Skeletal muscle characteristics in subjects with sickle cell trait and/or α-thalassemia: Special reference to physical ability and performance

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To investigate whether lower endurance and higher sprint abilities reported in sickle cell trait (SCT) carriers lie on specific skeletal muscle characteristics, controls, SCT carriers, α-thalassemic subjects and carriers of the dual hemoglobinopathy were subjected at rest to a muscle biopsy of the vastus lateralis muscle. Muscle fibre type distribution and activities of PFK, LDH, CS and HAD were similar in all groups. On the other hand, SCT carriers displayed i) lower capillary density and tortuosity, ii) enlarged microvessels, iii) trends towards lower CK and COx activities and iv) a trend toward a higher type IIx fibre surface area. Excepted a higher capillary tortuosity, α-thalassemia is not associated with specific muscular adaptations.

INTRODUCTION

Sickle cell trait (SCT) carriers are susceptible to a lower ability to sustain prolonged submaximal exercise. Le Gallais et al. (5) found no SCT carriers among the 22 international-level athletes having taking part in the Abidjan half-marathon, while 8.7% of partaking runners were SCT carriers. Thiriet et al. (8) reported that during the Mount Cameroon Ascent Race, performance times of SCT runners were lower during the portion at high altitude. In contrast, several lines of evidence have shown that SCT subjects are more likely to perform at higher level during brief and intense exercise. Hue et al. (4) reported higher performances in a jump-and-reach test by SCT carriers than control subjects with normal haemoglobin. This finding is further reinforced by epidemiologic studies that reported a higher percentage of SCT carriers among the track and field sprint, throw and jump record holders and title winners than the prevalence of SCT in the general population or national team (1, 6). The hypothetical differences in muscle metabolism and performance related to the SCT carrier state could be mediated by differences in their muscle structural and metabolic characteristics. For instance, performance on the jump-and-reach test has been demonstrated to be closely related to the strength of the lower limb extensor muscles, which is highly dependent on type II fibre content (2). However, the structural and metabolic characteristics of the skeletal muscle have never been investigated in subjects carrying SCT. Because α-thalassemia (α-t) is associated with microcytosis, decreased intraerythrocytic HbS concentration and lower haemorheological disorders (7), the coexistence of these two haemoglobinopathies could lead to greater endurance exercise tolerance and improved performance than in SCT carriers without α-thalassemia. Indeed, the single SCT runner ranked among the 22 international level runners participating in the first Abidjan half-marathon was also suggested to exhibit α-thalassemia (5). Thus in the present study we examined the muscle structural and functional characteristics in SCT, α-thalassemia, and dual haemoglobinopathy carriers.

MATERIALS AND METHODS

Thirty healthy active male Cameroonians paired in terms of physical ability volunteered to participate in the study. Subjects were allocated into four groups, namely, normal Hb control subjects (C, n = 10), α-thalassemic subjects (α-t, n = 5), SCT carriers without α-thalassemia (SCT, n = 6), and SCT carriers with α-thalassemia (SCT/α-t, n = 9). Age, height, weight and peak power were 24 ± 1 yr, 173 ± 1 cm, 67 ± 1 kg and 3.02 ± 0.14 W/kg (means ± SE), respectively. A biopsy of the vastus lateralis muscle was taken at rest. Muscle fibre type distribution, surface area (SA), capillary density (CD) and tortuosity (CapTor) and key

energetic enzymes activity (CK, PFK, LDH, CS, HAD, COx) were examined. A two-way ANOVA was used to compare the groups.

RESULTS

Muscle fibre type distribution was 32.5 ± 2.2%, 2.2 ± 0.7%, 52.8 ± 2.6%, 8.3 ± 1.0%, and 10.4 ± 1.8% for types I, I-IIa, IIa, IIa-IIx, and IIx, respectively. No intergroup differences were detected. The mean surface area of type IIx fibres tended to be greater in the SCT groups compared with the control group ($P = 0.0925$). No significant differences among the groups emerged for PFK, LDH, CS and HAD. On the other hand, trends towards lower COx and CK activities were noticed for SCT groups ($P < 0.1$). Sickle cell trait (SCT) was also associated with lower capillary density ($P < 0.05$) and tortuosity ($P < 0.001$), and enlarged microvessels ($P < 0.01$). The α-t subjects were characterized by a higher capillary tortuosity.

DISCUSSION

The similar muscle fibre type distribution and Krebs cycle enzyme activities found in the present study in SCT carriers and control subjects may account for the similar VO_{2max} and peak power output values achieved during graded exercises. The trend toward a higher type IIx fibre surface area in SCT carriers (17%, $P < 0.0925$) might constitute a possible explanation for the better performances during jump-and-reach tests in SCT carriers (4). Indeed, Hautier et al. (3) indicated that squat jump performance is related to the cross-sectional surface area of the IIx fibers. The lower CK and COx activities as well as the lower CD and CapTor could provide a possible explanation for the reduced ability of SCT carriers to engage in prolonged submaximal exercises (5, 8). α-t and the dual haemoglobinopathy do not alter significantly skeletal muscle structural and energetic characteristics.

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