STRUCTURAL AND FUNCTIONAL CHARACTERISTICS OF THE ELBOW EXTENSORS IN RESISTANCE AND ENDURANCE TRAINERS

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STRUKTURNE IN FUNKCIONALNE ZNAČILNOSTI IZTEGOVALK KOMOLCA PRI VADBI MOČI IN VZDRŽLJIVOSTI

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Abstract

The purpose of this investigation was to compare the myosin heavy chain (MHC) isoform expression of the triceps brachii muscle and isoinertial, isometric and isokinetic strength indices in bodybuilders (B; n=5), competitive rowers (R; n=5) and untrained control (C; n=5) subjects. Muscle tissue samples were analysed for MHC isoform content using electrophoresis. The B possessed significantly smaller ($p<0.05$) percentage of MHC type IIb proteins (12.9±7.1 %) than R (31.2±2.7 %) and C (38.2±3.0 %) groups (i.e., B<R<C). C (55.8±5.4 %) presented also significantly more type IIa MHC isoforms than R (42.8±3.0 %) and C (34.7±1.6 %) subjects. The MHC type I protein content did not differ significantly among different groups (B: 31.3±2.7 %; R: 25.4±1.7 %; C: 27.1±1.8 %). However, when the results of MHC type proteins were converted to effect sizes (ES), it appeared that low statistical power rather than the absence of an effect accounted for the non-significant differences between B and other groups (i.e., B>R≈C). Significant differences existed in isoinertial strength among B and R subjects (i.e., B>R≈C), while isometric and isokinetic strength were not significantly different among trained groups. However, the ES transformation of data demonstrated that large differences existed between B and other groups for isometric and isokinetic strength (i.e., B>R≈C). A statistically significant negative correlation ($p<0.05$) was found between MHC type IIb isoforms and isoinertial strength index ($r= –0.68$). The MHC type IIa proteins were positively related to all the strength measures considered ($r= 0.51–0.61$; $p<0.05$). These data demonstrated different patterns of MHC isoform expression among the different groups of athletes and it is suggested that these differences on occasion may affect the expression of strength.

Key words: MHC isoforms, resistance training, endurance training, strength indices

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Izvleček

Namen študije je bil primerjati izoformne miozinske težke verige (MHC) mišice triceps brachii ter izoinercijski, izometrični in izokinetični indeks moči bodybuilderjev (B; n=5), veslačev (V; n=5) in netreniranih subjektov – kontrolna skupina (K; n=5). V vzorcih mišičnega tkiva je bila izmerjena vsebnost MHC z uporabo elektroforeze.

Skupina B je imela značilno ($p<0,05$) manjši odstotek MHC tip IIb beljakovin (12,9±7,1 %) kot V (31,2±2,7 %) in K (38,2±3,0 %), torej B<V<K. Skupina B (55,8±5,4 %) je imela tudi značilno več tip IIa MHC izoform kot V (42,8 %±3,0 %) in K (34,7±1,6 %). Vsebnost MHC tip I beljakovine ni bila značilno različna po skupinah (B: 31,3±2,7 %; V: 25,4±1,7 %; K: 27,1±1,8 %). Vendar, ko so bili rezultati MHC tipa beljakovin pretvorjeni v velikosti učinka (VU), se je izkazalo, da je statistična neznačilnost razlik med skupino B in drugima bolj posledica (pre)majhne statistične moči kot pa odsotnosti vpliva (torej B>V≈K). Značilne razlike obstajajo v izokinetični moči med B in V (torej B>V≈K), medtem ko pri izoinercijski in izokinetični moči ni bilo značilnih razlik med obema treniranima skupinama. »VU pretvorba« podatkov je pokazala tudi, da obstajajo velike razlike med B in drugima skupinama v izometrični in izokinetični moči (torej B>V≈K).

Statistično značilna ($p<0,05$) negativna korelacija je bila dobljena med MHC tip IIb izoformami in izoinercijskim indeksom moči ($r=–0,68$). Vsebnost MHC tip IIa beljakovin je bila pozitivno povezana z vsemi uporabljenimi indeksi moči ($r=0,51–0,61$; $p<0,05$). Izmerjeni podatki kažejo na različne vzorce izražanja MHC izoforme merjenih skupin športnikov, menimo, da te razlike lahko včasih vplivajo na izražanje moči.

Ključne besede: MHC izoforme, trening moči, trening vzdržljivosti, indeksi moči

Introduction

Human skeletal muscle structure may differ largely between individuals (Abernethy, Jürimäe, Logan, Taylor and Thayer, 1994). For example, the muscle fibre content of elite endurance athletes may contain up to 90 % of slow-twitch muscle fibres (Saltin and Gollnick, 1983). Myofibrillar ATPase histochemistry has also demonstrated that bodybuilders may possess a similar (Alway, MacDougall, Sale, Sutton and McComas, 1988) or even lower (Bell and Jacobs, 1990) proportion of fast-twitch muscle fibres in the vastus lateralis muscle than sedentary controls. Furthermore, Tesch and Larsson (1982) showed that bodybuilders' fibre type distribution in the vastus lateralis muscle resembles the histochemical profile of skeletal muscles from endurance athletes. These cross-sectional data raise the question as to whether training has produced this particular fibre type profile. Equally, however, these data may be the product of sampling and/or genetic differences.

It has been suggested that myofibrillar ATPase histochemistry can not give an adequate characterisation of muscle contractile properties in athletes (Abernethy, Jürimäe, Logan, Taylor and Thayer, 1994), since the histochemical reaction of a muscle fibre reveals only the dominant MHC isoform present in this particular fibre (Danieli-Betto, Zarbato and Betto, 1986). Thus, in this study, the more sensitive electrophoretic technique was used to compare the contractile characteristics of skeletal muscle tissue from different athletes.

There were two purposes in this investigation. First, MHC isoform composition of the triceps brachii muscle was compared among bodybuilders (B), rowers (R) and untrained controls (C). Second, correlations between MHC isoforms and various strength indices were computed to determine the possible relationships between these variables.

Methods

Five B with an average training history of 4.8±1.2 years (range 3–6 years), 5 R with an average training history of 4.0±2.2 years (range 2–8 years) and 5 C subjects who had not been involved in any systematic physical activity during the previous 2 years participated in this study. All testing procedures were approved by the local ethics committee and subjects were aware of the purpose and potential benefits of the study as well as the possible risks and discomforts.

Strength was assessed isoinertially, isometrically and isokinetically (Abernethy and Jürimäe, 1996). Maximal isoinertial strength was measured using one repetition maximum (1RM) triceps extension. Maximal isometric strength was determined at an angle of 0.52 rad. from full extension and maximal isokinetic strength at the contractile speed of 5.20 rad.sec^{-1} according to Abernethy and Jürimäe (1996). Muscle biopsies were taken from the triceps brachii muscle and analysed for MHC isoform composition using 6 % sodium dodecyl sulfate-polyacrylamide gel electrophoresis as previously described (Jürimäe, Abernethy, Blake and McEniery, 1996).

Descriptive statistics (mean, standard deviation [SD]) for each of the dependent variables were determined. As the raw data were normally distributed, parametric analysis was completed. Specifically, a one-way analysis of variance (ANOVA) was used to test the effect of group for each dependent variable. An alpha level of 0.05 was adopted. The Scheffe method was used for post hoc analysis when a significant F ratio was found. In addition, the ES transformations were used to compare differences in dependent variables among B, R and C groups. ESs approximating 0.2, 0.5 and 0.8 were categorised as small, moderate and large differences, respectively (Cohen, 1969). The Pearson Product Moment Correlation analysis was used to determine the correlation among dependent variables.

Results

Maximal strength values are presented in Table 1. Significant differences existed in isoinertial strength among B and R subjects (i.e., B>R≈C), while isometric and isokinetic strength were not significantly different among trained groups. However, the ES transformation of data demonstrated that large differences existed between B and other groups for isometric and isokinetic strength (i.e., B>R≈C). (Table 1).

Table 1. Maximal isoinertial (one repetition maximum triceps extension in kg), isometric (extension in Nm) and isokinetic (extension at contractile speed of 5.20 rad.sec-1) strength for the bodybuilders, rowers and untrained control group.

Strength index	Bodybuilders	Rowers	Controls
Isoinertial	61.3±7.2	31.5±7.8*	32.3±8.8*
Isometric	117.2±19.9	84.2±16.9	76.4±14.1*
Isokinetic	79.4±13.1	62.6±5.0	50.6±6.4

* Significantly different from bodybuilders; $p<0.05$.

There were significant differences in the relative distribution of MHC isoforms among the different groups (Table 2). The B possessed significantly smaller ($p<0.05$) percentage of MHC type IIb proteins than R and C groups (i.e., B<R<C). B presented also significantly more type IIa MHC isoforms in comparison with other studied groups (i.e., B>R≈C). The MHC type I protein content did not differ significantly among different groups (Table 2). However, when the results of MHC type proteins were converted to ES, it appeared that low statistical power rather than the absence of an effect accounted for the non-significant differences between B and other groups (i.e., B>R≈C).

Correlational analysis revealed statistically significant negative correlations ($p<0.05$) between MHC type IIb proteins and maximal isoinertial strength index (Table 3). In contrast, MHC type IIa isoforms were positively related ($p<0.05$) to all considered strength values. However, no significant correlations were found between MHC type I proteins and the strength measures (Table 3).

Discussion

The present investigation demonstrated different patterns of MHC isoform expression for the triceps brachii muscle of B, R and C groups. The main finding of this investigation was that B presented significantly less MHC type IIb isoforms than endurance-trained R subjects. Traditionally, it has been thought that chronic endurance activity requires more muscle fibres with higher oxidative capacity than chronic resistance training (Saltin and Gollnick, 1983). However, in this experiment, bodybuilding type resistance training of B may have resulted in greater fast motor unit recruitment than the training protocol of R specified for endurance development. In agreement with this hypothesis, Kraemer et al. (1995) demonstrated that 12 weeks of novel resistance training decreased the histochemically typed fast-twitch glycolytic muscle fibres to a greater extent (19.1 to 1.9 %) than novel endurance training over the same time span (19.2 to 8.8 %) in previously untrained vastus lateralis muscle. Thus, the MHC type IIb isoform data were consistent with the concept of a »reserve population« of fast, type IIb MHC isoforms. That is, once regularly recruited, MHC type IIb isoforms start to transform towards type IIa MHC proteins (e.g., Adams, Hather, Baldwin and Dudley, 1993; Jürimäe, Abernethy, Blake and McEniery, 1996; Kraemer et al., 1995; Staron et al., 1994). Indeed, bodybuilding training should result a more complete recruitment of all the fast motor units, which muscle fibres mainly consist of MHC type IIb proteins. The statistically significant negative correlation between the amount of MHC type IIb isoforms and tested maximal isoinertial strength (Table 3) further supports the theory of the possible »reserve population« of MHC type IIb isoforms. Thus, according to these results, it appears that a lower percentage of type IIb MHC isoforms in muscle may indicate better isoinertial strength.

Correlational data (Table 3) demonstrated that type IIa MHC isoforms may play an important role in muscle tissue functional characteristics. The positive intercorrelations between MHC type IIa protein amount and all measured strength indices were statistically significant ($p<0.05$). Similarly, Nygaard, Houston, Suzuki, Jorgensen and Saltin (1983) and Schantz, Randell-Fox, Hutchinson, Tyden and Astrand (1983) have previously reported significant correlations between

Table 2. Relative type IIb, IIa and I myosin heavy chain (MHC) isoform content of the triceps brachii muscle of bodybuilders, rowers and untrained control group.

Subject groups	MHC IIb	MHC IIa	MHC I
Bodybuilders	12.9±7.1	55.8±5.3	31.3±2.7
Rowers	31.2±2.7*	42.8±3.0*	25.4±1.7
Controls	38.2±3.0*	34.7±1.6*	27.1±1.8

* Significantly different from bodybuilders; $p<0.05$.

Table 3. The inter-correlations between myosin heavy chain (MHC) isoforms and isoinertial, isometric and isokinetic strength indices.

Strength index	MHC IIb	MHC IIa	MHC I
Isoinertial	–0.68*	0.66*	0.35
Isometric	–0.45	0.51*	0.06
Isokinetic	–0.49	0.61*	–0.07

* Statistically significant; $p<0.05$.

the histochemically typed fast-twitch muscle fibres and various strength indices. However, this has not been observed in other studies (Clarkson, Droll and Melchionda, 1982; Frose and Houston, 1985). The inconsistency of these results may be due to the limitations associated with histochemical fibre type assessment and differential propositions of muscle fibres with different MHC isoform profiles to hypertrophy (Abernethy, Jürimäe, Logan, Taylor and Thayer, 1994). It should be noted that B, who possessed significantly higher percentage of MHC type IIa isoforms over R and C subjects, had also significantly higher maximal isoinertial strength value (Table 2). In the light of the results of our study, it could be argued that MHC type IIa proteins in muscle tissue are the most favourable for bodybuilding resistance training adaptations.

In summary, the present study compared the MHC isoform composition of the triceps brachii muscle in resistance and endurance trainers. According to the results, it appears that B possess significantly less type IIb MHC isoforms than untrained C or even endurance-trained R. Maximal isoinertial, isometric and isokinetic strength indices are significantly related to the amount of MHC type IIa proteins.

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