METHODS TO MEASURE STATIC COEFFICIENT OF FRICTION BETWEEN HAND AND OTHER MATERIALS

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INTRODUCTION

The friction between hand and other materials affects our ability to grasp and manipulate objects. Friction data are needed for the design of tool/consumer products, job analysis, and workstation design. This coefficient of friction is difficult to measure consistently, because it is affected by many factors including: contact force, hydration [1], area of contact, contaminates [2], and direction [3]. The purpose of this study is to develop a simple method of measuring the static coefficient of friction between skin and other materials so that this information can be readily calculated in the field.

METHODS

The proposed method is referred to as the "tilt" method. A flat plate is held in the hand. The hand is then tilted at a steady rate until the plate begins to slide. The static coefficient of friction (μ_s) is equal to the ratio of the shear (friction) force (F_f) to the contact (normal) force (F_n) just before the object starts to move.

F_f is equal to $W\sin\theta$ and F_n is equal to $W\cos\theta$, where W is the weight of the plate and θ is the angle of the plate with respect to the horizontal at the time the plate begins to slide. It can be shown that μ_s is approximately equal to $\tan\theta$.

The standard method entails holding the flat plate on the hand as in the tilt method, but the plate is attached to a force transducer. The subject then increases the horizontal force on the plate until it begins to slide. The μ_s is then calculated as the ratio of the F_f (measured by force transducer at the time the plate begins to slide) to its weight.

Independent variables for the tilt method were: contact area (fingertips vs. flat palm), materials (rubber (Rb), aluminum (Al), cardboard (Cb)), and plate weights (10, 20, 30N). The average F_n and shear force buildup rate (dF_f /dt) at which slippage occurs were calculated for each condition (subjects pooled). The F_n values ranged from 4.2–27N. The dF_f /dt values ranged from 0.8–5.4 N/s. Using the results from the tilt method, the appropriate F_n and dF_f /dt were chosen for each material and contact area, and used for the standard method. The dependent variable was μ_s. Subjects were allowed to practice tracking a constant dF_f /dt by following a bar indicator.

5 university students (3 males, 2 females) volunteered to participate. To remove possible contaminants, subjects washed their hands with soap and rinsed with tap water. They dried their hands with paper towels and air dried for 15 minutes. Each condition was tested 3 times, and trials were randomized.

RESULTS AND DISCUSSION

The μ_s measured by the tilt and standard method for each F_n and material is shown in Figure 1.

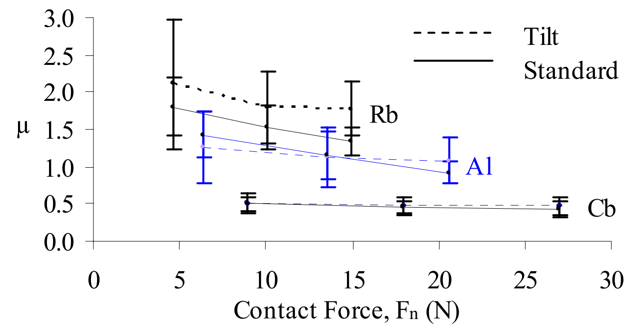

Figure 1: Static coefficient of friction from "tilt" and standard method between palmar skin and three different materials for different F_n's (contact area and subjects pooled, Rb: rubber, Al: aluminum, Cb: cardboard).

Analysis of variance revealed that the μ_s's from the tilt and the standard methods were not statistically different (p>0.05).

The μ_s's decreased with increasing F_n (p<0.05), as observed in the previous studies [1,2,3]. The relatively high μ_s's (2.11±0.88, for the tilt method with Rb) may have resulted from the low F_n's tested.

The μ_s's of fingertips were lower than those of the flat palm. This difference was statistically significant for Rb and Al, while only a trend was observed for Cb. This trend that a narrower skin contact area tended to have a lower μ_s than a wider contact area under clean skin condition was also observed in [2], even though a different material and kinetic coefficient of friction were investigated in [2].

In this study, the μ_s's for Al and Cb were found 1.15±0.37 and 0.48±0.12, respectively (F_n, contact area, method pooled). These values were higher than those calculated from the regression model in [1]: 0.39 and 0.30 for Al and paper, respectively (F_n pooled). This could be due to the difference in skin contact area, since only an index finger and a thumb were used in [1]. Higher values for dF_f/dt and F_n in [1] (15N/s and 22–39N, respectively) could also be the reason for the large difference in μ_s's between the two studies. The dF_f /dt was controlled in this study. However, the effect of different dF_f/dt on μ_s needs to be investigated.

The tilt method is easy to perform, and can be performed in the field. This provides timely, relevant information about μ_s in the workers' environment.

REFERENCES

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