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FRICTION COEFFICIENT BETWEEN SOCCER BALL AND GOALKEEPER GLOVE

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ABSTRACT
The present work investigates the influence of friction coefficient of the outer layer of the goalkeeper gloves on the ability to catch or punch the soccer ball. Catching and gripping soccer ball are performed by the palm of the goalkeeper gloves, while punching is touching the back of the gloves. It is important that both of palm and backhand of the glove has the same friction coefficient that displayed by sliding of the ball on the glove surface. 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.

The experiments revealed that attention should be considered to the fact that the friction properties of the outer layer of the backhand of the glove should be enough high. It is recommended to increase either the backhand force or friction coefficient of the material of the backhand to guarantee good punch and saving. The glove material is not safe at higher impact force of the ball and lower friction coefficient. The difference in friction coefficient between palm and backhand should be minimized. The drastic friction decrease vanished at water wet sliding. Based on the experimental observations it can be concluded that gloves of goalkeepers should provide high efficient catching and punching. They should enable the goalkeeper to punch the ball away at dry and rainy environment. This can be done by increasing adhesion between ball and both the palm as well as the backhand of the gloves.

KEYWORDS
Friction coefficient, sliding, soccer ball, goalkeeper, gloves, palm, backhand.

INTRODUCTION
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 ball, 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 ball. Quantitative measurements of the friction coefficient between ten types of glove materials and the ball surfaces were carried out, [1, 2]. 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 that 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, [3 – 7]. 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, [8, 9], 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, [10, 11]. Friction coefficient increases up to maximum then decreases with increasing velocity or normal force, [12]. Friction testing machine was developed to test the interaction between soccer ball materials and artificial turfs, [13]. 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, [14, 15]. The gloves should be designed to prevent bending backwards of the fingers when saving, [16], 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, [17, 18]. 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.

The aim of the present study is to determine the friction coefficient of the materials of the palm and backhand of the goalkeeper gloves sliding on the surface of the ball in order to ensure the efficiency in catching and punching the ball.

EXPERIMENTAL

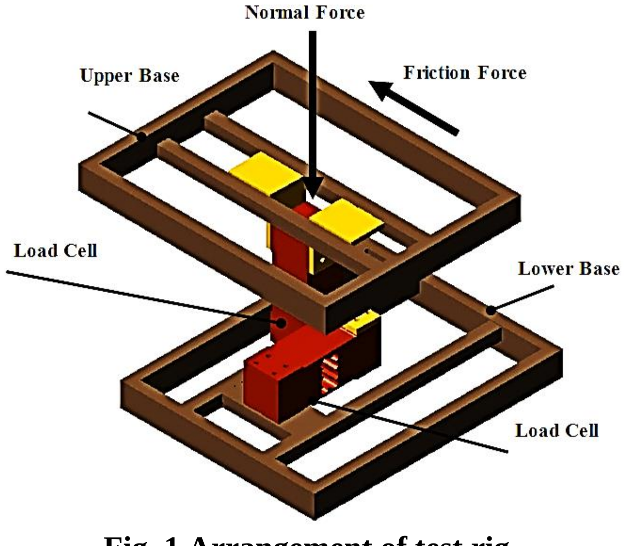

Fig. 1 Arrangement of test rig.

Fig. 2 Measurement of friction force between the ball and the glove.

Fig. 3 Configuration of the glove.

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. 2 and 3.

The friction force was detected just after the sliding of the ball to calculate the static value of friction coefficient. The outer cover of ball is made of polyurethane, which protects it from wear and gives the ball its appearance. Four different types of goalkeeper gloves were tested. Experiments were carried out 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 to have specific information about the friction coefficient of the materials of both the palm and backhand of the tested gloves.

RESULTS AND DISCUSSION

When the goalkeeper finds difficulties in catching the ball, he has to punch by the backhand part of the glove. Therefore, it is necessary to reduce the risk of the slip of the ball to keep it out of the goal. This can be achieved by increasing the value of friction coefficient of the outer layer of the backhand of the glove. The role of friction coefficient on the direction of the ball during punching is discussed.

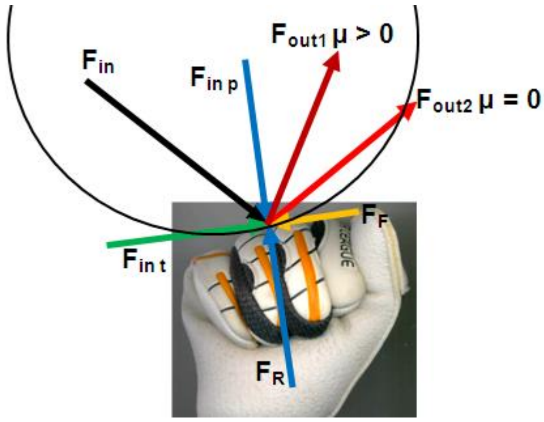

Fig. 1 Forces acting on the glove surface during oblique impact.

Figure 2 shows the direction of forces acting on the glove surface during punching, where the position and contact zone of the glove relative to the ball influence the direction of the ball after punching. Contact zone 1 represents safe saving for the goalkeeper, while zones 2 and 3 cause the ball to slip and cross the goal line. Figure 3 shows punching of the ball by the backhand of the glove, where zone 1 is normal impact which keeps the ball out of the goal and is considered as the optimum saving. Zone 3 is less safe compared to zones 1 and 2.

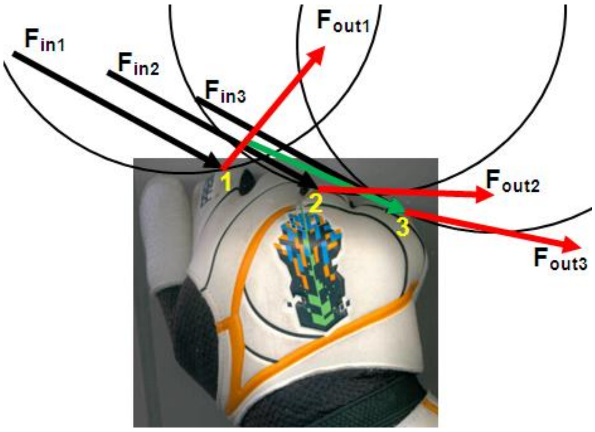

Fig. 2 Direction of forces acting on the glove surface during punching.

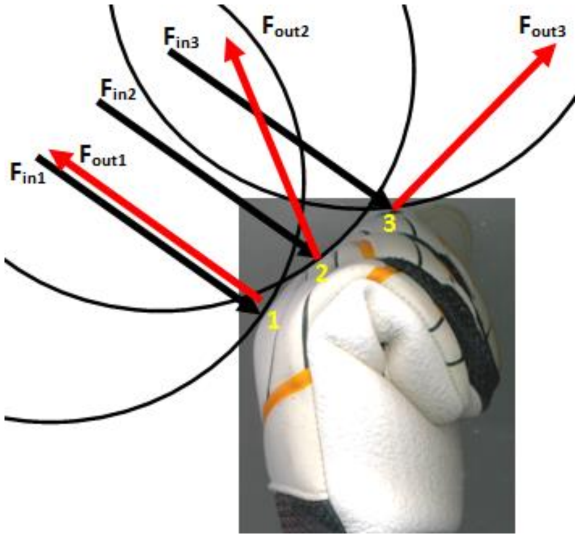

Fig. 3 Punching the ball by the backhand of the glove.

When the material of the backhand of the glove has relatively higher value of friction coefficient when sliding on the ball, punching will be more safe as illustrated in Fig. 4. The direction of the rebound force can be altered by increasing the value of friction coefficient. The friction force opposing the tangential component of the ball force increases with increasing friction coefficient and consequently the rebound force tends to keep out of the goal line.

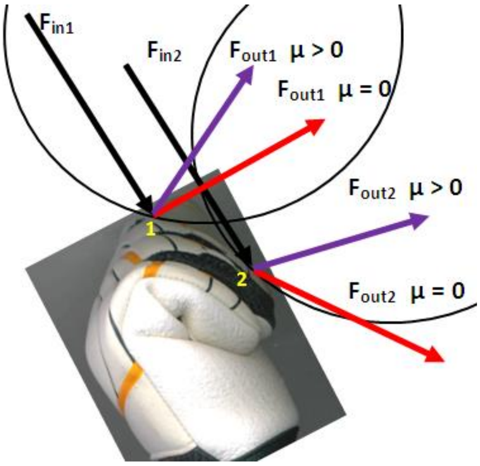

Fig. 4 Influence of friction coefficient on the rebound direction of the ball.

Forces acting on the backhand of the glove during punching the ball as well as forces acting on the ball are illustrated in Figs. 4 and 5 respectively. When the soccer ball initially impacts the backhand of the glove with no inbound spin it will leave the surface with spin actuated by the friction force exerted by the glove. That behavior introduces an opposing tangential force (F_f), [19]. The ball is subjected to sliding, rolling and static friction, [20, 21]. It was reported that static friction is more pronounced. Figures 6 and 7 show the ball direction after rebound for variable values of backhand force and friction coefficient respectively. When the goalkeeper touches the ball with no additional glove force, the ball force will equal to backhand force F_R, i. e.,

$F_{inp} = F_R$

then the friction force,

$F_f = \mu \cdot F_R$

The direction of the motion of the ball after impact will be affected by the magnitude of the glove force as well as friction coefficient displayed by the interaction of the ball and backhand of the glove. When the backhand force, F_r, is higher than the ball force, the direction of the ball will be as shown in Fig. 8. As the value of the friction coefficient increases, the total force, F_t, acting on the ball decreases, Fig. 8. As the value of the friction coefficient increases, the tangential force opposing the ball motion ($F_f + F_{Rt}$) increases and consequently the risk of the slip of the ball on the glove surface decreases. Based on those assumptions, it is recommended to increase either the backhand force or friction coefficient of the material of the backhand to guarantee good punch and saving.

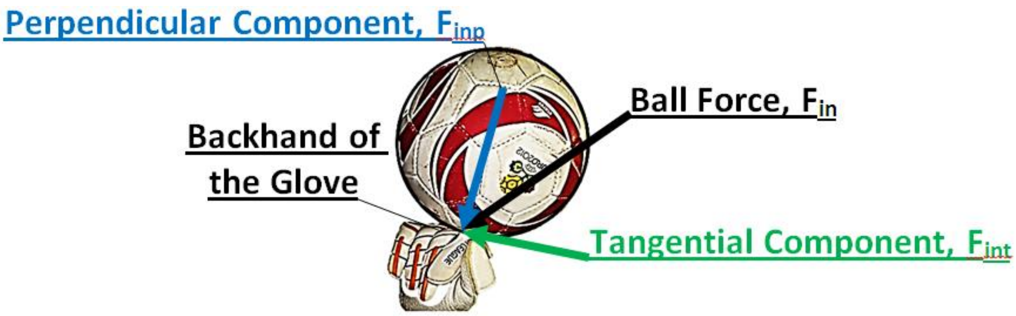

Fig. 4 Forces acting on the backhand of the glove during punching the ball.

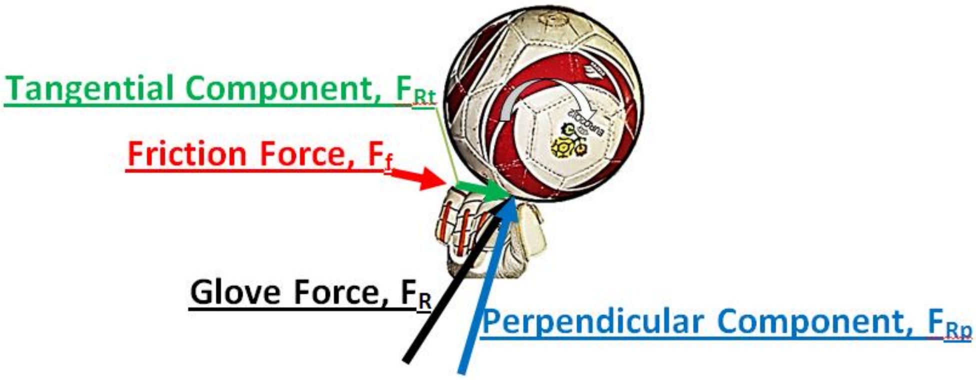

Fig. 5 Forces acting on the ball during punching by the glove.

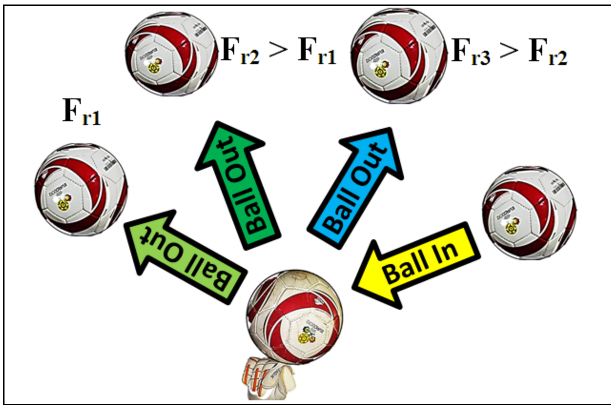

Fig. 6 Variation of ball direction with the increasing value of backhand force, at constant value of friction coefficient.

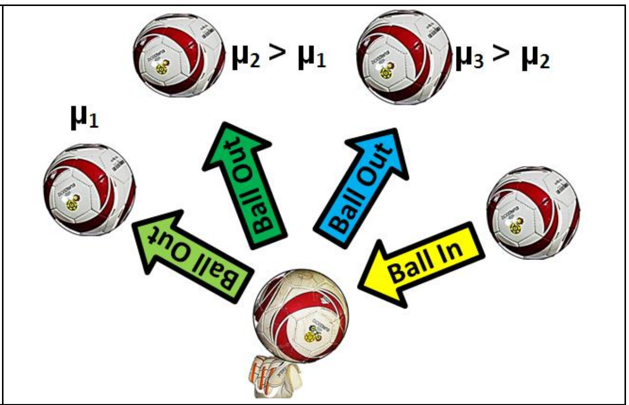

Fig. 7 Variation of ball direction with the increasing value of friction coefficient, at constant value of backhand force.

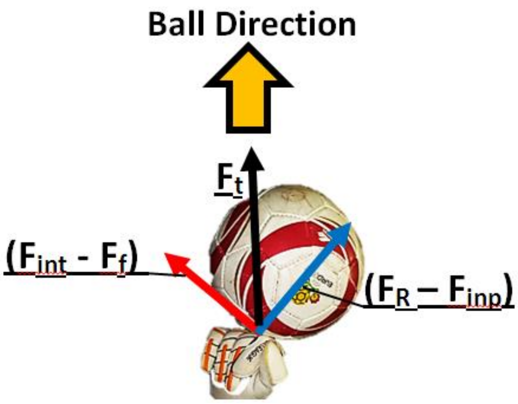

Fig. 6 Ball direction when the backhand force is higher than the ball force.

The results of the experiments carried out to determine friction coefficient of the tested gloves are illustrated in Figs. 9 – 14. Friction coefficient displayed by dry sliding of the ball on glove I is shown in Fig. 10, where backhand displayed higher friction than palm. As the load increases the difference decreases. This observation means that the backhand material presents lower performance at relatively higher values of load. Palm material shows consistent trend with increasing the load. Dry sliding of the ball on glove II shows drastic decrease in friction coefficient with increasing the load, Fig. 10. The palm displayed friction value of 1.38 and 0.4 at 0.5 and 18 N load respectively. Backhand outer layer showed the same trend with relatively higher values. That observation revealed that the glove is not safe at higher impact force of the ball. Glove III displayed

low difference between values presented by palm and backhand surfaces, Fig. 11, where the lower friction values at 20 N load were 0.48 and 0.48 for palm and backhand.

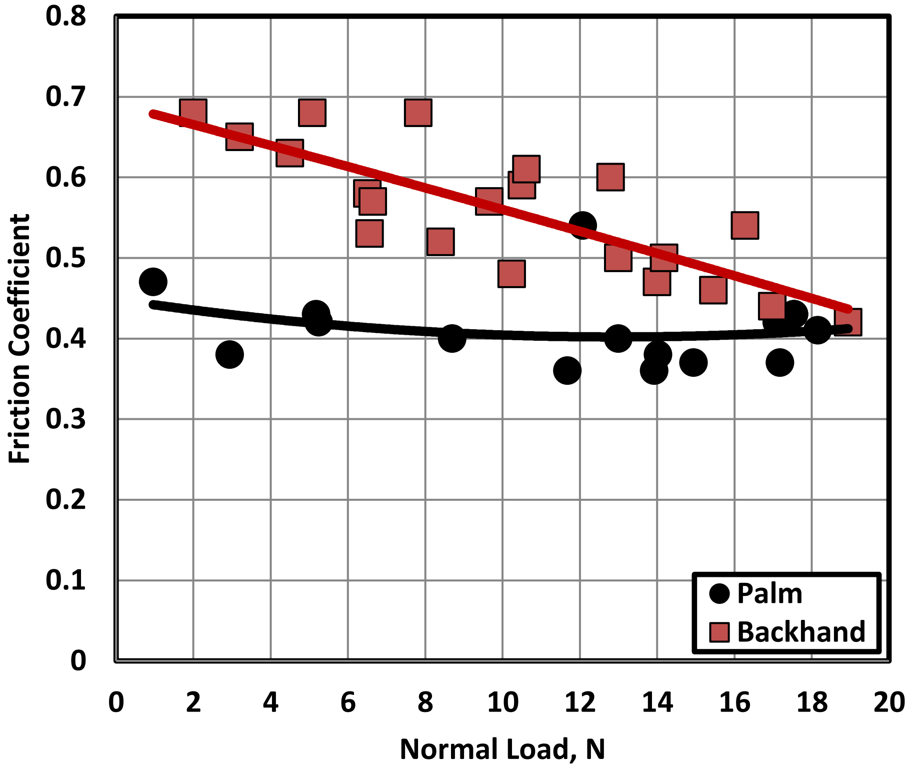

Fig. 8 Friction coefficient displayed by dry sliding of the ball on glove I.

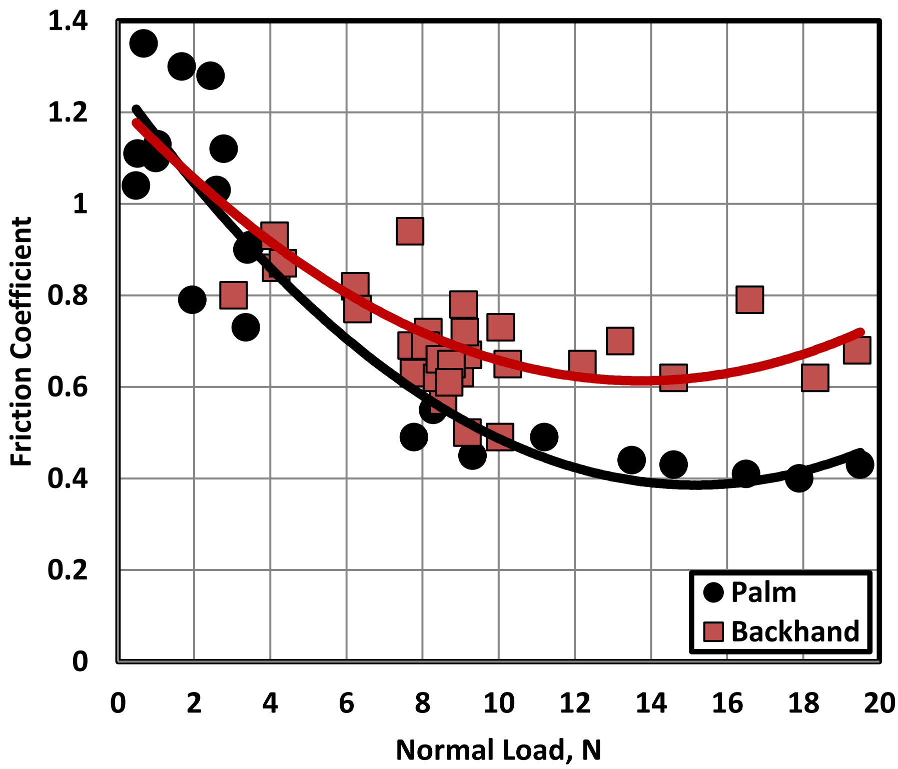

Fig. 9 Friction coefficient displayed by dry sliding of the ball on glove II.

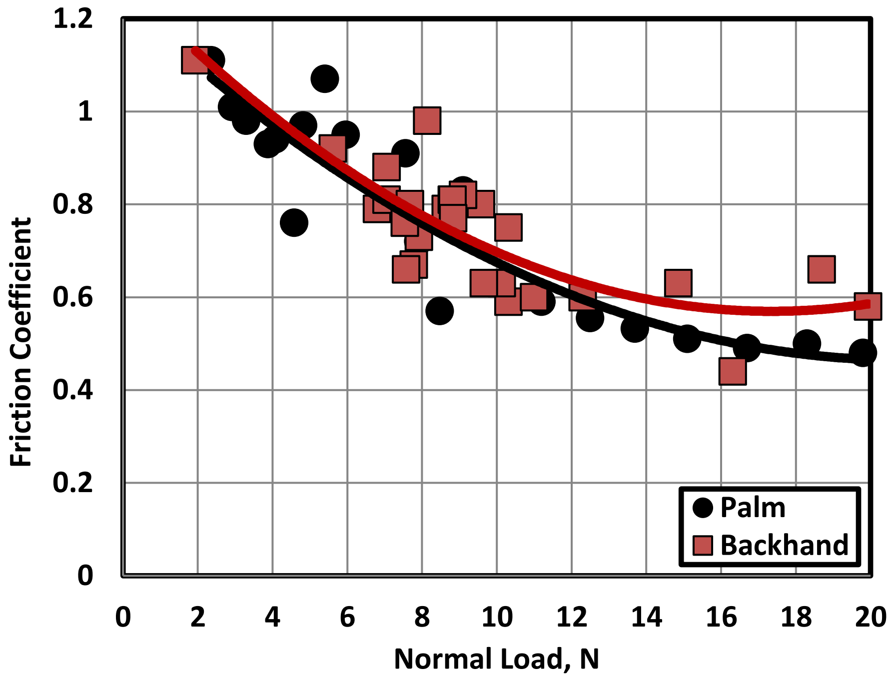

Fig. 10 Friction coefficient displayed by dry sliding of the ball on glove III.

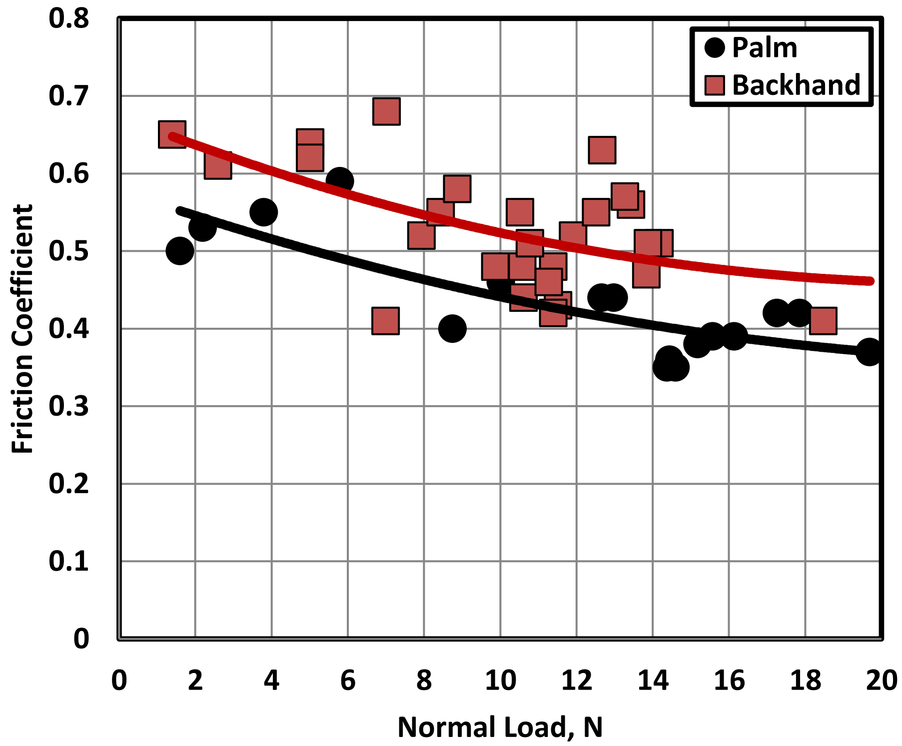

Fig. 11 Friction coefficient displayed by water wet sliding of the ball on glove I.

Testing friction coefficient displayed by water wet sliding showed that gloves I and II have the same trend observed for dry sliding. The difference in friction for palm and backhand was constant with increasing load, where backhand displayed higher friction than palm, Figs. 12 and 13, respectively. Besides, the drastic friction decrease vanished for wet sliding. Friction coefficient displayed by water wet sliding of the ball on the palm of glove III showed higher values than that represented by backhand. A drastic decrease with load increase was shown. Backhand showed slight friction decrease with increasing the applied load.

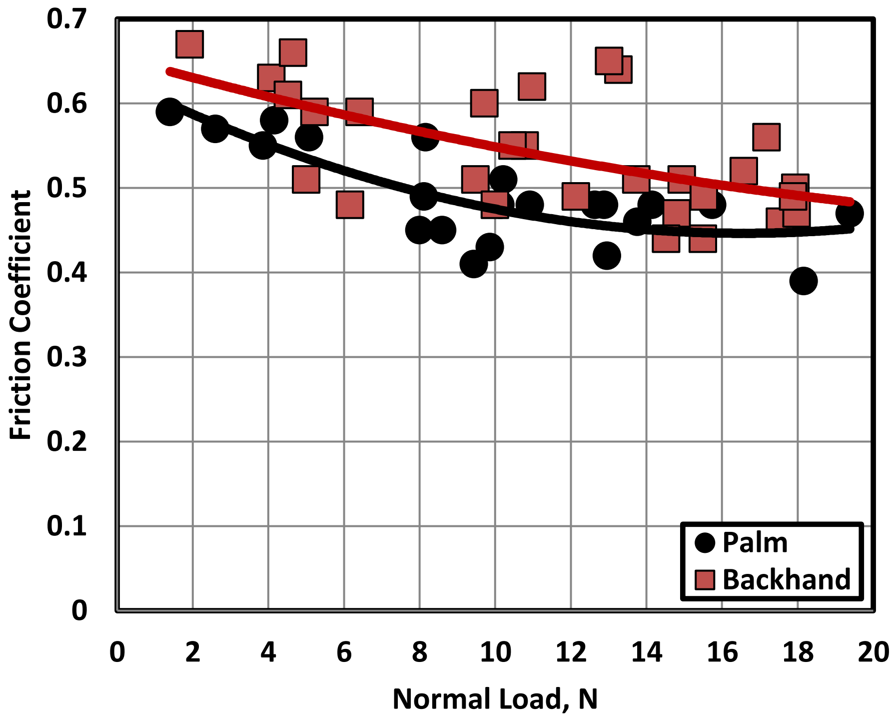

Fig. 12 Friction coefficient displayed by water wet sliding of the ball on glove II.

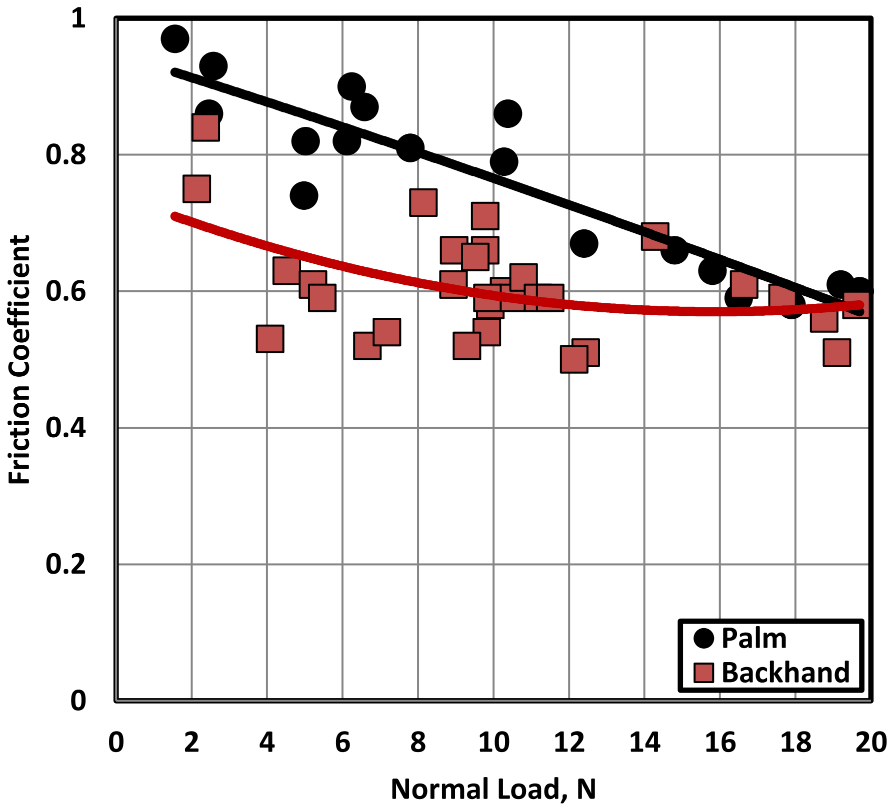

Fig. 13 Friction coefficient displayed by water wet sliding of the ball on the glove III.

Gloves designed for ball goalkeepers provide them with high efficient catching, holding and punching the ball. They should enable the goalkeeper to punch the ball away. The gripping as well as punching ability of the glove is the main factor to evaluate its quality. It should provide an adequate grip, tactile and punching response under a wide range of conditions. Finally, ball can be more competitive and exciting by providing highly advanced polymer coated gloves that enable one-handed catch and punch. The sport gloves should amplify both the grip and punch of the ball, enabling the goalkeepers to make successful catches and punches. This can be done by increasing adhesion between ball and both the palm as well as the backhand of the gloves.

CONCLUSIONS

1. Attention should be considered to the fact that the friction properties of the outer layer of the backhand of the glove should be enough high to punch the ball out of the goal.
2. It is recommended to increase either the backhand force or friction coefficient of the material of the backhand to guarantee good punch and saving.
3. The glove material is not safe at higher impact force of the ball and lower friction coefficient.
4. The difference in friction coefficient between palm and backhand should be minimized.
5. The drastic friction decrease vanished at water wet sliding.

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