COMPARISON OF TESTING PROTOCOLS OF ANKLE SPRAIN MECHANISM: INVERSION DROP TEST AND LANDING ON AN INVERTED SURFACE

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INTRODUCTION

The ankle is the most injured joint in sports and accounts for 10 - 30% of all sports injuries [1]. Of those ankle injuries, a lateral ankle sprain is the most common. A majority of studies has used an inversion drop platform to induce ankle inversion movement to study lateral ankle sprains. However, this testing method only induces the inversion movement and not the plantarflexion movement or sufficient vertical loading commonly seen in an ankle sprain suffered on the field. A very limited number of studies employed drop landing in their experimental protocol to study the lateral ankle sprain mechanism [2,3]. Therefore, the objective of the study was to investigate kinematics of two ankle brace testing protocols: drop landing on an inverted surface and inversion drop test with and without an ankle brace. The hypothesis was that drop landing on an inverted surface would better replicate the movement associated with ankle sprain.

METHODS

Eleven healthy subjects (6 females and 5 males, age: 24.6 ± 3.5 years, height: 1.70 ± 0.10 m, mass: 65.6 ± 14.9 kg) with no current ankle injury and no history of major lower extremity injuries participated in the study. A seven-camera motion analysis system (240 Hz, Vicon, UK) was used to collect 3D bilateral lower extremity kinematic data. Two force platforms (1200 Hz, AMTI, USA) were used to measure the ground reaction forces (GRF) simultaneously with the 3D kinematics. An inverted surface (Figure 1a) with a 25° inversion slope was mounted on top of the right force platform along with a flat surface (Figure 1a) mounted on top of the left force platform during drop landing conditions. A customized inversion drop trapdoor platform [91.5 cm (L) x 46 cm (W) x 20 cm (H)] (Figure 1b) was used in an inversion drop test to attempt to invert the ankle to 25º during testing conditions. The subjects performed five trials each of landing on the inverted surface without (LS_NB) and with (LS_BR) a semi-rigid ankle brace (Element, DeRoyal Industries, Inc.) and inversion drop without (ID_NB) and with (ID_BR) the brace.

a)  b) 

Figure 1. Landing on a) inverted landing surface and inversion drop on b) inversion drop platform.

3D kinematic variables were calculated using Visual 3D (C-Motion Inc.) for the right side lower extremity. Selected variables were analyzed using 2 × 2 (brace × movement) repeated measures ANOVAs ($p < 0.05$).

RESULTS AND DISCUSSION

The results of the two testing protocols showed that the time to the peak inversion angle (TMax_Inv) for the inverted surface landing occurred significantly sooner than in the inversion drop on the trapdoor (Table 1). Significantly higher contact and maximum inversion (Max_Inv_V) velocity and less time to maximum inversion velocity (TMax_Inv_V) were also found in the inverted surface landing compared to the inversion drop test. No significant difference was found for the contact plantarflexion angle between the two testing protocols, however the inverted surface landing produced significant higher dorsiflexion range of motion (ROM_DF) and maximum dorsiflexion velocity in the drop landing compared the inversion drop. These results implied that the landing protocol introduced greater inversion loading than the inversion drop.

For the brace effect, the results showed that there was a significant brace x movement interaction for peak inversion angle (Max_Inv) showing a greater inversion angle in inversion drop without brace compared to the landing conditions (Table 1). The dorsiflexion ROM significantly decreased while wearing the ankle brace in both movement conditions. The brace reduced the contact and peak inversion velocities and increased TMax_Inv_V during the inversion drop. However the brace increased the contact and peak inversion velocities and reduced TMax_Inv_V in landing on the inverted surface compared to the inversion drop. These results demonstrated that the ankle brace was more effective in reducing inversion loading in the inversion drop than in the landing protocol.

CONCLUSIONS

The results indicate that the inverted surface landing provides greater inversion velocity and loading and therefore simulates the ankle sprain mechanism better than the inversion drop protocol. The effectiveness of ankle brace in reducing inversion velocity and loading is diminished in the inversion landing protocol but it provides greater restriction in sagittal plane movement than the inversion drop protocol.

REFERENCES

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Table 1. Average frontal plane and sagittal plane ankle kinematic variables: mean ± STD.

Cond	Max_Inv* (deg)	TMax_Inv (s)	ROM_DF (deg)	Cont_V (deg/s)	Max_Inv_V * (deg/s)	TMax_Inv_V * (s)
LS_NB	25.2±3.9 [1]	0.060±0.011 [2]	35.3±5.1 [1,2]	163.9±128.0 [1,2]	273.8±156.0 [2]	0.027±0.009 [1,2]
LS_BR	22.6±5.2	0.055±0.010	28.1±6.2	256.7±119.7	373.1±121.1	0.021±0.007
ID_NB	27.7±6.1	0.239±0.046	16.7±5.2	-26.8±78.6	166.5±67.9	0.173±0.060
ID_BR	22.0±4.8	0.241±0.050	6.2±5.2	-17.2±50.6	69.1±59.7	0.245±0.085

[1]: significantly different between NB and BR in inverted surface and inversion drop conditions ($p<0.05$)
[2]: significantly different between inverted surface landing and inversion drop conditions ($p<0.05$)
[*]: significant brace × movement interaction in the inverted surface landing and inversion drop ($p<0.05$)