ISOKINETIC MUSCLE STRENGTH IN NORMAL ADULTS: REVISITED

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PURPOSE.

Isokinetic strength testing has been accepted into the clinical realm as a valid tool for evaluating functional deficits resulting from muscle strength deficiency. As new protocols are developed it is necessary to update our understanding of normal isokinetic muscle strength. Although many authors have reported normal values (Borges, 1989; Burnett, et.al, 1990; Cuhalan et.al, 1989; Davies, 1981; Davies, 1984; Donateli et. al, 1991; Freedson, et.al, 1993; Fugi-Meyers et.al, 1980; Fugi-Meyers, 1981), several questions remain unanswered. For example, in clinical practice it is common to want to compare strength of a pathological limb to a normal contralateral side. The pathology may reside in one or multiple joints and may be on the patient's preferred side. Normal side to side variations in strength have been reported. (Donateli, et al., 1991; Freedson, et al., 1993; Hall & Roofner, 1991). It is known that one leg is dominant to another. Some define dominance by strength alone Bäckman & Öberg, 1989), others have asked subjects to report limb preference (Borges, 1989). A better understanding of strength differences across multiple joints of a stronger compared to preferred side would be desirable. In addition, the relationships between strength across multiple joints of the same side have not been well documented.

This study was conducted to address the difference between preferred and stronger sides, determine a clinically relevant muscle imbalance threshold for various muscle groups, and to study the correlation of strength between various muscle groups.

METHODS

Fifteen subjects (8 female, 7 male) were evaluated. Average age for females was 29.1 (23 - 35) years and for males 30.7 (24 - 43) years. Average height for females was 1.66 (1.58 - 1.75) meters and for males was 1.8 (1.78 - 1.88) meters. Average weight for females was 64.5 (50 - 108) kilograms and for males was 77.6 (70 - 91) kilograms. The subjects had no previous orthopaedic and/or neuromuscular conditions. Informed consent was obtained from all subjects. Limb preference (hand and leg) and level of activity were recorded.

Isokinetic muscle strength data were collected on a Cybex II Isokinetic Dynamometer (Cybex®, Ronkonkoma, New York, USA) and analyzed using Humac 600 (Computer Sports Medicine, Inc., Waltham, MA, USA). Testing protocol included measurement of hip extension/flexion, abduction/adduction, and ankle plantar flexionldorsiflexion at 30 (slow), 60 (medium) and 120 (high) degreeslsecond; and knee extension/flexion at 60 (slow), 120 (medium) and 180 (high) degreeslsecond. These speeds are recommended by Cybex®, and correlate well with joint velocities during functional tasks such as walking and running.

One evaluator encouraged all subjects to statically stretch the appropriate muscles and to perform a warm up session which was 4 - 5 sybmaximal and 2 maximal repetitions for each movement. Subjects were then instructed to maximally perform each movement until instructed to stop. Five maximal repetitions were completed for the slow and medium speeds and 18 repetitions for the high speed. For slow and medium speeds, if maximum torques were not within 15% of one another, the maximal effort was questioned and the test was repeated.

We computed peak torque/body mass for all speeds and all movements, an average of the 3 maximum torque/body mass for slow and medium speeds for all movements, and fatigue index for high speeds. Fatigue index was calculated by dropping the first 3 repetitions, averaging repetitions 4, 5, 6, and 16, 17, 18, dividing the initial by the final and multiplying by 100. The percentage decline was considered the fatigue index. Stronger versus preferred sides were evaluated by computing a percentage of cases in which the stronger was not the preferred side, this was called a percentage of reversals. Paired t-tests were computed for stronger versus weaker sides and preferred versus non-preferred sides. A Pearson correlation was computed to compare all motions.

RESULTS

The percentage of reversals in which the strongest side was not the preferred side was highest for hip adduction (60%); hip extension, knee flexion (58%); hip abduction (57%); and knee extension (56%). Hip flexion and ankle plantar flexion reversed 49% and 39% respectively. Looking at each variable across all motions, the greatest incidence of reversals in peak torque were 60% at the high speed, 54% at the medium speed, and 51% at the slow speed. The average torque was comparable with 51% at the medium speed and 58% at the slow speed. Fatigue index had the lowest incidence of reversals at 36%. In comparing strong side to weak side, all variables demonstrated statistically significant differences, this was not true for comparison between preferred and non-preferred sides.

The peak torque per body mass for all motions at slow and medium speeds is presented in Table I for strong and weak sides. Muscle imbalance, the percentage side to side difference in peak torque per body mass, are presented as well. The greatest differences were seen in hip abduction/adduction and ankle plantar/dorsiflexion. Peak torque per body mass was more comparable for the motions of hip extension/flexion and knee extension/flexion. Muscle imbalance differed for females as compared to males. These differences were statistically significant for hip extension, ankle plantarflexion and dorsiflexion.

	Peak Torque/Body Mass (Nm/kg)																	
Motion	MEAN									FEMALE								
	Slow speed			Med speed			High speed			Slow speed			Med speed			High speed		
	S	W	%	S	W	%	S	W	%	S	W	%	S	W	%	S	W	%
Hip Ext	3.1	2.8	9.3	2.8	2.5	8.6	2.6	2.3	9.6	2.7	2.3	12.3	2.4	2.1	12.6	2.5	2.3	9.3
Hip Flex	1.6	1.5	10.3	1.4	1.2	12.1	1.3	1.1	10.6	1.3	1.2	10.8	1.2	1.0	15.0	1.3	1.2	8.5
Hip Abd	1.5	1.3	13.6	1.4	1.2	13.9	1.1	0.9	15.8	1.5	1.2	16.4	1.4	1.2	17.8	1.2	1.0	12.8
Hip Add	2.2	2.0	12.0	2.2	1.8	17.7	1.7	1.5	10.0	2.1	1.8	14.9	2.0	1.6	19.6	1.7	1.5	10.2
Kneeext	2.3	2.1	8.6	1.9	1.8	6.6	1.9	1.7	10.8	2.1	2.0	8.4	1.7	1.6	7.9	2.0	1.9	7.4
Knee **Flex**	1.6	1.4	9.1	1.3	1.2	7.9	1.3	1.2	10.0	1.5	1.3	12.1	1.2	1.1	10.3	1.4	1.3	7.2
Ankle Pf	1.5	1.4	9.2	1.4	1.1	16.3	1.1	1.0	7.1	1.5	1.3	11.2	1.4	1.1	21.3	1.4	1.3	7.1
Ankle Df	0.6	0.5	10.6	0.5	0.4	18.3	0.4	0.4	11.4	0.6	0.5	13.3	0.6	0.4	25.0	0.6	0.5	10.9

Motion	**MALE**								
	Slow speed			**Med speed**			**High speed**		
Hip Ext	3.6	3.4	6.7	3.2	3.1	5.2	2.7	2.4	10.0
Hip Flex	1.9	1.8	10.0	1.6	1.5	9.6	1.3	1.1	13.0
Hip Abd	1.5	1.3	10.4	1.4	1.3	9.4	1.0	0.8	20.1
Hip Add	2.4	2.2	9.0	2.4	2.0	15.8	1.6	1.5	9.9
Knee Ext	2.5	2.3	8.7	2.2	2.0	5.4	1.7	1.4	15.4
Knee Flex	1.6	1.5	6.0	1.4	1.4	5.5	1.2	1.0	13.8
Ankle Pf	1.6	1.5	7.1	1.3	1.2	9.9	0.8	0.7	7.0
Ankle Df	0.5	0.5	7.1	0.4	0.4	8.1	0.3	0.3	12.5

S=Strong side, **W=Weak** side, %=% difference

Analysis was done to determine whether particular muscle groups correlated in strength. All opposing muscle groups–hip extension/flexion; knee extension/flexion, hip flexion / knee flexion and knee flexion/ankle plantarflexion–were positively correlated. (R=.8, $p<.001$). In addition, hip flexion correlated positively with knee extension; knee extension with ankle plantarflexion, and knee flexion with ankle plantafflexion.

DISCUSSION

Sapega (1990) stated that imbalances of strength in an individual muscle group of less than 10% can be considered normal, differences of 10-20% possibly abnormal; those greater than 20% as probably abnormal. Our results indicate that one should expect different variations for different joints. Specifically, 20% can be expected for hip abduction/adduction in the normal population. It was noted imbalance was greater in females as compared to males. A side to side difference of 20% in ankle plantar flexion/ dorsiflexion was found to be normal in females.

Limb preference was not a good indicator of stronger side in isokinetic muscle strength testing. The percentage of reversals for peak torque normalized to body mass was higher than expected for most muscles groups. Approximately 50% of the time, the strongest side was not the preferred side. Interestingly ankle plantar flexion, a primary power generator during running and gait, had the lowest number of reversals.

There was a strong correlation between opposing muscle groups at all speeds. For, example, if you have strong hip extensors, you tend to have strong hip flexors. Interestingly, hip flexion and knee extension correlated, probably due to the contribution of the rectus femoris which crosses both joints in this plane. A similar explanation would follow for the correlation of knee flexion and ankle plantarflexion.

This is the beginning of our normal population database. We would like to continue to incorporate more comprehensive protocols which include data on multiple joints at various speeds on the same set of subjects.

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