Published in final edited form as:

Exp Gerontol. 2018 October 02; 112: 63–67. doi:10.1016/j.exger.2018.09.005.

Knee Extension Rate of Velocity Development Affects Walking Performance differently in Men and Women

Yusuke Osawa¹, Stephanie A. Studenski¹, and Luigi Ferrucci¹

¹Longitudinal Studies Section, Translational Gerontology Branch, National Institute on Aging, National Institutes of Health, Baltimore, Maryland, 21225

Abstract

PURPOSE: Acceleration capacity affects physical function, but whether it differentially affects men versus women or weak versus strong individuals is less known. We investigated whether knee extension rate of velocity development (RVD, a measure of acceleration) is associated with walking performance independent of peak torque and whether the relationships differ in men versus women and in weak versus strong individuals.

METHODS: Relationships of RVD with walking performance were assessed in 326 women and 365 men aged 26–96 years enrolled in the Baltimore Longitudinal Study of Aging. Tests included knee extension peak torque and RVD assessed during a 180 deg.sec⁻¹ isokinetic strength test and four walking performance measures (usual-paced and fast-paced 6m walks and 2.5 min usual-paced and 400m fast-paced walks). Sex-stratified linear regression models were adjusted for age, race, height, appendicular lean mass, fat mass, peak torque, knee pain, and RVD*peak torque interaction.

RESULTS: In men, RVD was not independently associated with any walking performance measure ($p > 0.05$), and, for the 6m-usual walk only, there was a significant RVD*peak torque interaction ($p < 0.0001$). In women, RVD was independently associated with usual-paced walks ($p < 0.05$) and there were significant RVD*peak torque interactions for all measures. Strength-specific analyses indicated that RVD was most associated with performance among weaker individuals.

CONCLUSION: RVD is associated with walking performance in women, but less in men, and is most related to performance when strength is low. Strategies to accomplish motor tasks may be

---

Corresponding author: Yusuke Osawa, National Institute on Aging, MedStar Harbor Hospital 5th floor, 3001 S. Hanover Street, Baltimore MD 21225, yusuke.osawa@nih.gov, Tel: 410-350-7381, Fax: 410-350-7304.

Author contributions:

Study design: Y. Osawa, L. Ferrucci and S. Studenski. Data collection, analysis and interpretation: Y. Osawa, S. Studenski and L. Ferrucci. Final statistical analyses: Y. Osawa. Critical revision of the draft: S. Studenski and L. Ferrucci. Draft of the report: Y. Osawa, S. Studenski and L. Ferrucci. All authors approved the final version of the report.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Conflict of interest

No conflicts of interest.

sex-specific. Future studies are needed to understand the mechanisms underlying such sex differences.

Keywords

Aging; Acceleration; Muscle strength; Isokinetic dynamometry; Gait; Sex difference

1. Introduction

Muscle strength is important to walking performance (2). The relationship between muscle strength and walking performance is usually explored by studying the independent correlation between maximum muscle strength, often as peak torque or force and some performance measure of walking capacity. Few and relatively small studies have selectively addressed acceleration capacity. The capacity to accelerate the limbs is important for various physical performance tasks (17, 24). Thus, assessing acceleration capacity may help gain insight into the motor strategies that individuals use to purposefully and efficiently move their limbs.

Rate of velocity development (RVD) is a metric of acceleration capacity during initial muscle contraction that is usually estimated from the time-velocity curve during the unloaded acceleration phase of isokinetic testing (3, 4). RVD can be operationally defined as the time required to reach a predetermined angular velocity (3). The relationships between RVD at various predetermined angular velocities and peak torques are weak ($r = -0.09$ to -0.29), suggesting that RVD captures a different aspect of muscle function than peak torque (4). In adults who are physically active, short-term velocity-specific training causes improvement of knee extension RVD, with little or no improvement in knee extension peak torque (3, 17). Since RVD reflects some effect of aging on muscle, especially neuromuscular changes (6), studying this parameter may help better understanding the effect of aging on mobility performance and provide novel insights into mechanisms and intervention strategies to prevent or treat mobility decline with aging.

Overall, men are stronger than women of the same size (5, 8, 18). In contrast, whether acceleration capacity during knee extension differs by sex remains controversial. One study reported that healthy young women compared to men, require on average more time to reach the target velocity, but only at velocities greater than $240 \text{ deg. sec}^{-1}$ (5), whereas another study did not find any sex differences in healthy young adults at angular velocities ranging from 30 to $300 \text{ deg. sec}^{-1}$ (6). Sex differences also exist in walking performance (22), which are only in part explained by differences in anthropometric characteristics (11, 18, 23). Further studies are needed to investigate how acceleration capacity contributes to walking performance, independent of peak torque in men and women.

We investigated whether knee extension RVD contributes to walking performance independent of peak torque in women and men aged 20 to 90 years. We further investigated whether, among men and women, the contribution of RVD to mobility performance differs in participants with higher and lower muscle strength. Addressing these questions may help inform mechanisms underlying walking performance and thus provide a rationale for sex

and strength-specific exercise programs for the prevention or treatment of mobility disability.

2. Methods

2.1 Participants

This study used cross-sectional data from the Baltimore Longitudinal Study of Aging (BLSA). The BLSA is a prospective observational cohort study aimed at examining mechanisms underlying the decline of physical and cognitive function with aging in humans (10). Between January 2006 and February 2011, 691 BLSA participants (26–96 years old) performed isokinetic, concentric knee extension tests and at least one of four walking performance measures (see legend in Table 1). The present study used data from the most recent visit when these measures were performed in each participant. The BLSA protocol was approved by the Institutional Review Board of record at the time of data collection (National Institute of Environmental Health Sciences, NC) and written informed consent was obtained from all participants.

2.2 Knee extension peak torque and RVD assessments

After two practice trials, participants performed three test trials of isokinetic knee extension at $180 \text{ deg. sec}^{-1}$ on a Kin-Com isokinetic dynamometer (Kin-Com model 125E, version 3.2, Chattanooga Group, Chattanooga, TN). Range of motion of the knee joint angle was set between 100 and 160-deg (full extension=180-deg). Participants were asked to extend their knee as hard as possible with an instructor's verbal encouragement (14, 15). Resting periods between trials were set as 15 sec.

All signals were sampled at 100 Hz. After exporting the raw data, we excluded trials where participants could not reach target velocity ($n=9$). Participants who performed these trials were older (76.0 ± 10.4 years) compared to those who were able to reach target velocity (66.4 ± 14.2 years). RVD was calculated as the slope of the velocity-time relationship obtained from the time of movement onset and the time when angular velocity first exceeded $178 \text{ deg. sec}^{-1}$ (Fig 1). For peak torque assessment, we considered the maximum torque generated over the period between the time when angular velocity first exceeded $178 \text{ deg. sec}^{-1}$ and the time when angular velocity started to decelerate at the end of movement. We selected the trial with the highest peak torque from either leg for both RVD and peak torque

2.3 Walking performance

The BLSA study began measuring walking performance between January 2006 and July 2007. Gait speed was calculated as distance divided by time of completion expressed to the tenth of a second. For short distance walking performance measures, participants performed the 6m walk at usual pace (6m-usual), and then the 6m walk at fast pace (6m-fast). For long-distance walking performance measures, participants performed a 2.5 min walk at usual pace (2.5min, m/s) and then 400m walk at fast pace (400m, m/s) (19, 20). For these two tests, a 20-meter walking course was set with two fluorescent orange traffic cones at each end and tape marking each meter between the cones. The examiner recorded the total time to complete in 400m walk and the distance covered in a 2.5min walk, respectively.

2.4 Body composition

We measured whole body fat mass and appendicular lean mass (sum of arm and leg lean mass)(ALM) by using a whole-body dual-energy X-ray absorptiometry (DXA; Prodigy Dual Photon X-ray Absorptiometry unit, General Electric, Milwaukee, WI) with DICOM software ver. 10.51.006 with the array mode (14).

2.5 Subjective knee pain

We asked the participants to report their subjective knee pain over the last 12 months as “in the past 12 months, have you had knee pain lasting at least one month?”.

2.6 Statistical analysis

Descriptive data are presented as the mean $\pm$ standard deviation (SD) or percentages. Normality of distributions were verified using the Kolmogorov-Smirnov test. A sex difference in age was assessed with an unpaired t-test and race difference (black versus non-blacks) was assessed with the chi-square test. Since anthropometric, morphological, and performance characteristics are affected by age, sex differences were assessed by using age-adjusted generalized linear regression models.

Because men and women tend to differ in skeletal muscle mass and performance, and because we hypothesized “a priori” that the role of RVD in walking performance would have been different between men and women, all analyses were sex-stratified. Nested linear regression models were used to assess the cross-sectional associations between RVD and each walking performance measures after adjusting for covariates. In Model 1, we examined the independent associations between RVD and four different walking performance measures after adjusting for age, race, body height, ALM, whole body fat mass, knee pain, and peak torque. In Model 2, we further included an interaction term “RVD*peak torque” to test whether the effect of RVD on walking performance was conditional to peak torque.

Because including an “RVD*peak torque” interaction significantly improved the fit of the model predicting at least one of the mobility performance measures in men and women, we further tested the effect of RVD on walking performance separately in participants with low (<sex-specific median) versus high (>sex-specific median) peak torque.

Based on our exploratory analyses, we assumed that RVD and walking performances both decline with aging and even more rapidly after the age of 50 years. Therefore, we repeated the analyses limited to participants who were 50 years old or older. SAS software version 9.4 for Windows (SAS Institute, Inc., Cary, NC) was used for all data processing and statistical analyses. The level of statistical significance was set as $p < 0.05$ (two-sided).

3. Results

A total of 691 participants (47.2% women) were included in the analysis. Participant characteristics are presented in Table 1. Significant sex differences were observed in all characteristics except 6m-usual ($p=0.47$).

We examined whether relationships of RVD with each walking performance are independent of peak torque in sex-stratified analyses (Table 2). In men, RVD was not associated with any measures of walking performance independent of peak torque, suggesting that RVD does not independently contribute to walking performance after accounting for the effect of peak torque (Model 1). A significant RVD*peak torque interaction ($p<0.0001$) was found only for 6m-usual gait speed, suggesting that the association between RVD and 6m-usual pace walk is different between weaker and stronger men (Model 2, $p<0.05$).

In women, RVD, significantly accounted for the 2.5min walk and 6m-usual walk independent of peak torque (Model 1, $p<0.05$). For all performance measures examined, we found a significant “RVD*peak torque” interaction term, suggesting that the association between RVD and walking performance is different between weaker and stronger individuals (Model 2, $p<0.05$).

To better understand and quantify the implications of the significant interaction terms in the analyses, we analyzed the effect of RVD on walking performance among participants with peak torque below and above the median value (men, 102–105 Nm; women, 70.5 or 71.0 Nm), separately in men and women and for the different walking performance measure (Table 3). Among men with low peak torque, higher RVD was significantly associated with faster gait speed in 6m-usual only ($p=0.001$), while among men with high peak torque, RVD was not significantly associated with any of the mobility performance examined (Model 2), suggesting that for this task, the effect of RVD on performance is greater for weaker participants. Among women with low peak torque, higher RVD was significantly associated with better performance in all measures except 6m-fast test ($p=0.050$). As in men, among women with high peak torque, RVD was not significantly associated with any of the mobility performance tasks.

In sensitivity analyses including participants aged 50 years and over, we observed substantially similar results compared to those that included all participants except that no significant interactions “RVD*peak torque” were observed in 2.5min and 6mfast walks in women (Supplemental Table).

4. Discussion

In this study, we found that the relationship between RVD and walking performance is different in men and women. In men, RVD was not associated with any walking performance measure independent of peak torque, and RVD contributed to performance only for the 6m-usual among men with weak peak torque. In contrast, in women, the effect of RVD on walking performance was associated with usual pace walks and consistently depends on peak torque. In women with low but not in those with high peak torque, higher RVD was associated with significantly better walking performance.

Why is RVD associated with walking performance only in persons with low strength, especially among women? A possible explanation is to consider relevant sex differences. Women have lower muscle strength than men, mainly due to morphological and muscle architectural characteristics such as muscle mass, the relative proportion of muscle fiber

types, and the pennation angle of muscles (1, 21). In addition, supra- and sub-spinal nervous systems involved in force production may differ, as indirectly demonstrated by Macaluso et al. (16), who found that women, especially older women, have greater co-activation of antagonist muscles, possibly to stabilize the involved joint (16). Factors such as less muscle mass, greater fat mass, shorter limb length, and/or greater joint instability, may disadvantage women's ability, compared to men, to generate force. To overcome these disadvantages, women might depend on not only the ability to produce force but also initial acceleration capacity to move a limb. Our study does not have sufficient sample size and power among younger adults to determine if these sex effects are already present at younger ages (12). The individual and separate effects of weakness, age and sex on the relationships between RVD and walking performance would require a larger sample with greater representation of young adults.

To understand how RVD is affected by age or sex, valid and feasible measures are needed. The approach to measuring RVD should account for feasibility and functional relevance. A feasible measure should be testable in a wide range of older adults, including those who are frail. When testing velocity using a unilateral isokinetic dynamometer, acceleration time is affected by the target angular velocity set by the machine and by the specific instructions given (6, 7). In knee extension, physically active young women and men may reach a target velocity up to 300 deg.sec⁻¹ (5, 6, 13). In contrast, some physically active 65–85 year old cannot reach target velocity at 300 deg.sec⁻¹ (13), and our study additionally shows some frail older cannot reach target velocity even at 180 deg.sec⁻¹. It is possible that sex and age-related associations might reveal additional insights at very fast angular velocities, but the functional relevance of such very high angular velocities is not clear. In addition, a higher RVD may be obtained with the instruction “as fast as possible” rather than “as hard as possible” (7). Since we found strong and consistent associations using only “hard as possible”, we feel that our findings are valid. It is possible that associations might be even stronger using “fast as possible”. RVD obtained using 180 deg.sec⁻¹, as reported here, may be both feasible across a range of ages and in both sexes, and is functionally relevant (13). Testing at slower angular velocities may increase feasibility for some frail older adults who cannot even reach 180 deg.sec⁻¹.

Our study has important strengths. The sample size of older adults is large. We adjusted for multiple confounders such as age, sex, race, body composition, and knee pain (8). We analyzed a variety of walking performance tests. In addition, the KinCom is highly reliable, with a velocity error within 1.5% (9). One limitation is that our participants are quite healthy. While some participants might have had joint pain in the past, we excluded those who reported pain on the day of testing. Findings might differ in persons with joint pain.

5. Conclusion

In summary, there are sex-specific associations between acceleration capacity and walking performance after taking muscle strength into account. In men, RVD is associated with performance on the 6m-walk in men with a lower peak torque. In women, the relationship depends on muscle strength. In those who have a lower peak torque, acceleration capacity plays a key role in a variety of walking performance measures. Future longitudinal studies,

including both women and men and a wide range of age are needed to test the hypothesis that the decline in RVD is linked to disability. From a practical perspective, RVD could be assessed during interventions for mobility disability prevention, especially among older adults with weak muscle strength.

Acknowledgements

This research was supported by the Intramural Research Program of the National Institutes of Health, National Institute on Aging.

Abbreviation

ALM	appendicular lean mass
BLSA	the Baltimore Longitudinal Study of Aging
DXA	dual-energy X-ray absorptiometry
RM	repetition maximum
RVD	rate of velocity development
SD	standard deviation

6. References

1. Abe T, Brechue WF, Fujita S, and Brown JB. Gender differences in FFM accumulation and architectural characteristics of muscle. *Med Sci Sports Exerc* 30: 1066–1070, 1998. [PubMed: 9662674]
2. Bohannon RW. Comfortable and maximum walking speed of adults aged 20–79 years: reference values and determinants. *Age Ageing* 26: 15–19, 1997.
3. Brown L, and Whitehurst M. The effect of short-term isokinetic training on force and rate of velocity development. *J Strength Cond Res* 17: 88–94, 2003. [PubMed: 12580662]
4. Brown LE, Sjostrom T, Comeau MJ, Whitehurst M, Greenwood M, and Findley BW. Kinematics of biophysically asymmetric limbs within rate of velocity development. *J Strength Cond Res* 19: 298–301, 2005. [PubMed: 15903365]
5. Brown LE, Whitehurst M, Gilbert R, and Buchalter DN. The effect of velocity and gender on load range during knee extension and flexion exercise on an isokinetic device. *J Orthop Sports Phys Ther* 21: 107–112, 1995. [PubMed: 7711759]
6. Chen WL, Su FC, and Chou YL. Significance of acceleration period in a dynamic strength testing study. *J Orthop Sports Phys Ther* 19: 324–330, 1994. [PubMed: 8025571]
7. Christ CB, Boileau RA, Slaughter MH, Stillman RJ, and Cameron J. The effect of test protocol instructions on the measurement of muscle function in adult women. *J Orthop Sports Phys Ther* 18: 502–510, 1993. [PubMed: 8298632]
8. Doldo NA, Delmonico MJ, Bailey JA, Hand BD, Kostek MC, RabonStith KM, Menon KS, Conway JM, Carignan CR, and Hurley BF. Muscle-power quality: does sex or race affect movement velocity in older adults? *J Aging Phys Act* 14: 411–422, 2006. [PubMed: 17215559]
9. Farrell M, and Richards JG. Analysis of the reliability and validity of the kinetic communicator exercise device. *Med Sci Sports Exerc* 18: 44–49, 1986. [PubMed: 3959863]
10. Ferrucci L The Baltimore Longitudinal Study of Aging (BLSA): a 50year-long journey and plans for the future. *J Gerontol A Biol Sci Med Sci* 63: 14161419, 2008.

11. Fragala MS, Clark MH, Walsh SJ, Kleppinger A, Judge JO, Kuchel GA, and Kenny AM. Gender differences in anthropometric predictors of physical performance in older adults. *Gend Med* 9: 445–456, 2012. [PubMed: 23123187]
12. Hicks AL, Kent-Braun J, and Ditor DS. Sex differences in human skeletal muscle fatigue. *Exerc Sport Sci Rev* 29: 109–112, 2001. [PubMed: 11474957]
13. Lanza IR, Towse TF, Caldwell GE, Wigmore DM, and Kent-Braun JA. Effects of age on human muscle torque, velocity, and power in two muscle groups. *J Appl Physiol* (1985) 95: 2361–2369, 2003.
14. Lindle RS, Metter EJ, Lynch NA, Fleg JL, Fozard JL, Tobin J, Roy TA, and Hurley BF. Age and gender comparisons of muscle strength in 654 women and men aged 20–93 yr. *J Appl Physiol* (1985) 83: 1581–1587, 1997.
15. Lynch NA, Metter EJ, Lindle RS, Fozard JL, Tobin JD, Roy TA, Fleg JL, and Hurley BF. Muscle quality. I. Age-associated differences between arm and leg muscle groups. *J Appl Physiol* (1985) 86: 188–194, 1999.
16. Macaluso A, Nimmo MA, Foster JE, Cockburn M, McMillan NC, and De Vito G. Contractile muscle volume and agonist-antagonist coactivation account for differences in torque between young and older women. *Muscle Nerve* 25: 858–863, 2002.
17. Murray DP, Brown LE, Zinder SM, Noffal GJ, Bera SG, and Garrett NM. Effects of velocity-specific training on rate of velocity development, peak torque, and performance. *J Strength Cond Res* 21: 870–874, 2007. [PubMed: 17685688]
18. Musselman K, and Brouwer B. Gender-related differences in physical performance among seniors. *J Aging Phys Act* 13: 239–253, 2005. [PubMed: 16192652]
19. Simonsick EM, Newman AB, Nevitt MC, Kritchevsky SB, Ferrucci L, Guralnik JM, Harris T, and Health ABCSG. Measuring higher level physical function in well-functioning older adults: expanding familiar approaches in the Health ABC study. *J Gerontol A Biol Sci Med Sci* 56: M644–649, 2001. [PubMed: 11584038]
20. Simonsick EM, Schrack JA, Glynn NW, and Ferrucci L. Assessing fatigability in mobility-intact older adults. *J Am Geriatr Soc* 62: 347–351, 2014. [PubMed: 24417536]
21. Staron RS, Hagerman FC, Hikida RS, Murray TF, Hostler DP, Crill MT, Ragg KE, and Toma K. Fiber type composition of the vastus lateralis muscle of young men and women. *J Histochem Cytochem* 48: 623–629, 2000. [PubMed: 10769046]
22. Tolea MI, Costa PT, Terracciano A, Griswold M, Simonsick EM, Najjar SS, Scuteri A, Deiana B, Orru M, Masala M, Uda M, Schlessinger D, and Ferrucci L. Sex-specific correlates of walking speed in a wide age-ranged population. *J Gerontol B Psychol Sci Soc Sci* 65B: 174–184, 2010. [PubMed: 20051464]
23. Tseng LA, Delmonico MJ, Visser M, Boudreau RM, Goodpaster BH, Schwartz AV, Simonsick EM, Satterfield S, Harris T, and Newman AB. Body composition explains sex differential in physical performance among older adults. *J Gerontol A Biol Sci Med Sci* 69: 93–100, 2014. [PubMed: 23682159]
24. Wilk KE, Romaniello WT, Soscia SM, Arrigo CA, and Andrews JR. The relationship between subjective knee scores, isokinetic testing, and functional testing in the ACL-reconstructed knee. *J Orthop Sports Phys Ther* 20: 60–73, 1994. [PubMed: 7920603]

Highlights

- Our study investigated the relationship between rate of velocity development and walking performance.
- The association differs by sex after taking muscle strength into account.
- Rate of velocity development is associated with walking in women, but less in men.
- Rate of velocity development is most related to performance when strength is low.

Figure 1.

An example of isokinetic, concentric knee extension at $180 \text{ deg} \cdot \text{sec}^{-1}$. Open circles are torque and filled circles are angular velocity. The dotted horizontal line is angular velocity at $178 \text{ deg} \cdot \text{sec}^{-1}$. Rate of velocity development was derived from dividing $\text{deg} \cdot \text{sec}^{-1}$ by time between onset of movement and the time point at which angular velocity exceeded $178 \text{ deg} \cdot \text{sec}^{-1}$.

Table 1.

Characteristics of the participants

	Men				Women				p-value
	Mean	±	SD	n	Mean	±	SD	n	
Age (years)	68.74	±	13.65	365	64.73	±	12.58	326	<0.0001
Race (black, %)	21.92			365	38.96			326	<0.0001
Weight (kg)	83.9	±	14.7	365	70.6	±	14.3	326	<.0001 *
Height (cm)	175.2	±	7.5	365	162.4	±	6.0	326	<.0001 *
ALM (kg)	25.04	±	3.77	365	17.12	±	2.61	326	<.0001 *
Fat mass (kg)	25.38	±	9.74	365	28.48	±	10.48	326	0.001 *
Knee pain (%)	3.84			365	6.44			326	0.004 *
Peak torque (Nm)	108.9	±	39.1	365	74.2	±	24.6	326	<.0001 *
RVD (deg.sec ⁻²)	1556	±	222	365	1531	±	207	326	0.015 *
400m walk (m.s ⁻¹)	1.6	±	0.3	285	1.5	±	0.3	245	<.0001 *
2.5 min walk (m.s ⁻¹)	1.2	±	0.2	284	1.2	±	0.2	238	<.0001 *
6m-fast (m.s ⁻¹)	1.8	±	0.5	354	1.7	±	0.3	323	<.0001 *
6m-usual (m.s ⁻¹)	1.1	±	0.3	357	1.2	±	0.2	323	0.470 *

ALM, appendicular lean mass by DXA; RVD, rate of velocity development.

* age-adjusted p-value

Assessment of 400 m walk started in April 2007. The 2.5 min walk started in July 2007. The 6 m gait tests started in January 2006.

Table 2.

The relationship between rate of velocity development or peak torque in isokinetic, concentric knee extension at 180 deg/sec and walking performance measures.

			Men			Women		
			RVD	PT	RVD*PT	RVD	PT	RVD*PT
400m	Model 1	β	0.02	0.25	–	0.25	0.18	–
		p-value	0.57	<.0001	–	0.13	0.004	–
	Model 2	β	–0.02	0.14	0.13	0.13	1.18	–1.20
		p-value	0.87	0.60	0.69	<.0001	<.0001	0.0001
2.5min	Model 1	β	–0.05	0.25	–	0.15	–0.07	–
		p-value	0.38	0.001	–	0.02	0.42	–
	Model 2	β	0.12	0.66	–0.52	0.54	0.98	–1.27
		p-value	0.41	0.046	0.20	0.0001	0.01	0.002
6m-fast	Model 1	β	–0.02	0.33	–	0.07	0.21	–
		p-value	0.6	<.0001	–	0.1	0.001	–
	Model 2	β	0.06	0.54	–0.25	0.32	0.89	–0.82
		p-value	0.59	0.04	0.41	0.001	0.0004	0.01
6m-usual	Model 1	β	0.07	0.18		0.12	0.02	
		p-value	0.15	0.01		0.02	0.77	
	Model 2	β	0.45	1.14	–1.20	0.38	0.75	–0.87
		p-value	<.0001	<.0001	<.0001	0.001	0.01	0.01

β values are standardized regression coefficients from generalized linear regression models.

Model 1 included age, race, height, appendicular lean mass, whole body fat mass, and peak torque. Model 2 further included the interaction of RVD and PT. PT, knee extension peak torque in isokinetic, concentric contraction at 180 deg/sec; RVD, rate of velocity development; 2.5min, gait speed in 2.5 min walk at usual pace (men, n=284; women, n=238); 400m, gait speed in a 400m walk at fast pace (men, n=285; women, n=245); 6m-fast, gait speed in a 6m walk at fast pace (men, n=354; women, n=323); 6m-usual, gait speed in a 6m at usual pace (men, n=357; women, n=323).

Table 3.

The relationship between rate of velocity development in isokinetic, concentric knee extension at 180 deg/sec and walking performance measures stratified by sex-specific median peak torque

		Men		Women	
		Poor	Strong	Poor	Strong
400m	β	0.05	0.09	0.15	0.005
	p-value	0.46	0.16	0.01	0.94
	n	142	143	120	125
2.5min	β	0.03	-0.01	0.17	-0.01
	p-value	0.66	0.94	0.02	0.94
	n	139	145	119	119
6m-fast	β	0.06	0.02	0.11	0.08
	p-value	0.41	0.74	0.050	0.25
	n	177	177	159	164
6m-usual	β	0.23	0.002	0.15	0.07
	p-value	0.001	0.98	0.02	0.35
	n	174	183	160	163

β values are standardized regression coefficients of rate of velocity development from generalized linear regression models. Models are adjusted for age, race, height, appendicular lean mass, whole body fat mass, and knee pain.

RVD, rate of velocity development; 2.5min, distance covered in 2.5 min walk at usual pace; 400m, gait speed in a 400m walk at fast pace; 6m-fast, gait speed in a 6m walk at fast pace; 6musual, gait speed in a 6m at usual pace.

Median peak torque values are follows: 400m walk in men, 105 Nm, in women, 71 Nm; 2.5 min walk in men, 102 Nm, in women, 70.5 Nm; 6m-fast in men, 103.5 Nm, in women, 71 Nm; in 6m-usual in men, 103 Nm, in women, 71 Nm.