EVALUATION OF SHOCK ATTENUATION

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INTRODUCTION

During each step, a rapid deceleration occurs at the foot-ground interface resulting in a shock imparted to the musculoskeletal system. The consequences of insufficient shock attenuation may be severe resulting in overuse injuries (Radin et al., 1982). The level of this shock wave depends on a number of external factors such as running speed, stride length and running surface. While skin, fat pad, bone, ligament, tendon and muscle all help to decrease the magnitude and frequency of the shock, footwear also can attenuate the foot-ground impact shock. Therefore, the purpose of this presentation is to describe several methods that manufacturers use to evaluate the shock attenuation or cushioning properties of footwear.

EVALUATION METHODOLOGIES

Footwear are generally evaluated either via mechanical testing of the materials comprising the footwear or by conducting human subject testing on the complete shoe. To test material components of footwear, a mechanical impact tester is often used. A known mass is dropped from a pre-set height to simulate the mass and velocity of the foot at touchdown. This test can be a useful measure but should not be used to definitively describe the capability of the shoe to attenuate shock. It should be noted that this is a mechanical test and cannot simulate the kinematic changes that a runner may make as they contact the ground in response to different footwear properties.

By far the most often used piece of equipment for evaluating shock attenuation in footwear is the force platform. Parameters of the vertical ground reaction force component (vGRF) such as the high frequency, impact peak and the loading rate have often been used to evaluate the shock attenuation properties of footwear. While differences in loading rate can be detected between firm and soft midsole footwear, several studies have reported no differences between similar footwear in the impact peak (Snel et al., 1985). It should be noted exactly what the vGRF is measuring. Bobbert et al. (1992) illustrated that the vGRF describes the vertical acceleration of the total body's center of mass and thus cannot be effectively used to evaluate specific actions at the foot/ground interface. Thus, the evaluation of impact attenuation using force platform parameters should be viewed with caution. There are numerical techniques, however, that may make it possible to evaluate shock attenuation using ground reaction force data. For example, using an FFT to transform the data into the frequency domain and then using an inverse FFT to return only the high frequency to the time domain would result in data that would describe the acceleration of the lower extremity. These data may be useful in comparing the attenuation properties of footwear.

Many researchers are now using in-shoe pressure sensors to evaluate the cushioning properties of footwear. There are a number of in-shoe pressure systems that have been used and it should be noted that the characteristics of the sensors are of critical importance. If the sensors

have a high hysteresis and are not linear, then the results should be viewed with caution. Several studies have shown that the cushioning properties of footwear can be illustrated by using a reliable in-shoe pressure system (Hennig and Milani, 1995). These researchers also showed good agreement between the vGRF and the summed pressure curves.

For most laboratories, however**,** tibial accelerometry is the accepted method of evaluating shock attenuation. Single peak acceleration values are considered to be a direct measurement of the foot-ground collision. However, great care must be taken to attach the accelerometer appropriately. Because attachment to the bone is not practical, Shorten and Winslow (1992) suggested that evaluation of tibial accelerometry should take place in the frequency domain rather than the time domain.

SUMMARY

There are a number of techniques that have been used to evaluate the shock attenuation properties of footwear. While a shock attenuation evaluation of footwear can be accomplished using all of the methods discussed above, it should be noted that the appropriate evaluation technique should be used based on the question being asked. In addition, great care must be taken in terms of the experimental protocol for each experimental technique.

REFERENCES

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