

# Portable Force Measurement System for Roller-Ski Skating

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**Abstract**—For a detailed biomechanical analysis of roller-ski skating a precise measurement of ground reaction forces is needed in addition to the measurement of the kinematic parameters. An innovative portable force measuring system was developed from processed roller skis and ski poles equipped with strain gauges. The measuring system can measure the normal (with respect to the upper surface of the roller-ski) and transverse forces (in the axial direction of the wheel) on each wheel, and the axial forces in the ski poles. Force sensors are connected by cables to the data acquisition system carried in a backpack by the runner. In case of terrain usage also a remote computer and a power supply are carried in the backpack. The estimation of the measurement uncertainty of the entire measuring chain of individual roller-ski sensor, at a confidence level of 95%, is up to  $\pm 2.3\%$  of the maximum calibration forces, which are similar size as the real load during roller skating. For the sensors of the poles this value makes up to  $\pm 1.7\%$  of the maximum calibration force. The force measurement system supplemented with the kinematic data of the roller-skies' and poles' orientation enables transformation of the measured reaction forces to the global coordinate system. Sample data from a skating trial on a treadmill are presented.

**Key words**—Cross-country skiing, Force measurement system, Kinematics, Kinetics, Treadmill roller-skiing.

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