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Research article

**Differential Response of Heat Shock Proteins to Uphill and Downhill Exercise in Heart, Skeletal Muscle, Lung and Kidney Tissues**Pablo C. B. Lollo , Carolina S. Moura, Priscila N. Morato, Jaime Amaya-Farfan

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[Author Information](#)[Publish Date](#)[How to Cite](#)[Email link to this article](#)**ABSTRACT**

Running on a horizontal plane is known to increase the concentration of the stress biomarker heat-shock protein (HSP), but no comparison of the expression of HSP70 has yet been established between the uphill (predominantly concentric) and downhill (predominantly eccentric) muscle contractions exercise. The objective of the study was to investigate the relationships between eccentric and concentric contractions on the HSP70 response of the lung, kidney, gastrocnemius, soleus and heart. Twenty-four male Wistar weanling rats were divided into four groups: non-exercised and three different grades of treadmill exercise groups: horizontal, uphill (+7%) and downhill (-7% of inclination). At the optimal time-point of six hours after the exercise, serum uric acid, creatine kinase (CK) and lactate dehydrogenase (LDH) were determined by standard methods and HSP70 by the Western blot analysis. HSP70 responds differently to different types of running. For kidney, heart, soleus and gastrocnemius, the HSP70 expression increased, 230, 180, 150 and 120% respectively of the reference (horizontal). When the contraction was concentric (uphill) and compared to downhill the increase in response of HSP70 was greater in 80% for kidney, 75% for gastrocnemius, 60% for soleus and 280% for the heart. Uric acid was about 50% higher ( $0.64 \pm 0.03 \text{ mg-dL}^{-1}$ ) in the uphill group as compared to the horizontal or downhill groups. Similarly, the activities of serum CK and LDH were both 100% greater for both the

uphill and downhill groups as compared to the horizontal group ( $2383 \pm 253$  and  $647.00 \pm 73$  U/L, respectively). The responsiveness of HSP70 appeared to be quite different depending on the type of tissue, suggesting that the impact of exercise was not restricted to the muscles, but extended to the kidney tissue. The uphill exercise increases HSP70 beyond the eccentric type and the horizontal running was a lower HSP70 responsive stimulus.

**Key words:** HSP70, stress, concentric exercise, eccentric exercise, metabolic stress

### Key Points

- Exercise can induce increases in HSP70 in the lung, kidney and heart, and in the soleus and gastrocnemius muscles, probably due to systemic alterations such as hypoxia, increase in temperature and the production of free radicals.
- Predominantly concentric contractions (running uphill), seem to be the most efficient way of increasing the HSP70 concentrations in the different tissues, followed by eccentric contraction (downhill) and lastly the concentric-eccentric cycle (horizontal).
- The energy demand, already known to influence HSP70, appears not to be the only factor responsible for the response of these proteins, considering that for the kidney and the soleus muscle, downhill running was more efficient in raising the HSP70 response than horizontal running.
- Future research should explore the mechanisms by which the eccentric, concentric and eccentric-concentric contractions are capable of influencing the responses of the heat shock proteins, opening possibilities for increasing the levels of these proteins in desirable situations, such as to protect against excess free radicals or injuries.

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