The effects of jumpamine chloride on jumping performance in two species of frogs of the genus Rana

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Introduction

Jumpamine chloride (JCl-) is a natural waste product of muscle metabolism in many species of frogs. Phrogsucker et al. (1957) first reported that up to 60% of this chemical is reabsorbed from the bladder before excretion. This result lead to a number of studies attempting to identify the advantage of reabsorption of this product. One recent study showed that injection of JCl- into the bloodstream increased muscle mass in the grass frog Rana pipiens (Hylaflex and Smith,1988). Anurheight (1990) was the first to demonstrate an actual improvement in performance capability, by showing that swimming performance in Xenopus laevis was improved by adding JCl- to the diet.

The present study was carried out in order to see if JCl- had any direct effects on jumping performance in frogs of the genus Rana. We hypothesized that the increased muscle mass shown in earlier studies (Hylaflex and Smith, 1988) would result in improved jumping distance. Such a result would suggest the biological function of JCl- reabsorption. We also investigated the influence of temperature in modifying JCl- levels, which then induced changes in jumping performance. Demonstrating temperature effects would shed light on the underlying mechanism involved in the changes in muscle induced by JCl- Based on earlier studies we hypothesized that JCl- acts by increasing the activity of a number of enzymes associated with muscle contraction. If this is the case, we hypothesize that jumping distance will improve exponentially with temperature over a certain temperature range.

We tested the effects of JCl- on jumping performance by injecting the drug into the bloodstream and measuring average jumping distance under specific conditions. We looked at temperature effects by carrying out the same experiments at a range of different ambient temperatures. We conducted the study on two different species to see if the effects observed were species-specific or more general in nature.

Methods

Effects on jump distance:

Ten specimens of Rans pipiens were given 1.0 ml. of 10% JCl solution Ten control frogs were given injections of 1.0 ml of a salt solution. All frogs were maintained at 25°C for 1 day in 1 inch of water. At this time each frog was placed on an open floor and induced to jump 2 times by slapping the ground behind the frog. The jump distance was defined as the sum of two jumps. The same procedure was repeated using Rana iwanna.

The effects of temperature:

Each of the JCl- treated frogs was placed in a temperature controlled tank, ranging from 0 to 90°C in intervals of 10°C. One control frog was placed in the tank with each treated frog. The frogs were left in the temperature controlled tanks for 24 h, and then tested, as above, for jumping performance. Each frog was tested 10 times.

Results

The effects of JCl- on jumping distance depended on the species tested. These results are summarized in Figure 1. It is clear from this figure that JCl- had a striking impact on Rana pipiens, but had little or no effect on
The mean 2-jump distances (at 25° C) for *Rana pipiens* were 2.3 m (sd=1.5) for controls and 4.2 m (sd=1.2) for JCl- treated. The mean distance was significantly longer for the treated frogs (t-test, O.O05<P). *Rana iwanna* the mean for untreated frogs was 2.6 m (sd=1.5), and for the treated frogs, 2.5 m (sd=2.0). The difference in means was not significant (t-test, p=0.11).

The relationship between temperature and jump distance is shown for *Rana pipiens* in figure 2. The same relationship for *Rana pipiens* is shown in figure 3. It is clear from Fig. 2 that for *R. pipiens* jump distance increases linearly with temperature. For *R. iwanna* temperature also affects jump distance in an approximately linear fashion, but does not begin to have an effect until the temperature exceeds 30°C.

![Figure 1. The effect of JCl injection in two species of frogs at 25°C. Bars indicate mean 2-jump distances. Shaded bars are *R. pipiens* and open bars are *R. iwanna*. Error bars indicate 1 standard deviation from the mean (n=10).](image1)

![Figure 2. The effects of temperature on mean jumping distance for *Rana pipiens* (n=10). Distance s are the sum of two jumps. Error bars indicate standard deviation. (+1-1).](image2)
Discussion

JCl- has the clear effect of increasing jump distance in both frog species (see figures 1, 2 and 3). These results support our original hypothesis that JCl- would improve jumping performance. The effect on jumping distance is clearly temperature-dependent. However, there are differences between the species in how this effect appears. For example, in R. iwanna no increase in performance occurs until the temperature exceeds 30°C. This explains why no significant difference in jumping distance was observed at room temperature (Fig. 1).

The nature of the relationship between temperature increase and JCl- effects on jumping distance was not consistent with our original hypothesis regarding the molecular mechanism of action of JCl-. We had proposed that its effect might be an enhancement of activity of certain enzymes. This led us to predict an exponential performance increase with temperature. The linear increase we observed is not consistent with the proposed mechanism. It suggests that JCl- may be directly acting on the mechanical properties of the muscles themselves. Such a mechanism has been proposed for the action of the hormone gogetemall in the tree lizard Philanthropus fabricus (Herpbrain and Phutz, 1992). This suggests an interesting line of study for future experiments in which JCl- would be administered to isolated muscle preparations and its direct effects on contractile elements observed directly.

The observation that weight loss occurs when frogs are exposed to higher temperatures also suggests an effect of JCl- on the overall metabolism of frogs. We are currently carrying out a study to test the direct effects of JCl- on metabolic rate.

The results described above are important for understanding the role of JCl- in the natural biology of these frogs. In Rana pipiens reabsorption of JCl- will clearly lead to increased jumping ability which can be expected to improve its survival chances. Moreover this advantage will occur at temperatures during which it is normally active (20-40 °C). The comparison with R. iwanna is interesting however. R. iwanna is not normally active above 30°C. Nonetheless R. iwanna absorbs JCl- from its bladder. This strongly suggests that improved jumping performance alone cannot account for the evolution of the general tendency of frogs to reabsorb this substance. It would be very interesting to compare the relative amount of reabsorption in frogs active at temperatures where the effects on jumping performance occur versus those where it does not.

![Graph showing the effects of temperature on mean jumping distance in R. iwanna. Distances were determined as in Figure 2. Error bars indicate standard deviation.](image-url)
The results presented here also have serious implications for the use of JCl- in frog jumping contests. Twainson (1990) expressed concern that the increased occurrence of doping with this drug in frog jumping contests may have dire consequences for the sport. Here we clearly show that this drug has the potential to influence the outcomes. The seriousness of the effect on the results clearly depends on the temperature at which contests are held, as well as the species involved. Moreover we have recently found that use of JCl- compromises the health of our frogs. Our results support the conclusions of Twainson (1990), and suggest that government regulation and drug testing may be in order.

References


