528.

## RESEARCH LETTER

### Oxygenated Water and Athletic Performance

**To the Editor:** Bottled waters described as “oxygenated” are sold with claims that they confer health benefits. The waters are advertised to contain 7 to 40 times more oxygen (O<sub>2</sub>) than ordinary water and to enhance exercise, with statements such as “enhanced sports performance”<sup>1</sup> and “improves cardiovascular and muscle endurance”<sup>2</sup> commonly used. We measured O<sub>2</sub> in oxygenated water and assessed its effect on maximal performance during exercise.

**Methods.** We first measured the PO<sub>2</sub> in 5 brands of bottled water advertised as “oxygenated” and compared the values with those of well-stirred tap water. Samples were obtained by inserting a needle into the bottles through the sidewall or cap and drawing water into a gas-tight syringe. PO<sub>2</sub> was measured in triplicate using a blood gas analyzer calibrated into the hy-

**Table 1.** Results of Water PO<sub>2</sub> Measurements\*

Sample	PO <sub>2</sub> , mm Hg	Calculated O <sub>2</sub> Content, mL O <sub>2</sub> per 100 mL Water
Oxygenated water		
Brand 1	133	2.5
Brand 2	505	9.5
Brand 3	555	10.5
Brand 4	637	12.0
Brand 5	1184	22.6
Tap water	127	2.5

\*Maximum value of triplicate measurements corrected to 37°C.

**Table 2.** Summed Data for Maximal Exercise Performance Variables in Participants (N = 11) Following Consumption of Oxygenated or Tap Water

Performance Variable	Oxygenated Water, Mean (SD)	Nonoxygenated Water, Mean (SD)	Mean (95% CI) Difference	P Value (2-Tailed)
VO <sub>2max</sub> , L/min	3.13 (0.67)	3.14 (0.72)	-0.01 (-0.12 to 0.10)	.90
VO <sub>2max</sub> , mL/min per kg	40.2 (6.1)	40.1 (6.3)	0.1 (-1.20 to 1.40)	.87
Metabolic equivalents*	11.5 (1.8)	11.5 (1.8)	0 (-0.40 to 0.40)	.92
VCO <sub>2</sub> , L/min	3.88 (0.77)	3.88 (0.96)	0 (-0.20 to 0.20)	.96
Peak heart rate, bpm	179 (11)	181 (14)	-2 (-7.00 to 3.00)	.38
Ratio of CO <sub>2</sub> output to O <sub>2</sub> uptake	1.26 (0.07)	1.25 (0.10)	0.01 (-0.03 to 0.05)	.62
V <sub>E</sub> , L/min	123.6 (33.2)	123.1 (37.1)	0.5 (-9.60 to 10.60)	.93
Ventilatory equivalent for O <sub>2</sub> (V <sub>E</sub> /VO <sub>2</sub> )	39.553 (6.246)	39.150 (7.140)	0.404 (-1.84 to 2.64)	.73
O <sub>2</sub> pulse, mL/beat†	17.563 (4.186)	17.424 (4.604)	0.139 (-0.52 to 0.80)	.69

Abbreviations: VCO<sub>2</sub>, carbon dioxide production; V<sub>E</sub>, minute ventilation at peak exercise; VO<sub>2max</sub>, maximal oxygen uptake.

\*O<sub>2</sub> uptake divided by standard assumed resting oxygen uptake (3.5 mL/kg per min).

†O<sub>2</sub> uptake divided by heart rate.

perbaric range (Model 1604, Instrumentation Laboratory, Lexington, Mass). Water O<sub>2</sub> content was calculated from PO<sub>2</sub> with a standard formula.<sup>3</sup>

Participants were 11 healthy adults (7 men, 4 women; mean age, 35 [SD, 7] years). Each performed 2 standard maximal cardiopulmonary exercise tests on separate days at least 3 days apart. Five minutes before exercise, the participants drank in random order and double-blind fashion either 355 mL (12-ounce bottle) of oxygenated water (brand 5; TABLE 1) or a bottle of the same brand that had been deoxygenated by agitation in air. A graded maximal exercise protocol was performed on a cycle ergometer and measurements obtained using a computerized metabolic cart. Differences between exercise after consumption of oxygenated and ordinary water were analyzed by paired *t* test. Our study was approved by the Duke University institutional review board. All participants provided written informed consent.

**Results.** Four of 5 brands of water had PO<sub>2</sub> values greater than that of tap water and 1 was similar (Table 1). The water with the highest PO<sub>2</sub> (brand 5) was the only one packaged in a glass bottle. There were no significant differences in exercise results after participants drank either oxygenated or tap water for any measured variables (TABLE 2). Furthermore, the participants were unable to identify oxygenated water by taste.

**Comment.** Of 5 tested brands of oxygenated water, 4 contained more O<sub>2</sub> than tap water, but their O<sub>2</sub> content was not great because O<sub>2</sub> is relatively insoluble in water. The highest contained 80 mL of O<sub>2</sub> in a typical 12-ounce bottle.

However, air is 20.9% O<sub>2</sub>, and a normal human tidal breath of roughly 500 mL contains 100 mL of O<sub>2</sub>. Thus, a single breath of air contains more O<sub>2</sub> than a bottle of oxygenated water. Given that hemoglobin is already nearly saturated with O<sub>2</sub> during air breathing, and that only a small amount of additional O<sub>2</sub> can be dissolved in plasma, it is not surprising that oxygenated water did not improve maximal exercise performance. Furthermore, given the small amount of oxygen in bottled water compared with that in air, any benefit would likely be quite brief.

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