A NEW VALID SHOCK ABSORBENCY TEST FOR THIRD GENERATION ARTIFICIAL TURF

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This study aims to re-examine how much the current mechanical testing procedure is valid to evaluate the shock absorbency of third generation artificial turf (3-g turf) and to establish a new testing procedure which precisely reflects the acute load by human sports action. The standard DIN test was conducted for the 3-g turfs with different infill rubber size and the number of layers. The baseline of the load of acute sports action was obtained from the ground reaction force of landing of 50 cm height with minimal shock attenuation. For reproducing the force similar to such hard landing, a testing rig was developed and several types of the 3-g turf with different infill and depth: sand 40 mm, rubber 40 mm, rubber 15 mm and sand/rubber 40 mm were tested. The standard test was found to be inappropriate to evaluate the shock absorbency of the 3-g turf, in particular for likely acute, high loading by human sports action. In contrast, the newly developed testing rig succeeded in illustrating the differences of shock attenuation properties between the 3-g turfs. The need of replicate high loading test using an alternative testing procedure was highlighted.

KEY WORDS: new testing procedure, human landing, DIN test.

INTRODUCTION:

Use of artificial turf is becoming very common for many sports, in particular for association football (soccer). It seems that third generation artificial turf (3-g turf) actualized more “natural turf” like appearance and properties: ball-surface and shoes-surface interaction. Football organizations FIFA and UEFA recently accepted the use of the 3-g turf for official and international tournaments (UEFA, 2004; 2005). Moreover, possible use of the 3-g turf for the next World Cup tournament is under consideration. However, there still exists an indistinct anxiety that some of the mechanical characteristics of artificial sports surfaces may link acute or chronic sports injuries. Several studies (Nigg, 1983; 1990) already suggested that mechanical properties of artificial sports surfaces may be linked to acute or chronic sports injuries.

Various aspects are important in the selection of a surface. Relevant surface properties include the cushioning ability, friction characteristics and the influence on energy loss (Dixon, 1998). Of these aspects, the cushioning ability can be considered as a key feature. From the FIFA guideline (2005), “Shock Absorbency” of the 3-g turf has been approved by the simple mechanical testing (DIN test). However, it has been suggested by several studies (Blackburn, 1995; Dixon, 1998; Nigg, 1990) that the current, conventional testing procedure does not reflect actual loading action occurring in sports movements. The present study aims to re-examine how much the current mechanical testing procedure is valid to evaluate the shock absorbency of the 3-g turf and to establish a new testing procedure which precisely reflects the acute load by human sports action.

METHOD:

Three experiments were conducted in the present study as follows.

Figure 1: Stadndard DIN test.

Experiment 1: To obtain the baseline of the load of acute human sports action, four healthy male subjects were volunteered. "Hard landing" was chosen as a task which represents acute human sports action because this action is expected to produce the biggest impact on surfaces. All subjects performed landing from 50 cm height on the bare rigid surface of the force platform for three times. They are instructed to land with minimal shock attenuation. Ground reaction force was measured using a Kistler force platform at 1000 Hz.

Experiment 2: Validity of the DIN standard test was re-examined. From the FIFA guideline (2005), the standard DIN test was conducted for the 3-g turfs with different infill rubber size and the number of layers. In this test, a 20 kg mass is released from 55 mm height onto a load cell with spring on the top (Figure 1).

Experiment 3: For reproducing the load similar to the human hard landing, a testing rig was newly developed (Figure 2). For producing a constant vertical load, the rig applied a drop mass system using a length adjustable pendulum. A solid tyre was used for the top. Several types of the 3-g turf tray (90 ×90 cm) with different infill component and depth: sand 40 mm, rubber 40 mm, rubber 15 mm and sand/rubber layers 40 mm were made and tested in two loading conditions (approximately 7000 N and 11000 N to the bare rigid surface of the force platform).

Figure 2: New testing rig

RESULTS:

Human landing: Figure 3 shows a typical example of the loading aspect by human hard landing. As shown, clear one peak was observed during the hard landing with magnitudes ranged approximately 9000 N to 13000 N

DIN test: Figure 4 shows typical examples of the loading aspect of the standard DIN test for different types of the 3-g turfs. As shown, the first peak occurs at the same time and with the same magnitude over different types of the 3-g turfs. The peak load of the DIN test was approximately 3500 N which was distinctively smaller than that caused by the human landing.

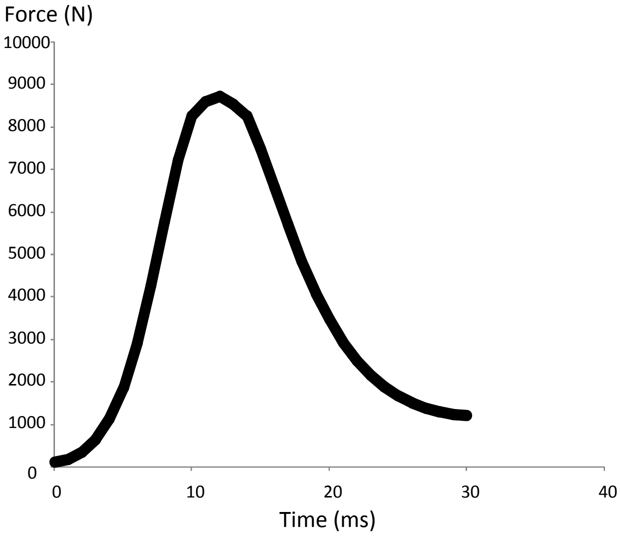

Figure 3: Typical loading aspect of human hard landing.

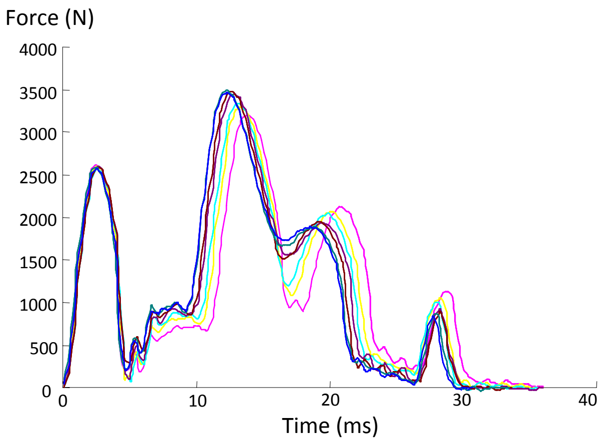

Figure 4: Typical loading aspects of standard DIN test.

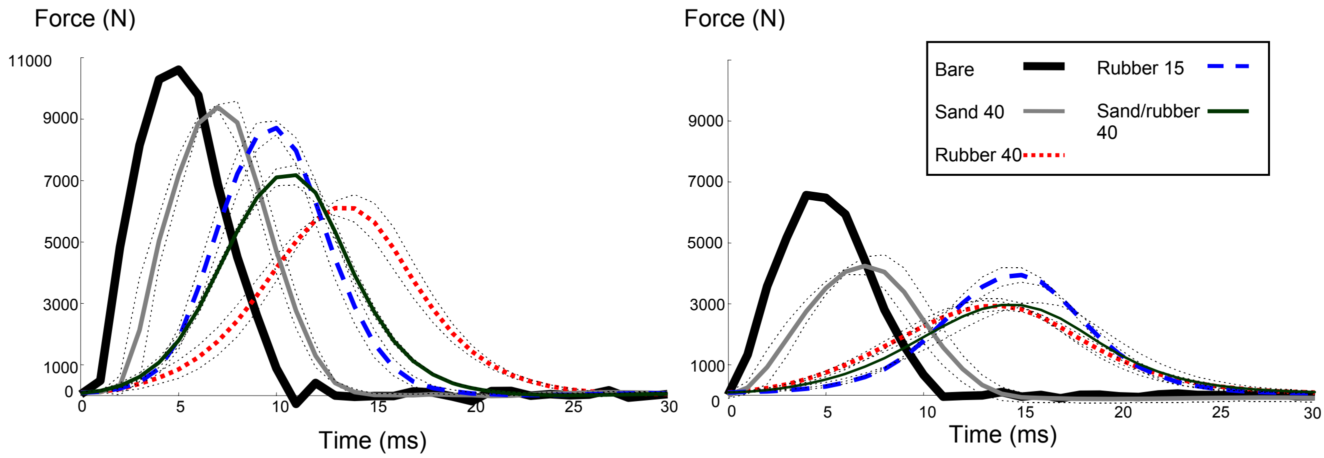

Figure 5. The average (±SD) change of the load applied by the new testing rig in high loading (left) and low loading (right) condition.

New testing procedure: Figure 5 shows the average (±SD) change of the load applied by the new testing rig in high loading (left) and low loading (right) conditions. These two loading conditions apporximately simulated the load of the human hard landing and that of the standard DIN test, respectively. It can be seen that the history of the shock attenuation was clearly illustrated by the new teting procedure. In the high loading condition, the 3-g turfs attenuated the peak impact load to 55% and extended the time to peak up to 300 % to compare with the bare rigid surface. The difference of shock attenuation property between the 3-g turfs was clearly illustrated in the high loading condition whereas the difference was unclear for some of the 3-g turfs in the lower loading condition which reproduced the similar load made by the DIN test.

DISCUSSION:

In the present study, the validity of the DIN test which has been accepted as the standard testing procedure to measure "Shock absorbency" for the 3-g turf was re-examined in detail and an attempt was also made to develop a new testing procedure which precisely reproduce acute load by human sports action.

The DIN test produced multiple peaks during loading (Figure 4). Of these, the peak magnitude has been evaluated as only the parameter. This unique loading aspect indicates the force measuring part (the load cell with spring) oscillates between the impacting mass and the surface of the 3-g turf during loading (Figure 4). Moreover, as shown, the first peak occurred at the exact same time and with the same magnitude over the different infill 3-g turfs. It is obvious that the first peak produced by the DIN test does not reflect the shock attenuating property of the 3-g turfs but reflects some mechanical property inside of the system. Likewise, the load caused by the DIN test (approximately 3500 N) was apparently smaller than that of the human hard landing (Figure 3). It can be assumed that the standard DIN test is not appropriate to evaluate the shock attenuation of the 3-g turf.

In contrast, the newly developed testing rig succeeded in reproducing the load of human hard landing (Figure 5). The new testing procedure allows evaluating the loading rate assumed as an important measure of human feeling. In the high loading condition (approximately 11000 N) did clarified the difference of shock attenuation properties (peak and loading rate) between the 3-g turfs with different infill components whereas the difference was unclear for some of the 3-g turfs in the lower loading condition (approximately 7000 N). This demonstrated that the high loading condition should be taken into account to evaluate the shock attenuation of the 3-g turf.

CONCLUSION:

The standard DIN test was found to be inappropriate to evaluate the shock absorbency of the 3-g turf, in particular for likely acute, high loading by human sports action. The new testing procedure developed in the present study demonstrated its distinct advantage to adequately evaluate the shock absorbency of the 3-g turf.

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