The dynamic control of feeding in rabbits

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Summary

The rabbit is a widely used model system in comparative and clinical sciences for understanding correlations between anatomy and function in the masticatory system. Previous studies have hypothesised that the rabbit is able to modulate chewing mechanics to process a variety of food types with high efficiency. Through synchronously measuring 3D jaw motions (using biplanar x-ray videography), muscle length change (using fluoromicrometry) and muscle activity (using electromyography) while feeding on foods of varying material properties we have begun to test these hypotheses. Processing tougher food types resulted in an increase in whole chew-cycle duration, and particularly in the slow-closing proportion of chewing. Additionally, working side muscles are recruited more during feeding on tougher food types. Our data suggest that the masticatory system modulates power output through two mechanisms, primarily through changes in masticatory frequency, specifically modulating the power stroke phase of the chew cycle, while also modulating muscle recruitment.

Introduction

The rabbit is widely used as a model system across multiple areas of musculoskeletal research [1]. Their near global geographic distribution makes them a valuable model system for understanding of wider functional, behavioral and ecological adaptation, particularly in the context of natural environmental change and human domestication of animals. Rabbits have been hypothesised to function as 'generalist' masticators, able to dynamically modulate muscle activation and jaw kinematics to process a range of food types. Here, we sought to explore the anatomical and kinematic properties of the rabbit while challenging the masticatory system with a range of foods with different material properties.

Methods

All experimental procedures were performed in accordance with the UK Animal Scientific Procedures Act (1986) and approved by the Universities of Liverpool (PPL: P84984FFD) Animal Welfare and Ethical Review Committee. Ten New Zealand white rabbits (Envigo) were used in this study. Rabbits underwent a single surgery to implant 1mm tantalum beads in the skull and mandible for digital reconstruction of the temporomandibular joint (using biplanar x-ray videography and XROMM workflow) to quantify kinematics while feeding on different food types. Fine wire stainless steel electrodes were implanted into the superficial masseter (SM) muscle to record muscle activity using electromyography (EMG) as well as a pair of tantalum beads to track muscle fascicle length change [2]. Rabbits were recorded feeding on foods with a variety of material properties.

Results and Discussion

Kinematics reveal that the chewing cycle duration is significantly higher when chewing tougher foods (pellets *vs.* apple, 248ms *vs.* 214ms, respectively), and the proportion of the masticatory cycle producing the slow closing 'power stroke' phase is also greater when processing tougher foods (pellets *vs.* apple, 41% *vs.* 32%, respectively). EMG of the SM recover significant differences when function on the working *vs.* balancing side, and show that recruitment is graded with food material property.

The masticatory system of the rabbit is highly compartmentalised. Here we present novel anatomical data for the SM, specifically, the ventrally located pars reflexa. This reflected portion of the SM consists of significantly longer fibre lengths to the main body of the SM, anatomically optimised to function as a displacement specialist and facilitate molar shearing, when compared to the main body of the SM, which is anatomically optimised to generate power and ideal for molar crushing.

Conclusions

Our data suggest that the masticatory system modulates power output through two mechanisms, primarily through changes in masticatory frequency, specifically modulating the power stroke phase of the chew cycle, while also dynamically modulating muscle recruitment.

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References

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