# Development of Measurement and Training Devices Using Variable Mechanical Impedance Systems Based on Viscous Load

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Measurement of human dynamic joint torque is extremely useful for evaluation of human motion ability and development of new effective training machines. In general, torque measurement load is categorized by isometric load (without motion), isotonic load (with constant force) and isokinetic load (with constant velocity). Those three types of load are not natural as human motions. From a view point of motion specificity, it is desirable that measurement and training of human motion can be attained by the motions which are close to the actual motions such as sports.

To solve this problem, this thesis focuses on isoviscous load (with constant viscous coefficients) which has not been used for human dynamic torque measurement so far. Isoviscous load can measure human joint torque from slow speed motions to high speed motions by changing the viscosity parameter values. Moreover, it is a merit to easily guarantee safety for humans in comparison with other load. However, it has been expected that measurement variation is larger than those of other loads.

This thesis measured human dynamic joint torque by using isoviscous load. For this purpose, a variable mechanical impedance system was developed at first and isoviscous load with high accuracy was realized from low viscosity to high viscosity. Moreover, validity and repeatability of the data given by the isoviscous load were experimentally confirmed. Secondly, dynamic torque measurement was achieved by using the variable mechanical impedance system. As the result, high repeatability of torque measurement was made clear through the measurement data of some subjects.

Furthermore this thesis challenged development of a high speed motion training machine based on viscous load. If isoviscous load is directly utilized for training, isoviscous load cannot effectively increase for the motions with low speed in acceleration/deceleration phases. To solve this problem, this thesis proposed methods in which an appropriate inertia or elastic load is added to isoviscous load. Especially, the method to eliminate the inertia load during motion (inertia zeroing method) was developed. It was experimentally confirmed that the proposed method effectively increased the maximum torque and the energy consumption without decreasing the maximum speed as compared with those of viscous load. As the result, it became possible to give high intensity load to target muscles in the wide motion range.