The Rotterdam Intrinsic Hand Myometer (RIHM)

A technical note

T.A.R. Schreuders[1], F. Eijskoot[2], A. den Ouden [3], H.J. Stam [1]

[1] Department of Rehabilitation Medicine, Erasmus MC - University Medical Center Rotterdam, P.O. Box 2040, 3000 CA Rotterdam, The Netherlands

[2] Department of Experimental Medical Instruments (EMI), Erasmus MC, Room Ee1900a, P.O. Box 1738, 3000 DR Rotterdam, The Netherlands

[3] Senior Advisor, Medical Technology, Den Hamel 10, St Annaland, The Netherlands

Correspondence to: Ton A.R. Schreuders,
Department of Rehabilitation Medicine,
Erasmus MC - University Medical Center Rotterdam,
P.O. Box 2040, 3000 CA Rotterdam,
The Netherlands.

E-mail: a.schreuders@erasmusmc.nl
Tel +31 10 463 5844
Fax +31 10 463 3843

Abstract

The Rotterdam Intrinsic Hand Myometer (RIHM) is designed to measure the forces of the intrinsic hand muscles for research and clinical purposes. Earlier attempts to measure these muscle forces were with devices designed to measure the abduction force of the thumb, some were hand-held, or mounted on a jig or standard and could not measure the opposition of the thumb. All such instruments made measurements by pushing on the digit, increasing the risk to produce forces not perpendicular to the digits. Our device is a hand-held dynamometer that uses a pulling method and has novel technical features to improve reliability.

Keywords - *Dynamometer, hand force measurements*

1 Introduction

In the assessment of the muscle forces of the intrinsic muscles of the hand there is a need for specific measurements of these muscles in isolation. Dynamometers are available that measure grip strength and pinch strength of the hand (AN *et al.*, 1980; BECHTOL, 1954; MATHIOWETZ *et al.*, 1985; ROSEN *et al.*, 2000), but few dynamometers have the possibility to measure the intrinsic muscles of the hand separately(BOATRIGHT *et al.*, 1997; LIU *et al.*, 2000; MANNERFELT, 1966; TRUMBLE *et al.*, 1995). Knowledge on the specific force of the intrinsic muscles will provide important information for developing, for example, new methods to repair peripheral nerves of the hand, new therapies aimed at strengthening the intrinsic muscles of the hand, and bio-mechanical analyses of muscles forces of the lumbricals and interossei muscles in the clinical situation.

A previous study tested the reliability of measurements made with a generic industrially designed hand-held dynamometer (AIKOH) to assess the force of several of the intrinsic muscles of the hand. It was found that only relatively large changes in intrinsic muscle force could be detected (SCHREUDERS *et al.*, 2000). Another disadvantage was that, for the median nerve innervated muscles of the thumb, only one muscle could be measured i.e. the Abductor Pollicis Brevis (APB), while several ulnar nerve innervated muscles could be measured. Measuring the APB with sufficient isolation from the other thenar muscles providing abduction to the thumb is difficult. The possibility to measure two muscles innervated by the median nerve, i.e. the APB as well as the Opponens Pollicis (OP), would be valuable.

The aim of this study was to develop an instrument with specific requirements: i.e. improved reliability to measure the muscle force of the intrinsic muscles, hand-held and portable, possibility to measure the OP force of the thumb, ergonomically designed grip, appropriate visual feedback of line of pull, and minimal errors from off-axis loading thus allowing measurement of axial forces only.

2 Design

2.1 Design of dynamometer

The new Rotterdam Intrinsic Hand Myometer (RIHM) (Figure 1) is made of a strong lightweight plastic (PED) which contains the battery, the force sensor and the electronics. The peak forces can be read from a digital display on top of the device. The grip is positioned at a 97° angle to the horizontal, allowing the tester to hold the wrist in a stable, neutral position.

An important difference compared with other instruments is the pulling technique of the RIHM, whereby the forces are measured by pulling on a leather band placed on the digit. Placing the band around the thumb allows measuring the forces of the OP muscle. From the tester's viewpoint pulling towards their own body with their upper arm supported against the side of the thorax enables better control than pushing. For practical reasons (e.g. hand size) a 15-cm long leather band is used; this length allows the angle of deviation angle to be easier observed (Figure 2).

To further decrease any erroneous forces introduced by the tester of the device, a small cylindrical part is connected to the curved section of the instrument by means of a ball joint, and contains a button load cell type BC301 from DS Europe. This construction, together with a rotating handgrip, ensures loading perpendicular to the load cell. This prevents the examiner from introducing torques in the horizontal and vertical planes, as well as rotation around the line of work and rotation of the band around the finger.

2.2 Electronic circuit

The cylindrical part of the device houses the rechargeable battery, the curved part houses the printed circuit, and the display unit with control buttons is on top of the device.

A diagram of the electronic circuit (Figure 3) shows the strain gauge bridge of the load cell (left-hand side): the bridge signal is amplified by the differential amplifier 1, and amplifier 2 performs lowpass filtering and level shifting. The force curve signal is available on the force output connector connected to this amplifier. The force curve signal is connected to a peak detector with a fast peak response of < 10 msec.

By pushing the start button the power supply switches on and the peak detector will be reset. To save power, the device automatically switches off every few minutes. A programmable LCD digital panel meter (LASCAR type SM1) displays the maximal reading. This microcontroller-based module is designed around an alphanumeric LCD. The LED back light display shows the 4.5 digit voltmeter readings as well as a comprehensive operator menu. The user can select the desired range, decimal place, as well as calibration settings. Because all set-ups, including calibration, are performed via software, there are no user adjustable potentiometers. The module stores all settings when the power is switched off. The unit is powered by the internal 9-volt rechargeable NiMHy battery or an external plug in a power adapter; when connected to this adapter the battery will be charged automatically.

2.3 Clinical experience

Reliability of the RIHM has been studied in patients with peripheral nerve injuries and was found to have smaller measurement error compared with the AIKOH measurements (SCHREUDERS *et al.*, 2003). In clinical use the measurements have provided important data showing that the conventionally used grip and pinch strength dynamometers do not adequately reflect recovery of the intrinsic muscles (SCHREUDERS *et al.*, 2003b).

We conclude that the RIHM is an easy to use (hand-held) instrument providing reliable measurements of the intrinsic muscles of the hand.

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Figure captions

Figure 1 *Photograph showing the force measurements of the abductor of the thumb with the RIHM. The leather band is placed around the thumb*

Figure 2 *Drawing of the Rotterdam Intrinsic Hand Myometer (RIHM)*

Figure 3 *Diagram of the electronic circuit of the RIHM*

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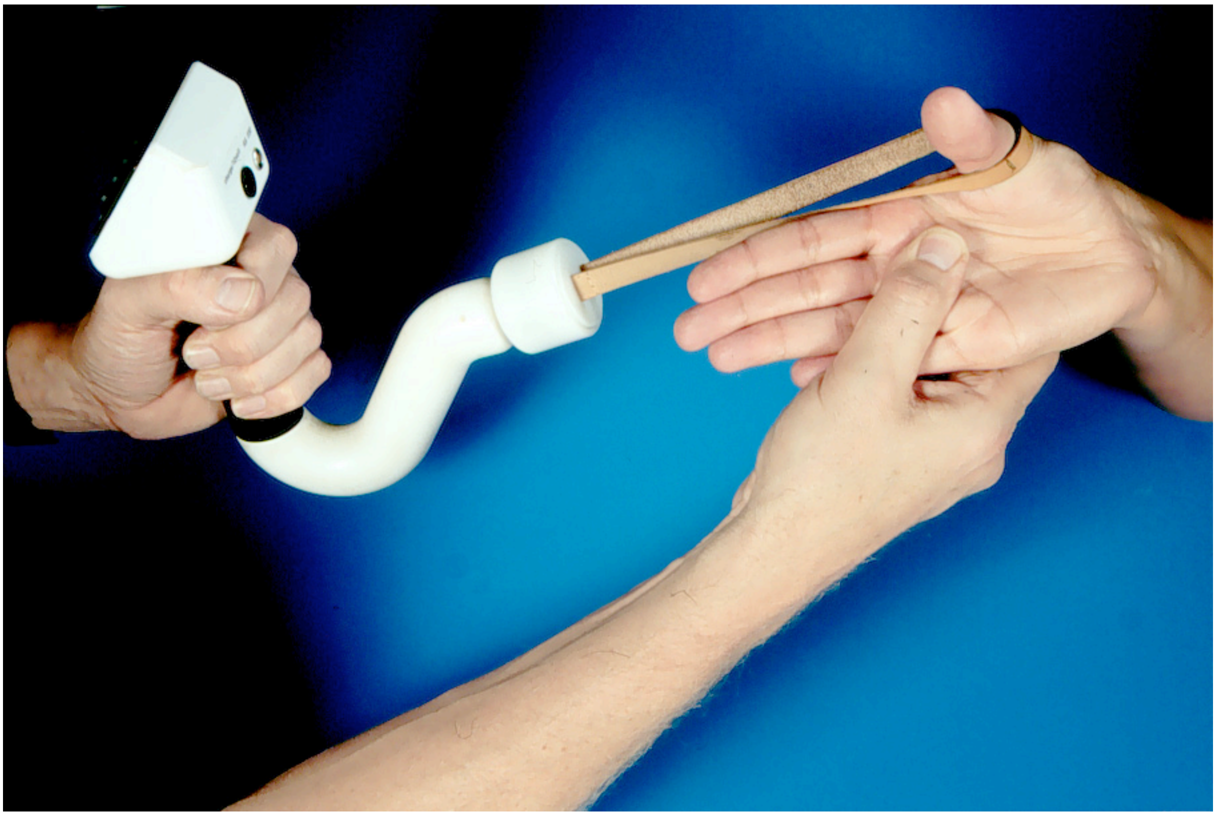

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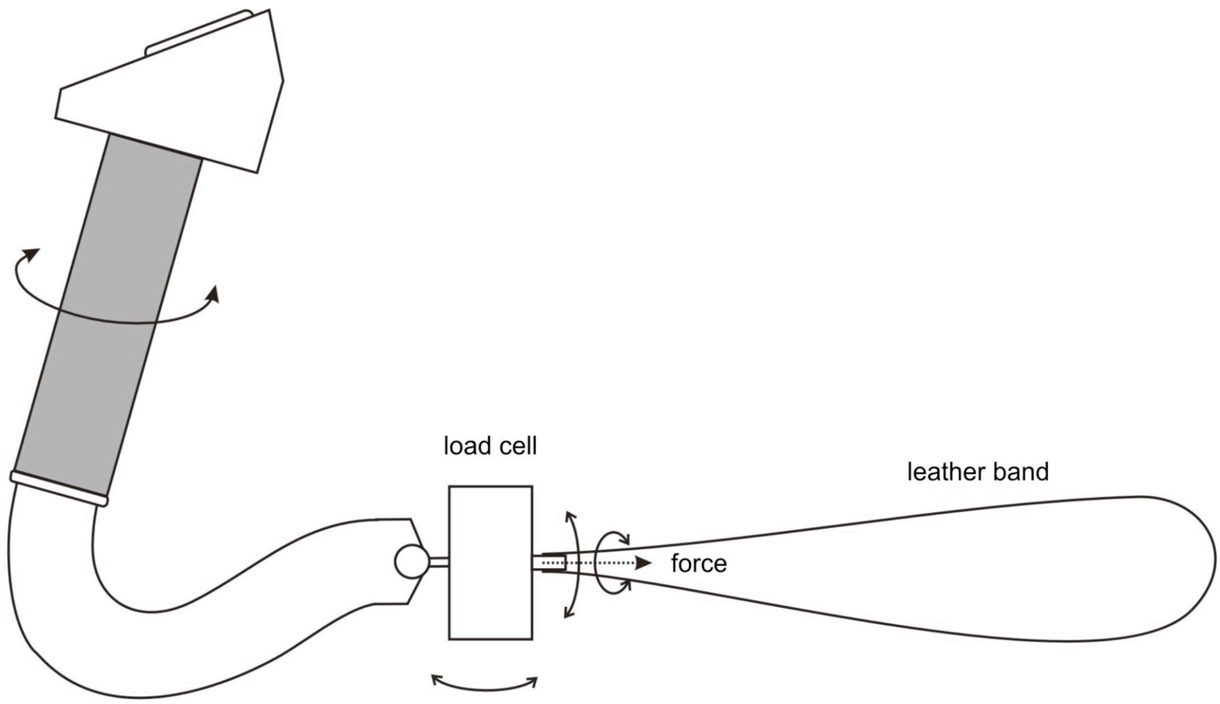

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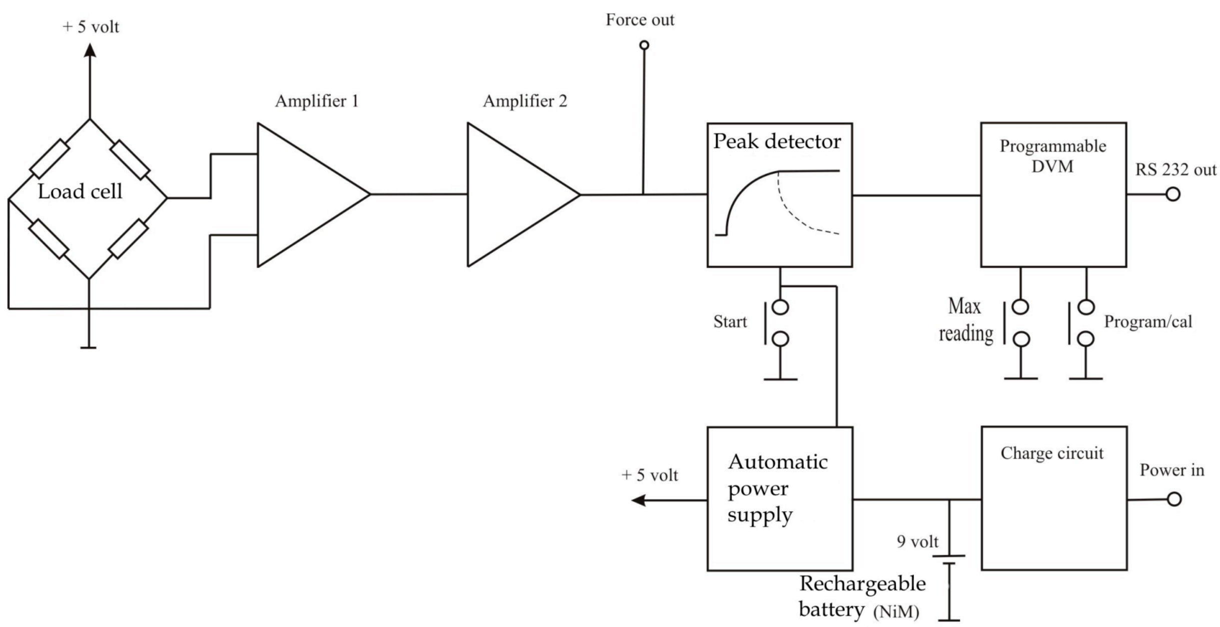

Diagram of the electronic circuit