Effects of various models of orthoses on undisturbed stance control.

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Introduction

Ankle orthoses are usually prescribed to patients suffering from sprained ankles or simple excessive joint mobility. The main effect of this is a restriction of the amount of sway in specific directions, depending on the physical characteristics of the orthoses. However, the conception of the orthoses is mainly based on subjective data. Consequently, the biomechanical and physiological effects on healthy subjects are incompletely assessed. The aim of the study is to test several models of orthoses, conceived to respond to various pathologies, through a simple protocol in order to accurately evaluate the effects on the postural control mechanisms involved in maintaining undisturbed upright stance.

Methods

Fourteen adults were required to stand still for periods of 64 s with their eyes closed. Three models, (Dynastab, Ligacast and Ligaflex) were compared in a random order to another model (Ortel), which was taken as reference since it is recognised by the manufacturer as having no more effect than a simple sock. Six trials, with rest periods of a similar duration, were performed to test each model, 10 minutes being allowed between each model. The subjects stood on a dynamometric force platform from which the centre of pressure trajectories (CP) were recorded at a 64 Hz frequency.

A subsequent analysis was performed in order to compute, from this CP, the horizontal motions of the centre of gravity (CGv), recognised as the main variable controlled in quiet stance, and the difference CP-CGv, thought to express the characteristics of muscles activity when the subject behaves as an inverted pendulum. The method is based on a frequential relationship of the amplitudes of CP and CGv (Brenière, 1996). To quantify these elementary motions, a frequential analysis was performed, consisting in computing for both motions and both medio-lateral (ML) and antero-posterior (AP) directions RMS and MPF values. For each parameter, the differences observed relative to the Ortel model, were then statistically tested through an ANOVA, the simple effects being assessed by a non-parametric Wilcoxon test. For all statistical tests, the first level of significance was set at p<.05.

Results & discussion

As demonstrated by figure 1, which represents the average spectra for both CP-CGv and CGv motions for each model of orthosis, some effects, depending on the model worn by the subjects are observed. As a general rule, the sway amplitudes decrease more or less proportionally when compared to the reference Ortel. Among the three models, Ligacast is undeniably the one that induces the largest effect. What is more, this effect concerns both ML and AP directions even though the effect appears to be more pronounced in the former direction. On the other hand, from these frequency spectra, Ligaflex does not really seem to modify the amount of sway. Lastly, Dynastab, by comparison with the two other orthoses mentioned above apparently determines intermediate effects which appear nonetheless more pronounced in the ML direction. These visual impressions are indeed confirmed by the statistical analysis. To be more precise, the one-way ANOVA indicates a strong general effect of the RMS parameter, especially in the ML direction. The strongest effect is observed for CP-CGv motions ((F(39,2)=11.83; p<.0001) whereas those for CGv motions demonstrate a lesser statistical significance (F(39,2)=7.41; p<.002). On the other hand, only CP-CGv motions are able to elicit significant trends in the AP direction (F(39,2)=3.60; p<.05).

The simple effect study reveals some specificities for each of the tested models, when compared to Ortel. As a general feature, one should point out that when an amplitude effect is noticed, it concerns the
complete frequency bandwidth whatever the motion considered, as shown by the spectra of figure 1. As a consequence, the mean power frequencies remain unchanged for all models of orthoses.

Figure 1: Frequential decomposition spectra for each direction (ML and AP) and each elementary motion (CP-CG$\text{v}$ and CG$\text{v}$) characterizing the whole sample population (mean in continuous lines ± s.d. in thinnest dashed lines). Traces relative to each of the three tested models of orthoses are presented in grey whereas the reference (Ortel) is presented in black. Note the larger effects for Ligacast and the lack of effect for Ligaflex.

**Dynastab**: The amplitudes induced by this model tend to decrease when compared to Ortel, the reference model. Although no statistical trend is observed for the RMS parameter for CG$\text{v}$ motions in both ML and AP directions, this difference appears more significant for those of CP-CG$\text{v}$. This feature is true for the ML direction (T=1; p<.001) whereas the statistical threshold is higher on AP (T=16; p<.05).

**Ligacast**: Out of the three models, this one undeniably induces the largest effects. CP-CG$\text{v}$ and CG$\text{v}$ motions indeed demonstrate highly significant differences for the RMS parameter in the ML direction (T=1; p<.001; T=2, p<.001, respectively). Interestingly, this trend is found again for the AP direction, even though the statistical result is slightly reduced (CP-CG$\text{v}$: T=6; p<.01; CG$\text{v}$: T=18; p<.05).

**Ligaflex**: The spectra seems unable to significantly distinguish any difference in postural behavior of the tested subjects. This visual impression is confirmed by the statistical tests on RMS values since no effect is observed for either CP-CG$\text{v}$ and CG$\text{v}$ motions or ML and AP directions.

From a general point of view, the present results confirm the capacities of the posturographic measurements to accurately evaluate the behavioral effects induced by wearing specific ankle orthoses. To our knowledge, several attempts have previously been made in order to test such material through this kind of analysis. However, most of these investigations were conducted on the basis of unipedal stance (Tropp et al., 1984; Feuerbach et al., 1993; Baier et al., 1998), which were unsuccessful in modeling instantaneous stance control as an inverted pendulum and thus the horizontal CG motions. Nevertheless, all these investigations and one of the few experiments conducted on bipedal stance (Calmels et al., 1991) had already highlighted the decreased amount of sway induced by wearing rigid or semi-rigid ankle orthoses. In addition to the decrease in the amplitudes of elementary motions CP-CG$\text{v}$ and/or CG$\text{v}$ induced
by each model, which serves to confirm these previous studies, our analysis method allows to identify several particularities for each model.

The different behavioral effects induced by wearing each model has to be related to their physical characteristics. From our results, it appears that the more rigid model (Ligacast) and the more supple (Ligaflex) induce the largest and lowest effects in terms of amplitudes of CP-CGv and CGv, respectively. The relative rigidity determined by each model indeed seems to be the main reason for these amounts of sway diminutions. This increased rigidity can be observed on both orthogonal directions ML and AP for Ligacast whilst the effect appears principally in the ML direction for Dynastab even there is also a slight tendency in the AP direction. The lack of real effect for Ligaflex suggests that the elastic straps do not contribute in any way to the control of body sway.

The knowledge of these functional implications can be of great interest for the practitioner. The prescription of a specific model of orthoses must indeed take into account the traumatologic constraints (nature of the injured ligament, gravity of the lesions, malleolar fractures) but also, from a prophylactic point of view, must consider the impact these orthoses could have on ankle movements from a quantitative point of view. Another interest lays in the possible use of ankle orthoses for postural rehabilitation purposes. The decreased ankle stiffness these models apparently induce could be of interest for the momentary, but significant, reduction of the muscular co-contractions which generally characterize patients with equilibrium problems or more simply, during the eyes closed condition. This increase in CP-CGv amplitudes can be interpreted principally as a way of facing unexpected events. One may note that this increase for protective purposes can partly disappear in individuals who have been suffering from blindness for a long period, this phenomenon resulting from long-term training (Rougier et al., 2000). Along these lines, the rigid ankle orthosis may constitute a valuable auxiliary for helping patients presenting excessive ankle stiffness to reduce it, at least for a while, providing therefore the possibility to solve, by appropriate exercises, the problems relative to CG control, the other component implicated in instantaneous upright postural control.

Finally, the knowledge of the specific effects generated by various models of ankle orthoses on the characteristics of the muscles activity involved in controlling undisturbed stance in the ML and AP directions is also helpful for its relevance in therapy. It seems thus rather pertinent to use Ligacast to decrease the constraints in the tendinous diseases of the long peronaeus muscles for instance. On the other hand, it seems that wearing such a brace over a too long period can blunt the muscular vigilance of the ankle and requires, therefore, some preventive muscular activity.

References


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