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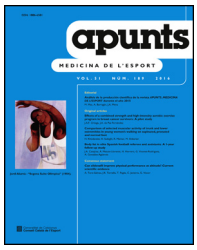

ORIGINAL ARTICLE

The effect of 12 weeks endurance training at 2 different intensities on GLUT4 mRNA expression of soleus and gastrocnemius muscles in obese mice

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KEYWORDS
Endurance training;
Muscle type;
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Abstract The aim of this study was to investigate the expression of GLUT4 mRNA in soleus and gastrocnemius muscles in obese mice in response to endurance training. Forty male C57BL/6 mice were used in this study. Eight mice (Normal Base [NB]) served as non-obese non-trained controls, and 32 mice were put on a high fat diet (HFD) regimen (60% kcal fat) for 12 weeks. At week 16, the obese mice were randomized into the following treatment groups ($n = 8$ each group): Obese Base [OB]; Low Intensity [LI]; High Intensity [HI]; or Obese Control [OC] groups. LI and HI trained for 5 days/week for 12 weeks on a motorized treadmill at 15 m/min on a 5% slope (for LI), and/or at 22 m/min on a 5% slope (for HI). OC mice were kept sedentarily in the cage during the training program. GLUT4 mRNA expression was measured in gastrocnemius and soleus muscles using a Real Time-PCR method. GLUT4 mRNA expression of soleus muscle in LI group increased about 2.2 fold, against about 1.6 fold for gastrocnemius ($p < .05$). In addition, GLUT4 mRNA expression of soleus and gastrocnemius muscles in LI and HI groups were significantly higher than OB and OC groups ($p < .05$). It can be concluded that any disturbance in body energy balance, especially by exercise training and/or high fat diet can influence these molecular and cellular mechanisms that act to establish a stable homeostasis.

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PALABRAS CLAVE
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Tipo muscular;
Obesidad;
GLUT4

El efecto de 12 semanas de entrenamiento de resistencia con 2 intensidades diferentes en la expresión de GLUT4 mARN en los músculos sóleo y gastrocnemio en ratones obesos

Resumen El objetivo de este estudio fue investigar la expresión de mARN de GLUT4 en los músculos sóleo y gastrocnemio en ratones obesos en respuesta al entrenamiento de resistencia. Cuarenta machos C57BL/6 ratones fueron utilizados en este estudio. Ocho ratones (normal base [NB]) sirvieron como no obesos controles no entrenados, y 32 ratones fueron puestos en una dieta alta en grasa (HFD), régimen que siguieron (60% de grasa, kcal) durante 12 semanas. En la semana 16 los ratones obesos fueron distribuidos aleatoriamente en los siguientes grupos de tratamiento (n = 8 cada grupo): base obesos (OB); baja intensidad (LI); alta intensidad (HI); o grupos de control (OC) obesos. LI y HI fueron entrenados durante 5 días/semana durante 12 semanas en una cinta rodante motorizada a 15 m/min en una pendiente del 5% (para LI) y/o en 22 m/min en una pendiente 5% (para HI). Los ratones OCse mantuvieron sedentariamente en la jaula durante el programa de formación. GLUT4 expresión de mRNA se midió en los músculos gastrocnemio y sóleo, utilizando el método en *real time*-PCR. La expresión de GLUT4 del mARN del músculo sóleo en el grupo LI aumentó aproximadamente ∼2,2 veces, frente a ∼1,6 veces para los gemelos ($p \leq 0,05$). Además, la expresión de GLUT4 mARN en los músculos sóleo y gastrocnemio en los grupos LI y HI fue significativamente mayor que en OB y en los grupos OC ($p \leq 0,05$). Se puede concluir que cualquier alteración en el equilibrio energético del cuerpo, especialmente por la práctica de ejercicio y/o dieta alta en grasas puede influir en esos mecanismos moleculares y celulares que actúan para establecer una homeostasis estable.

Introduction

It is generally accepted that obesity is predominantly associated with an impaired insulin-stimulated glucose uptake rate in skeletal muscle, which has been attributed to insulin resistance. Many studies have focused on the glucose transporter system as part of the underlying mechanisms. Glucose transport into the skeletal muscle cell mediated by the glucose transporter proteins GLUT1 and GLUT4.[1] The GLUT1 glucose transporter isoform is thought to support basal glucose transport,[2,3] while the GLUT4 isoform increases glucose transport in response to insulin and contraction. Insulin and contractions translocate the GLUT4 from the intracellular pool to the plasma membrane and to the T-tubules.[4,5]

In rodents, it is well known that the glucose uptake capacity is greater in red oxidative muscles than in white glycolytic muscles.[6–10] One underlying mechanism seems to be a greater level of GLUT4 expression, both intracellularly[6,7] and at the plasma membrane.[8] In human skeletal muscle, glucose uptake was positively associated with the proportion of type I fibers and negatively associated with the proportion of type IIb fibers.[11] These results were supported in the in vitro study by Zierath et al.[12] that reported the insulin-stimulated increase in glucose uptake over basal is strongly correlated, both positively with the percentage of type I muscle fibers and negatively with the percentage of type IIa fibers. However, unconvincing results regarding the relationship between fiber type distribution and GLUT4 content in human muscle have been reported.[13–15] Andersen et al.[13] found no correlation between fiber type and GLUT4 content, whereas Houmard and colleagues[15] showed a weak correlation between fiber type composition and GLUT4 content.

It has been shown that different muscles exhibit large differences in their GLUT4 content, and this variation is often associated with differences in insulin-stimulated glucose uptake.[16,17] As different muscles are composed of a mixture of several different muscle fiber types,[18] it is possible that a significant difference exists in GLUT4 content between muscles.

Possibly, the differences in GLUT4 content and insulin-stimulated glucose uptake are more related to training status. Changes in the skeletal muscle activity level is a key regulator of GLUT4 content in rats.[19,20] In humans, athletes have more GLUT4 than untrained age-matched control subjects,[21,22] and in both normal healthy control subjects and individuals with diminished insulin-stimulated glucose uptake, exercise training has been shown to increase GLUT4 content.[20,23,24] Additionally, a decrease in activity level will decrease GLUT4 content.[20,25] Finally, changes in physical activity and GLUT4 content have been shown to be connected with changes in insulin-stimulated glucose uptake.[20]

The main objective of our work was to investigate the GLUT4 mRNA expression in soleus (a predominantly slow-twitch muscle) and gastrocnemius (a predominantly fast-twitch muscle) in obese mice in response to endurance training.

Subjects and methods

Animals

Forty male C57BL/6 mice (4 weeks age) were used in this study. Eight non-obese mice (Normal Base [NB] group;