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ROLE OF FRICTION ON THE ABILITY OF GOALKEEPER TO CATCH SOCCER BALL

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ABSTRACT
The objective of this research is to improve the performance of the goalkeeper in catching soccer ball. This can be achieved by investigating the static friction displayed by the soccer ball and the top layer of the goalkeeper glove, goalkeeper hand skin as well as his short sleeve jersey under dry and water wet conditions. Besides, the comfort of the goalkeeper depends on the electrostatic charge (ESC) generated from the triboelectrification of ball, gloves and jersey of the goalkeeper. ESC was measured for the sliding of the tested materials.

It was observed that, at dry and wet sliding, backhand of the glove showed higher friction than the palm. The friction values guaranteed good ability for the goalkeeper to catch the ball. Friction coefficient displayed by the ball sliding on jersey of the goalkeeper showed the lowest values. That observation increases the danger of ball slip when it touches the jersey of the goalkeeper. In contradiction to that, sliding of the ball on the hand skin displayed higher friction coefficient compared to that observed for sliding on the jersey.

Backhand of the glove gained higher ESC than palm at both dry and wet sliding. The ball surface at dry and wet sliding conditions gained positive ESC of relatively lower values. ESC generated from sliding the ball on the jersey generated very high values and migrated to the goalkeeper body. ESC values generated from sliding of the ball on hand skin were lower than that recorded for sliding against jersey. After more rubbing, the jersey gains more charge. Then the goalkeeper will be subjected to high intensity of electric field. This observation confirmed the necessity to develop new materials of low ESC.

KEYWORDS
Friction coefficient, soccer ball, goalkeeper, gloves, hand skin, short sleeve jersey.

INTRODUCTION
Catching and punching soccer ball are performed by the palm and the backhand of the goalkeeper gloves. Besides, during catching the ball, it slides on the gloves, hand skin, and cloths of the goalkeeper. Experiments were carried out to measure the friction coefficient displayed by the sliding of soccer ball on the palm and backhand of goalkeeper glove at different values of applied load at dry and water wet contact, [1].

The experiments revealed that the difference in friction coefficient between palm and backhand should be minimized. The gripping ability of the glove is one of the main factors to evaluate its quality. It should provide an adequate grip and tactile response under a wide range of conditions. In football, goalkeeper needs gloves to keep his hand safe and enhance his ability to catch the ball. This ability can be developed by controlling the friction between gloves and the football. Quantitative measurements of the friction coefficient between ten types of glove materials and the ball surfaces were carried out, [2, 3]. It was observed that neoprene coated glove recorded the highest friction coefficient that approached 1.13 followed by nitrile, latex, polyvinyl chloride. In addition to that, the proposed sport gloves should be covered by a layer made of rubber to provide non-slip gripping. Those gloves should comprise a textile which includes a plurality of small dots of rubber disposed on its surface to facilitate improved gripping. Many researches have reported the theoretical analysis of the dynamics of soccer ball, while some have discussed the effect of friction. Little attention was directed to the experimental measurement, [4 – 8]. The friction force between the soccer ball and the materials used for the goalkeeper gloves was measured.

The friction between hand and ball in rugby was studied, [9, 10], using three different gloves and the bare hand. Visualization of the handling of four pimple patterns of the ball at dry and wet conditions was discussed, [11, 12]. Friction coefficient increases up to maximum then decreases with increasing velocity or normal force, [13]. Friction testing machine was developed to test the interaction between soccer ball materials and artificial turfs, [14]. The friction is measured by monitoring changes in torque through the use of an inline torque transducer. It is necessary for the goalkeeper to wear gloves to enable him to catch the ball. The material of the gloves should provide grip properties, protect the hands, act as a shock damper and improve ball retention properties, [15, 16]. The gloves should be designed to prevent bending backwards of the fingers when saving, [17], and allow the fingers to flex forwards to catch the ball. Variety of materials such as foamy polymers and sandwich-like microstructures were tested as friction materials, [18, 19]. Measurement of friction coefficient is of critical importance in assessing the proper friction properties of gloves and their suitability to be used in application to enhance the safety and stability material handling.

ESC includes potentially dangerous electrical fields. The charge generated can be more than 25,000 volts. It is well known that when two different materials contact each other, they may get charged. This tribocharging phenomenon is also known as triboelectrification when materials rub against each other, [23]. It was found that material strain can strongly influence triboelectric charging. Besides, straining a material can produce ions, electrons, and radicals that can react to form charged species, [24]. Tribological studies to correlate friction coefficient and wear with the role of the electric charges were carried out. Polymers are characterized by a low mobility leading to a strong localization of the electric charges, and consequently to their trapping on structural defects inducing local variations of the dielectric susceptibilities, [25]. Then, an external stress can permit releasing of the trapped charges, [26], and, consequently, the release of the stored polarization energy, inducing catastrophic effects, such as dielectric breakdown, rupture or wear.

The wide use of polymer fibers in textiles necessitates to study their electrification when they rubbing other surfaces. ESC generated from the friction of different polymeric textiles sliding against cotton textiles, which used as a reference material, was discussed,

[27]. Experiments were carried out to measure the electric static charge generated from the friction of different polymeric textiles sliding against cotton under varying sliding distance and velocity as well the load.

The aim of the present study is to discuss the variation of friction coefficient displayed by the soccer ball and the top layer of the goalkeeper glove, goalkeeper hand skin as well as his cloths under dry and water wet conditions.

EXPERIMENTAL

The present work studies the role of in the ability of the goalkeeper to catch soccer ball. Experiments have been carried out to determine friction coefficient displayed by sliding the soccer ball on the palm and backhand of the tested gloves at different values of applied load at dry and water wet contact. Saving may include slip of the ball on the hand skin of the goalkeeper and his jersey. It is necessary to have specific information about the friction coefficient of the materials that are in contact with the ball. The friction force was detected during the sliding of the ball on the tested surfaces to calculate the static value of friction coefficient. The outer cover of football is made of polyurethane, which protects it from wear and gives the ball its appearance. The material of the jersey was consisting of two types of polyester (PET I and PET II). The experiments aim to determine the friction coefficient displayed by the sliding of the ball on the palm of the glove, Fig. 2, the backhand of the glove, Fig. 3, the jersey, Fig. 4, and hand skin of the goalkeeper, Fig. 5. Besides, the measurement of ESC generated by the sliding of the ball on the tested surfaces was performed. The electrostatic fields (voltage) measuring device (Ultra Stable Surface DC Voltmeter) was used to measure ESC (electrostatic field) generated from the test specimens.

The friction coefficient was evaluated using a test rig, Fig. 1, through measuring the friction force and applied normal force. The tested gloves are placed in a base supported by two load cells, the first measures the horizontal force (friction force) and the second measures the vertical force (applied load). Friction coefficient was determined by the ratio between the friction force and the normal load. Loads were applied by hand pressing the ball into the palm and backhand of the glove and sliding the ball on it.

Fig. 1 Measurement of friction force between the ball and the glove.

Fig. 2 Friction between the ball and the palm of the glove.

Fig. 3 Friction between the ball and the backhand of the glove.

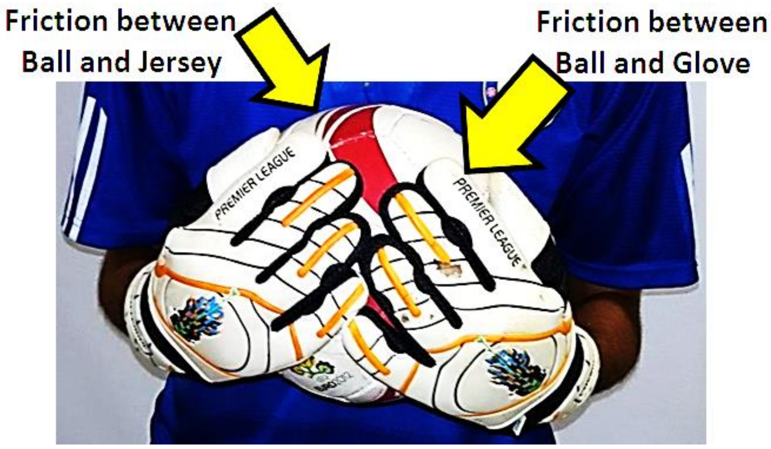


Fig. 4 Friction between the ball and the glove as well as the ball and the short sleeve jersey.

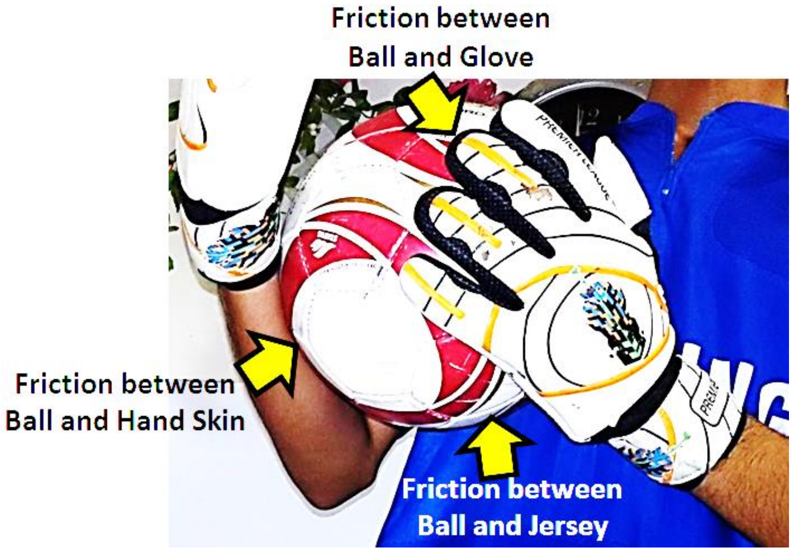


Fig. 5 Friction between the ball and the glove, the ball and hand skin as well the ball and the short sleeve jersey.

Besides, the measurement of ESC generated by the contact and separation as well as dry sliding of shoe (polypropylene) against floor (epoxy) of people who are working in

hospitals. The electrostatic fields (voltage) measuring device (Ultra Stable Surface DC Voltmeter) was used to measure the electrostatic charge (electrostatic field) for test specimens, Fig. 1.

RESULTS AND DISCUSSION

Friction coefficient displayed by dry and water wet sliding of the ball on the palm and backhand of the glove is illustrated in Fig. 6. Generally, friction coefficient slightly decreased with increasing normal load. The slight variation of friction coefficient with increasing load gave higher performance for the glove. At dry sliding, palm surface of the glove displayed the lower values than that observed for the backhand. It was interesting that at water wet sliding, backhand showed higher friction than the palm. The highest values displayed by wet backhand were ranging from 0.95 to 0.8, while the lower values displayed by dry palm were 0.68 and 0.56 at 25 and 200 N respectively. The friction values guaranteed good ability for the goalkeeper to catch the ball.

Friction coefficient displayed by the ball sliding on polyester I showed relatively lower values, Fig. 7. Dry sliding displayed higher friction than wet one. The friction values were ranging between 0.38 and 0.19 representing very low friction, where the possibility of ball slip was high. PET II gave lower friction values than PET I, Fig. 8. Those observations arise the danger of ball slip when it touches the jersey of the goalkeeper. It is necessary to increase the friction property between ball and jersey.

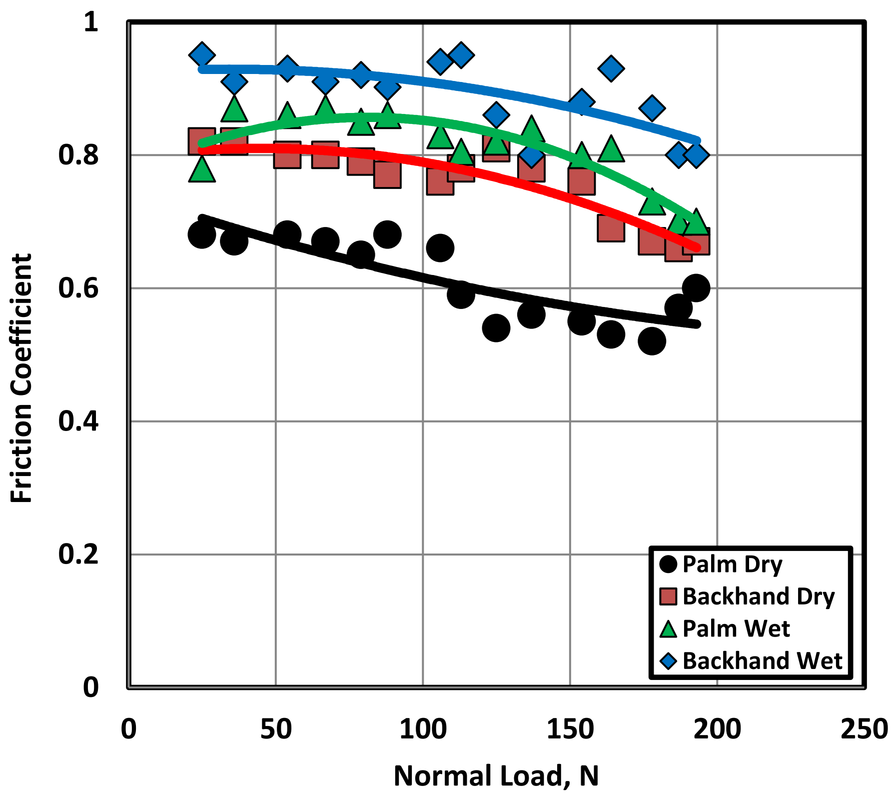


Fig. 6 Friction coefficient displayed by dry and water wet sliding of the ball on the palm and backhand of the glove.

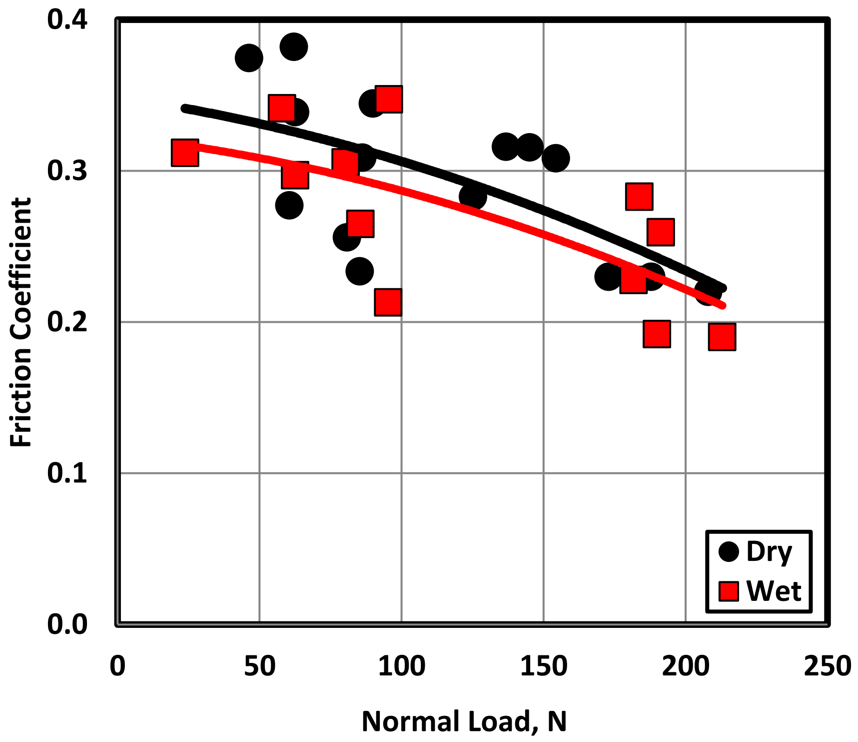


Fig. 7 Friction coefficient displayed by the ball sliding on polyester I.

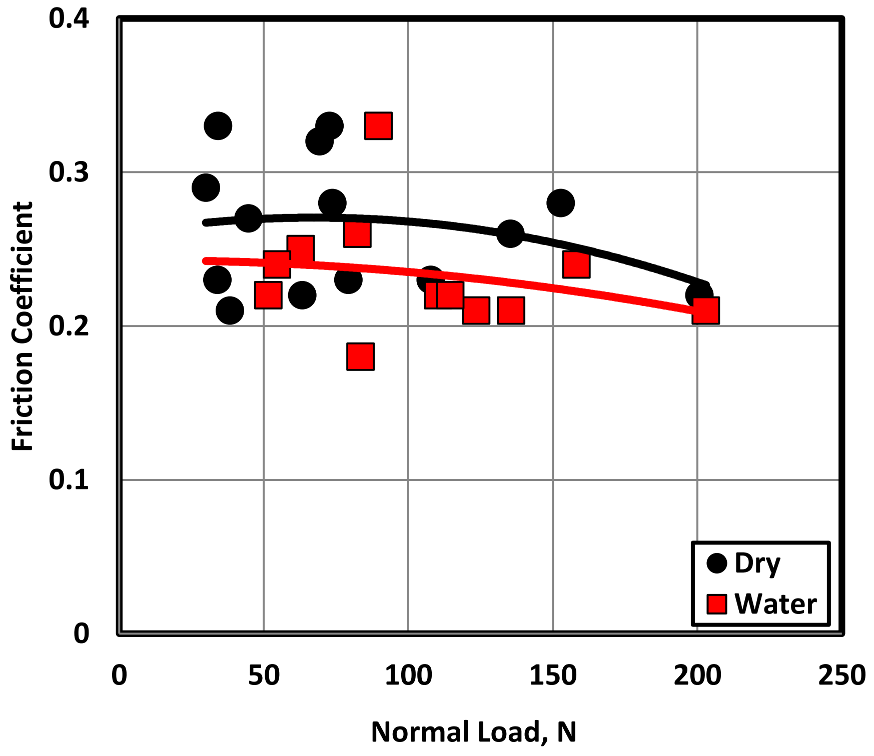


Fig. 8 Friction coefficient displayed by the ball on the polyester II.

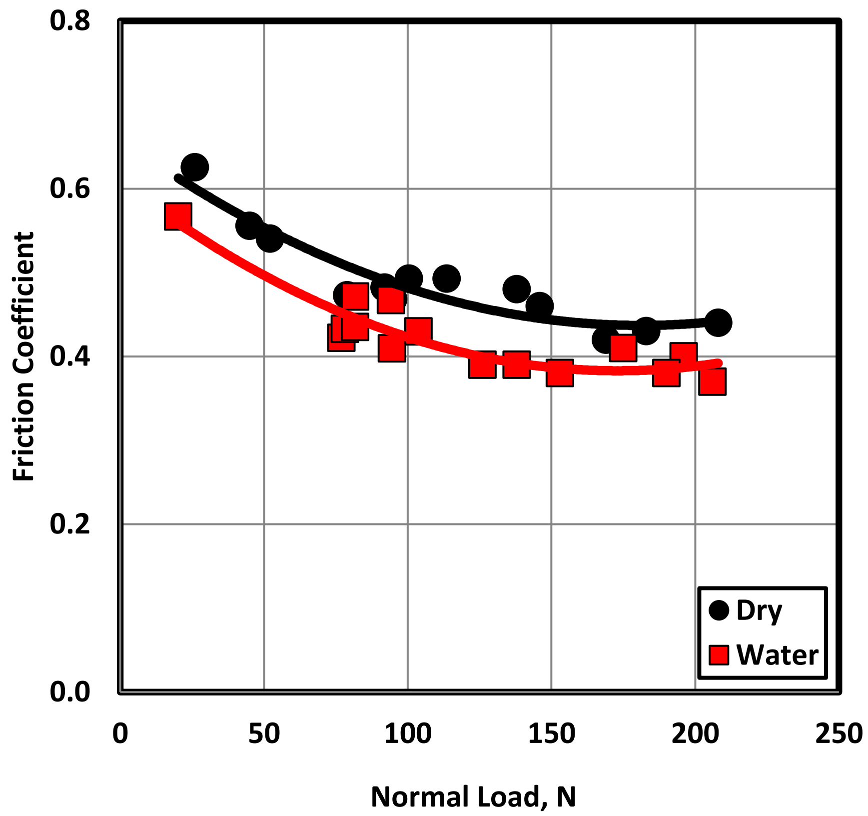


Fig. 9 Friction coefficient displayed by the ball on the hand skin.

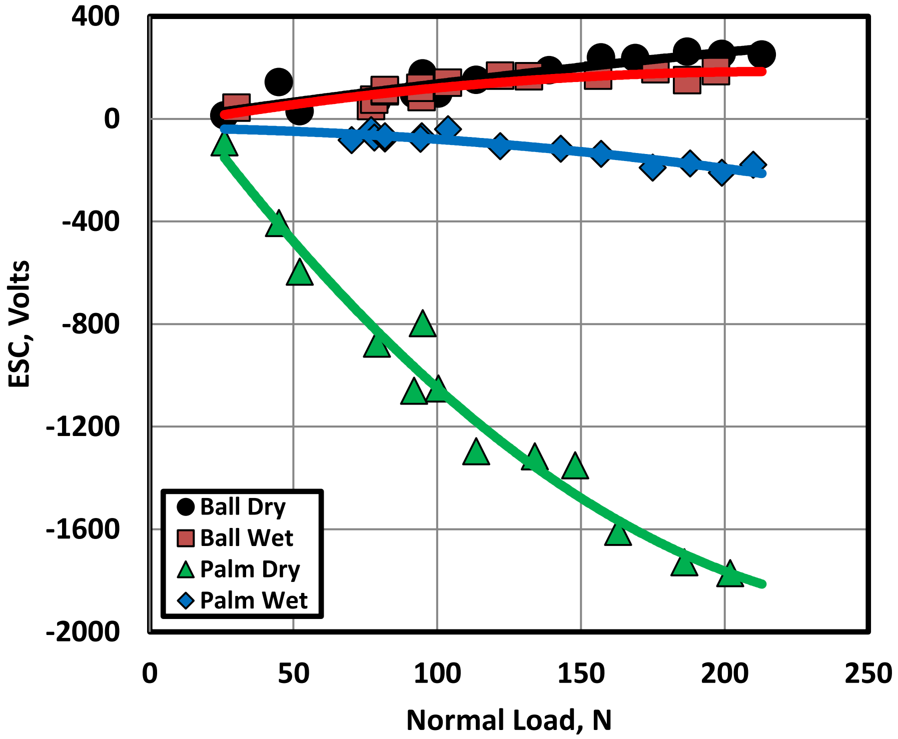


Fig. 10 ESC generated from sliding the ball on the palm of the glove.

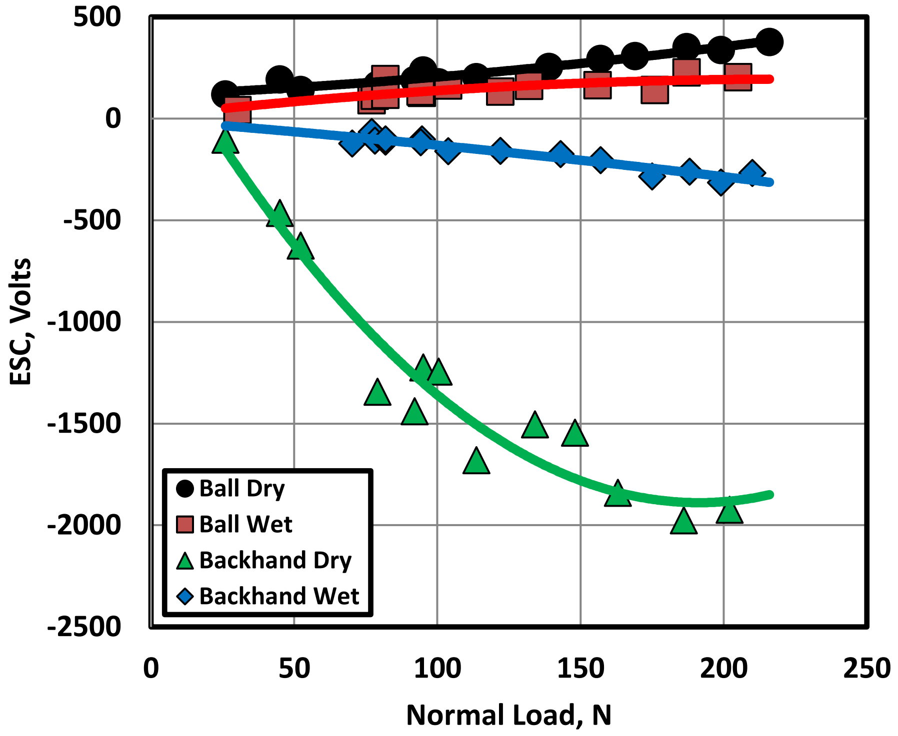


Fig. 11 ESC generated from sliding the ball on the backhand of the glove.

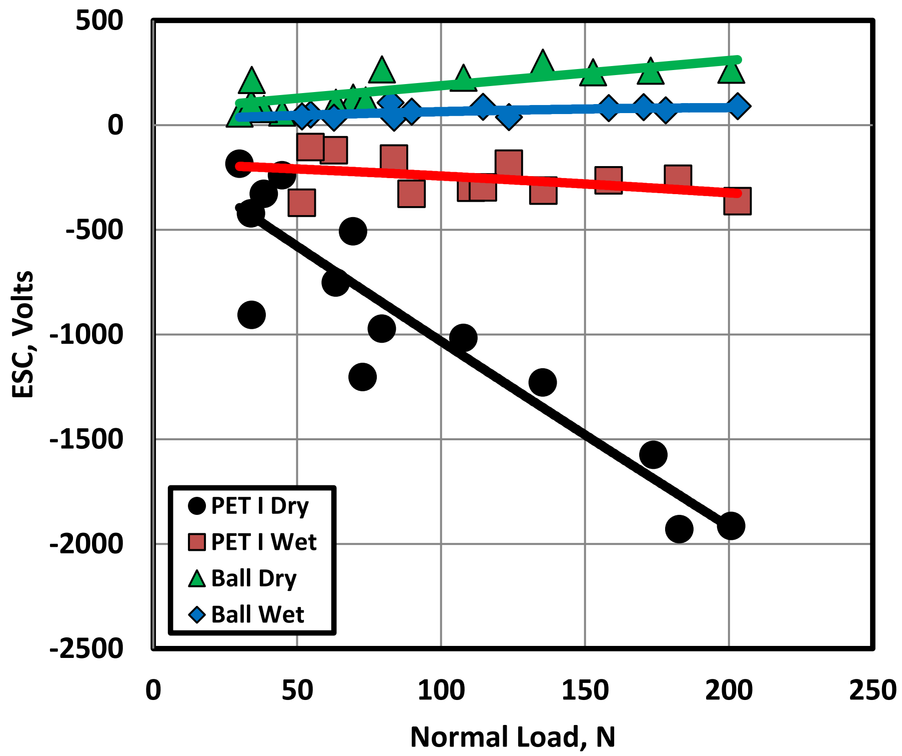
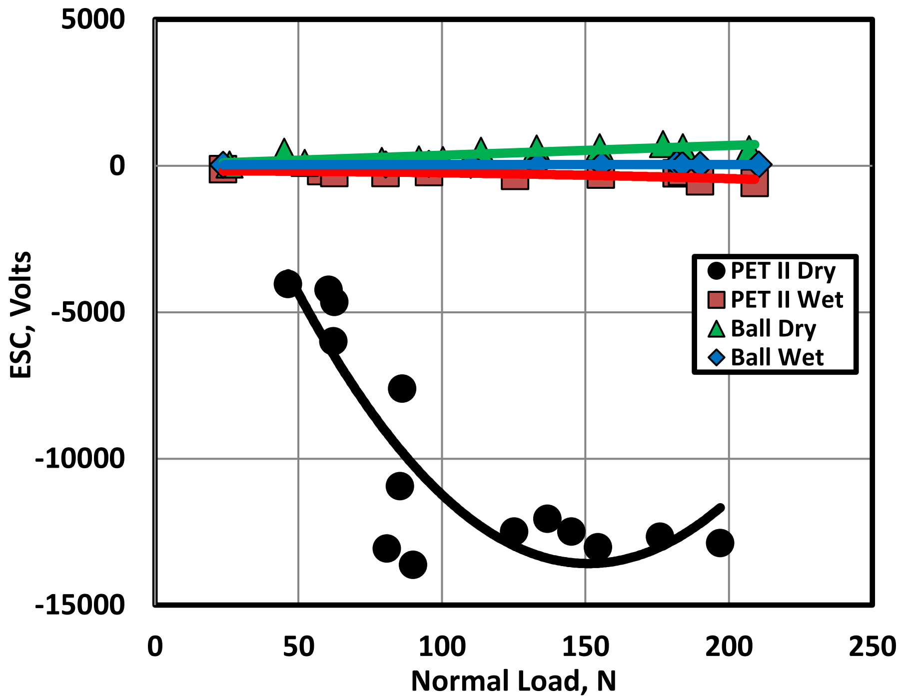


Fig. 12 ESC generated from sliding the ball on the polyester I.

When the ball slid on the hand skin friction coefficient remarkably increased compared to that observed for sliding on the jersey, Fig. 9, where dry sliding showed higher friction than wet one. The friction values are ranked between that observed from glove and jersey. As the normal load increased friction coefficient decreased.

The extensive use of polymeric materials in sport cloths necessitates studying their electrification when rubbing other surfaces, [28 – 31]. ESC generated from sliding the ball on the dry and wet palm and backhand of the glove is shown in Figs. 10 and 11 respectively. Dry palm gained the highest value of ESC that approached -1700 volts. At wet sliding ESC drastically decreased, Fig. 10. The ball surface at dry and wet sliding conditions gained positive ESC of relatively lower values. Backhand of the glove gained higher ESC than palm at both dry and wet sliding, Fig. 11.



13. ESC generated from sliding the ball on the polyester II.

The measurement of ESC generated from sliding the ball on the PET I is shown in Fig. 12. Dry PET I generated the highest ESC that reached -1800 volts at 200 N. Wet PET I generated -400 volts at the same load value. The ball which is coated by PU showed positive ESC of very low values at dry and wet sliding. ESC generated from sliding the ball on the polyester II is shown in Fig. 13. PET II generated very high ESC which reached -13000 volts. ESC gained by the jersey will migrate to the goalkeeper body. After more rubbing, the clothes gain more charge. Then the goalkeeper will be subjected to high intensity of electrical field. This observation confirmed the necessity to develop new materials of low ESC.

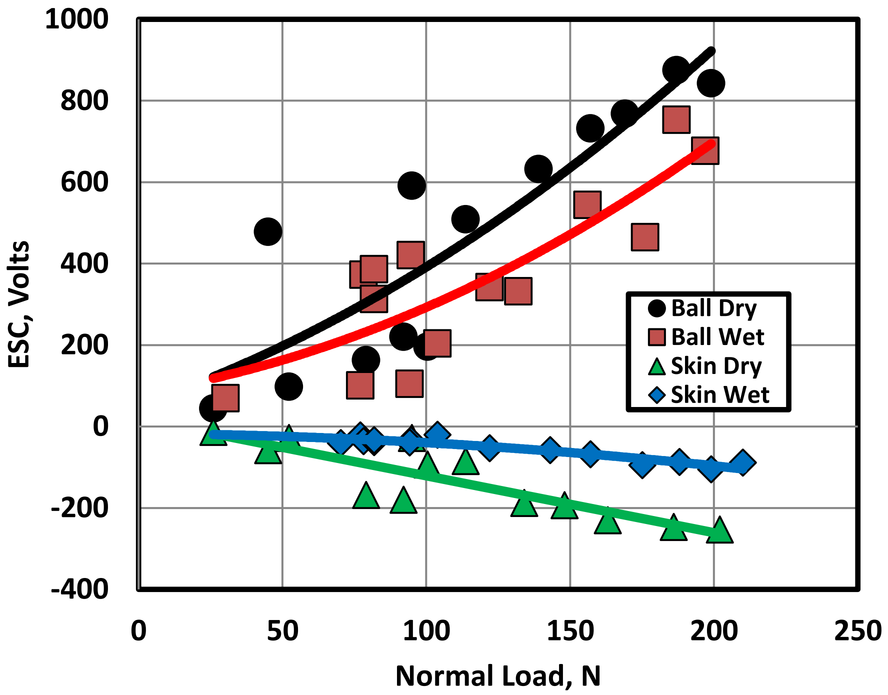


Fig. 14 ESC generated from sliding the ball on the hand skin.

Sliding of the ball on skin can give specific information about the triboelectrification of skin and ball when the ball touches the hand skin of the goalkeeper. It was observed that, ESC values were lower than that recorded for sliding against jersey, where the highest ESC values reached 860 volts at 200 N, Fig, 14, generated on the ball surface. Voltage generated on the dry skin was -250 volts. This behavior can be attributed to the fact that the skin is good conductor so that most of ESC leaked to the goalkeeper body during measurement.

CONCLUSIONS

1. At dry and wet sliding, backhand of the showed higher friction than the palm. The friction values guaranteed good ability for the goalkeeper to catch the ball.
2. Friction coefficient displayed by the ball sliding on jersey of the goalkeeper showed relatively lower values. Dry sliding displayed higher friction than wet one. Those observations increase the danger of ball slip when it touches the jersey of the goalkeeper.
3. Sliding of the ball on the hand skin displayed higher friction coefficient compared to that observed for sliding on the jersey.
4. Backhand of the glove gained higher ESC than palm at both dry and wet sliding. The ball surface at dry and wet sliding conditions gained positive ESC of relatively lower values.
5. ESC generated from sliding the ball on the jersey generated very high ESC that migrates to the goalkeeper body. After more rubbing, the jersey gains more charge. Then the goalkeeper will be subjected to high intensity of electrical field. This observation confirmed the necessity to develop new materials of low ESC.
6. ESC values generated from sliding of the ball on hand skin were lower than that recorded for sliding against jersey. Voltage generated on the dry skin was -250 volts.

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