

## **PROJECT REVIEW**

### **"Can Sildenafil Improve Exercise Performance at Moderate Altitude?"**

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Sildenafil (Viagra®) has been reported to improve exercise performance at high altitude (>3,800 m) in a subset of athletes by greater than 35%. At altitude, exercise capacity is reduced because lower oxygen pressures result in decreased delivery of oxygen to the tissues. Altitude induced performance decrements can be exacerbated by the constriction of lung vessels (pulmonary hypertension) that can occur in some individuals causing reduced cardiac output (blood pumped from the heart per minute) and further impaired gas exchange in the lungs. Sildenafil is thought to improve performance at altitude by relaxing the pulmonary vessels thereby reducing pulmonary arterial pressure, increasing cardiac output, improving gas exchange, and allowing enhanced oxygen delivery during exercise. It is currently unknown whether sildenafil could improve performance at more moderate elevations relevant to Olympic competition. Therefore, the primary objective of this investigation is to determine whether sildenafil enhances athletic performance in men and women at moderate elevations. In part one, competitive male and female cyclists will undergo two cycling exercise tests (each with a set workload and time trial component) while breathing hypoxic gas simulating an altitude of  $\approx 3,900$  m following ingestion of either placebo or sildenafil. Subjects who demonstrate drug induced benefits in time trial performance at 3,900 m will then perform similar paired exercise performance tests at 1,500 m, 2,100 m, and 2,700 m to determine whether the benefits are also present at lower elevations. In study 2, athletes will be flown to an elevation of 2,200 m. On days 4 and 5, they will perform 2 exercise tests (one each day) with either placebo or sildenafil. On day 7, subjects will be driven to 4,300 m where they will again undergo paired performance tests on days 4 and 5. Thus, the two studies will determine the efficacy of sildenafil as an ergogenic aid at moderate elevation both acutely and in partially acclimatized athletes.

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### **Results and Conclusions**

**Background:** Sildenafil increases oxygen delivery and maximal exercise capacity at very high altitudes ( $\geq 4300$  m) and has been shown to improve short-duration exercise performance in some individuals at simulated high altitude (3900 m). It is unknown whether sildenafil improves maximal exercise capacity and longer duration exercise performance at moderate and high altitudes where competitions are more common. Additionally, the effects of sildenafil on women exercising at altitude have not been examined. **Purpose:** The purpose of this study was to determine the effects of sildenafil on cardiovascular hemodynamics (heart rate, stroke volume, and cardiac output), arterial oxygen saturation (SaO<sub>2</sub>), peak exercise capacity (W<sub>peak</sub>), and exercise performance in endurance-trained men and women at simulated altitude. During Year 1 of the study exercise performance was examined by having subjects complete a 6-km cycling time trial at simulated high altitude (HA; 3900 m, 12.8% FIO<sub>2</sub>), while during Year 2 subjects completed a 15-km time trial at both simulated moderate (MA; 2100 m, 16.2 % FIO<sub>2</sub>) and HA. **Methods:** Endurance trained male and female subjects between the ages of 18-39 yr completed two HA W<sub>peak</sub> trials following the ingestion of placebo or 50 mg sildenafil in randomized, counterbalanced, and double blind fashion. Subjects also completed exercise trials (30 min at 55% of W<sub>peak</sub> + time trial) at MA and HA following the ingestion of placebo or 50 mg sildenafil in randomized, counterbalanced, and double blind fashion. **Results:** Sildenafil had little influence on cardiovascular hemodynamics for either gender at MA or HA, but did result in higher SaO<sub>2</sub> values compared to placebo during steady state and time trial exercise in men at HA only. Sildenafil did not affect W<sub>peak</sub> or 6-km time trial performance in either gender at HA or 15-km time trial performance in either gender at MA or HA. **Conclusions:** The efficacy of sildenafil during exercise at altitude is integrally related to its ability to improve oxygen delivery by increasing SaO<sub>2</sub> and/or cardiac output. The magnitude of these effects appears to be dictated by the severity of the altitude and associated hypoxia as well as individual susceptibility to hypoxic pulmonary vasoconstriction. Sildenafil is unlikely to exert beneficial effects in oxygen delivery or exercise performance at altitudes < 4000 m for the vast majority of the endurance trained men or women

### **Publications**

Kressler, J, Stoutenberg M, Roos B, Friedlander AL, Viskochil R, Jacobs KA. Sildenafil does not improve exercise performance during acute hypoxia in trained men or women. *Medicine and Science in Sports and Exercise (Supplement)*, 41: S130, 2009.

Jacobs KA, Stoutenberg M, Kressler J, Roos B, Friedlander AL. Trained women demonstrate greater preservation of peak exercise capacity during acute hypoxia than trained men. *Medicine and Science in Sports and Exercise (Supplement)*, 41: S374, 2009.

