Glycogen concentration and bioenergetics in young and older women

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Introduction

Old age is associated with changes in skeletal muscle function, including decreased mass and force, but increased fatigue resistance during isometric contractions [1]. Notably, muscle in healthy older adults exhibits a lower ATP cost per twitch [2] and greater reliance on oxidative ATP production *in vivo* [3,4], suggesting that energetic differences may contribute to differences in metabolic economy in young and old. The potential role of differences in muscle [glycogen], which could arise due to selective atrophy of type II fibers in older muscle [5], in these energetic changes has not been investigated. The **purpose** of this study was to investigate muscle metabolic economy and [glycogen] in relation to ATP flux during short, maximal isometric contractions, using ^{13}C and ^{31}P Magnetic Resonance Spectroscopy (MRS) in young and older women.

Methods

The ankle dorsiflexor (DF) muscles of 8 young (YW, 35±3 years) and 9 older (OW, 73± 5 year) healthy women were investigated. Daily physical activity was similar in both groups, as quantified by accelerometry (Actigraph GT1M, USA).

DF muscle fat-free cross-sectional area (mCSA, cm^2) was determined by Magnetic Resonance Imaging at 1.5T: 40 T_1-weighted leg images; slice thickness = 4mm, TE= 11ms, TR= 400ms and matrix = 512 x 512, as previously described [6].

MRS experiments were performed on a 4T (Bruker), Medspec system as follows:

1) [glycogen] was measured at rest by ^{13}C MRS (**Figure 1**), using a probe assembly containing a 3 X 3 cm ^{13}C and 7 X 10cm ^{1}H (with quadrature Tx/Rx) surface coil and 8.5 min blocks of 1024 acquisitions (TR=500µs, adiabatic 13C pulse-acquire sequence with WALTZ4 decoupling). [Glycogen], in mM glycosyl units, was calculated from the C1-glycogen peak relative to a phantom containing 155 mM glycosyl units.

2) Changes in phosphorus metabolites and pH were determined by ^{31}P-MRS before, during and for 10 min following a 16-s maximal DF contraction, using a probe assembly with 7 X 7cm ^{1}H and a 3 X 5 cm ^{31}P and surface coil; TR =2s, 90° adiabatic pulse, time-averaged to 4s.

3) ATP production from the creatine kinase reaction (ATP PCr), non-oxidative glycolysis (ATP gly) and oxidative phosphorylation (ATP ox) was calculated, as described in [4].

4) ME was calculated as (total Nm·mCSA^{-1})·mM ATP^{-1} during the 16s contraction. ^{13}C and ^{31}P data were processed by line fitting using NUTS software 5Acorn NMR,USA).

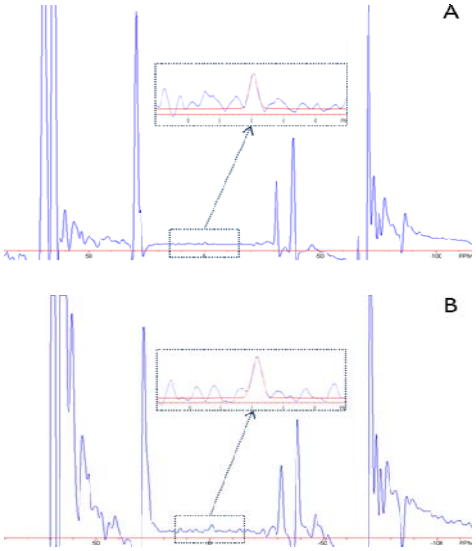

Figure 1: *Representative ^{13}C spectra for 1 young (A) and 1 older (B) woman. The red line shows the linefit of the glycogen peak.*

Results

While intramuscular fat was lower in YW than OW (mean ± SD, 5.4 ±3.3 % vs. 12.1 ±7.2% respectively; *p=0.029*), mCSA (YW 8.3 ±1.0 cm^2; OW 8.0 ±1.0 cm^2), specific strength (YW 3.8 ±0.7 N.cm^{-2}; OW 3.3 ±0.8 N.cm^{-2}, *p=0.193*) was similar in both groups. Muscle [glycogen] was similar in YW (91.3 ±15.3 mM) and OW (96.8 ±38.9, *p=0.716*). During contraction, total ATP demand was met mainly by ATP PCr and ATP ox, with the contribution from ATP gly markedly lower in both groups (**Figure 2A**). No age-related differences were observed for the contribution from each energetic pathway, or Metabolic Economy (**Figure 2B**).

Discussion

We report here for the first time similar [glycogen] in the DF muscles of healthy young and older women. This result, in conjunction with the similar ATP flux and ME in our study groups, suggests that energetics do not differ in the unfatigued muscles of young and old. Additional studies are needed to determine whether these similarities extend to fatiguing conditions.

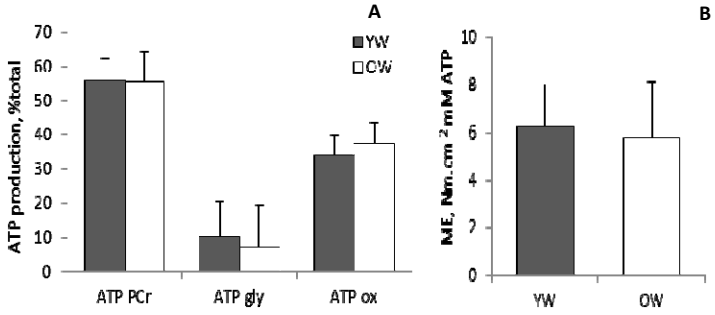

Figure 2 : *A) Relative contribution (% total ATP production), of Creatine Kinase reaction (ATP PCr),glycolysis activity (ATP gly) and oxidative metabolism (ATP ox) to the total energy demand. B) Metabolic economy (ME) of the total contraction, in young (dark bars) and older (open bar) women..*

References

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