Influence of studs material and applied weight on the rotational resistance.

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Introduction

One of the frequent injuriesincurred during a soccer game originates from a trauma brought on by torsion of the leg and without contact with an opponent. This trauma is frequent at the time of a pivotal rotation when the foot is fixed (Torg & Quedenfeld, 1971; Cameron & al., 1973; Andreasson and al., 1986). Two-thirds of the injuries in soccer are linked to this interaction between the surface and the shoe (Nigg, 1987).

The objective of this paper is to measure the influence of the studs material and the applied force on two types of new generation artificial turf with international standardized methodology.

Methodology

The general methodology used is the same as that in the previous paper (Vachon, 2004).
The rotational resistance to the surface was determined from the torque required to rotate the weighted disc in contact with the surface, as shown in Figure 1. The standard disc (figure 1) was loaded with a mass of 45kg and 65kg and dropped onto the surface from a height of 100mm.

Figure 1. Rotational resistance apparatus

Surface description

Surface 1 = No infill (XL Generation, XL Pro)
Surface 2 = Infill artificial turf (SBR, 20mm)

Studs description

15mm Teflon studs = Standard from the ISSS
13mm Rubber studs = For hard surface (soft rubber)

Results

The first phase of the analysis consisted in determining if there existed an acceptable reproducibility among various conditions of the tests. Figures 2, 3 and 4 show that for five consecutive tests there was a good reproducibility between each test for the variables mass (weight), surface and stud.

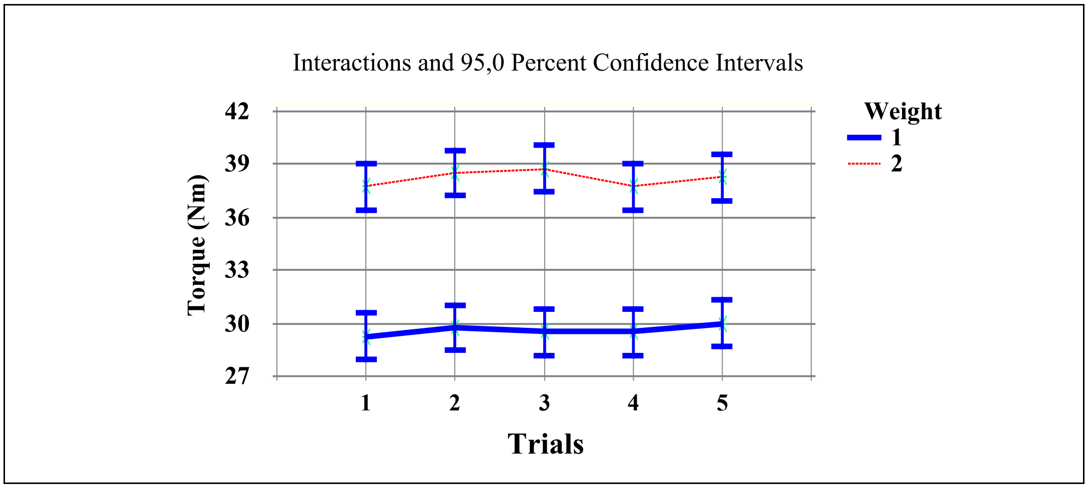

Figure 2. Weight effect of five consecutive trials.

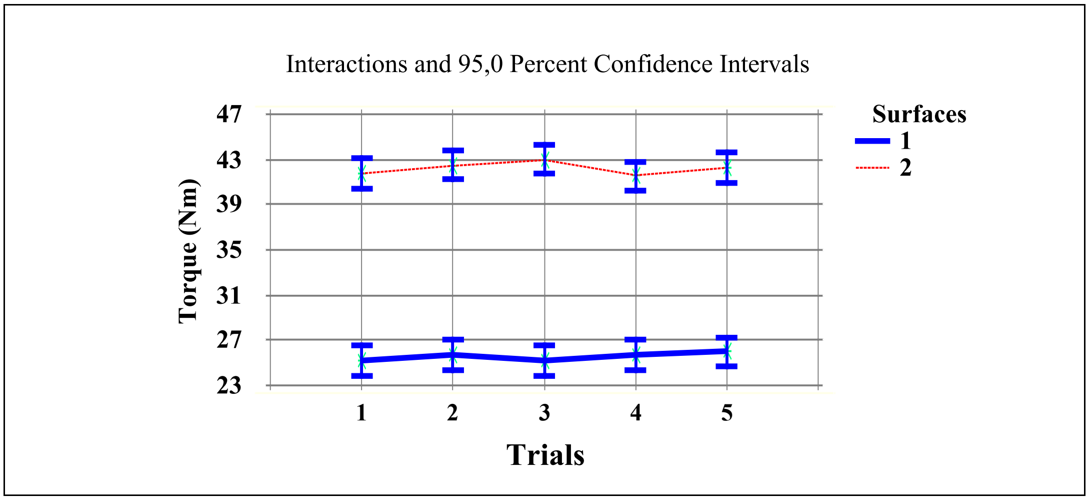

Figure 3. Surface effect of five consecutive trials.

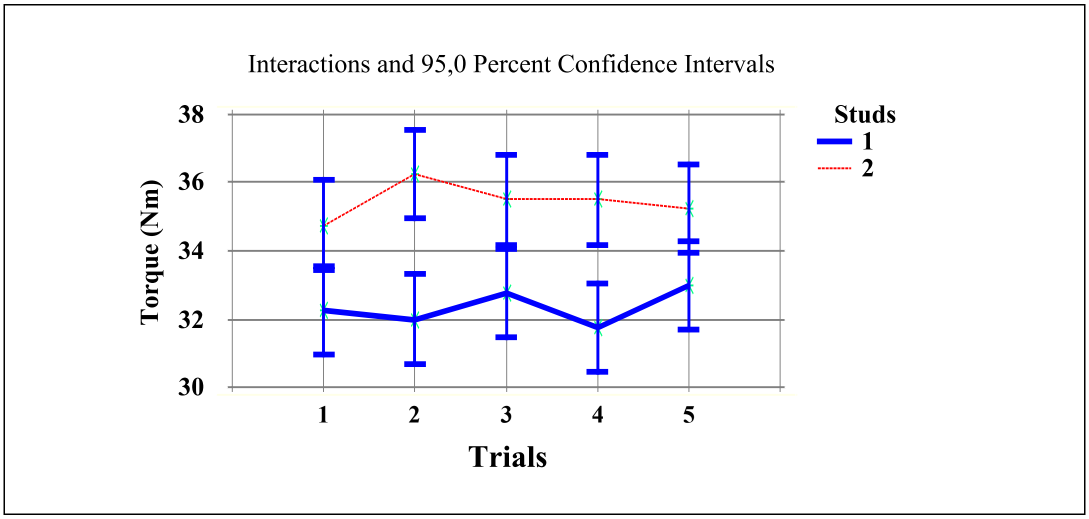

Figure 4. Studs effect of five consecutive trials.

Table 1 as well as figures 5, 6 and 7 illustrate the various relationships between surfaces, type of material used for the studs and the loads applied to the surfaces at the time of the measurements of rotational resistance (torque).

Figure 5 illustrates the relationship between the two surfaces and the two types of studs used.
Notwithstanding the type of stud, the surface with SBR rubber develops a larger torque (95 % confidence level), varying between 41 Nm and 43 Nm in comparison to the surface without infill which develops torques of 23 Nm using Teflon studs and 28 Nm using rubber studs. The statistical analysis indicates that the infill surface shows no difference no matter the type of studs used compared to the surface without infill showing results significantly different depending on the type of studs.

These results suggest that the use of rubber studs increases the rotational resistance on the surface without infill.

Figures 6 and 7 tend to illustrate that the mass applied to the surfaces influences the torque and that comparison can be made for the types of surface used. These figures together with the results posted in Table 1 clearly show that the mass influences the torque with an average score of 30 Nm for a mass of 45 kg and of 38 Nm for a mass of 65 kg. It must also be noted that the load influences the result when the types of surface are isolated. Thus, the average results are significantly different, being for the two different loadings 24 Nm and 28 Nm for the surface without infill and 36 Nm and 49 Nm for the surface with SBR infill. In this, the difference is significant.

Finally, Figure 8 illustrates the relationship between the load applied and the type of stud. This figure shows that for the same isolated mass (45kg and/or 65kg), the type of stud significantly influences the rotational resistance. This observation corroborates the study of Bonsting et al. (1975) and others, which demonstrates that the normal force (applied to the surface at the time of a rotational movement) influences the torque directly to initiate the movement.

Table 1. Relationships between the types of surfaces, studs material and weight.

Groups	*Observations*	*Mean*	*Lower limit*	*Upper limit*
Surface				
Infill	20	42,2	41,61	42,78
Without infill	20	25,6	25,01	26,18
Studs				
Teflon	20	32,35	31,76	32,93
Rubber	20	35,45	34,86	36,03
Weight				
45kg (441N)	20	29,6	29,01	30,18
65kg (637N)	20	38,2	37,61	38,78
Interactions				
Infill-Teflon	10	41,3	40,47	42,12
Without Infill-Teflon	10	23,4	22,57	24,22
Infill-Rubber	10	43,1	42,27	43,92
Without Infill-Rubber	10	27,8	26,97	28,62
Infill-45kg	10	35,7	34,87	36,52
Without Infill-45kg	10	23,5	22,67	24,32
Infill-65kg	10	48,7	47,87	49,52
Without Infill-65kg	10	27,7	26,87	28,52
Teflon-45kg	10	28,9	28,07	29,72
Rubber-65kg	10	30,3	29,47	31,12
Teflon-65kg	10	35,8	34,97	36,62
Rubber-65kg	10	40,6	39,77	41,42

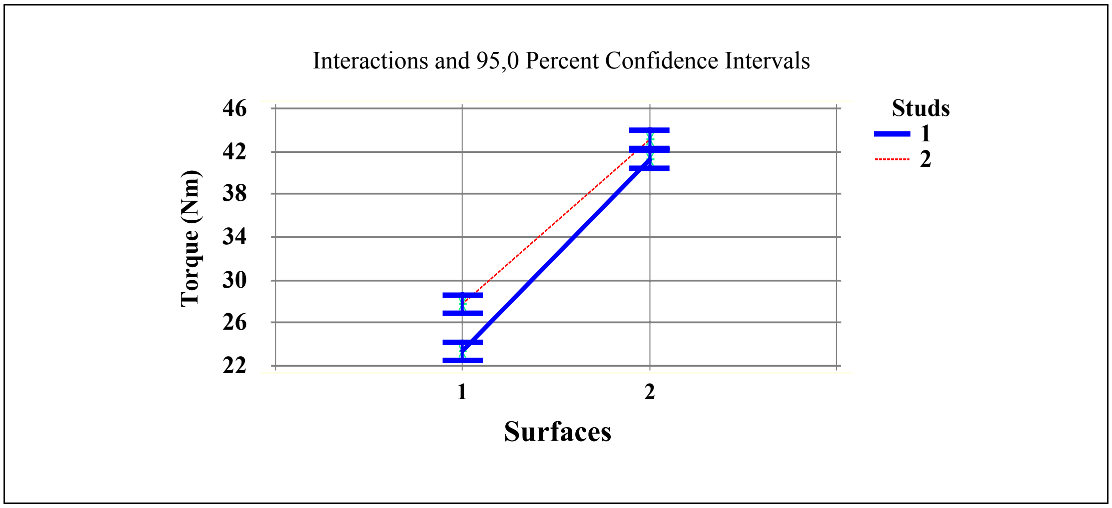

Figure 5. Relationship between the surface and the material stud for rotational resistance.

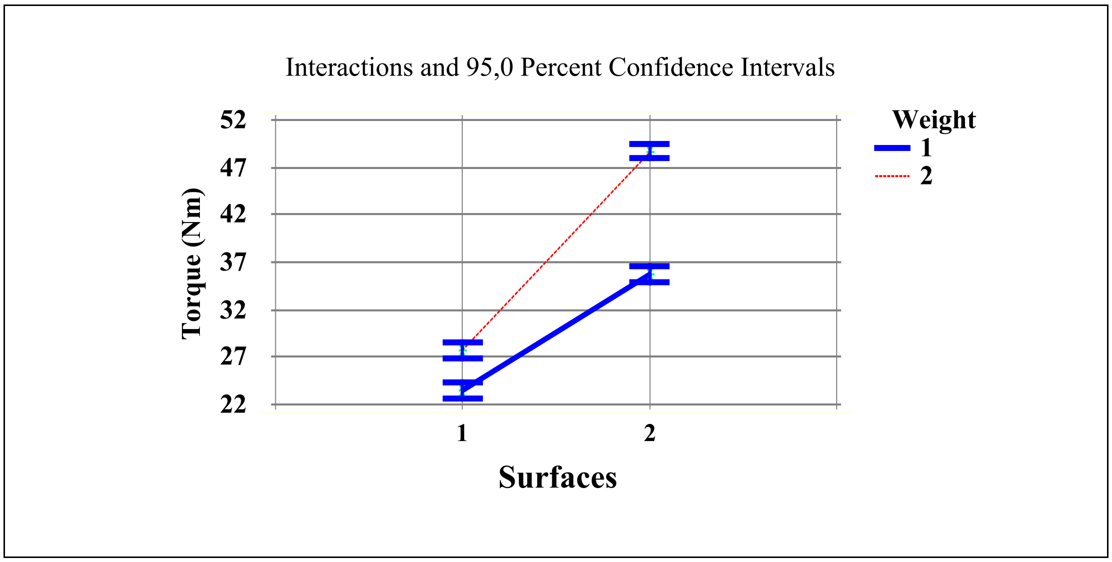

Figure 6. Relationship between the surface and the weight for rotational resistance.

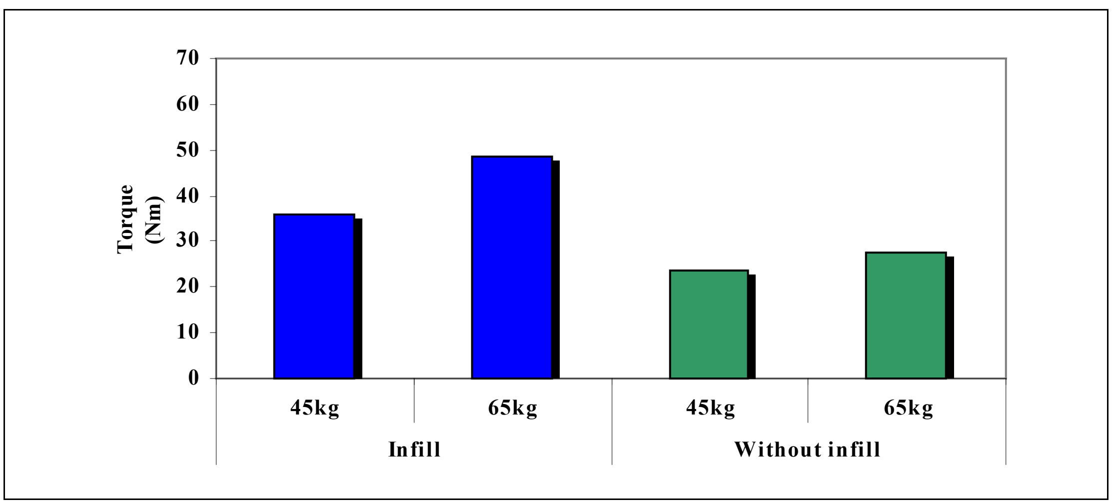

Figure 7. Relationship between the surface and the weight for rotational resistance.

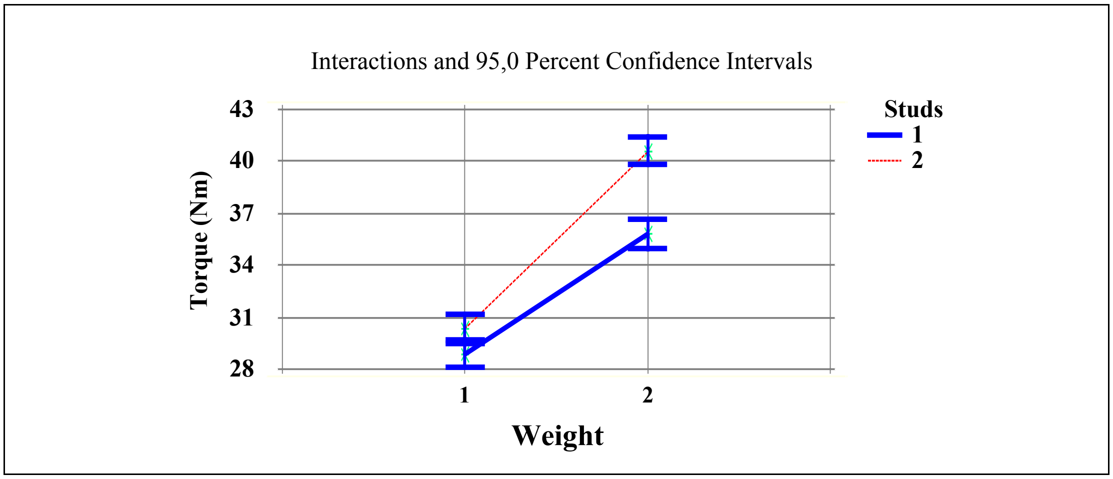

Figure 8. Relatioship between the stud material and the weight for rotational resistance.

Discussion and Conclusion

Several studies (Stucke and al., 1984; Valiant 1987; Dura, 1999) have shown an unconscious adaptation by the athlete in the adjustment of applied forces to the ground at the time of a rotation movement. Stucke & al. (1984) used a force platform and measured the horizontal and vertical forces plus the torque at the time of departures, stops rushes and turns on three different surfaces. The athletes exhibited an adaptation of the motor scheme by kinematic modifications. These modifications brought on by the athlete were aimed at obtaining a resistance of less than 25 Nm on any type of surface. Another similar study (Valiant 1987), has shown that the torque developed by the athlete was 17 Nm. This same author has established a maximum limit of 40 Nm in order to assure the safety of the athlete on a surface. The results of these two studies are confirmed and directly transferable to the world of Soccer by a study done in the Laboratory of the University of Calgary during the summer of 2002 (Stefanyshyn & al., 2002). The results deriving from the comparative study of 20 surfaces designed for soccer have shown an adaptation by the athlete when performing their pivotal movements to obtain a moment in rotation (torque) of more or less than 25 Nm. Based on biomechanic principles, this study has determined that the acceptance criterion for rotational resistance must be less than 25 Nm.

Several experimental protocols have illustrated a weak relation between the torque applied to the ground by the athlete and those measured mechanically (Van Gheluwe & al., 1983; Nigg & al., 1988). This weak relation is explained by the fact that the athlete reacts to the variation of the friction characteristics of the surface by adapting the motor skills (Nigg, 1986).

Despite this weak relationship, it is unrealistic and non-objective to utilize only real subjects in each evaluation. In evaluating mechanically the adherence of the boot sole to the surface during a rotation, it is important to consider that the rotational resistance is directly dependent on the applied forces to the ground at the time of the mechanical tests. According to Bonsting & al., (1975), Andreason & al. (1986), Nigg, 1990 and Dixon & al. (1999), the rotational resistance is directly influenced by the varied material of the soles and by the applied load .

In reality the force applied to the ground will depend on the mass of the athlete amplified by the acceleration that his body undergoes at time of contact with the ground. A static 45kg mass is insufficient to represent this situation. Figure 9 is extracted from a study done by the Valencia Biomechanical Institute (Dura, 1999) shows that the rotational movement appears after the first peak (braking phase) and before the second peak (starting phase) at the time when the normal force is at its lower level. The average value of these vertical forces is 800 N, which is of the same order of magnitude as that used in these tests.

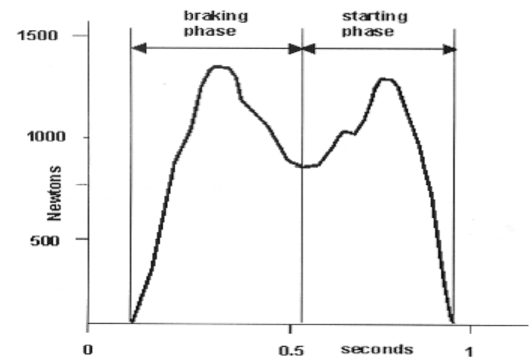

Figure 9. Typical vertical force in the turning movement (Dura, 1999).

It has been clearly shown, in laboratory (Denoth and al. 1978; Stucke and al., 1984; Valiant 1987; Dura, 1999), or on natural, well maintained fields (Canaway and al., 1990) that the player instinctively looks for a rotational resistance of about 20-25 Nm and thi,. How do variouis Standards account for the norm of 25- 40 Nm?

When evaluating a surface, attention should be paid to the material of which the studs are made as well as the representative applied vertical force used in order to assure that this product is evaluated correctly. There is at times a tendency to transpose the adherence characteristics of a natural surface to the artificial surfaces. This method does not take into account the fact that the rotational resistance itself has to be as low as possible with an acceptable minimum of 15-20Nm and a maximum of 40Nm (Valiant, 1990) for the player's safety.

If the same hard studs used on a natural surface are used to evaluate a surface that does not allow the penetration of the studs (surface 1 without infill), a surface type without infill or another similar product, such a surface would be classified as too slippery in translation as well a in rotation according to some established criteria (FIFA-UEFA) and methodology. The experience of the majority of the players might be to declare that the soles or stud made of soft rubber are a must for surfaces without infill and that the ''hard'' studs (Teflon, metal…) should never be used on these surfaces. The truth is that the player is able to choose the stud-material-surface combination to obtain, if he so wishes, the same interaction as for natural grass.

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