MUSCLE FIBRE LENGTH-TO-MOMENT ARM RATIOS IN THE HUMAN LOWER LIMB

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INTRODUCTION

The fibre length (L)-to-moment arm (d) ratio (L/d) is functionally significant because it determines the active excursion range and the relative contributions of the contractile element and its mechanical advantage to the pattern of the torque-angle relation. Despite their importance, data on L/d ratios are rather scarce [e.g., 1,2], but suggest that the L/d ratio in a given muscle-joint is constant between individuals. In the present study we have quantified the L/d ratio in main human knee extensors and ankle plantarflexors from in vivo measurements of L and d. A secondary aim was to examine whether the d values in the knee extensors and ankle plantarflexors scale with each other.

METHODS

Twenty-one men (age: 25±6 years, body height: 182±8 cm, body mass: 79±8 kg; mean±SD) without any musculoskeletal injuries in the lower limbs volunteered to participate after the study was approved by the local Ethics Committee. Measurements of L were taken from the vastus lateralis (VL), vastus intermedius (VI), gastrocnemius medialis (GM), gastrocnemius lateralis (GL), and soleus (SOL) muscles, using ultrasonography [e.g., 3,4]. The sonographs were taken from the central region of each muscle, with the knee fully extended and the ankle at the anatomically neutral position. Measurements of d were taken at the above joint configuration in the Achilles tendon (AT) and the patellar tendon (PT) using magnetic resonance imaging [e.g. 5,6]. From the measurements taken, the relations between a) L in each ankle plantarflexor muscle and d_{AT}, b) L in each knee extensor muscle and $d_{PT,}$ and c) d_{AT} and $d_{PT,}$ were analyzed with Pearson correlation coefficients.

RESULTS AND DISCUSSION

The L/d_{AT} ratios ranged from 0.78 to 1.35 in the GM muscle, from 0.72 to 1.32 in the GL muscle and from 0.61 to 1.1 in the SOL muscle. The L/d_{PT} ratios ranged from 1.5 to 2.24 in the VL muscle and from 1.1 to 2 in the VI muscle. The d_{AT}/d_{PT} ratios ranged from 1.21 to 1.61. None of the relations examined was significant (P>0.05), which therefore also precludes that the quantities involved in each relation scaled with each other. The Pearson correlation coefficients obtained ranged from -0.2 to 0.29 (Table 1).

Table 1. Relations between the parameters examined.

Relations	r	P
L_{GM} vs. d_{AT}	0.059	P>0.05
L_{GL} vs. d_{AT}	0.129	P>0.05
L_{SOL} vs. d_{AT}	0.092	P>0.05
L_{VL} vs. d_{PT}	-0.203	P>0.05
L_{VI} vs. d_{PT}	-0.245	P>0.05
d_{AT} vs. d_{PT}	0.29	P>0.05

The varying L/d ratios in the present in vivo study contrast previous findings in other muscle-joint systems [1,2], indicating that d differences in a given joint between individuals may not always accounted for by differences in muscle length caused by L differences. It may be the case that in some pennate muscle-joint systems the above inter-subject muscle length differences are primarily accommodated by differences in muscle fibre number and/or cross-sectional area. The present findings indicate that L may not always scale to d and need to be accounted when the L/d ratio of a given muscle-joint system needs to be known, e.g., when seeking a donor muscle to surgically substitute functional loss.

The lack of relation between d_{AT} and d_{PT} precludes that these quantities can be predicted from one another when one of these d values is already known.

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