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Improved Performance Through Gait Analysis

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Abstract

The biomechanical relationship between gait pattern and sprint performance was investigated in an elite skeleton athlete. The athlete, who was found to have deficits in push-off power at the start of the sprint, showed rotation of the right heel in slow-motion recordings of the start process. A high-resolution pressure measurement plate served as an experimental platform for further analysis. Additional video analyses provided a comprehensive picture of the biomechanical processes. Gait analyses revealed significant differences in pressure distribution between the left and right feet. It also became clear that, as a result of the outward rotation, the big toe had almost no contact with the ground, which led to a lack of power development. In response to the video and pressure plate examinations, the shoe was adjusted and the training program adapted accordingly. The increase in starting speed was very impressive.

Figure 1: Start phase of a skeleton race. Source: BSD/Viesturs Lacis.

Introduction

The start in skeleton racing is not just a prelude, but a measurable determinant of the overall time: a tenth of a second ahead or behind triples at the finish line. For example, if you start on the Winterberg bobsleigh track in 4.99 seconds instead of 5.00 seconds, the running time is reduced by three hundredths of a second, which is decisive for victory given the very strong international competition. Unlike in athletics [1–5], there are hardly any scientific analyses of sprinting and asymmetries in sprinting in sled sports (bobsleigh and skeleton).

Test Setup

A 2 m long and 60 cm wide pressure measurement plate (molibso dyneos 2) was used for the standing and gait analysis, with 15,360 capacitive force sensors integrated into its surface. The forces are read in real time and presented to the operator on the screen as precise pressure information. After 10 seconds, the measurement is complete and a comprehensive picture with up to 64 individual parameters of the biomechanical processes during walking is available.

Standing and Gait Analysis

A standing analysis was performed at the beginning of the measurement, see Fig. 2. Due to the very high resolution of the pressure measurement plate, approximately 1,200 sensors were activated in the tread area. This allowed details such as the pressure pattern of individual toes to be resolved. In the subsequent gait analysis, see Fig. 3, the test person was sent over the plate several times. All pressure patterns left behind were averaged and the course of the center of pressure was indicated by dotted lines. The wider the individual gait lines scatter, the more uneven the walk across the plate.

Boot Fitting

The first step was to adjust the running shoes. In bobsleigh and skeleton sports, running shoes (also known as spikes) are a crucial piece of equipment that has been specially developed for sprint starts. Their design differs significantly from conventional running shoes and is optimally tailored to short, explosive starts on ice. The upper material is lightweight and close-fitting, often made of synthetic materials or imitation leather. It provides lateral support to hold the foot in place. The sole is stiff in the midfoot for optimal power transfer. It is flat and thin to ensure a direct feel for the ice and enable a highly dynamic running motion. Very fine metal spikes are embedded in the shoes for traction on the ice, usually 250 to 300 per shoe.

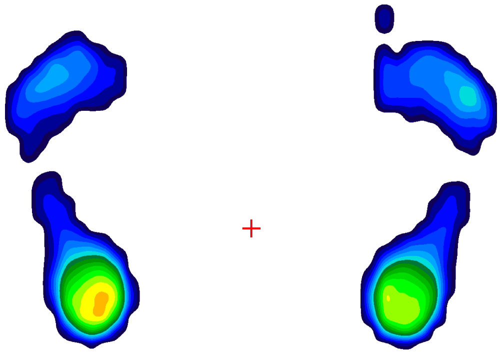

Figure 2: Standing analysis.

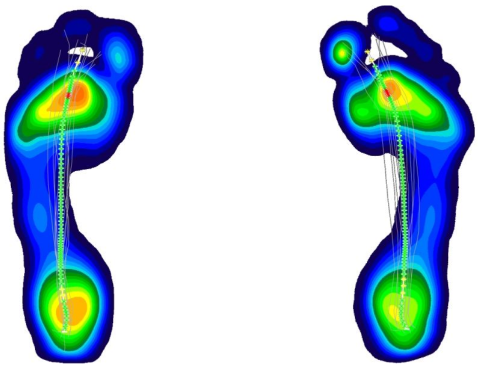

Figure 3: Gait analysis. The lines mark the average gait line, calculated from the individual contacts during movement.

Training Adjustments

A special training plan was developed and implemented in collaboration with the athlete's physiotherapist prior to the biomechanical tests. The highly intuitive results of the pressure plate tests acted as a catalyst for this intervention. Biomechanically correct rolling movements resulted in a significantly more economical sprinting pattern, which also significantly reduced the risk of injury, especially to the foot and ankle. Parallel to the optimization of technique, specific drills were used to reduce heel initiation in favor of big toe rolling in the long term, so that even without insoles, the desired rolling pattern was more pronounced. During the very first training session with the customized insoles, the coach noticed a significant increase in acceleration. Measurement data confirmed this impression: the 30 m sprint time was reduced by 0.05 s – 0.10 s.

Conclusions

Features of the sprinting movement that could not be identified by visual means were revealed by high-resolution and dynamic pressure plate tests. Special shoe and training adjustments significantly mitigated the factors that reduced propulsive force. The litmus test will take place when the athlete has to prove himself in the upcoming races.

About the Authors

Jens Hollenbacher is the founder and managing director of molibso GmbH in Langenfeld. He learned the craft of sales engineering at the Bochum Chair of Business-to-Business Management (eurom) and graduated with a doctorate. He then headed the part-time continuing education program for sales engineers at VDI. In 2015, he founded molibso GmbH with his brother Lars and has been managing it ever since.

Matthias Scherge is a professor of tribology, which is the science of friction, wear, and lubrication. Prof. Scherge heads the Fraunhofer MicroTribology Center, teaches at the Karlsruhe Institute of Technology, and manages Team Snowstorm. He also advised the Nordic Paraski Team Germany and provides consulting to several national and international athletes on scientific and technical issues.

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