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The effect of ankle brace type on braking response time—A randomised study

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ABSTRACT

Introduction: The question whether or not a patient with an ankle brace should drive a car is of obvious importance because brake response time (BRT) is considered one of the most important factors for driving safety.

Materials and methods: Applying a crossover study design, 70 healthy participants (35 women, 35 men) participated in our study. BRT was assessed using a custom-made driving simulator. We assessed BRT under six conditions: without a brace (control) (1), with a typical postoperative ankle brace with adjustable ROM and the settings: unrestricted (2), fixed at 15° (3) plantar flexion, restricted with 15°/50° (4) (dorsal/plantar flexion), a brace for ligament instabilities (5) and an elastic ankle bandage (6). Participants were instructed to apply the brake pedal exclusively with the right foot as quickly as possible on receipt of a visual stimulus.

Results: The 70 participants showed significantly impaired BRT with the ankle brace for ROM restriction in the settings: unrestricted ($p < 0.001$), fixed at 15° plantar flexion ($p < 0.001$) and 15°/50° dorsal/plantar flexion ($p < 0.001$) as compared to the control group. BRT was not impaired with the brace for ankle instabilities or the elastic ankle bandage.

Conclusions: In conclusion, right-sided ROM restricting ankle braces involve significant impairment of BRT in healthy participants. No such prolonged BRT was found for an elastic ankle bandage or the ligament brace.

Introduction

Ankle braces are often used as conservative treatment (e.g. ligament instability, ankle sprains) [1]. Moreover, a number of surgical procedures in the field of joint-preserving ankle surgery require a postoperative ankle brace over several weeks [2]. Especially the safety of performing daily activities such as driving a car is an issue for those patients. Such patients usually seek advice from their treating physiotherapist or doctor about whether they will be able to drive and whether the ankle brace will impair their driving performance. This challenging question is of obvious importance, because patient mobility and independence are very important for quality of life. Moreover, loss of motion and functional limitation after common ankle surgeries are frequent concerns expressed by patients.

Driving performance relies on various factors, but brake response time (BRT) is considered one of the most important factors responsible for driving safety [3–5]. Braking involves a complex interaction between ankle dorsal and plantar flexion, hip internal and external rotation and subtle hip and knee flexion and extension [6].

To our knowledge, very few experimental studies have looked at BRT during orthopedic immobilisation of the right lower limb [7,8]. Waton et al. [8] studied immobilisation of the right knee. Tremblay et al. [7] investigated BRT with a walking cast and an Aircast walker. Tremblay et al. found that the mean total braking time was shorter with the shoe than it was with either type of investigated ankle immobilisation [7]. They concluded that wearing a walking cast or an Aircast walker on the right limb increases emergency braking time and the ability to drive safely is questionable [7]. However, the findings made in that study did not cover the full spectrum of ankle orthoses (e.g. ankle braces that do not completely restrict motion).

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Apart from the issue of braces, previous research investigated the effects of various orthopedic procedures on BRT [5,6,9–18]. A number of studies have investigated how long it takes to recover normal brake reaction time following various orthopedic procedures and suggest a one- [19] to eight-week [9] abstinence before resuming driving [14–17].

The purpose of this study was to test the hypothesis that BRT would show significant increased differences between several types of ankle brace and an unrestricted control run in healthy adults.

Materials and methods

Participants were recruited between March and May 2013 at our Orthopedic Department. The local university ethics committee approved the study protocol, and written informed consent was obtained from all subjects before participation. All subjects were given the same standardised instructions following the study protocol. Moreover, each participant was asked to evaluate his own driving frequency according to the following responses: never, rarely, sometimes, often, and very often.

A total of 70 healthy participants (35 males, 35 females) participated in this study. To be included in the study group participants had to have a valid driving license, use exclusively the right foot for accelerating and braking and not have any medical condition that might impair their ability to drive. Excluded were participants taking medication that could affect reaction time, who have a history of alcohol and/or drug abuse, a entral nervous system disorder such as epilepsy, a metabolic disorder, psychiatric disorder, musculoskeletal disease, as well as participants with any recent (previous three months) surgery of the right lower limb.

The right ankle was assessed in six settings: without an ankle brace (control group) (1), with a typical postoperative ankle brace with adjustable range of motion (MaxTrax™ ROM, Donjoy Inc., Vista, CA, USA) set at one of the following settings: unrestricted (MaxTrax unrestricted) (2), fixed at 15° plantar flexion (MaxTrax 15-15) (3) and 15°/45° dorsal/plantar flexion (MaxTrax 15-45) (4), a brace for ligament instabilities (Procare Surround ™ FLOAM™, Donjoy Inc., Vista, CA, USA) (5) and an elastic ankle bandage (Malleoforce®, Donjoy Inc., Vista, CA, USA) (6) (Fig. 3).

The order of the measuring sequence was randomised to counteract a possible learning effect (cross-over protocol). This was performed with an Internet-based randomiser provided by the department of medical statistics and informatics of a medical university.

BRT was measured with an experimental apparatus (Fig. 1) as used in previous research [5,14–18]. The seat was adjusted by the participant to simulate his or her familiar driving position with regard to seat inclination, headrest and seat-pedal distance, as in previous research [19]. The external case containing the logic gate electronics, a green and a red lamp, was positioned on a table at a constant distance in front of the driving simulator [14] and at the subject's eye level. The participant was asked to place his or her right foot on the accelerator pedal at the beginning of each trial and to depress the accelerator pedal fully. This triggered the green light, indicating that the participant was in a "driving" position. After an interval of five to 30 seconds, the investigator pushed an external button (concealed from the patient's view) that turned on a red light and the electronic time clock. All participants were instructed in a standardised way to release the accelerator pedal and depress the braking pedal as quickly as possible when the red light came on. The time lapse between when the red lamp was switched on and when the brake pedal was suppressed was recorded and defined as the BRT (measured in milliseconds). Each participant performed the test with the right foot while the left foot rested on the coupler pedal. Each subject first did five trial runs and also walked a distance of 50 meters to familiarise himself with the ankle brace before starting the experiment. BRT was measured ten times for each ankle brace model with an interval of five to ten seconds between measurements.

A statistician was consulted for data analysis. An a priori sample size estimation was performed with G*Power [20,21] for the repeated measures ANOVA with each person in the sample being tested with each of the 6 ortheses (the ortheses being the within-subject factor). With the input data of alpha 0.05, $P = 0.80$ and an effect size of 0.125 (small to medium effect) a sample size of 70 was

Fig. 1. Custom-made apparatus for measurement of brake reaction time (BRT). Pedals from left to right: coupler pedal; brake pedal; accelerator pedal. External suitcase: red light: (visual stimulus initiating the braking procedure); green light: (indicating that the accelerator is fully depressed – subject not in a 'ready-to-brake fashion'). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of the article.)