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COMPLEX SKILL ACQUISITION: A TEST OF THE BERNSTEIN'S ASSUMPTIONS ON MOTOR LEARNING.

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INTRODUCTION

Bernstein (1967) has proposed an intuitive picture of the process of skill acquisition. The problem of learning can be conceived as the progressive mastery of redundant degrees of freedom. In a first step, the subject solve this problem by "freezing out" a portion of the degrees of freedom set. This strategy allows a reduction of the control constraints. In a second step, degrees of freedom are progressively released, and incorporated into larger functional unit, labelled coordinative structures. A third stage, according to the author, is devoted to the search of movement efficiency: the subject tends to exploit optimally passive forces.

Despite a considerable appeal for the understanding of motor learning, these intuitions of Bernstein have received few empirical support (Vereijken, 1991). The present experiment was designed to test Bersntein's assumptions in the learning of a gymnastics task on parallel bars.

METHODS

8 subjects volunteered for this experiment. None of them had previous experience in gymnastics. They were asked to learn to swing under the parallel bars, in bent inverted hang position (Figure 1). The task was performed during 10 training sessions, with 10 trials for each session. A day of rest was proposed between each session. A video-taped model was provided at the beginning of each training session.

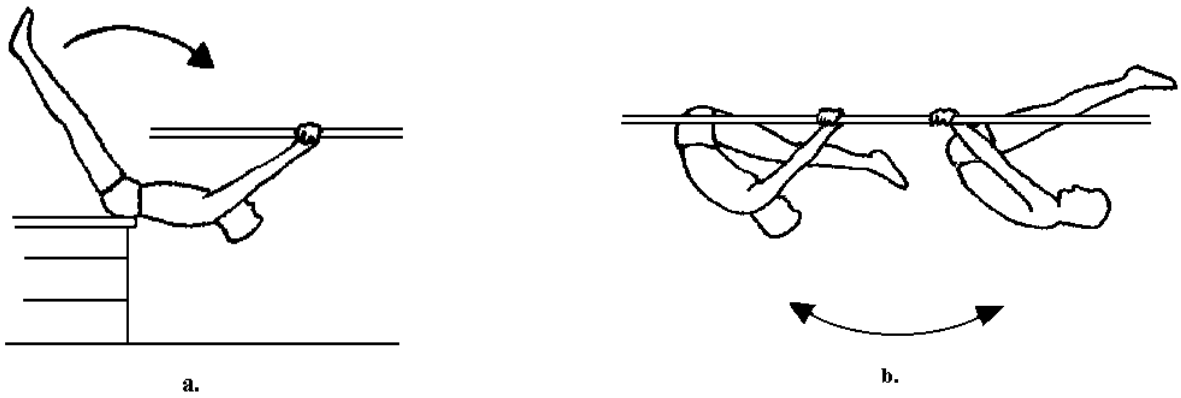

Fig 1: The experimental task (a: starting position; b: swings in bent inverted hang position).

The subjects were equipped with passive markers, located on the right side of the body on (1) knuckle 3 middle finger, (2) wrist axis, (3) glenohumeral axis, (4) ear canal, (5) T12-L1, (6) L4-L5, (7) great trochanter, (8) femoral condyle, (9) lateral malleolus. Markers positions were recorded in two dimensions (saggital plane) by a ELITE Motion Analyser (BTS), at a sampling rate of 100 Hz. Data were smoothed and filtered, and then relevant dependant variables were computed, as time series:

- The upper limb-trunk angle
- The trunk-lower limb angle
- The angle between the axis center of gravity of the body (COG)-shoulder line and verticality
- The phase lag between the pendular oscillations of the COG around the hands, and the vertical oscillations of the COG over the shoulder line.

RESULTS

Results revealed a progressive increase in the variability of the upper limb-trunk and trunk-lower limb angles. This increase began very early in practice, often during the first session of training.

The variability of the angle of the axis COG-shoulder line to verticality tended to decrease with learning. Progressively the subjects were able to hold their COG at the vertical of the shoulder line.

A progressive decrease of the phase lag between the pendular and vertical oscillations of the COG was described. With learning, subjects tended to initiate the vertical displacement of the COG more closely to the beginning of the resistant phase of the oscillation of the body.

DISCUSSION

These results are consistent with the assumptions of Bernstein, concerning the acquisition of complex coordinations. The low variability of body angles during the first trials was consistent with the idea that in a first step, subjects found a solution in a general freezing of their degrees of freedom. This strategy allowed them to sustain the inverted position, and to explore the work space to find a solution to amplify the swing. Then these degrees of freedom are progressively reintroduced into a controllable system.

With learning, subjects tended to optimize the exploitation of gravity. Firstly they minimized the torque of the COG around the shoulder line. Secondly, the decrease of the phase lag between the pendular and vertical oscillations of the COG indicated that if subjects understood quite early in practice that the vertical displacement of COG over the shoulder line constitutes the only viable way to amplify swing, they learned very progressively to fully exploit the gravity during the descendant phase of the swing, and to diminish the resistant work of the weight during the ascendant phase, by reducing the torque of the COG around the hands.

The discussion will focus on the theoretical implication of these results, and on the future exploitation of these data, and particularly the analysis of the individual strategies to search the solution of the problem (Newell et al., 1989).

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