

Introduction

Humans, for many generations, have been attempting flight through the imitation of animals and their mechanical and physiological adaptations. Mock flight has been achieved with the construction of artificial structures such as the hang glider. These structures are often modelled after animals such as the flying squirrel that have achieved successful gliding locomotion via morphological and physiological adaptations. Humans, however, are not well adapted for flight and therefore face many physiological stresses that must be dealt with when attempting these aerial activities.

Objectives/Goals

- To examine the structural and physiological adaptations that make flying squirrels adjusted to gliding locomotion
- To determine how humans have used or could use this information to develop and improve exercises such as hang gliding

Methods

We performed a literature review to investigate the above questions

- With flying squirrels we focused on information regarding:
 - Morphological features that allow gliding locomotion
 - How the body is moved and oriented to best accommodate successful glides
 - Wing loading
- With humans we focused on information regarding:
 - Artificial adaptations for gliding
 - Physiological stresses on human body

Acknowledgements

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Results and Discussion

Squirrels

Morphological features:

- Patagium: wing membranes stretching from wrist to ankle (Bishop 2006)
- Propatagium: extension of wing membrane stretching from wrist to neck (Bishop, 2006).
- Wing tip: styliform cartilage (Thorington et al 1998)
- Considerably longer limbs (Flaherty et al, 2010).

Body movements:

- The wing can be held at varying angles to the body and adjusting the limbs can change the angle of attack of the wings with respect to oncoming airflow. (Bishop, 2006)
- Can adjust camber of wings in two different ways: by bringing forelimb and hindlimb closer together or relaxing/tensing intrinsic musculature in the skin of the wing (Bishop, 2006)
- Can move left and right limbs independently, meaning they can most likely move the left and right wings independently from one another leading to sideways acceleration (Bahlman et al, 2013).
- Propatagium can be oriented downward in regards to the rest of the wing membrane, increasing the overall curvature of the wing (Bishop, 2006)
- Can make complete rolls and turns (Bishop and Deforest, 2008)
- Wing Loading (see Table 1.)

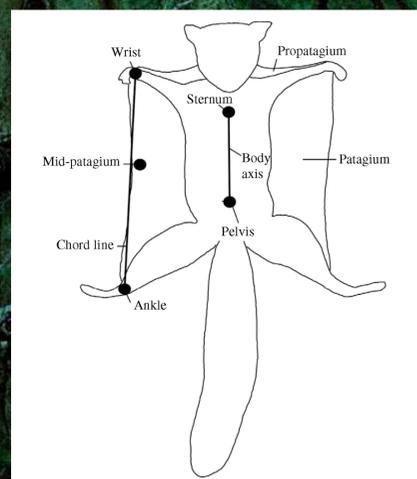


Figure 1. Diagram of flying squirrel anatomy (Bishop, 2006)

Table 1. Comparison of wing loading estimates for various species of flying squirrels, compared to that of human controlled hang gliders, adapted from Thorington and Heaney (1981).

Species	Loading (N/m ²)
Petaurillus kinlochii	40
Petinomys vordemanni	30
Petinomys setosus	40
Hylopetes spadiceus	50
Glaucomys volans	50
Petinomys genibarbis	50
Glaucomys sabrinus	50
Pteromyscus pulverulentus	40
Petaurista elegans	110
Aeromys tephromelas	80
Hang Gliders (Humans)	50

Results and Discussion con't

Humans

Humans not meant to fly/glide so need special equipment such as hang gliders that mimic flying squirrel structure and anatomy to give them the desired wing loading and glide ratio capabilities

Increased physiological stress brought about by hang gliding (Morton et al, 2010)

- Heat, cold, hypobaric, anxiety
- Heart rate at take-off/landing (relatively stable during glide)



Conclusions

Flying squirrels have become very adapted to arboreal life with many morphological and physiological modifications to improve gliding locomotion. Humans, through studying flying squirrels and other such animals, have created artificial structures to allow for the performance of similar gliding motions. We were limited in our comparison of the physiology of flying squirrels and hang gliders as there was restricted literature on the subject. In the future, it would be interesting to perform a more complete comparison including adrenaline and resulting heart rates of humans and flying squirrels during glide, human muscle movements needed to control and stabilize the hang glider and how wingsuits compare to both flying squirrels and hang gliders

References

- Background photo: <http://www.wallpaper.com/wallpaper/3ark-forest-101807.html>
 Flying squirrel photo: <http://www.warrenphotographic.co.uk/11474-southern-flying-squirrel>
 Hang glider photo: <http://www.paperresource.com/wallpapers/7768/hang-glider-hd-wallpaper.html>
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