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Study on Frictional Characteristics of Medical Wipes in Contact with Mechanical Skin Equivalents

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Abstract
The optimum surface and frictional properties of textiles depend on their specific application. In this study, we examined the frictional behaviour of medical wipes against 15 mechanical near skin equivalents using synthetic leather material and bovine leather. The frictional behaviour characteristics, both static and kinetic, were evaluated at four different normal loads. It was seen that the static and kinetic frictional coefficients decrease with an increasing normal load for all the reference candidates studied. Higher friction was experienced for the movement of the cotton and viscose wipe against leather than that for synthetic polyurethane (PU) and silicone material. The friction of the wipe against any equivalent skin material was found to be dependent on its surface nature and the morphology of the material against which it is in contact and moves. Friction is necessary in real-time use for a wipe to have an inherent frictional resistance for movement against skin during use.

Key words: *hydroentangled nonwoven, kinetic friction, mechanical skin equivalent, viscose, surface roughness, static friction, tribology, wipe.*

Introduction

The friction of textiles, especially for medical wipes used during and after surgery, is very much of importance and can be critical with respect to the handle and comfort behaviour. This friction depends on various factors that exist which include the normal force or load, the area of contact, the speed of sliding or movement of the wipe over the skin, the surface texture of the wipe, etc. Many publications have been made on the friction of fabrics [1-5], where the sliding friction behaviour of fabrics against solid surfaces was studied. A few papers have dealt with the frictional characteristics of fabrics against human skin and skin equivalents relating to the handle properties of apparel fabrics [6-8].

Most of the test methods for the measurement of friction in fabrics use variables such as the mode of contact, the morphology of the contacting materials, the speed of movement, the normal force applied and the existing preconditions at the area of contact. A medical wipe may rub against the skin where the above-mentioned variables come to play a crucial part. The friction parameter needed to describe the friction trace when a wipe is rubbed against the skin is critical and conforms to the procedures of many researchers [9-12]. Hence a study was made to investigate the tribology of medical wipes in contact with near skin equivalents, as the frictional properties of wipes are of importance in contact with human skin.

Many authors are in consensus in suggesting that textile materials fail to obey Amonton's laws of friction [13-16]. The relationship as proposed by Wilson [17] and substantiated by Howell and Mazur [18], $F = cN^n$ is seen to be the best form representing the relationship between the frictional force and normal load. The frictional properties are represented by the following two parameters: c – frictional parameter and n – the material or friction index. These can be evaluated from the frictional force and normal load. Ramkumar [19] suggested a new constant 'K', where $K = c^{1/(1-n)}$, which can be used to compare and characterise the frictional properties of different textile materials.

Derler [20] suggested that the tribology of skin in contact with textiles is important because the tactile properties of fabrics are closely related to their surface and frictional properties. In this study, the mean frictional coefficient between the skin and reference textile material measured ranged from 0.27 to 0.71, showing considerable differences among the individual subjects. Furthermore as mechanical contacts can be especially problematic for sensitive, injured skin, the frictional characteristics of medical wipes become more relevant.

In the case of medical wipes, the main focus of product development has been fibre material and the combination of fabric types like woven, nonwoven etc., where frictional characteristics of these material types are expected to have a critical influence on their selection.

Sivamani [21] and Dowson [22] reviewed the literature on the tribology of human skin from dermatological studies and suggested that skin hydration, the lipid content of the skin surface, and the surface structure are important factors that affect the frictional properties of skin against textile materials. Cottenden *et. al* [23], in their study of a new method for measuring the friction on nonwoven materials and the curved surface of the volar forearm, found that the coefficient of static friction for normal and over-hydrated skin varied in the ranges of about 0.3-0.5 and 0.9-1.3, respectively.

The aim of the present study was to investigate the friction of two types of reference materials, viz., a commonly used woven bleached cotton surgical gauze wipe and a hydroentangled nonwoven wipe made from viscose fibre against various synthetic leather polyurethane materials of varied texture, cattle skins of different surface finishes and silicone sheet to simulate human skin. The nature of fabric friction is analysed using frictional parameters such as the ratio F/N, n, c and c/n. Furthermore the theoretical concepts of friction were related to the adhesion mechanisms and the friction of elastomeric skin equivalents of varied topographical nature at the skin-material interfaces.

Materials and methods

Materials

In the study reported, a 100% cotton woven bleached ply surgical mopping wipe (India) and 100% viscose hydroentangled nonwoven fabric wipe (Birla Cellulosic, India) were used as the testing materials. The physical properties of these tested under standard test methods; ASTM D1777-07 for thickness measurement, ASTM D3776-09-C for fabric weight evaluation, etc. are given in ***Table 1***.

For the purposes of measuring the friction resistance of these wipes against various mechanical skin equivalents, six types of synthetic leather polyurethane sheet materials, one silicone smooth, one elastoflex polyurethane and seven differently textured bovine leather samples served as reference materials (India). The physical parameters of the wipes and mechanical skin equivalents used in this study are also given in ***Table 1***.

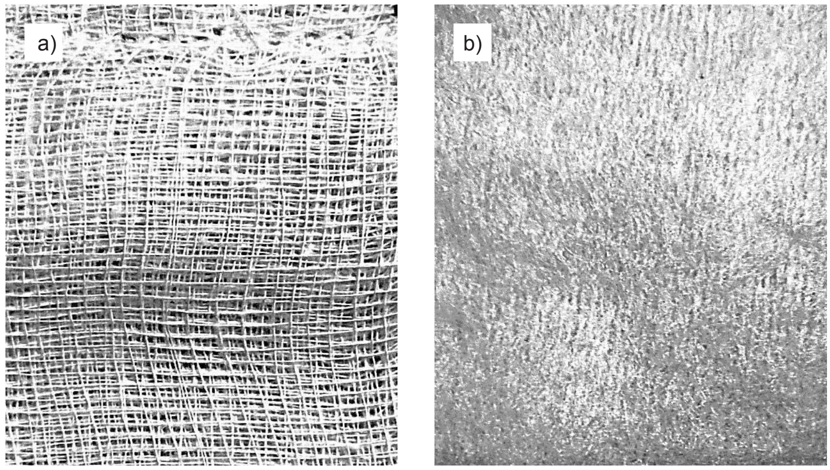

Figure 1. *(a) Cotton woven wipe, (b) viscose hydroentangled nonwoven wipe.*

Table 1. *Physical parameters of the wipes and mechanical skin equivalents.*

Fibre type/fabric type	Fabric thickness, mm	Fabric areal density, g/m²
Natural-cotton Woven fabric-gauze ply	0.98	130-150
Synthetic-viscose (1.1 dtex, 38 mm) Hydroentangled nonwoven fabric	0.86	120-130
Polyurethane sheet—-P_1	0.67	1123
Polyurethane sheet—-P_2	0.56	608
Polyurethane sheet—-P_3	1.09	616
Polyurethane sheet—-P_4	0.68	546
Polyurethane sheet—-P_5	0.92	619
Polyurethane sheet—-P_6	0.46	490
Bovine leather—-L_1	1.56	1082
Bovine leather—-L_2	1.83	1227
Bovine leather—-L_3	1.86	1277
Bovine leather—-L_4	1.62	1021
Bovine leather—-L_5	1.80	1267
Bovine leather—-L_6	1.50	1015
Bovine leather—-L_7	1.31	822
Polyurethane sheet Elastoflex—-Pe	4.10	2268
Silicone smooth sheet—-Ps	2.23	246

Methods

Friction measurements

The frictional properties of the cotton surgical wipe and viscose hydroentangled wipe against the various candidates taken for skin equivalents were measured using standard tensile testing apparatus. All the experimental work was done in a standard atmosphere of 21 ± 1°C and 65 ± 2% RH.

In the method used for measuring the static and dynamic or kinetic friction force, an INSTRON universal tensile strength tester (MODEL 5500R) fitted with an appropriate friction assembly was utilised (ASTM D 1894-modified with respect to the crosshead speed and distance traversed). The principle of measurement was based on the rectilinear motion of a wooden sled (80 x 50 mm) weighing 25 g over a horizontal platform made of aluminium (520 x 150 mm) at a constant speed of 50 mm/min attached to the INSTRON crosshead by means of an inextensible Kevlar towing yarn passing over a frictionless pulley (***Figure 2.a,*** see page 122).

The frictional behaviour of the wipes was evaluated by mounting the skin equivalent candidates one at a time on the experimental table, securing it by means of clips to the platform so as to hold it stable and prevent slipping or folding during the experiment, as shown in ***Figure 2.b.*** (see page 122). The sled is covered with the surgical wipe on the sliding surface and securely fastened with adhesive tape. The sled with the wipe was weighed before doing the test. Fresh samples were used for all the tests, and the test with each skin equivalent and a sled load was done five times.

The sled was positioned on the platform ensuring fabric to bottom alignment. As the crosshead clamping of the free end of the towing yarn moves at a constant speed of 50 mm/min, it pulls the sled, and frictional resistance to movement arises between the surfaces in contact, which is recorded graphically and numerically by the computer over a distance of 0 to 50 mm traverse. The experiment was also carried out by loading the sled with selected weights of 20 g, 50 g and 100 g to increase the normal force applied and compression on the fabric studied.

Fifteen different materials were investigated as mechanical skin equivalents. The surface roughness and shore hardness parameters were also determined for these materials. Surface roughness has a microcosmic geometric form on the work-piece surface composed of peaks and valleys with small interspaces. The surface roughness is defined by the Ra (μm) value and is the common parameter for analysing the surface structure, which was determined using portable mechanical profilometer Mitutoyo SJ201P (Japan) series equipment (***Figure 3,*** see page 122). The surface tester is a surface measuring device used to trace the surface profile of different surfaces.

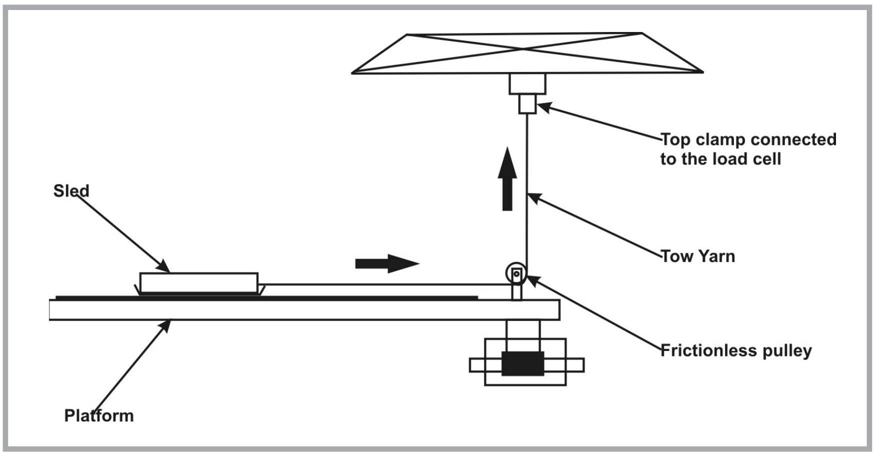

Figure 2.a. *Schematic diagram of the friction measuring set-up.*

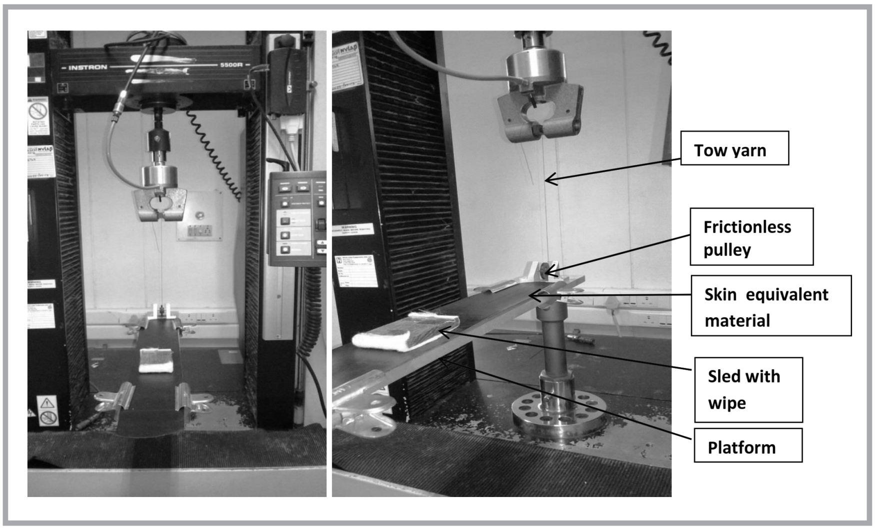

Figure 2.b. *Friction measuring set-up on INSTRON tester.*

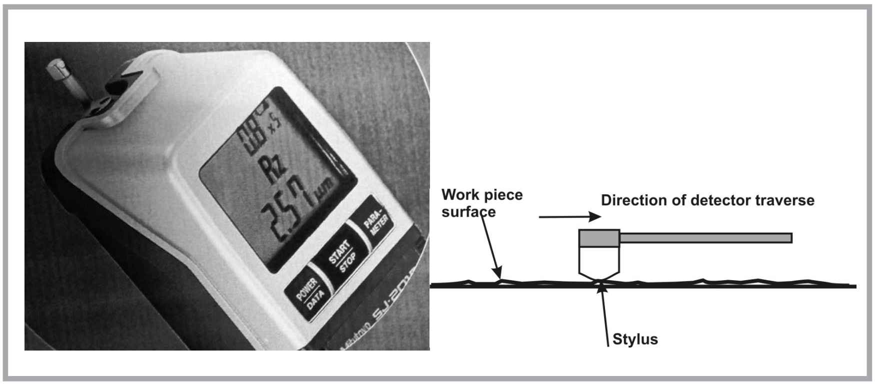

Figure 3. *Surface roughness tester.*

The vertical stylus of the device senses minute irregularities of the surfaces and presents the results digitally on the LCD screen. The roughness value is measured employing the principle of center line average (differential inductance method). The average roughness is computed by comparing all the peaks and valleys to the mean line and then averaging them over the entire cut-off length (0.8 mm) and evaluation length. The sum of the maximum profile peak height and maximum profile valley depth in one sampling length is defined as Rz (μm), which was also measured.

The shore hardness 'A' was measured using a Durometer (USA) with multi-layer samples having a total thickness of 8 to 10 mm. as per the ASTM D2240 standard. A Durometer is an instrument for testing the hardness of various plastics and rubber and measures the depth of an indentation in the material created by a given force on a standardised presser foot. This depth is dependent on the hardness of the material, its viscoelastic properties, etc.

Experimental results and discussion

Surface roughness and shore hardness of near skin equivalents

From ***Table 2***, it can be seen that the materials investigated had varied surface roughness. The 'Ra' value, 'Rz' value and shore hardness 'A' ranged from 18 for silicone sheet material [Ps] to 85 for polyurethane sheet material [Pi]. In this context, hardness could be taken as the property of a material that enables it to resist plastic deformation. A low value of shore hardness for a silicone smooth sheet indicates the flexible nature and compressible character of that material.

Static and kinetic friction of near skin equivalents

Frictional forces measured for the wipes against the reference skin equivalents using the friction testing set-up on an Instron tester varied depending upon the surface texture of the reference candidates. The trace of the frictional force or resistance versus the traverse length is shown in ***Figure 4***. The maximum value of the friction corresponds to the force needed to start the movement of the sled, which is called the static frictional force. After the sliding starts, the frictional resistance decreases, and one can see a characteristic stick-slip phenomenon curve. Once the motion is in progress, the amplitude of the resistive force would depend on the surface nature of the skin equivalents as well as on the morphology and structure of the wipe.

The typical static and kinetic frictional coefficients were measured with four levels of normal loads expressed in pressure units of Pascal after normalising the load values by the apparent area of contact, respectively, for the cotton wipe and viscose wipe used as reference materials in this study when the surface resistive forces were measured over a range of four normal loads. ***Tables 3*** & ***4*** give the static [F/N]_s and kinetic frictional [F/N]_k behaviour of the cotton wipe against the polyurethane sheet, elastoflex polyurethane sheet and silicone smooth sheet materials used as skin equivalent candidates in this study.

From ***Table 3***, it is observed that for all skin equivalent synthetic PU materials marked P1 to P6, Pe and Ps, both the static and kinetic frictional values for the movement of the cotton and viscose wipes against them tend to decrease as the normal pressure increases. This trend may indicate deviation from Amonton's law in the case of viscoelastic materials like the textile wipes used in this study. It can also be seen that the kinetic friction is lower than that of the static friction. With the start of the sliding movement, the fabric [wipe] surface smoothens, the effect of which is more pronounced with higher lateral compression and there is a more even load distribution as the normal pressure is increased, resulting in structural flattening. It is also observed that in the case of Pe and Ps, the static and kinetic frictional resistance to motion of the cotton wipe is comparatively higher. In the case of Ps, the [F/N]_k value ranges from 0.793 to 0.693 over the normal load ranges considered.

Comparing the data from ***Table 4*** (see page 124) for the frictional behaviour of the viscose wipe against the synthetic PU skin equivalents, it can be seen that the static and kinetic frictional values are considerably less than those for cotton wipes, which may be due to the fact that hydroentangled viscose wipes are more compressible and resilient than cotton gauze ones and that the load-compressible properties of these two wipes are different. In the case of the cotton gauze wipe, the yarn interlacement points and loose surface fibres offer higher resistance to the movement of the wipe compared to the viscose hydroentangled wipe, where there are no prominent interlacements and the fibres are embedded or entangled and locked in the fabric structure and do not come out freely to the surface to resist the movement.

Tables 5 and ***6*** (see page 124) show [F/N]_k values for the movement of the cotton wipe and viscose wipe against seven differently textured bovine leather samples considered as skin equivalents. It can be perpetually observed from ***Figures 5*** & ***6*** (see page 124) that in the case of leather samples the static and kinetic frictional values are considerably higher for the movement of wipes compared to the synthetic skin equivalents. These higher values may be due to the different surface morphology in the case of leather samples and can be related to the surface roughness [Ra value] data presented in ***Table 2***. The Ra [µm] values for the leather samples are significantly higher than those for synthetic PU materials. The frictional values follow the same

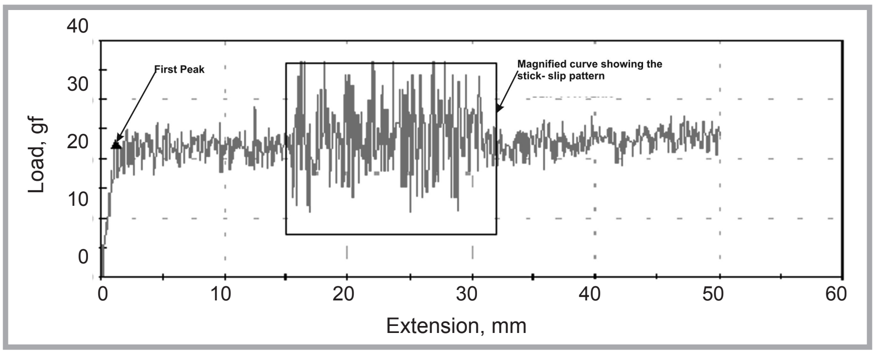

Figure 4. *Typical fabric with skin equivalent frictional load vs. extension trace (frictional trace).*

Table 2. *Surface roughness and shore hardness of mechanical near skin equivalents.* ***Note:*** *P_{1-6} – polyurethane sheet, L_{1-7} – bovine leather, Pe – elastoflex polyurethane sheet, Ps – silicone smooth sheet.*

Material	Surface roughness Ra, µm	Parameter Rz, µm	Shore hardness 'A'
P1	2.62–2.73	10.34–2.73	85
P2	1.40–7.66	10.43–28.89	80
P3	2.09–4.51	13.52–20.75	50
P4	1.37–1.77	7.80–10.73	62
P5	2.66–2.79	13.68–15.30	45
P6	16.18–33.05	57.53–108.80	88
Pe	16.52–20.66	3.87–5.91	20
Ps	0.75–1.03	78.05–83.90	18
L1	3.87–5.84	20.75–24.59	76
L2	5.26–5.53	27.50–33.38	72
L3	3.36-5.24	50.58–58.79	69
L4	7.25–9.98	37.21–46.23	60
L5	6.45–6.94	32.40–42.81	74
L6	3.31–3.79	18.52–21.25	80
L7	3.65–4.02	20.71–23.44	78

Table 3. *Frictional characteristics of cotton wipe against mechanical near skin equivalents (synthetic leather).*

Sample No.	Friction type	Normal pressure, Pa			
		67.91	116.95	190.5	313.08
P1	(F/N)_s	0.235	0.218	0.213	0.212
	(F/N)_k	0.224	0.196	0.187	0.182
P2	(F/N)_s	0.531	0.514	0.496	0.485
	(F/N)_k	0.472	0.461	0.452	0.451
P3	(F/N)_s	0.303	0.277	0.274	0.271
	(F/N)_k	0.281	0.262	0.260	0.258
P4	(F/N)_s	0.380	0.369	0.368	0.366
	(F/N)_k	0.330	0.326	0.322	0.317
P5	(F/N)_s	0.486	0.462	0.446	0.436
	(F/N)_k	0.433	0.412	0.387	0.385
P6	(F/N)_s	0.414	0.373	0.367	0.366
	(F/N)_k	0.392	0.367	0.362	0.359
Pe	(F/N)_s	0.562	0.554	0.549	0.547
	(F/N)_k	0.518	0.508	0.498	0.492
Ps	(F/N)_s	0.820	0.814	0.784	0.755
	(F/N)_k	0.793	0.737	0.704	0.693

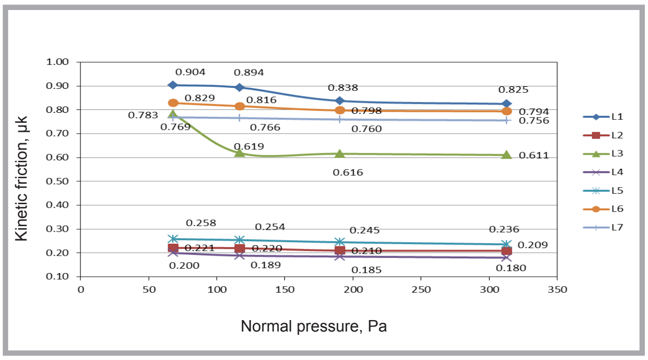

Figure 5. Kinetic friction coefficient vs. vormal pressure (Pa) for cotton wipe against bovine leather.

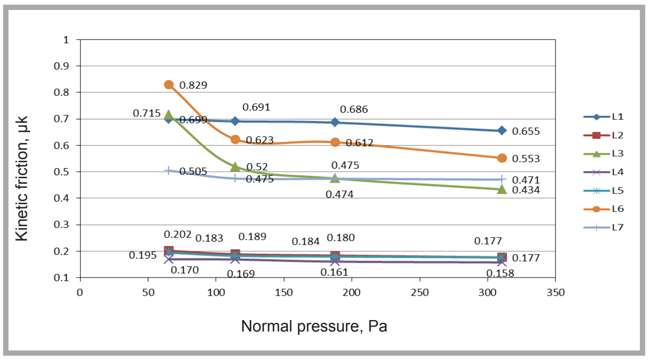

Figure 6. Kinetic friction coefficient vs. normal pressure (Pa) for viscose nonwoven wipe against bovine leather.

Table 4. Frictional characteristics of viscose wipe against mechanical near skin equivalents (synthetic leather).

Sample No.	Friction type	Normal pressure, Pa			
		65.22	114.25	187.80	310.39
P1	(F/N)_s	0.278	0.264	0.255	0.251
	(F/N)_k	0.257	0.238	0.236	0.223
P2	(F/N)_s	0.485	0.461	0.457	0.455
	(F/N)_k	0.447	0.441	0.439	0.435
P3	(F/N)_s	0.358	0.345	0.340	0.338
	(F/N)_k	0.290	0.288	0.287	0.282
P4	(F/N)_s	0.276	0.269	0.267	0.264
	(F/N)_k	0.253	0.241	0.236	0.233
P5	(F/N)_s	0.430	0.408	0.390	0.387
	(F/N)_k	0.361	0.348	0.345	0.342
P6	(F/N)_s	0.393	0.381	0.372	0.370
	(F/N)_k	0.371	0.354	0.346	0.345
Pe	(F/N)_s	0..579	0.558	0.549	0..540
	(F/N)_k	0.476	0.467	0.463	0.460
Ps	(F/N)_s	0.671	0.657	0.656	0.638
	(F/N)_k	0.627	0.626	0.620	0.617

Table 5. Frictional characteristics of cotton wipe against near skin equivalents (leather).

Sample No.	Friction type	Normal pressure, Pa			
		67.91	116.95	190.5	313.08
L1	(F/N)_s	0.912	0.902	0.900	0.881
L2	(F/N)_s	0.313	0.253	0.245	0.243
L3	(F/N)_s	0.830	0.719	0.708	0.689
L4	(F/N)_s	0.248	0.232	0.227	0.224
L5	(F/N)_s	0.282	0.272	0.268	0.266
L6	(F/N)_s	0.887	0.865	0.863	0.862
L7	(F/N)_s	0.943	0.819	0.797	0.790

Table 6. Frictional characteristics of nonwoven viscose wipe against near skin equivalents (leather).

Sample No.	Friction type	Normal pressure, Pa			
		65.22	114.25	187.80	310.39
L1	(F/N)_s	0.772	0.761	0.722	0.719
L2	(F/N)_s	0.227	0.203	0.200	0.193
L3	(F/N)_s	0.767	0.567	0.523	0.493
L4	(F/N)_s	0.198	0.193	0.188	0.186
L5	(F/N)_s	0.211	0.202	0.195	0.193
L6	(F/N)_s	0.909	0.671	0.627	0.608
L7	(F/N)_s	0.591	0.582	0.569	0.562

decreasing trend as the normal pressure increases over the range considered in this study.

Frictional parameters related to the surface contour of near skin equivalents

According to the relationship between the normal load and frictional force as proposed by Wilson, Howell & Mazur, the values of friction parameters ‘c’ and ‘n’ were calculated using regression analysis, and are given in ***Tables 7.a** & **b*** for both cotton and viscose wipes during movement on skin equivalent materials. The friction of a viscoelastic material like a wipe sliding on a surface is characterised by the bending of both the materials in contact and also depends on the surface morphology of the material on which the wipe moves. The friction of skin in real-time is determined by the adhesion, meaning that both the static and kinetic coefficients tend to decrease with an increasing normal pressure or load [24, 25]. As the experiments were carried out with skin equivalent reference materials, no general relationship could be established for the deformation that takes place with different loads applied.

From ***Table 7.a***, it can be seen that for synthetic skin equivalents the ratio of ‘c/n’ ranges from as low as 0.0634 (cotton wipe) and 1.1832 (viscose wipe) for Ps material. The value of the friction parameter ‘c’ is also comparatively less for Ps. This lower value for Ps could be related to the area of contact and also to the surface roughness (Ra value) and shore hardness (A), reported in ***Table 2***. It can also be seen from ***Tables 3** & **4*** that the smooth skin equivalent material Ps had the highest friction coefficients, both static and kinetic, as expected for increased effective adhesion and contact area.

In the case of leather skin equivalents in ***Table 7.b***, the 'c/n' ratio ranged from 0.0850 for L1 to 0.6617 for L4 for the cotton wipe. With the viscose wipe the ratio ranged from 0.0286 to 0.6204, lower than those for the cotton wipe. The comparatively lower values of 'c' and 'c/n' for viscose wipes could be due to the smoother surface presented by the hydroentangled nonwoven, offering lesser resistance to movement against the skin equivalents.

Figures 7 & ***8*** show the relationship between the normal load for the cotton wipe and viscose wipe and the the skin equivalent frictional force for synthetic material references, respectively, as a logarithmic plot.

From the data presented in ***Tables 7.a*** & ***7.b***, it can be seen that the frictional coefficients measured for the movement of the wipes very much depend on the contact pressure. Furthermore another component of importance is the surface morphology of the surface over which the wipe is in contact. ***Figure 9*** (see page 126), shows the varied morphology of the bovine leather samples examined in this study. However, the frictional coefficients decreased with increasing contact pressure in the experiments for both the cotton wipe and nonwoven viscose wipe under dry conditions. For a smoother material like Ps (silicone smooth material), the friction coefficients are much higher, indicating a higher resistance to movement mainly determined by the adhesion due to the molecular bonding of surface atoms in both contacting materials. The mechanism that frictional forces can be generated through two actions can be explained as being from the "ploughing" action, and the other from the force required for overcoming adhesion between the two surfaces [25]. The former produces friction forces due to the mechanical interlocking of surface roughness elements, while the latter generates friction forces due to dissipation when the atoms of one material are plucked out of the attractive range of their counter-parts on the material surface. The higher friction coefficients for the movement of wipes against L1, L3 & L6 could be related to their surface roughness characteristics (Ra & Rz), explained by their surface morphology (***Figure 9***). The mechanism of adhesion is greater for smoother surfaces compared to rough, wherein the real contact area is small between the wipe and the surface asperities of the leather. This phenomenon can also

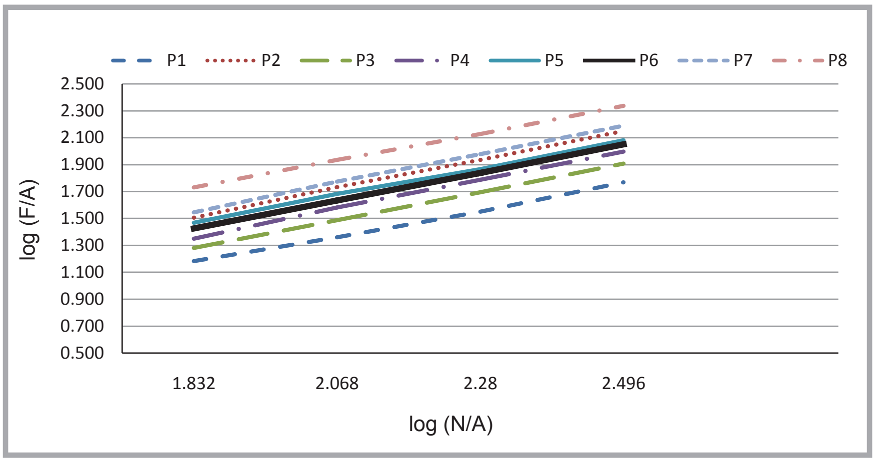

Figure 7. *Logarithmic plot of (F/A) vs. (N/A) for kinetic friction of cotton wipe against synthetic skin equivalents.*

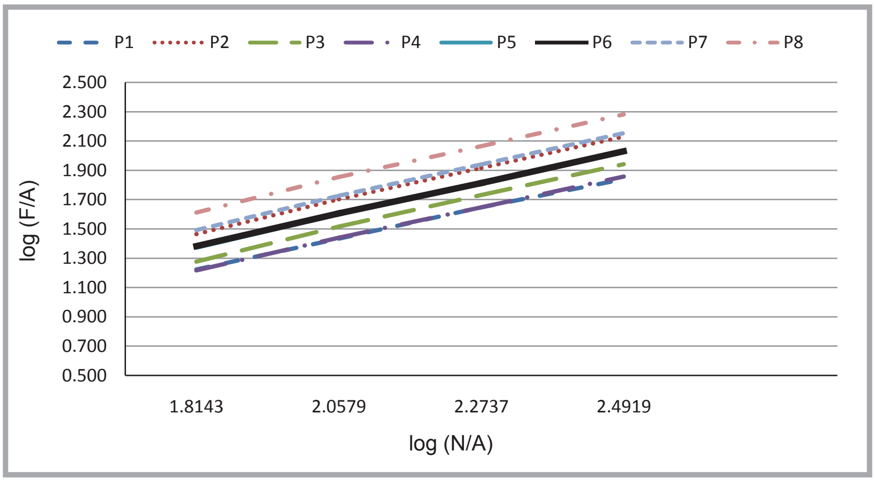

Figure 8. *Logarithmic plot of (F/A) vs. (N/A) for kinetic friction of viscose wipe against synthetic skin equivalents.*

Table 7.a. *Friction parameters of wipe-to-skin equivalents.*

	Cotton wipe *vs.* synthetic skin equivalents			Viscose wipe *vs.* synthetic skin equivalents		
Sample No.	n	c	c/n	n	c	c/n
P1	0.8657	0.4152	0.4796	0.9159	0.4414	0.4819
P2	0.9685	0.2699	0.2787	0.9823	0.3180	0.3237
P3	0.9476	0.4624	0.4880	0.9826	0.5085	0.5175
P4	0.9729	0.4314	0.4434	0.9481	0.5066	0.5343
P5	0.9176	0.2150	0.2343	0.9654	0.3823	0.3960
P6	0.9346	0.3098	0.3315	0.9532	0.3500	0.3671
Pe	0.9662	0.2243	0.2321	0.9790	0.2858	0.2919
Ps	0.9106	0.0577	0.0634	0.9884	0.1811	0.1832

Table 7.b.

	Cotton wipe *vs.* leather skin equivalents			Viscose wipe *vs.* leather skin equivalents		
Sample No.	n	c	c/n	n	c	c/n
L1	0.9611	0.0817	0.0850	0.9337	0.0806	0.0863
L2	0.9188	0.5509	0.5996	0.9587	0.5784	0.6033
L3	0.6910	0.3883	0.5619	0.8494	0.1419	0.1670
L4	0.9481	0.6274	0.6617	0.9326	0.5786	0.6204
L5	0.9383	0.6024	0.6420	0.9404	0.4761	0.5062
L6	0.7590	0.3331	0.4388	0.9704	0.0278	0.0286
L7	0.9582	0.2275	0.2374	0.9913	0.0983	0.0992

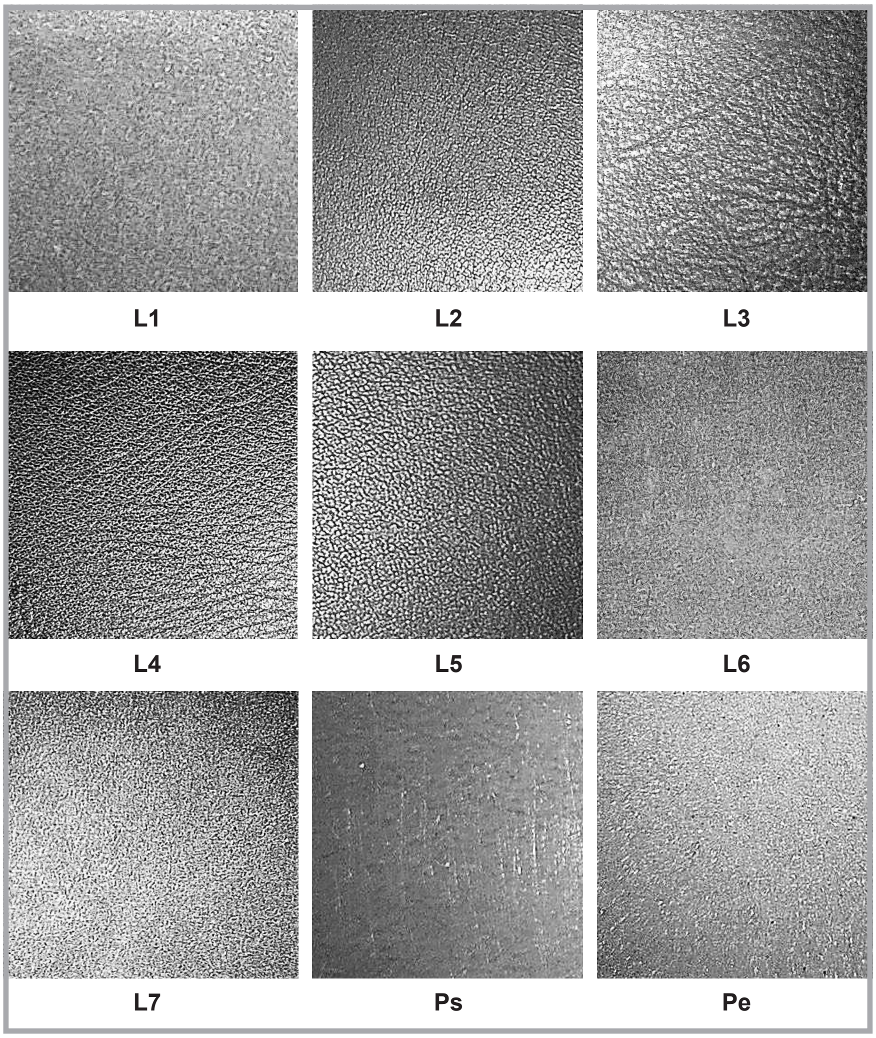

Figure 9. Surface contour of the different bovine leather (Li, i = 1 to 7), silicone smooth (Ps) and elastoflex PU (Pe) used in this study.

be extended to the movement of wipes against skin in real time use.

This behaviour was also studied by Bowden [26], who attributed the frictional resistance to movement to the higher number of contact areas and the size of the contact area directly influencing the coefficient of friction. The higher friction coefficients for the movement of the wipe on a smooth surface would be due to an increased effective contact area and adhesion [27, 28].

Conclusions

- Friction coefficients measured between the cotton wipe, viscose wipe and the synthetic and leather reference materials were found to vary considerably among individual reference candidates.
- In all cases studied, for the four levels of normal loads used, the static friction is found to be always higher than the kinetic friction.
- Frictional resistance to the movement of the cotton wipe against both the synthetic and leather reference candidates studied were greater than that of the viscose wipe, which can be explained by the adhesion phenomenon.
- The lower frictional coefficients for the viscose hydroentangled wipe compared to the woven cotton one indicate the higher sensitiveness of the study to the surface texture and the roughness characteristics of the wipes during motion.
- The friction coefficient tends to decrease with an increase in normal pressure or load, indicating that as the pressure on the fabric increases, compression takes place and relatively a structural flattening and smoothening of the wipe surface occurs with movement.
- A decrease in friction coefficients with increasing normal pressure is consistent with experimental studies in which the friction of dry skin was investigated using mechanical skin equivalent materials.
- As one would expect, for medical wipes to always present a dry smooth surface, their frictional behaviour under different levels of hydration needs to be evaluated under moist conditions.
- In real-time use where it is necessary for the wipe to rub against human skin, factors of the skin like the moisture level, the elastic nature, the underlying muscle support, the existing oil content on the skin surface and the skin texture are certain factors that need a critical consideration.
- For efficient removal of blood or oozage from the surgical site, one would expect that the wipe used to offer a certain level of frictional resistance so that it does the job intended without causing damage to the wound.
- With the advancement in material sciences, an efficient skin model inculcating the different levels of skin hydration in real-time use would be very useful to medical textile technologists for the development of improved wipes of the best functionality and frictional properties.

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