The effects of grip force and skin moisture on friction during dextrous manipulations

André T.[1,2], White O.[1,2], Lefèvre P.[2,3], Thonnard J.-L.[1]

[1]Rehabil & Phys Med Unit, [2]CESAME, [3]Lab. Neurophysiol, Université catholique de Louvain, Belgium

When an object is held between the thumb and index finger, the normal grip force (GF) at the contact surface produces a frictional force that counteracts the tangential load force (TF). This GF must be sufficiently large to prevent the object from slipping. During dextrous manipulations, the nervous system relies on a mechanism that codes the frictional condition at the interface between the object and the fingers, so as to optimally adjust the required GF according to the generated TF. In this study, we examine how GF and moisture of the skin affect the friction at the object-finger interface.

Ten naïve subjects participated in this study. Participants were asked to exert different constant levels of GF on a manipulandum equipped with force-torque sensors (Mini40, F/T transducer; ATI Industrial Automation) and custom moisture sensors. Participants were provided with visual feedback of the GF they generated. Two sensors measured online the moisture of the skin which was classified on an ordinal scale (dry, normal, wet, very wet). A mechanical setup based on a linear motor and springs generated a monotonic increase of TF at the fingertips, until slippage of the manipulandum occurred. The static coefficient of friction (CF) was measured as the value of the ratio TF/GF at slippage. Five consecutive measures of CF were performed for seven values of GF (0.2, 0.5, 1, 2, 5, 10 and 25 N) and 4 moisture conditions.

The results demonstrate that the effects of GF and moisture on the CF present a complex interaction. On the one hand, CF was independent of GF for large values of moisture and independent of moisture for large values of GF. On the other hand, for small and moderate values of GF and moisture, we found significant variations of CF with the two parameters. For a given moisture condition, CF varied as a power function of GF whereas for a given GF, CF could be described by a “bell-shaped” function of moisture. Altogether, we derived a global expression of CF as a function of GF and moisture.

This study provides an online estimate of friction which is of prime importance during dextrous manipulation of small objects.

Supported by Prodex, SSTC, ESA