Reexamining skeletal muscle fatigability and fiber type in resistance trained men: 40 years after Thorstensson and Karlsson

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ABSTRACT

INTRODUCTION: Nearly 40 years ago Thorstensson and Karlsson developed an equation (THOR) allowing a fatigue test to estimate the percentage of fast-twitch muscle fibers (%FT) in an individual's vastus lateralis (VL). Fiber-typing methodologies have advanced considerably since this time. Moreover, THOR was developed from a heterogeneous group of habitually active men. PURPOSE: Reexamine THOR using modern muscle fiber-typing techniques and in resistance-trained men. METHODS: Fifteen resistance-trained males (strength/power-trained a 3x/ wk for ≥3months; age=24.8±1.3y, height=1.79±0.05m, mass=82.2±8.0kg) performed 60 maximal knee extensions at 180°/s on an isokinetic dynamometer, returning on a separate day for a VL muscle biopsy. Approximately 200 individual fibers (per participant) were isolated and analyzed for fiber type using sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE). Individual muscle fibers were identified as either expressing myosin heavy chain (MHC) I, I/IIa, IIa, IIa/IIx, or IIx. %FT was determined as a combination of MHC I, IIa, and IIx. RESULTS: The original correlation between FT% and percent decline in peak torque (r=0.86, p<0.01) was not reproduced here (r=0.11, p>0.05). Moreover, a Bland-Altman plot suggested THOR underestimated FT% in participants with less fast-twitch fibers, and overestimated FT% in participants with more fast-twitch fibers. CONCLUSIONS: This collectively suggests fiber phenotype alone does not predict performance during a fatigue test in strength-trained men. These findings likely differ from Thorstensson and Karlsson because: (a) activation in resistance exercise activates all fiber types, compared to only 2 in THOR; (b) THOR was developed from a cohort of untrained men. We utilized the highly precise single fiber-typing method to allow differentiation of fibers into 6 isoform categories (as opposed to only 2 in THOR). Our results displayed a limited agreement, 95% Confidence Interval) in our participants. Also, the data indicated THOR underestimated FT% in participants with less fast-twitch fibers, and overestimated FT% in participants with more fast-twitch fibers.

INTRODUCTION

Nearly forty years ago Thorstensson and Karlsson (1976) famously established the link between whole muscle performance and fiber type composition in humans. Their landmark study allowed for the establishment of a prediction equation which uses performance on non-invasive leg extension fatigue test to estimate fast-twitch fiber type percentage. However, fiber typing techniques and nomenclature have evolved considerably since this seminal work. A more sensitive approach was developed in the 1980’s wherein single muscle fibers can be categorized by their myosin heavy chain (MHC) isoforms (spectrum of slow to fast: MHC I, MHC IIa, MHC IIx). This advancement led to the discovery that some individual “hybrid” fibers even co-express multiple isoforms (MHC I/IIa, MHC IIa/IIx, MHC IIa/IIx/IIb). Accuracy is critical as muscle fiber types have extremely high specificity such that this relates specifically to a given stimulus by modifying inherent contractile and/or metabolic properties, and/or its actual protein isoform. Furthermore, persons most interested in identifying their fiber type composition are presumably those involved in some aspect of physical activity and/or sport, which is problematic as the original equation was derived from a cohort of untrained men.

PURPOSE

To develop a non-invasive fiber type composition prediction equation similar to Thorstensson and Karlsson, but with updated fiber typing techniques and in resistance-trained men.

METHODS

Fifteen resistance-trained males (strength/power lifted at least 3 d/wk for ≥6months; age=24.8±1.3y, height=1.79±0.05m, mass=82.2±8.0kg) performed 65 maximal knee extension contractions (range of motion from 0°-10° of flexion; 0° at full extension) at 180°/s to determine peak torque and fatigue index (decrease from first to 50th contractions) (Figure 1). 24-48 hours later, participants underwent a biopsy of their same vastus lateralis to determine skeletal muscle fiber type. Approximately 150 single fibers per sample were mechanically isolated and analyzed for their MHC content via sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) (Figure 2).

RESULTS

Our results displayed a limited relationship between muscle fiber phenotype, fatigue, and muscle activation in resistance exercise trained men. These findings likely differ from Thorstensson and Karlsson because:

- Fiber phenotype alone does not predict performance during a fatigue test for strength trained men.
- We utilized the highly precise single fiber-typing method to allow differentiation of fibers into 6 isoform categories (as opposed to only 2 in THOR).

Thus, THOR may still be valid when examining across heterogeneous exercise backgrounds or “habitually active” participants.