EFFECTS OF BILATERAL AND UNILATERAL SEMI-RIGID ANKLE ORTHOSES ON ANKLE STABILITY AND GROUND CONTACT KINETICS

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Injuries of the ankle complex are common in the sporting, civilian and military populations. The purpose of this study was to ascertain and compare the effects of unilateral and bilateral orthoses on the range of inversion and eversion at the ankle complex and on Ground Reaction Forces. Isokinetic goniometric measurement and the assessment of peak loads and timing parameters during the gait cycle were assessed in subjects with no history of ankle injury (n=31) and subjects recovering from ankle injury (n=24). There were differences in inversion angle between the braces ($P<0.05$). In contrast there were no differences in kinetic profiles. The stability provided by semi-rigid ankle orthoses does not appear to result from moderation of ground reaction forces.

KEY WORDS: ground reaction forces, injury, orthoses

INTRODUCTION:

Injuries to the lateral ligament complex of the ankle are especially prevalent in the sporting, civilian and military populations (Garrick, 1977; The Army Health Unit, 1999). Although the majority of these injuries resolve with time, appropriate treatment and rehabilitation, between 39% (Verhagen *et al.,* 1995) and 70% (Yeung *et al.,* 1994) may have residual or recurrent symptoms. In the last two decades, the use of semi–rigid stirrup type orthoses has become commonplace in the prevention and treatment of initial and recurrent ankle injury. Several major studies have been undertaken to ascertain the effectiveness of these braces. In a meta-analysis of the data from 8,279 participants studied in 14 randomised trials, of which 12 were focused on healthy adults participating in high risk activities and two on injured patients, Handoll *et al.* (2006) concluded that there was good evidence to support the conclusion that semi–rigid stirrup type orthoses provided protection for athletes involved in sporting activities considered to be at high risk for ankle injuries. Further analysis of the data showed a pronounced effect of the effectiveness of semi-rigid orthoses on patients who have previous episodes of ankle ligament injury. The aim of this study was to examine the effect of two types of orthoses on the kinetic profiles and inversion/eversion movement at the ankle when compared to bare feet and when wearing training shoes.

METHOD:

Participants: The non-injured group consisted of 31 military personnel (25 Male: 6 Female) with a mean age of 27 (±7) yrs and mass 73 (±12) kg. The patient group consisted of a population of 24 military personnel (20 Male: 4 Female) with a mean age of 27 (±5) yrs and mass 84 (±18) kg, who had been referred to a physiotherapy department following Grade II or III inversion injury to their ankles. Seven of these patients had bilateral injury/instability.

Data Collection: Participants from each cohort were randomly assigned to one of two groups. Oddly numbered participants were assigned initially to goniometric assessment using an Isokinetic Dynamometer (Biodex Medical Systems 2, Single Chair, USA) followed by kinetic gait analysis using a force plate (Kistler Instruments Ltd, 9281B, Switzerland) samling at 500 Hz and set in a 10 m walkway. Evenly numbered participants were tested in the reverse order.

Data Analysis: To explain the difference between the selected braces; Gelcast bilateral ankle orthoses (Johnson & Johnson, New Jersey, USA) and Aircast unilateral ankle orthoses (Aircast Ltd, Neubeuern, Germany) each was compared with the non-injured condition when 'barefoot' and when wearing a training 'shoe'. Tests for normality were carried out using an Anderson Darling Normality Test. Parametric statistical techniques were employed to determine the difference between each condition: An alpha level of $P<0.05$ was used as the statistical limit however for clarity and to prevent analytical limits effecting the conclusions drawn the true P value was included.

RESULTS:

There was a significant decrease ($P<0.05$) in the range of ankle inversion when Gelcast and Aircast ankle orthoses were used for the injured and non-injured subjects (Table 1). In contrast there were no significant differences in the ranges of ankle inversion between the 'barefoot' and 'shoe' conditions for either group. Furthermore, no significant decrease in the range of ankle inversion was found between the unilateral (Aircast) or bilateral (Gelcast) ankle orthoses. The ranges of active inversion angles of injured and non-injured subjects are summarised in Table 1.

Table 1 Mean (±sd) Ankle inversion angles with and with out orthoses (Gelcast = bilateral) and (Aircast = unilateral) for Injured and non-injured subjects.

Injured	Inversion (º)	shoe	gelcast	aircast	non-Injured	Inversion (º)	shoe	gelcast	aircast
barefoot	45 (12)	0.144	0.000	0.000	**barefoot**	50 (04)	0.022	0.000	0.000
shoe	43 (11)		0.000	0.000	**shoe**	48 (17)		0.000	0.001
gelcast	34 (12)	0.000		0.339	**gelcast**	34 (10)	0.000		0.396
aircast	33 (12)	0.000	0.339		**aircast**	36 (12)	0.001	0.396	

There were no significant differences ($P>0.05$) between any of the four injured test parameters for the Medial/Lateral ground reaction forces (Figure 1) for 'peak force' or 'time to peak force' between any of the test conditions ($P>0.05$) for the injured subjects.

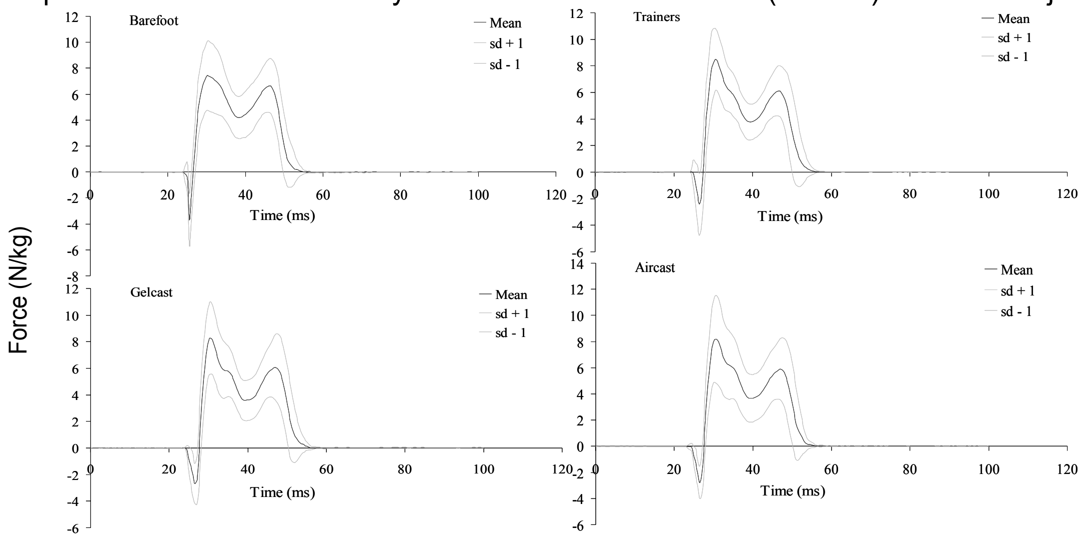

Figure 1. Medial/ Lateral Ground Reaction Force time histories (N/kg) for injured subje

DISCUSSION:

Inversion was consistently less in the injured subjects compared to the non-injured group, and although it could be expected that ligamentous laxity experienced as a result of injury may predispose individuals to a larger range of movement, it can be argued that functional insufficiencies and strength deficits in both ankle invertors and evertors experienced by patients with Chronic Ankle Instability (CAI) may have had an effect on the generation of torque. Decreased muscle power and latency experienced as a result of these insufficiencies can prevent the prime talocrural invertors from generating force equitable to the non-injured subjects. The effects of footwear on biomechanics of the ankle are demonstrated by the significant decrease in the inversion range of movement when barefoot compared to when wearing a shoe for the injured subjects (Table 1). There was a less pronounced difference (P=0.022) for the non-injured group. Studies have shown that athletic shoes can decrease the incidence of ankle injury but no evidence exists to show that this is due to a decrease in range of movement at the ankle. Medial/Lateral peak ground reaction forces were very similar in all conditions and showed no significant differences (P>0.05) between any of the four parameters for either the injured or the non-injured subjects. Medial Peak ground reaction forces were the same for both un-injured subjects and injured subjects (Figure 1). There were no differences in lateral ground reaction forces, (8-10 N/kg in the non-injured subjects and 8-9 N/kg in the injured subjects). Times to peak ground reaction forces were also similar between groups and showed no significant difference (P>0.05) between any of the four parameters in injured and non-injured subjects. Times to peak medial ground reaction force were similar in the groups at 26-29 ms for the non-injured and 27-29 ms for the injured. Times to peak lateral ground reaction forces were the same for both groups at 32-36 ms. There was a clear increase of variability at the peaks of both medial and lateral ground reaction forces in all eight (injured and non-injured) test parameters (Figure 1). Research has been equivocal regarding the effect that semi-rigid ankle orthoses have on medial and lateral ground reaction forces. Stuessi *et al.* (1987) found an increase in the forces during a lateral shuffle and Hamill *et al.* (1986) found no differences in any of the orthogonal directions whilst subjects ran at a controlled speed. The data from this study clearly shows that medial and lateral forces during initial foot contact are not moderated or changed by wearing either of the two braces studied and therefore the stabilising effect is likely to be due another mechanism.

CONCLUSION:

This research utilised a biomechanical method to evaluate the effectiveness of two semi-rigid ankle orthoses against one another and against baselines from ‘barefoot’ and when wearing a ‘shoe’ conditions. Both injured and non-injured Service personnel were assessed by isokinetic dynamometry and Ground Reaction Force evaluation to improve the understanding of whether the stability provided is mechanical or a result of moderation or modification of forces through the foot during the stance phase of normal gait. Having investigated these parameters, an improved understanding of the mechanical effects of the braces and their action on Ground Reaction Forces has been achieved. Anterior-posterior (F_y), Vertical (F_z) and Medial/Lateral (F_x) peak ground reaction forces were similar and showed no significant difference (P>0.05) between any of the four parameters in either the injured or non-injured subjects. These results were the same for times to reach peak Ground Reaction Forces. It would therefore appear that the stability provided by semi-rigid ankle orthoses is a result of a mechanical process, which provides a resistance to motion which results in a decreased end range of movement and joint moment and consequent moderation of strain on primary ligamentous restraints. It is unlikely that this protection is afforded by moderation of Ground Reaction.

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