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ENCODING OF HINDLIMB KINEMATICS BY SPINOCEREBELLAR CIRCUITRY

G. BOSCO [1,2*] AND R.E. POPPELE[1]

[1] Department of Neuroscience, University of Minnesota, 6-145 Jackson Hall, 321 Church Street S.E., Minneapolis, MN 55455, USA and [2] Department of Neuroscience, Human Physiology Section, University of Rome at Tor Vergata and Scientific Institute "Santa Lucia", Via Ardeatina 306, 00179 Rome, Italy

INTRODUCTION

The dorsal spinocerebellar tract (DSCT) represents one of the major projection pathways from the spinal cord to the intermediate part of the cerebellum. The neurons of origin of the DSCT receive converging sensory information from hindlimb muscle, skin and joint receptors and their projection to the cerebellum is considered to be the product of the spinal sensory processing of movement-related information (1, 13, 14).

In fact, earlier studies suggested that DSCT activity might relate to global rather than to local parameters of hindlimb postures and movement (5, 6, 7, 8). Specifically, it was proposed that DSCT neurons might elaborate a representation of the limb endpoint kinematics. The proposal stemmed mainly from the result of a principal component analysis of DSCT responses to step-like trajectories applied passively to the left hindfoot of anesthetized cats (8, 15). The first two principal component (PC) waveforms, which accounted for a large fraction of the ensemble activity of DSCT neurons, were correlated respectively with either the waveform of the limb axis length or orientation trajectories.

This finding was rather suggestive of separate sensory representations of limb axis length and orientation. However, a law of intersegmental covariance that has been found to couple the motion of limb segments (3, 7, 9, 10), because of the passive limb biomechanical properties, might produce a unique correspondence between the limb geometry and the limb axis coordinates. As a consequence, a local joint angle reference frame might become indistinguishable from a global limb axis reference frame, when relating neuronal activity to the limb kinematics. In other words, this segmental interdependence makes it unclear whether such global representations unveiled at the level of the DSCT may result from neural processing or from biomechanical factors alone. Moreover, it raises the question of whether explicit representations of joint angles might also be required to encode local changes in limb geometry.

To address these issues, in the present study we decoupled limb geometry from endpoint position by mechanically constraining the knee joint during passively applied movements patterned after a step cycle. Then, we used principal components

*Address for correspondence: Dr. G. Bosco, Sezione di Fisiologia Umana, Fondazione "Santa Lucia", Via Ardeatina 306, 00178 Roma, Italy. Tel. 39 06 72596402, Fax: 39 06 51501477, E-mail: bosco002@umn.edu