

DIFFERENCES OF THE TENSIOMYOGRAPHY-DERIVED BICEPS FEMORIS MUSCLE CONTRACTION TIME AND DISPLACEMENT BETWEEN DIFFERENT AGE AND FITNESS GROUPS

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ABSTRACT

Introduction: The aim of this study was to compare tensiomyography-derived biceps femoris muscle (BF) contraction time (T_c) and maximal radial displacement (D_m).

Methods: Ninety male participants were divided into three age groups: young adults (YA; 23.7 ± 4.3 years), middle-aged adults (MA; 46.7 ± 5.6 years), and older adults (OA; 64.2 ± 6.5 years). Furthermore, the participants were divided in two physical activity groups – the sedentary and those who were regularly engaged in recreational sports activities (at least three times a week). Tensiomyography (TMG) method was used to measure the BF D_m and T_c during isometric single-twitch maximal contraction.

Results: We found shorter T_c in active YA than sedentary YA ($P = 0.001$). Active YA had also shorter T_c than active OA ($P = 0.046$). Active YA had also a lower D_m than sedentary YA ($P = 0.031$), while pooled YA showed a trend towards a lower D_m than pooled MA ($P = 0.073$) and pooled OA ($P = 0.120$).

Discussion and conclusions: TMG data indicates a transition towards higher slow-twitch muscle fibre type with age and sedentary lifestyle. Furthermore, TMG data also indicates a lower muscle tone with age and sedentary lifestyle. Data obtained with TMG can be used to assess muscle imbalances in human body, which may be of clinical importance.

Keywords: tensiomyography, biceps femoris, lifestyle, aging, sport.

Z METODO TENZIOMIOGRAFIJE IZMERJENE RAZLIKE MED ČASOM KONTRAKCIJE IN ODMIKOM MIŠICE MED RAZLIČNO STARIMI IN FIZIČNO AKTIVNIMI SKUPINAMI

IZVLEČEK

Uvod: Namen pričujoče študije je bil primerjati s tenziomiografsko metodo (TMG) pridobljen čas kontrakcije (T_c) in maksimalni odmik (D_m) trebuha dvoglave stegenske mišice (BF).

Metode: Devetdeset moških udeležencev je bilo razdeljenih v 3 starostne skupine: mladi odrasli (YA; 23.7 ± 4.3 let), odrasli v srednjih letih (MA; 46.7 ± 5.6 let) in starejši odrasli (OA; 64.2 ± 6.5 let). Nadalje so bili udeleženci razdeljeni v 2 skupini glede na rednost ukvarjanja s fizično aktivnostjo- sedeči in tisti, ki so se redno ukvarjali z rekreativno obliko športne dejavnosti (vsaj 3-krat na teden). Metoda TMG je bila uporabljena za merjenje odziva parametrov D_m in T_c mišice BF na en maksimalni dražljaj.

Rezultati: Ugotovili smo, da imajo aktivni YA krajši T_c od sedečih YA ($P = 0.001$) in tudi krajši T_c od aktivnih OA ($P = 0.046$). Aktivni YA imajo nižji D_m kot sedeči YA ($P = 0.031$). Za YA je značilen trend nižjega D_m v primerjavi z MA ($P = 0.073$) in z OA ($P = 0.120$).

Razprava in zaključki: Dobljeni podatki kažejo, da mišica BF z leti in s sedečim načinom življenja postaja počasnejša in manj tonizirana. Na osnovi pridobljenih TMG podatkov se lahko oceni mišična neravnovesja v človeškem telesu in rezultate se lahko interpretira tudi v okviru klinične pomembnosti.

Ključne besede: tenziomiografija, biceps femoris, življenjski slog, staranje, šport

INTRODUCTION

The world's population is aging, and the proportion of elderly people keeps increasing. In 2010, the proportion of people aged over 65 years accounted for about 8 % of the world's population. The forecast for 2050 projects that the percentage will increase to 16 %, which will represent some 1.5 billion people (2010 Revision of the World Population Prospects).

According to the Statistical Office of the Republic of Slovenia (2015), which summarizes Eurostat's data projections, it is expected that in the year 2060 a third of Slovenians will be aged over 65 years. In 2015, the proportion of Slovenians older than 65 amounted to 20 %, whereas it is estimated that this will increase to 30 % in 2060. Longer life spans as well as larger proportions of elderly population will likely lead to an increase in the number of diseases that are more prevalent with age.

It is clear that physical inactivity significantly contributes to mortality, as the WHO (2013) reported that over 3.2 million people die each year due to physical inactivity. Many non-communicable chronic health conditions, prevailing in developed and developing countries are associated with physical inactivity (Blair, Sallis, Hutber, & Archer, 2012; Chodzko-Zajko et al., 2009; Paterson, Jones, & Rice, 2007).

In addition to the higher incidence of these risk factors with aging, a decline in many physiological systems occurs along with the loss of muscle mass, impaired balance, reductions of muscle strength and endurance (Sakuma & Yamaguchi, 2012) as well as cognitive capacities, all of which impacts functional independence (Salthouse, 2003).

There are various guidelines for physical activity of people aged 65 years and above: (i) The WHO's recommends (WHO, 2010) at least 150 minutes of moderate-intensity aerobic physical activity per week, or at least 75 minutes of high intensity physical activity per week, or an equivalent combination of moderate and high intensity exercise; (ii) The American College of Sport Medicine (ACSM) and the American Heart Association (AHA) recommend 30 minutes of moderate intensity aerobic physical activity 5 times per week, or 20 minutes of high intensity physical activity 3 times per week, or an equivalent combination of moderate and high intensity exercise with a duration of at least 10 minute bouts is recommended (Nelson et al., 2007). While WHO is not specific, the ACSM and the AHA emphasize that it is also necessary to incorporate strength training twice per week, which should be composed of 8 to 10 exercises with 10 to 15 repetitions and 1 to 2 sets.

Šimunič, Pišot, & Rittweger (2009) investigated the age and sport activity type on postural (VL, vastus lateralis) and non-postural (BF, biceps femoris) muscle contraction time in master athletes and non-athletes. Authors performed Tensiomyographic (TMG) assessment of 35+ years of control group, explosive athletes and endurance athletes. They found that the sport activity type significantly affects contraction time (T_c) only in non-postural BF muscle. BF muscle deteriorates in all groups, but least in explosive athletes, which emphasizes strength and power training to maintain skeletal muscle contractile properties. They explained that postural muscles receive enough daily stimuli to be prevented from major deterioration. Although they reported T_c data, they failed to report maximal displacement of TMG response (D_m).

Therefore, we decided to obtain TMG responses and calculate T_c and D_m of BF in 3 age groups and 2 fitness groups. We decided to measure BF as, according to Valenčič & Djordjevič (2002) in Djordjevič, Rozman, & Pišot (2005), there are indications that BF muscle is one of the most sensitive to deterioration or improvement after physical inactivity or age and training, respectively.

METHODS

Participants

Ninety male participants were divided into 3 age groups and measured in *the laboratory* of the Institute for *Kinesiology Research* in Koper, using TMG: young adults (YA), middle-aged adults (MA), and older adults (OA). The selection of participants was based on the following criteria: 15 YA (age: 23.7 ± 4.3 years; body height: 172 ± 8.0 cm; body mass: 59 ± 10.5 kg), 15 MA (age: 46.6 ± 5.6 years; body height: 182 ± 6.7 cm; body mass: 88 ± 7.0 kg), and 15 OA (age: 64.2 ± 6.5 years; body height: 175 ± 2.6 cm; body mass: 87 ± 5.0 kg). In each group, half of the participants were active 2 to 3 times in organized sport activities, while 15 were not.

Tensiomyography

Two contractile parameters, Dm and Tc of BF muscle were measured in ninety males by TMG (TMG – BMC, Ljubljana, Slovenia). The measurement point in BF muscle was defined at the midpoint of the line between the fibula head and the ischial tuberosity. Positioning the sensor directly on the skin above the muscle belly makes the method sensitive to mechanical displacement of the underlying muscle tissue. The measurements were performed isometrically in relaxed predefined position with fixed joint angle at 5 degrees knee flexion, with the participants lying on their front. Self-adhesive electrodes were placed directly on the muscle belly: the cathode was placed 5 centimetres distally, while the anode was 5 centimetres proximally from the measurement point. The amplitude of the electrical stimulation was gradually increased to get maximal response. From the twitch response, the Dm was analysed in mm and Tc was calculated in ms as time of the response reaching from 10 % to 90 % of the maximal amplitude.

Statistics

All data are presented with mean values (\pm SD). After checking for normality of distribution with visual inspection, we proceeded with 3×2 analysis of variance with post hoc t-tests for independent samples and using Bonferroni corrections. All decisions were accepted with alpha set at 0.05.

RESULTS

In Table 1 we found shortest Tc in active YA that is increasing with age ($P = 0.003$) and lifestyle groups ($P = 0.041$). Dm was found to be higher in active YA than in se-

dentary YA ($P = 0.031$). Post hoc analysis revealed also shorter Tc in active YA than in sedentary YA ($P = 0.001$). Active YA had also shorter Tc than active OA ($P = 0.046$). Active YA had also lower Dm than sedentary YA ($P = 0.031$), while pooled YA has trend towards lower Dm than pooled MA ($P = 0.073$) and pooled OA ($P = 0.120$).

Table I: Comparison between active / sedentary participants of three age groups in BF contraction time and maximal displacement.

Age group	Lifestyle group	Contraction time (ms)	Displacement (mm)
Young adults	Active	26.2 ± 10.2	5.5 ± 1.1
	Sedentary	49.0 ± 11.7	8.8 ± 4.3
Middle-age adults	Active	35.2 ± 16.4	6.4 ± 2.1
	Sedentary	42.8 ± 17.2	6.4 ± 2.5
Older adults	Active	33.6 ± 4.6	6.0 ± 2.5
	Sedentary	37.8 ± 7.1	5.9 ± 1.1

DISCUSSION

It is well established that aging leads to progressive changes in the human body, which causes a loss of muscle function, weakness, disease and death. Older people are also the most sedentary and physically inactive segment of society, according to certain evidence (Paterson & Warburton, 2010), therefore, it is hard to study the aging effect solely, independently of physical activity or fitness level. Therefore, it is important to study different age groups but levelled on physical or sport activity.

There are differences in skeletal muscles between physically active and inactive people, as evident in muscle composition analysis conducted with TMG. This method enables easy as well as selective measurements of contractile properties of the muscle belly and was recently shown to be a valid, repeatable and non-invasive assessment of muscle composition (Šimunič et al., 2011; Šimunič, 2012; Šimunič, 2015).

Comparison of Dm between active / sedentary participants

The biggest differences are between active and sedentary YA. YA have expectedly lowest Dm, which indicates the highest BF tone. Pišot et al. (2008) provided evidence that Dm reflects physical activity or inactivity and demonstrated that Dm increases after acute muscle atrophy. There were no differences in Dm regarding the lifestyle between

MA and OA. Pišot et al. (2008) further explained that the smaller the Dm value before bed rest, the larger the change induced by bed rest, which puts TMG amplitude Dm as a measure of muscle belly stiffness.

Comparison of Tc between active / sedentary participants

Shortest Tc was in active YA and was getting higher with age and sedentary lifestyle. Tc reflects muscle composition, whereas shorter Tc indicates lower proportion of myosin heavy chain type 1 (Šimunič et al., 2011). Šimunič, Pišot, Rittweger, and Mekjavić (2008) found that BF muscle deteriorates in much greater scale than VL with age and sport group and they evaluated this with Tc calculated from mechanical response of muscle belly, using TMG.

The data obtained highlighted the importance of physical / sports activity and the importance of TMG as method of evaluating muscles status and as method for monitoring the effects of PA on the physical fitness of people.

Based on the data obtained it would be possible to choose the most optimal training method and the means to plan and modify the physical preparation of the individual or of homogenous groups and such adjusted physical / sporting activity can improve their physical condition. It consequently improves physical health of people and especially in elderly it contributes to increased stability, autonomy, mobility, self-confidence when moving, which has a great impact on both well-being and satisfaction of older adults.

It is well known that regular physical activity and exercise are beneficial for physical and mental health. Hence, it is important that people consider this already in their younger age and educate themselves about the positive effects of being active, the importance of maintaining motor abilities as well as the value of quality of life in older age.

Without data on movement, physical, physiological and biochemical characteristics, it is difficult to accurately design, programme and model exercise, adapted to the needs of individuals of a certain age and capacity.

CONCLUSION

In conclusion, Tc and Dm were found to be sensitive of age and fitness level in our participants. That makes TMG useful for a variety of purposes. Since TMG data correlates to muscle composition and muscle atrophy, it makes TMG useful in the field of aging, preventive assessment, sport training, rehabilitation, etc.

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