Evaluation of a computer controlled Test Device to quantify the functional Sports Shoe Parameter Torsionability

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Introduction & Aim of the Study

Most sports specific movements include any type of running. KÄLIN et al. (1987), SEGESSER et al. (1989), STACOFF et al. (1989 & 1990), STÜSSI (1993), and KLENDIENST (2003) indicate that a sports shoe should allow a sports specific torsional range of motion between the fore and the rear foot. The aim of the study is to determine the reliability, objectivity and validity of a sports shoe testing tool (TOM IV) to quantify the sports shoe parameter termed torsionability (torque). Furthermore, a Finite Element Analysis (FEA) simulation was conducted to determine the comparability of the measurement results with the simulation results. In addition the simulation is used to visualize the stress distribution within the specimen.

Method

Nine EVA (**e**thylen**v**enyl**a**cetat) test specimen of different shoe size adapted geometries and different material hardness' (cp. Table 1 & Fig.1) were tested using a novel test device (cp. Fig.2) which measures the resistance against a defined twist of the specimen.

Table 1. Test Specimen

Hardness [Asker C]	Skin On			Skin Off		
	Size			Size		
	UK 3.5	UK 8.5	UK 14.5	UK 3.5	UK 8.5	UK 14.5
50	x	x	x	x	x	x
55	x	x	x	x	x	x
60	x	x	x	x	x	x

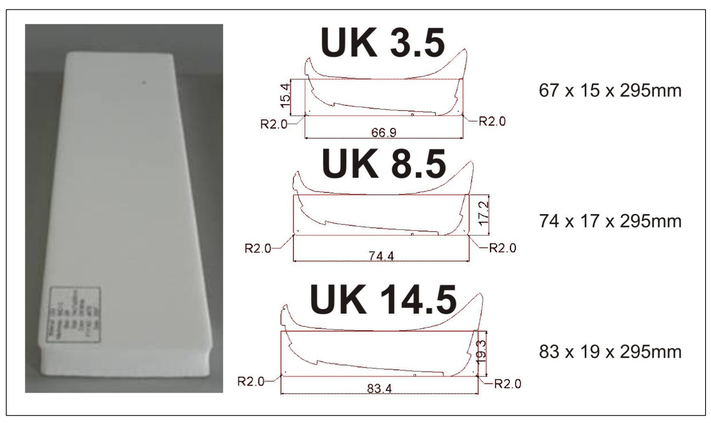

Fig. 1. Geometry of Test Specimen

A total of 180 tests were carried out by two different testers using a test/retest method. All test were performed in a clima-controlled lab (temp.: 22°/ humidity: 50%) to an angular displacement of 10° and a max. speed of 10°/sec. The distance between the fore foot and rear foot plate was adjusted to the specimens geometry. Each test series was compared to each other and the recorded data curves were analyzed and checked for correlation and consistency by analyzing the standard deviation. One EVA specimen (UK8.5 geometry) was CAD modeled and also twisted using Finite Element Analysis software to show the stress distribution.

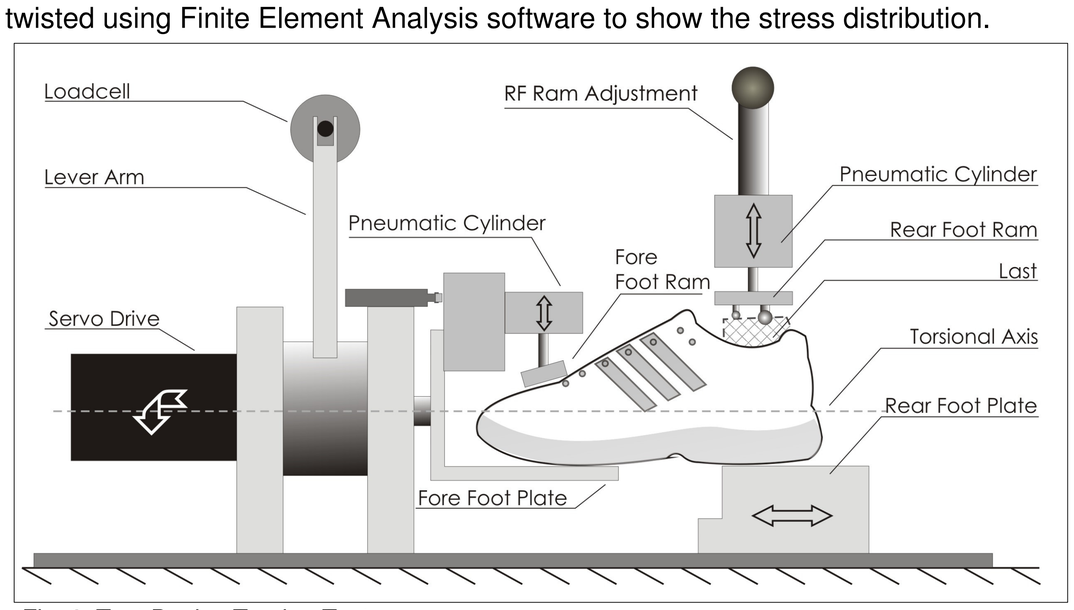

Fig. 2. Test Device Torsion Tester

Results

Typical hysteresis distributions of the torque vs. angular displacement curves recorded with the test device are shown in Fig.3. A standard deviation of only 0.038Nm (3.14% of mean) of the comparative maximum torque values showed the high reliability of the test device. If tests were performed by different test personnel, the standard deviation was 0.023Nm (1.83% of mean). Furthermore, a worst case value of 0.99 for the partial correlation between the different value series shows the high repeatability of the results. In addition, test result confirm that EVA blocks with skin show on average approx. 46% stiffer torque values than the same geometries without the so called skin. This influence decreases with the hardness of the EVA specimen (cp. Fig.4). Asymmetric torque values are most likely due to the so called Mullin's Effect.

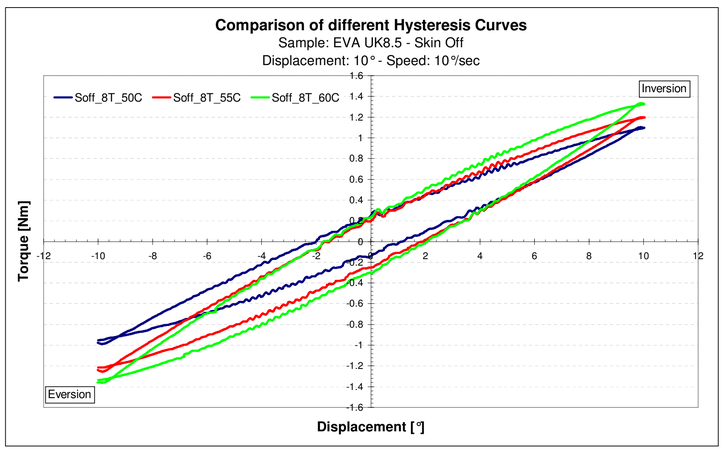

Fig. 3. Comparison of Hysteresis Distribution

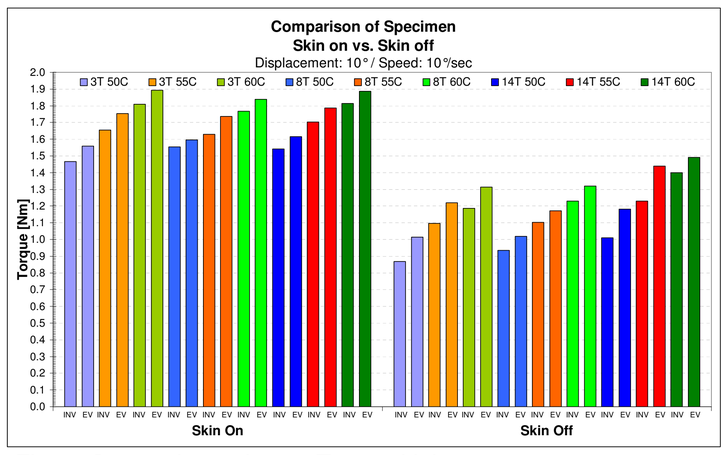

Fig. 4. Comparison of max. Torque Values at 10°

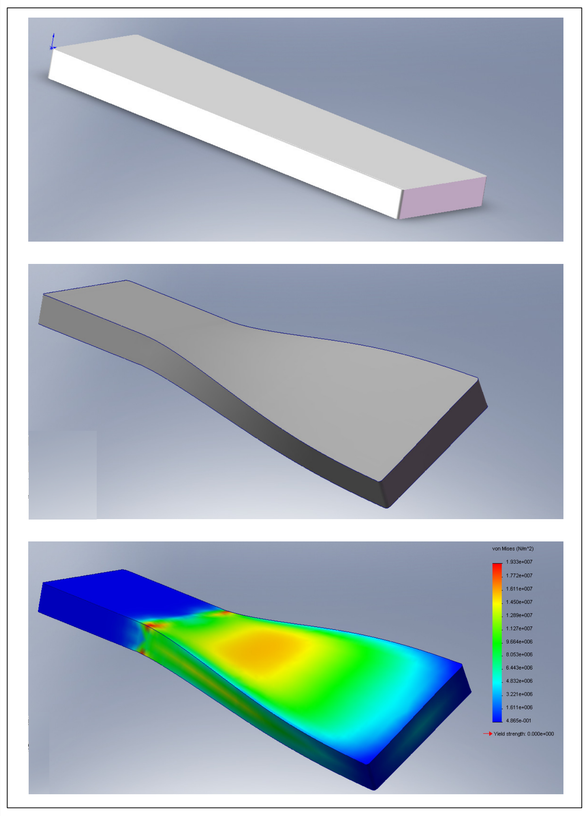

Fig. 5. Simulated EVA Specimen

Figure 5 shows the simulated EVA specimen in initial and twisted condition. Red and yellow colors in the bottom visualization show the highest stress distributions at the edge of the rear foot plate and in the mid section of the specimen. This is a very important result for ongoing studies regarding test with sport shoes, since this test procedure will primarily focus on material properties in this area . Strain Further studies regarding material characteristics of EVA foam need to be carried out to compare results of the testing method and the FEA method.

Discussion

The evaluated measurement tool is a reliable, objective and valid test device to measure a specimen's resistance against a twisting movement. The device also represents advancement to the previous manual testing tool (cp. KLEINDIENST, 2003). Further investigation of the recorded torsional moment of a sports shoe and whether it represents or correlates to a subject's perception is part of an ongoing diploma thesis. An additional benefit of the device is the complete measurement of the torque moment characteristics that allows an analysis of different ranges of the rotation and therefore, the analysis of defined stiffness distributions. The device's ability to twist the specimen at different speeds and to asymmetrical displacement angles (INVERSION vs. EVERSION) and their effect on the measurement results is also investigated in an ongoing study.

The results of the FEA simulation indicate the material behavior of EVA specimen during a twisting motion. Further investigation should be carried out to generate a better understanding of EVA material properties (Shear modulus, Young's Modulus). Simulated results gave a good first impression of the materials' response to torsion. In the future, shoe simulations using improved and adequate material models can be used during development and optimization of shoes with tuned torsional stiffness.

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