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FRICTION COEFFICIENT DISPLAYED BY SLIDING THE FOOTBALL ON THE GLOVES OF THE GOALKEEPER

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ABSTRACT

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. The aim of the present work is to make quantitative measurements of the friction coefficient between glove and the ball surfaces. The tested gloves are made of ten different materials to be sticky. Friction tests have been carried out by sliding the football against the surface of the glove fixed on the table of the test rig.

From the results it can concluded that neoprene coated glove recorded relatively higher friction coefficient values reached to 1.13. Therefore, it is recommended to use such types of gloves. The high friction values highlight the importance of proper choice of the glove materials. Besides, the materials tested as surface coatings for the gloves of the football goalkeepers can be ranked based on friction coefficient displayed by sliding against football. Those materials are neoprene, nitrile, latex palm, polyvinyl chloride, nylon knit nitrile, cotton, kevlar, polypropylene, latex, and styrene butadiene copolymer. The first fourth types are recommended for application. 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. Polyvinyl chloride coated gloves provides high grip at relatively higher loads. The high friction difference at low and high loads confirms the importance of proper choice of glove materials of consistent friction trend with increasing the applied load. Finally, kevlar, styrene, nylon knit nitrile butadiene copolymer, polypropylene and cotton displayed very low values of friction coefficient. These observations can limit the use of those materials as glove materials.

KEYWORDS

Friction coefficient, sliding, football, gloves, goalkeeper.

INTRODUCTION

The friction between hand and ball in rugby was studied, [1, 2], 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, [3, 4]. Friction coefficient increases up to maximum then decreases with increasing velocity or normal force, [5]. Friction testing machine was developed to test the interaction between soccer ball materials and artificial turfs, [6]. 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, [7, 8]. The gloves should be designed to prevent bending backwards of the fingers when saving, [9], and allow the fingers to flex forwards to catch the ball.

Tactile behaviour is one of the critical properties that control the safety of materials handling. The tested materials based on their friction coefficient in order to increase the safety of glass handling were screened, [10]. Friction measurements were carried out to eight different materials by sliding against glass sheet at dry, water wet and oily conditions. Sensors that can reveal tactile were developed in order to equip robot hands with such a sense, [11, 12]. Development of the materials used in robots is a critical factor for increased safety and efficiency. Gripping forces may be reduced using high-friction surfaces, [13]. Thus, we selected foamy polymers as a suitable type of friction-enhancing material for grippers of the climbing robot. Friction coefficient of the contacting surfaces can control the safety of material handling through increasing the gripping force. The friction coefficient of the tactile sensor was tested, [14].Variety of materials such as foamy polymers and sandwich-like microstructures were tested as shoe soles for potential robot, [15, 16]. The friction coefficient displayed by hands sliding against the surface of the steering wheel covers was discussed, [17]. Measurement of friction coefficient is of critical importance in assessing the proper friction properties of steering wheel covers and their suitability to be used in application to enhance the safety and stability of the steering process during car driving. Experiments showed that friction coefficient displayed by the dry sliding of hand against the tested steering wheel covers decreased with increasing normal load. Besides, friction coefficient showed significant increase for covers compared to wheel without cover. In addition to that, friction coefficient drastically decreased due to the presence of the grease film covering the sliding surfaces.

It is well established that there is an increasing rate in car accidents. It is necessary to introduce laboratory and simulating studies to ensure the safety of the different elements from which the car is constructed. Although a number of studies were related to safety of the driving of the car, no attention was actually taken up that can indicate safety, stability and control of the steering wheel. An acceptable value of friction should be obtained to prevent slip between the hands of the driver and the surface of the steering wheel. It is necessary to measure the friction coefficient of the driver's hands sliding against dry, water wetted and greasy steering wheel covers. The knowledge of steering-wheel grip force characteristics of the drivers may benefit the automobile designers and manufacturers to improve the quality of their products in terms of comfort and driving performance. The steering-wheel grip force of male and female drivers driving an automobile was studied, [18, 19]. Results indicated that the vehicle speed and the road condition did not significantly affect these response variables.

Friction coefficient, displayed by clothes sliding against car seat covers, was discussed, [20]. The frictional performance of two groups of covers, the first was contained five different types of synthetic leather and the second contained nine different types of synthetic textiles, was measured. It was found that, synthetic leather displayed relatively higher friction coefficient than synthetic textiles when sliding against dry polyester clothes, where the highest friction value exceeded 0.6. At water wetted sliding, significant drop in friction coefficient was observed for synthetic leather specimens.

Synthetic textiles showed relatively higher friction than synthetic leather. For the sliding of dry cotton clothes, significant friction increase for synthetic leather was observed.

The aim of the present study is to determine the friction coefficient of the materials of the goalkeeper gloves sliding on the surface of the football in order to ensure his efficiency in catching the ball. Ten different types of materials were tested by sliding against football surface at dry conditions.

EXPERIMENTAL

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 surface of the glove and sliding the ball on it, Fig. 2. The friction force was detected just after the sliding of the ball to calculate the static value of friction coefficient. The different types of glove materials are illustrated in Table 1. The outer cover of football is made of polyurethane, which protects it from wear and gives the ball its appearance.

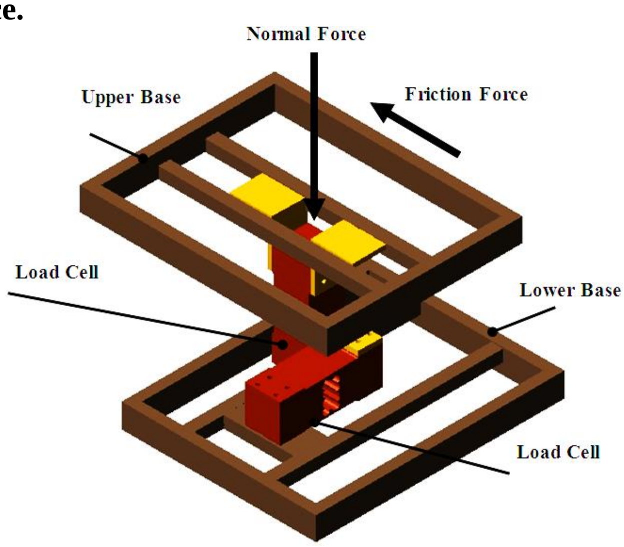
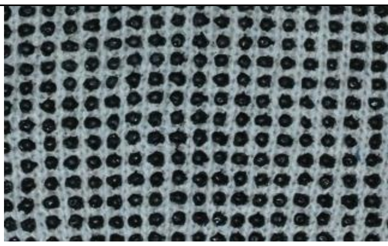
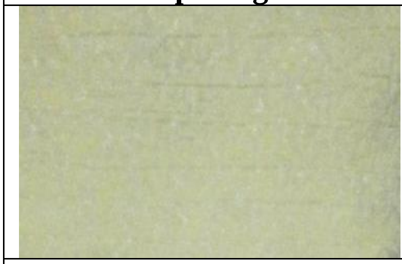
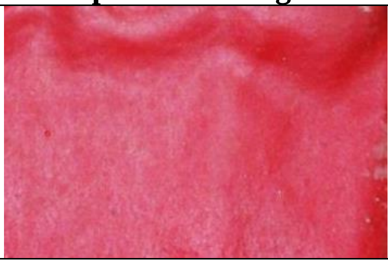
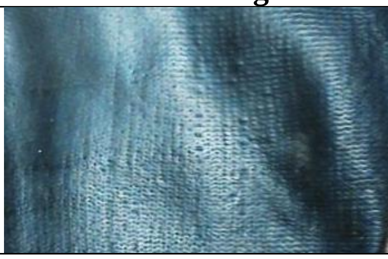
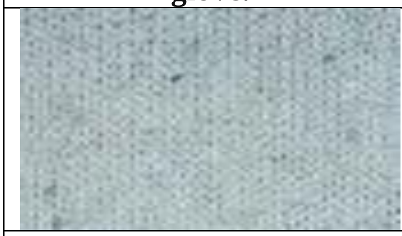


Fig. 1 Arrangement of test rig.

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

The different types of glove materials are illustrated in Table 1.

	
Latex palm glove.	**Neoprene coated glove.**
	
Polyvinyl chloride glove.	**Nitrile coated glove.**
	
Kevlar glove.	**Styrene butadiene copolymer coated glove.**
	
Nylon knit nitrile coated glove.	**Polypropylene glove.**
	
Cotton glove.	**Latex coated glove.**

RESULTS AND DISCUSSION

Friction coefficient displayed by football sliding against glove 1 is illustrated in Fig. 3. Glove 1 is made of latex palm coating which offers strong grip. The coating makes gloves suitable for use in the different applications too. Latex has very high elasticity and exceptional grip capabilities. Based on the results shown, friction coefficient showed increasing trend with increasing load. The highest friction value was 0.75, while the lowest was 0.43.

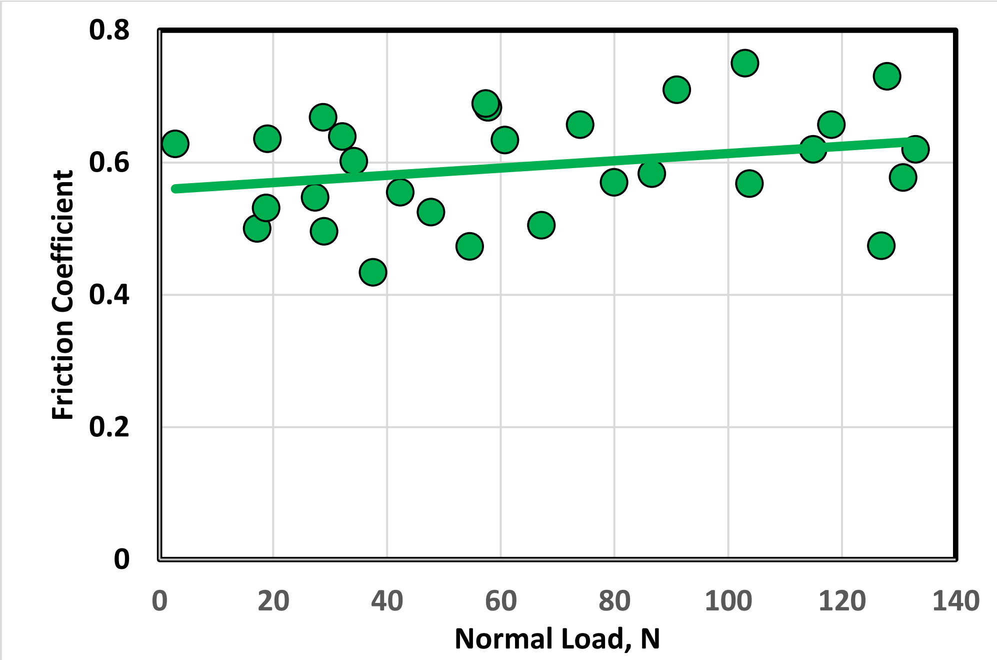


Fig. 3 Friction coefficient displayed by ball sliding against glove 1.

Sport gloves are covered by a layer made of rubber to provide non-slip gripping. Those gloves comprise a textile which includes a plurality of small dots of rubber disposed on its surface to facilitate improved gripping. Glove 2 is made of neoprene which is a part of the chloroprene. Friction coefficient displayed by that glove recorded relatively higher values reached to 1.13, Fig. 4, therefore it is recommended to use such types of gloves. The high friction values highlight the importance of proper choice of the glove materials.

Glove 3 is made of polyvinyl chloride which is a thermoplastic polymer used to coat the outside of gloves in order to provide high grip as well as protection from chemicals, punctures, cuts and abrasion. The highest value of friction coefficient exceeded 1.22 at 130 N load, while the lowest values were close to 0.2 at 5 N load. The relatively high friction difference confirms the importance of proper choice of glove materials of consistent friction trend with increasing the applied load.

Friction coefficient displayed by ball sliding against glove 4 that made of nitrile rubber is shown in Fig. 6. The values of friction coefficient are ranging between 0.55 and 1.16 and increasing with the increase of the load. Glove 5 which is made of para-aramid synthetic fibres (Kevlar) displayed very low values of friction coefficient, Fig. 7. The range of friction coefficient is between 0.2 and 0.38. Although Kevlar is high strength material its friction property is very low compared to the four types of gloves tested above. This observation can limit the use of Kevlar as glove materials.

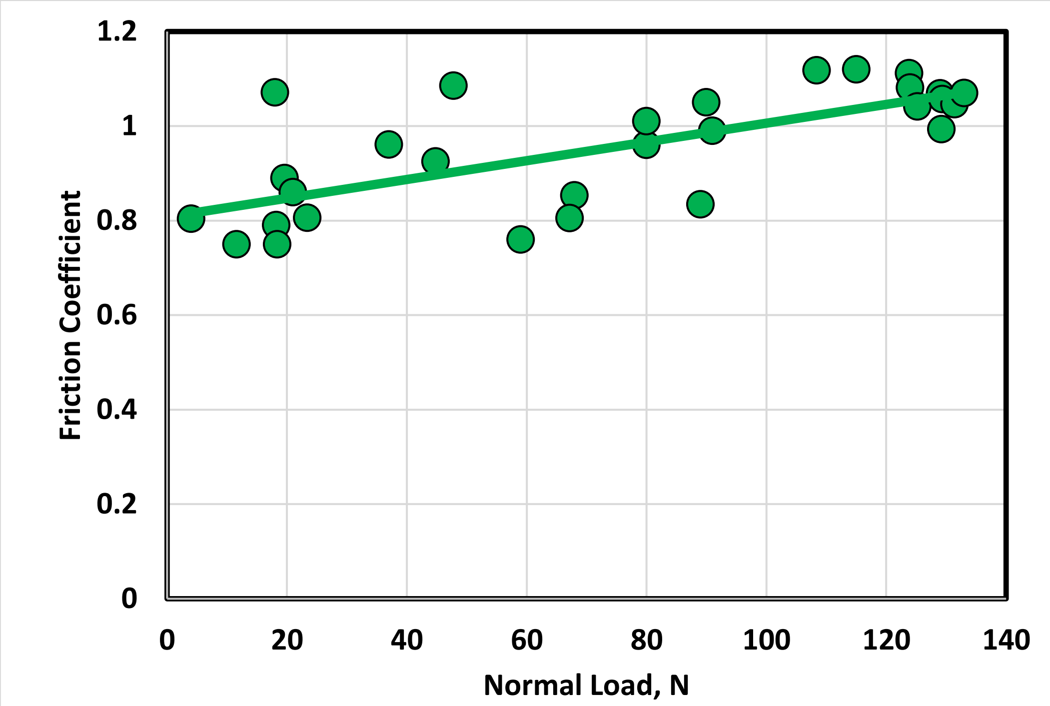


Fig. 4 Friction coefficient displayed by ball sliding against glove 2.

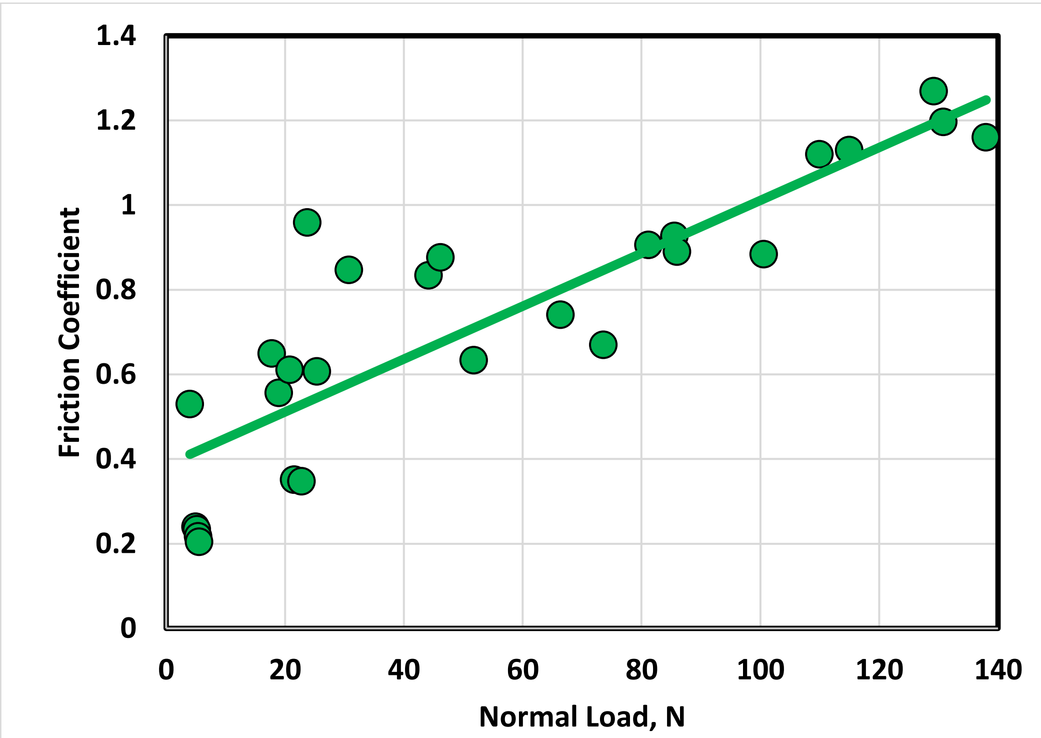


Fig. 5 Friction coefficient displayed by ball sliding against glove 3.

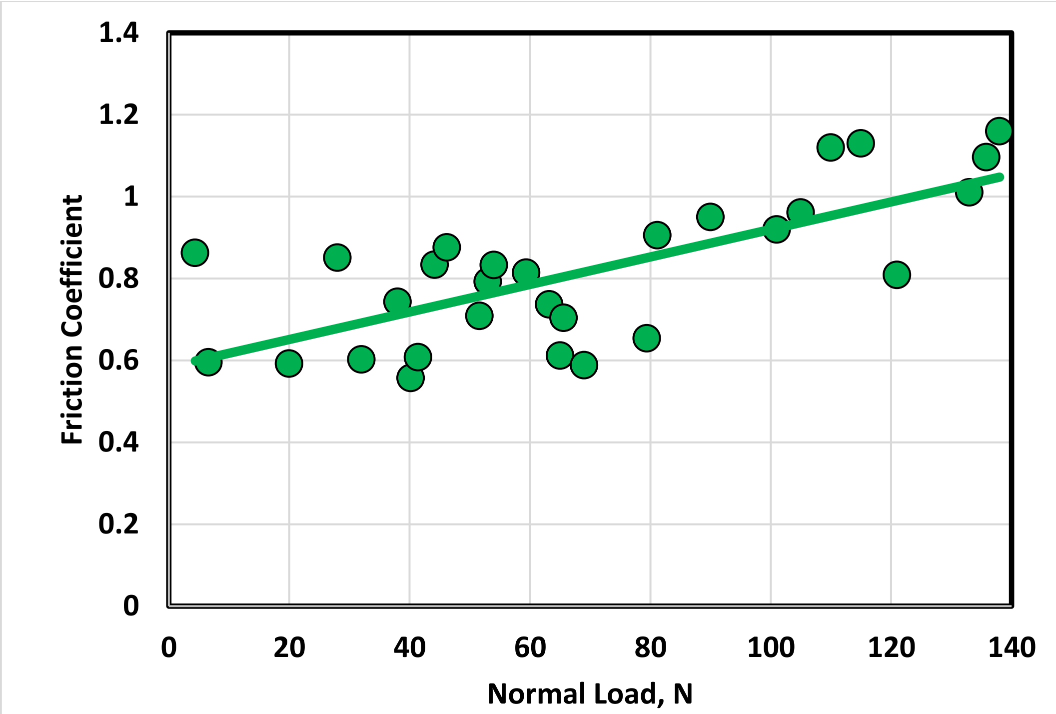


Fig. 6 Friction coefficient displayed by ball sliding against glove 4.

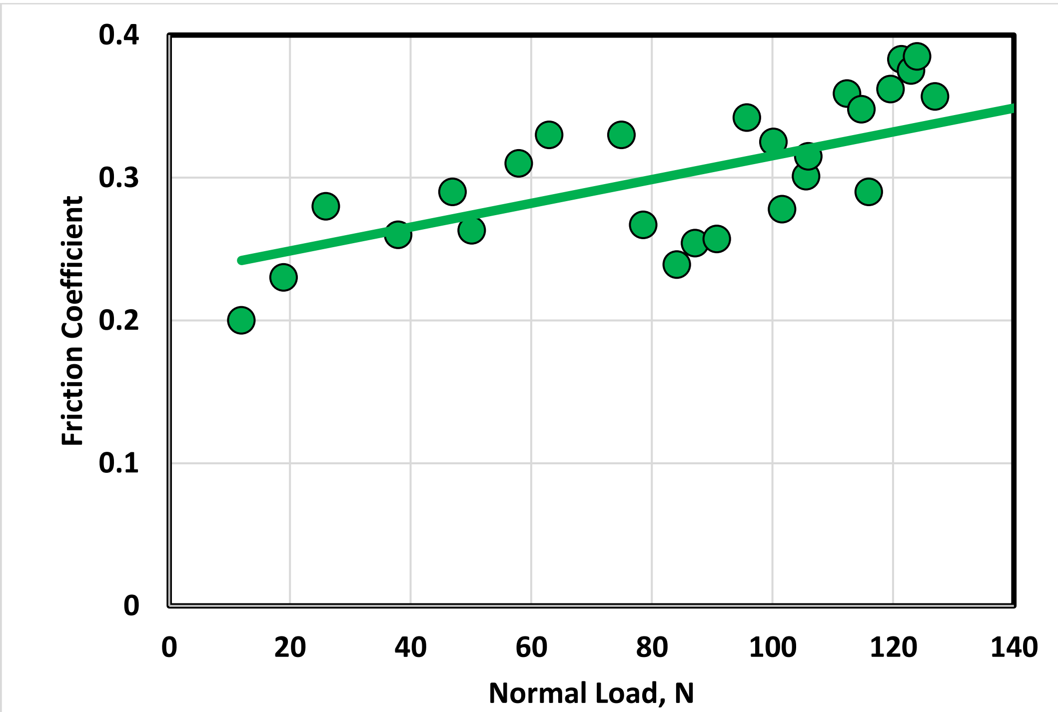


Fig. 7 Friction coefficient displayed by ball sliding against glove 5.

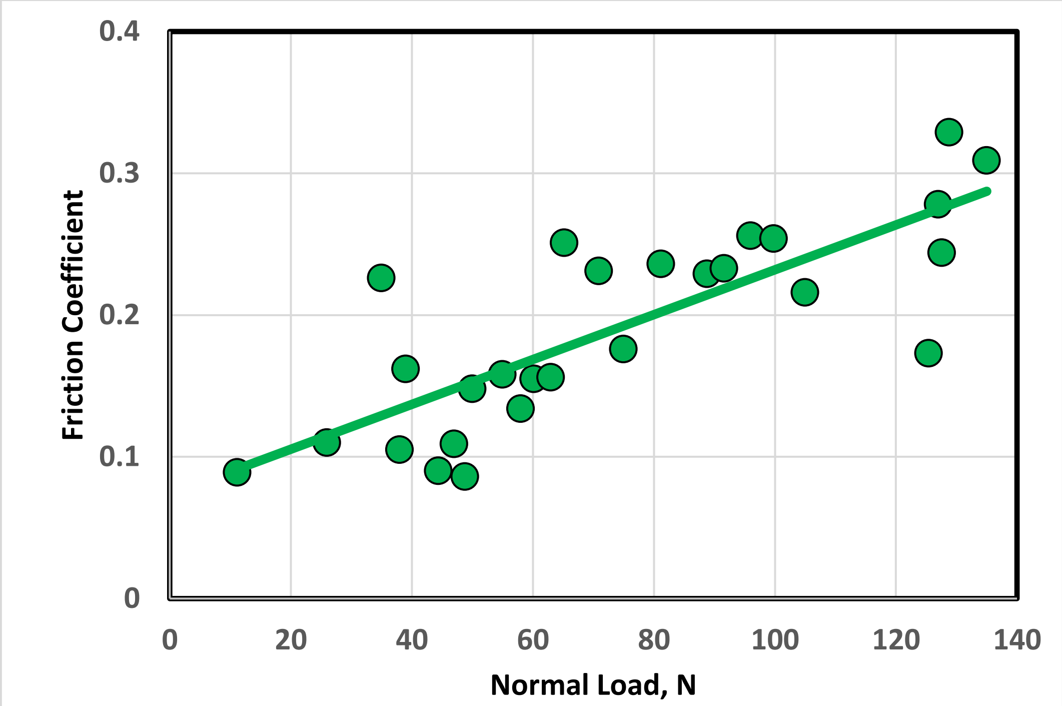


Fig. 8 Friction coefficient displayed by ball sliding against glove 6.

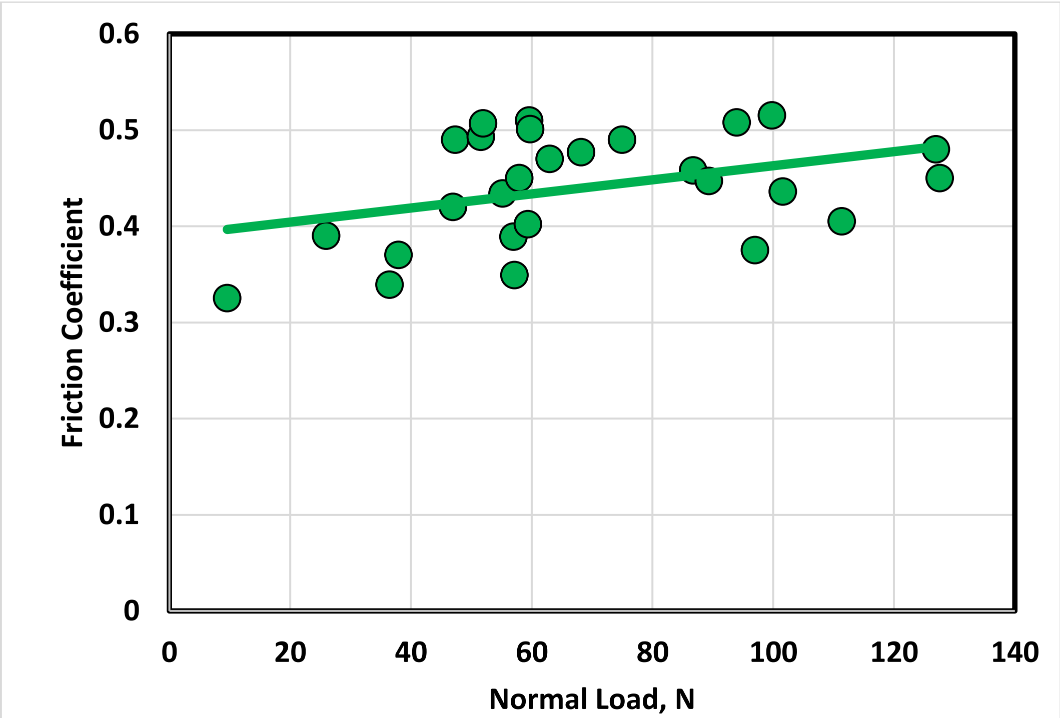


Fig. 9 Friction coefficient displayed by ball sliding against glove 7.

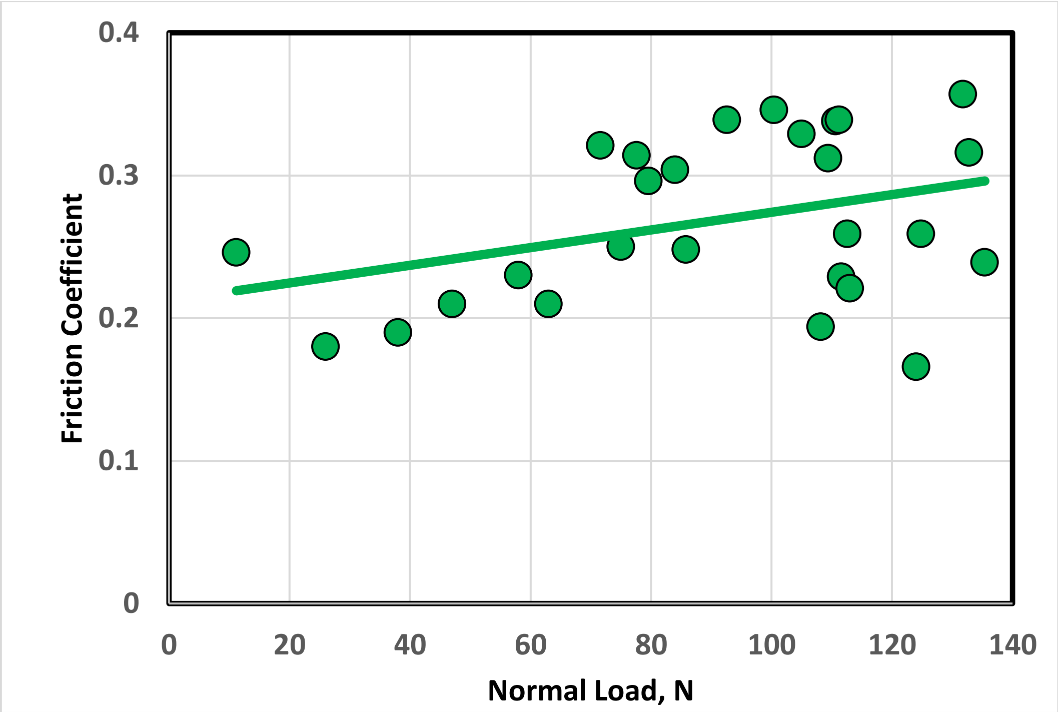


Fig. 10 Friction coefficient displayed by ball sliding against glove 8.

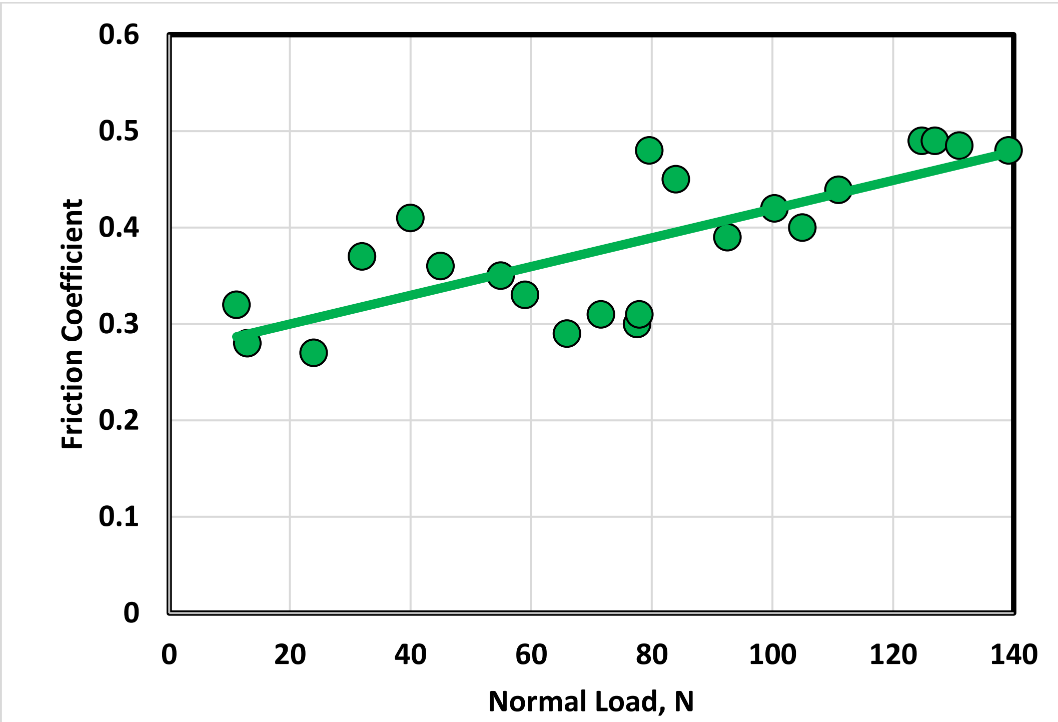


Fig. 11 Friction coefficient displayed by ball sliding against glove 9.

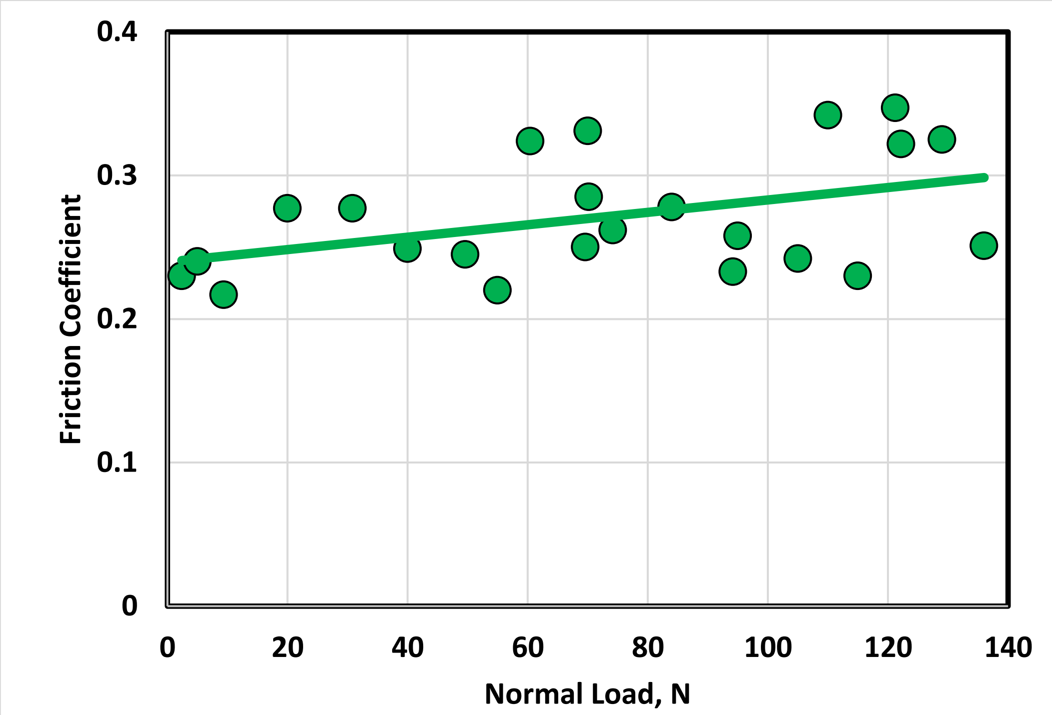


Fig. 12 Friction coefficient displayed by ball sliding against glove 10.

Styrene butadiene copolymer as glove 6 material displayed relatively lower friction values than kevlar, Fig. 8. The frictional properties of glove surfaces can be modified by coating them by rubber to increase the friction and give the surface appropriate qualities for practical use. Nylon knit nitrile coated glove 7 showed relatively higher friction coefficient values than kevlar and styrene butadiene copolymer, Fig. 9, where the highest value was 0.51 and the lowest one was 0.32. Polypropylene like kevlar (glove 8) showed low friction values, Fig. 10. That material should be coated by layer made of rubber to provide non-slip gripping and improve the gripping strength.

Cotton glove 9 showed low friction values, Fig. 11. This behavior may be attributed to the fact that as the load increases the pressure applied on the fibre fringes increases, flattens the fringes and makes their surface smoother. In consequence, friction coefficient decreases, [21]. The second explanation indicated that the fringe behaves more like a sheet of fibres, presenting more uniform area of contact, [22, 23], and leading to the decrease of friction coefficient.

Gloves designed for football goalkeepers provide them with high efficient catching and holding the ball. They enable the goalkeeper to catch and punch a ball away. Gloves have also come into widespread use in sports such as football. The gripping ability of the glove is the main factor to evaluate its quality. It should provide an adequate grip and tactile response under a wide range of conditions. Although latex (glove 10) has very high grip capability, its sliding against football displayed very low values of friction coefficient, Fig. 12. Finally, football can be more competitive and exciting by providing highly advanced polymer coated gloves that enable one-handed, catches. The sport gloves should amplify the grip of the goalkeepers on the football, enabling them to make successful catches. This can be done by increasing adhesion between football and gloves.

CONCLUSIONS

1. The materials tested as surface coatings for the gloves of the football goalkeepers can be ranked based on friction coefficient displayed by sliding against football. Those materials are neoprene, nitrile, latex palm, polyvinyl chloride, nylon knit nitrile, cotton, kevlar, polypropylene, latex, and styrene butadiene copolymer. The first fourth types are recommended for application.

2. Friction coefficient showed increasing trend with increasing load.

3. The proposed sport gloves that are covered by a layer made of rubber to provide non-slip gripping. Those gloves should contain textiles which include a plurality of small dots of rubber disposed on its surface to facilitate improved gripping.

4. Polyvinyl chloride coating the outside of gloves provides high grip. The relatively high friction difference confirms the importance of proper choice of glove materials of consistent friction trend with increasing applied load.

5. Kevlar, styrene, nylon knit nitrile butadiene copolymer, polypropylene and cotton displayed very low values of friction coefficient. These observations can limit the use of those materials as glove materials.

REFERENCES

1. Oomen M. A., "Interaction between gloves and ball surfaces in AFL and Rugby", MSc Thesis in Mechanical Engineering, Royal Melbourne Institute of Technology, School of Aerospace, Mechanical and Manufacturing Engineering,
Bundoora East Campus, VIC 3083, Melbourne Australia, August 30, (2012).

2. Tomlinson, S. E., Lewis, R., Carrffe, M. J., Friction between Players' Hands and Sports Equipment, The Engineering of Sport 7, Vol. 1, pp. 26 - 34, Springer Verlag France, Paris, (2008).

3. Tomlinson, S. E., Lewis, R., Ball, S., Yoxall, A., Carrffe, M. J., "Understanding the effect of finger-ball friction on the handling performance of rugby balls, Sports Engineering 11, pp. 109 - 118, (2009).

4. Tomlinson, S. E., Lewis, R., Liu, X., Texier, C., Carrffe, M. J., "Understanding the friction mechanisms between the human finger and at contacting surfaces in moist conditions", Tribology Lett. 41, pp. 283 - 294, (2011).

5. Fuss, F. K., "Friction of a pimpled rugby ball surface: force and velocity weakening and strengthening of the coefficient of friction", Journal of Engineering Tribology, Vol. 226, No. 7, pp. 598 - 607, July (2012).

6. Plint G., "Tribology: Test Methods", University of Cambridge – Cambridge, (2005).

7. Meuller D., Meythaler D., "Reinforcing Element", 20060253951, US Patent, (2006).

8. Staihar S., Avis R., "Soccer goalkeeper's glove", 6,654,964 BI, US Patent, (2003).

9. Hochmuth, P., "Goalkeeper's glove and method for making same", US7065795, United States, (2006).

10. Khashaba M. I., Ali A. S., Ali W. Y., "Increasing the Safety of Material Handling of Robots", 1st International Workshop on Mechatronics Education, March 8th -10th 2015, Taif, Saudi Arabia, pp. 246 – 254, (2015).

11. Voigt D., Karguth A., Gorb S., "Shoe soles for the gripping robot: Searching for polymer-based materials maximising friction", Robotics and Autonomous Systems 60 (2012) 1046–1055, (2012).

12. Moisio S., Len B., Korkealaakso P. and Morales A., "Model of tactile sensors using soft contacts and its application in robot grasping simulation", Robotics and Autonomous Systems 61, p. 1–12, (2013).

13. Maempel J. J., Andrada E., Witte H. H., Trommer C. C., Karguth A., Fischer M., Voigt D. D., Gorb S.N., "Inspirat—towards a biologically inspired climbing robot for the inspection of linear structures", in: Proceedings of the 11th International Conference on Climbing and Walking Robots, CLAWAR, Coimbra, Portugal, 8–10 September 2008, pp. 206–213, (2008).
14. Drumwright W., Shell D., "An evaluation of methods for modeling contact in multibody simulation", IEEE International Conference on Robotics and Automation, (2011).
15. Varenberg M., Gorb S.N., "Hexagonal surface micropattern for dry and wet friction, Advanced Materials 21 pp. 483 - 486, (2009).
16. Murarash B., Itovich Y., Varenberg M., "Tuning elastomer friction by hexagonal surface patterning", Soft Matter 7, pp. 5553 - 5557, (2011).
17. Abdel-Jaber G. T., Al-Garni S. M. and Ali W. Y., "Friction Coefficient Displayed by Hand Sliding Against Steering Wheel Cover", September 27 – 29, 48, 2014, Tribologie Fachtagung, Göttengen, Germany, pp. 47/1- 47/11, (2014).
18. Eksioglu M., Kızılaslan K., "Steering-wheel grip force characteristics of drivers as a function of gender, speed, and road condition", International Journal of Industrial Ergonomics 38, pp. 354–361, (2008).
19. Edgren, C. S., Radwin, R. G., Irwin, C. B., "Grip force vectors for varying handle diameters and hand sizes", Human Factors 46 (2), pp. 244 – 251, (2004).
20. Sulaimany A. A., AlGethami A. A. and Ali W. Y., "Friction Coefficient Between Clothes and Car Seat Covers", Journal of the Egyptian Society of Tribology Vol. 8, No. 4, October 2011, pp. 35 – 46, (2011).
21. Nair A. U., Sheela R., Vivekanadan M. V., Patwardhan B. A., Nachane R. P., "Studies on Friction of Cotton Textiles: Part I- A Study on the Relationship between Physical Properties and Frictional Characteristics of Cotton Fibres and Yarns", Indian Journal of Fibre and Textile Research, Vol. 38, pp. 244 – 250, (2013).
22. Gowda M. R., Mohanraj S., "A Novel Approach to Measure Friction in Textile Fibre Assemblies", RJTA Vol. 12 No. 2, pp. 30 – 38, (2008).
23. Mahmoud M. M., Ibrahim A. A., "Friction Coefficient and Triboelectrification of Textiles", Journal of Multidisciplinary Engineering Science and Technology (JMEST), Vol. 3 Issue 2, pp. 3970 – 3976, (2016).