

Control strategy of biped walking of humans that acquired through evolution: from the view point of variance control

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Bernstein, a Russian physiologist in the 20th century, discovered that the arm trajectory of a skilled blacksmith showed variance in every trial during a hitting task, however, his hammer hit the target precisely. From this observation Bernstein concluded that our nervous system exploits joint coordination (joint synergy) mutual compensation of the variance of the joint angles, at some critical points to accomplish a task. During walking, the leg joint trajectories also show some variability in every stride. In our previous study, we analyzed the leg joint synergy from the variance of the leg joint trajectory during bipedal walking of humans and Japanese macaques (*M. fuscata*) by the UCM (UnControlled Manifold) analysis in order to investigate the critical points to realize stable bipedal walking. The results show that in human walking the variance of the toe position relative to the hip position is suppressed by the joint synergy around the second double support phase and the toe position around the moment when the toe passes the lowest position during leg swing. The former is the important period to stabilize the trunk posture and the latter is important to avoid stumbling. Contrary the amplitude of joint synergy of the bipedal walking of macaques was much lower than that of humans during the second double support phase. These results suggest that the utilization of joint synergy during the second double support phase is a control strategy that humans acquired through evolution. Although the effect of the variance of each joint angle on the toe position depends on the amplitude of joint synergy, the leg posture itself also affects the amount of the variance of the toe position. In this study, we have investigated the difference of the leg postures during walking between humans and macaques from the view point of the suppression of the variance of the toe position relative to the hip position. We will report how the leg posture and joint synergy are organized in order to realize stable walking and how the organization manner is different between humans and macaques.