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Quadriceps muscle tone, elasticity and stiffness in older males: Reliability and symmetry using the MyotonPRO

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ABSTRACT

Background: The MyotonPRO (Myoton Ltd; London) is a new portable device for measuring muscle mechanical properties (e.g. tone) and its reliability has yet to be established. Little is known about between-limb symmetry of mechanical properties in healthy older people, despite symmetry often being used as a measure of unilateral abnormalities in clinical assessment. Since quadriceps is important for mobility, it was selected for the present study.
Aims: To investigate: (i) between-day intra-rater reliability of a novice user of MyotonPRO; (ii) between-side symmetry of mechanical properties of quadriceps in older males.
Methods: Twenty healthy, community dwelling, right-lower-limb-dominant males (mean age 71.7, range 65–82 years) were studied. With the participant in relaxed supine lying, the MyotonPRO applied two consecutive sets of 10 taps to induce muscle oscillations of rectus femoris, from which measurements of decrement (elasticity), frequency (tone), and stiffness were obtained. Tests were performed on two occasions at the same time and day of the week, one week apart.
Results: Repeated measurements had very high within-day (intraclass correlation coefficient, ICC 3,1 $>$ 0.90) and high between-day (ICC 3,2 $>$ 0.70; mean of two measurement sets) reliability. There was no statistically significant difference between muscle mechanical properties of the dominant and non-dominant muscles ($<$2.5% difference; $p > 0.05$), thereby indicating symmetry.
Conclusions: High intra-rater reliability was established for MyotonPRO measurements of quadriceps in healthy older males, which were symmetrical between sides. These findings indicate that larger studies are warranted to establish normal reference ranges of data with which to compare patients with muscle abnormalities.

1. Introduction

Decline in muscle structure and function is a normal consequence of aging, occurring as a result of decrease in muscle mass and strength (Narici and Maffulli, 2010; Samuel and Rowe, 2012). Cross-sectional and longitudinal studies have demonstrated this decline to be greater in men (Hughes et al., 2001; Arts et al., 2010) and preferentially associated with the lower body (Janssen et al., 2000; Candow and Chilibeck, 2005; Samuel et al., in press), in particular the extensor muscles such as the quadriceps (Hughes et al., 2001).

1.1. Quadriceps muscles in the older population

The importance of quadriceps muscles in the older population is well established, with literature reporting that decline in quadriceps function is associated with hip fracture (Nguyen et al., 2007), decreased functional performance (Skelton et al., 1994), and decreased independence (Hairi et al., 2010). In addition, asymmetry in quadriceps power has been observed in older people, and implicated in one study as a risk factor for falls (Skelton et al., 2002); a serious concern both for older people and the health system, impacting on quality of life, health and health care costs (DH, 2001; NICE, 2004). However, reports on asymmetry in quadriceps muscle characteristics are mixed (e.g. Skelton et al., 2002; Arts et al., 2010).

1.1.1. Mechanical properties of muscle

Mechanical properties can be used to describe the mechanical firmness that exists when skeletal muscles are in a steady-state condition with no voluntary contraction. Components of muscle tone at rest can be classified as neural or non-neural (intrinsic); neural aspects of muscle tone comprise active muscle tension and stretch reflex contractions and non-neural aspects of muscle tone comprise passive stiffness and the inherent mechanical properties of the tissues (Britton, 2004). Whilst effects of healthy aging on muscle mass and strength have been well documented, characteristics of

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muscle tone (i.e. a mechanical property) in quadriceps muscles of older people have been less well documented, in particular with regard to between-limb symmetry. Such abnormalities are of particular clinical interest, as they can be an indicator of neurological dysfunction (Ward, 2000).

1.2. Clinical importance of between-limb muscle symmetry

Physiotherapy rehabilitation commonly relies on between-limb symmetry, using the non-affected side as a matched control for changes in muscle strength, tone and functionality for the affected side (Cheng et al., 2004; Prado-Medeiros et al., 2011). This is useful in conditions that result in muscle asymmetry, an example of which is stroke – a neurological condition that occurs predominantly in people aged over 65 years (NINDS, 2004). Following stroke, 80% of patients suffer from some degree of hemiparesis contralateral to the side of stroke injury (Bamford et al., 1991; NSA, 2006), causing asymmetry between limbs, and consequently placing them at risk of falling (NICE, 2004). Accurate assessment and management of tone is central to rehabilitation and evaluation of treatment efficacy in neurological conditions such as stroke. Robust and objective clinical measurement is therefore important, as well as an understanding of levels of normal symmetry in healthy populations.

1.3. Clinical assessment of muscle tone

Clinical assessment of muscle tone commonly involves semi-subjective manual testing, graded using scales such as the modified Tardieu scale (Tardieu et al., 1954; Yam and Leung, 2006) and the modified Ashworth scale (Bohannon and Smith, 1987; Ansari et al., 2008). However, reliability of these scales has been questioned in the literature (Yam and Leung, 2006; Fleuren et al., 2010). Recently, objective, portable devices have become available for measurement of muscle mechanical properties (e.g. tone) in a clinical setting. Techniques such as Myoton (Myoton Ltd; London), and the Myotonometer® (Neurogenic Technologies®, Inc.) have been used for a wide range of neurological applications (Leonard et al., 2003) in conditions such as Parkinson's disease (Rätsep and Asser, 2011; Marusiak et al., 2011), stroke (Rydahl and Brouwer, 2004; Chuang et al., 2012), and cerebral palsy (Aarrestad et al., 2004). The MyotonPRO is the latest of the Myoton devices and has yet to be tested for reliability.

1.3.1. Myoton

The Myoton is a hand-held device that provides objective measures of three mechanical properties of muscle: tone, stiffness and elasticity (Viir et al., 2007). Oscillation frequency (Hz) indicates tone (i.e., intrinsic tension) of a muscle in resting state. Logarithmic decrement of a muscle's natural oscillation indicates the elasticity of the muscle, e.g., its ability to recover its shape after contraction. Dynamic stiffness (N/m) characterises the resistance of the muscle to contraction. There have been several prototypes of Myoton, and much of the literature reports results from Myoton-2 and 3. The present study uses MyotonPRO; the basic principle is the same in all prototypes but the MyotonPRO has several updates such as a triaxial accelerometer, compared with the single axis accelerometer in the earlier prototypes, making it more versatile in terms of application.

Test–retest reliability of Myoton-2 has been reported in several muscle groups, including quadriceps (Bizzini and Mannion, 2003; Viir et al., 2006), but reliability in the older male population has yet to be established. Symmetry of muscle mechanical properties using Myoton has been reported in studies of trapezius (Viir et al., 2006) and quadriceps muscles (Gavronski et al., 2007) in younger populations. Other literature on Myoton in quadriceps is scarce but includes studies of mechanical properties related to trunk forward flexion and knee extension (Hein and Vain, 1998), and following knee surgery (Gapayeva et al., 2002) in younger populations. It cannot be assumed that research to date can be generalized to relate to quadriceps in the normal healthy older population.

1.4. Study aims

The study aimed to: (i) examine between-day intra-rater reliability of measurements of mechanical properties of quadriceps using the MyotonPRO by a novice user, and (ii) investigate whether dominant and non-dominant quadriceps are symmetrical, in healthy males over the age of 65 years.

2. Materials and methods

This was a comparative, cross-sectional, intra-rater reliability, observational study in a convenience sample of 20 healthy, right-lower-limb-dominant male volunteers (65–82 years) from the local community.

2.1. Sample

Published recommendations of sample size requirements vary, but 15–20 participants has been suggested as sufficient for reliability studies (Atkinson and Nevill, 2001), and previous studies with Myoton have used 20 or fewer subjects (Bizzini and Mannion, 2003; Viir et al., 2006; Janecki et al., 2011); thus $n = 20$ was selected for the present study. Recruitment was by posters displayed in local community areas and presentation at social groups relevant to the target population. Interested participants received study information and completed a screening questionnaire before being invited to take part. Inclusion and exclusion criteria were selected to ensure representation of the normal healthy population, whilst screening for conditions that may skew data. Participants included in the study were healthy (no uncontrolled medical conditions), independently mobile (able to walk for $\geq$5 min without holding onto anything, inside and outside), community dwelling, right-lower-limb-dominant males (foot dominance was assessed by the commonly used ball-kick test (Hoffman et al., 1998; Kong and Burns, 2010)). Participants were excluded if they were ambidextrous, had conditions or medications known to affect muscle tone or movement, participated in exercise to more than moderate levels (measured by the validated and reliable Physical Activity Scale for the Elderly [PASE] (Washburn et al., 1993)), had a body mass index (BMI) >30 kg/m^2 (Gapeyeva and Vain, 2008), had cognitive impairment that would preclude understanding of the study, or had skin conditions that contraindicate use of MyotonPRO.

The study was approved by the Faculty of Health Sciences Ethics Committee, University of Southampton, and followed recommendations of the World Medical Association (WMA) Declaration of Helsinki (WMA, 2008). Participants were informed of risks and aims of the study and written consent was obtained.

2.2. Measurement of muscle mechanical properties using MyotonPRO

MyotonPRO measures the deformation properties of natural damped oscillations produced following a brief (15 ms) mechanical tap to the surface of the skin. Full details of previous versions of Myoton have been reported in the literature (Bizzini and Mannion, 2003; Korhonen et al., 2005; Gapeyeva and Vain, 2008), including reliability studies in quadriceps in other populations (Bizzini and Mannion, 2003). The MyotonPRO is a more compact version of the technology, but the fundamental principles remain unchanged. Previous versions had a single accelerometer, which required the