Tribology International 63 (2013) 29–33

Contents lists available at SciVerse ScienceDirect

Tribology International

journal homepage: www.elsevier.com/locate/triboint

Friction and tactile perception of textile fabrics

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ARTICLE INFO

Article history:
Received 29 October 2011
Received in revised form
12 May 2012
Accepted 22 August 2012
Available online 7 September 2012

Keywords:
Skin friction
Textile fabrics
Tactile perception

ABSTRACT

Measuring the friction coefficient between human skin sliding against different types of fabrics has an important role in the development of sport and medical materials.

The characteristics of the skin vary significantly along the human body, so to be able to measure the corresponding friction coefficient at every point of the human body, a portable and easily usable measuring probe is indispensable. The probe developed within the scope of this work is based on a multi-component force sensor whereby the normal and tangential forces can be measured to determine the friction coefficient.

The friction coefficient of human skin against five different fabrics was assessed in two body regions and the average results were compared with the tactile perception. By comparing the answers to a questionnaire about tactile perception with the results of the friction measurements, a positive correlation was obtained especially concerning the slippery and the smoothness properties.

1. Introduction

Our skin is the largest organ of the body—a complex and dynamic system that is vitally important to our health. Skin is also the outermost part of our sensory system and when in interaction with the surrounding objects, it acts as both a force transmitter and a sensor. The friction between the skin and the counter-contact surfaces reflects this double role, limiting the transferred tangential force and reporting about the counter-surface texture, through pleasant and unpleasant sensations.

However, human skin spends most of its time in close contact with clothing and garments made of different fibres. Therefore, measuring the friction coefficient between human skin sliding against different types of fabrics has an important role in the scientific field and in the research and development of sport and medical materials. The friction coefficient between human skin and fabrics is affected by numerous factors like humidity, the fabric itself and of course the properties of the skin [1–4]. The characteristics of the skin can be very different along the human body and depend on the conditioners and moisturisers used [5]. Pailler-Mattei et al. [6] have shown that the lipidic film on the skin surface can be related to the skin adhesion, and the kinetics of sorption/desorption of distilled water by the skin will affect the skin friction coefficient. To be able to measure the corresponding friction coefficient at every point on the human body, a portable and easily usable measuring probe is indispensable.

Friction is an important factor in the pleasant feeling produced when touching an object, especially garments. Additionally, friction plays an important role in skin contact injuries. Therefore, this paper aims to investigate the correlation between the tactile perception and the friction assessed directly by in vivo tests. In this paper, the assessed values of friction are compared with answers to the questionnaire, and we try to determine the reason for the different frictional behaviours.

2. Experimental work

2.1. Textile materials and body regions

Five types of fabrics were used in the scope of the present work (Fig. 1). The materials tested include two knitted fabrics, one with 82% polyamide and 18% elastane (Fig. 1a), and the other with 100% polyester; and three plain weave fabrics made of cotton, silk and wool (Fig. 1c, d and e) respectively.

The friction was measured on the ventral face of the forearm and then on the palm of each volunteer. Nineteen people, both females and males, of different ages were investigated (Table 1).

2.2. Equipment and test procedures

A hand-held probe was specially designed to carry out the present study. The main concern in the development of the equipment was that it should be easy to use and drive by hand. Other requirements were the ability to change the probe tip and to easily access several body regions. The probe, pushed by hand,

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http://dx.doi.org/10.1016/j.triboint.2012.08.018

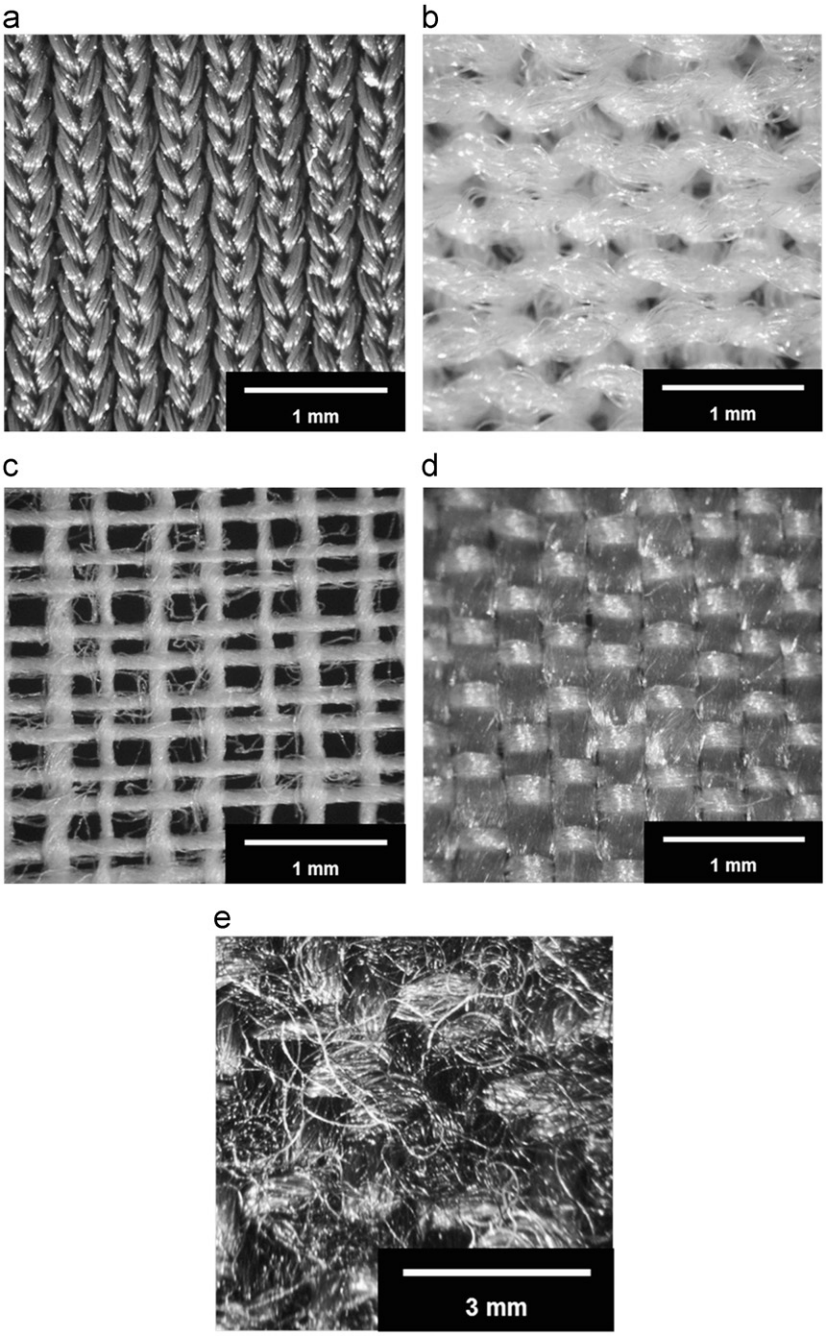

Fig. 1. Morphology of the tested textile fabrics: (a) polyamide based; (b) polyester; (c) cotton; (d) silk; and (e) wool.

Table 1
Volunteers involved in the current study.

Nb.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
F/M	F	F	F	F	F	F	F	M	M	M	M	M	M	M	M	M	M	M	M
Age	21	24	25	27	36	44	48	23	24	24	25	25	26	26	27	35	39	48	57

includes a sensor tip for application onto the skin surface, which is connected to the two-axis force sensor in order to measure both the friction and the normal forces during the movement of the tip across the skin.

The probe holder was designed with a handle to be easily pushed by hand to promote the movement of the probe tip in contact with the body region being analysed. In the current prototype (Fig. 2), the probe comprises of a double cantilever type load-cell to allow the measurement of both the normal and the tangential forces. The probe is connected by a cable to the signal conditioner and the A/D board to allow computer data acquisition during the test. The signal processing and data acquisition are done using the LabVIEW® software development platform.

To avoid edge effects, the PVC probe tip has a gentle spherical surface with a radius of 26 mm. As the sliding results from the hand-pushed action of the probe, the test conditions are not exactly the same for all tests; however, the average conditions consist of a sliding distance of around 40 mm, and a normal load ranging from