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Original Article

Utility of peak torque and rate of torque development characteristics to identify walking performance ability in older women

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Abstract

Objectives: It is unclear whether peak torque and rate of torque development (RTD) measurements can characterize functional differences in older adults according to their performance on a six-minute walk test. This study aimed to examine the efficacy of isometric peak torque and RTD characteristics of the knee extensors to differentiate between functional status in older women who are able (higher functioning) versus those who are unable (lower functioning) to walk 550 m in six minutes. **Methods**: Ten higher functioning (67±4 years) and 10 lower functioning (68±4 years) older women performed three isometric knee extension maximal voluntary contractions followed by a six-minute walk test. Peak torque and early (RTD100), late (RTD200), and maximum (Peak RTD) RTD measurements were obtained from each contraction. **Results**: The higher functioning group exhibited greater peak torque, Peak RTD, RTD100, and RTD200 compared to the lower functioning group ($P \leq 0.011$), with larger differences occurring for RTD characteristics (39.9-54.9%) than peak torque (20.3%). Multiple regression analysis indicated that RTD200 was the single best predictor of the distance covered during the six-minute walk test ($R^2=0.437$, $P=0.002$). **Conclusions**: These findings suggest that knee extensor muscle strength, and in particular RTD, may be an effective discriminator and predictor of walking performance ability in older women.

Keywords: Contraction, Dynamometer, Isometric, Knee Extension, Rapid Strength

Introduction

In older adults, preservation of walking ability is essential for maintaining functional independence. However, previous studies investigating walking ability as a function of age have reported reduced walking performances in older populations[1,2]. A common measure used to assess walking performance in the elderly is the distance covered during a six-minute walk test[3]. Previous investigations in older adults have reported mean six-minute walk distances ranging from 401 to 714 m[1,2,4]. Because 550 m is considered the approximate walking distance required for important activities of daily living (i.e., grocery shopping, going to department stores, etc.)[5], the ability to walk this distance in six minutes may be used as a criterion to determine functional status in older adults. Decreased six-minute walk distance (<550 m) has been associated with an increased incidence of functional limitations[3], which may lead to an elevated risk of future disability and mortality[6,7]. It has been suggested that the six-minute walk test is an effective tool for evaluating physical function[3]. However, because this test is long and potentially fatiguing[8], the prospect of identifying physiological measurements from a less strenuous test that can successfully differentiate between walking performance abilities in older adults may be advantageous in the evaluation and treatment of functional decline with aging.

Strength-based torque measurements, such as peak torque and rate of torque development (RTD), are often assessed from a 3-4 s isometric maximal voluntary contraction (MVC)[9]. Research suggests that during an isometric MVC, both slow- (type I) and fast-twitch (type II) muscle fibers contribute to

Ty B. Palmer and Jarrod Blinch developed the Dynamo Torque Analyzer. The remaining authors have nothing to declare.

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torque production[10,11]. Isometric peak torque and RTD have been shown to be significant predictors of walking ability[12] and thus, could be potentially useful for distinguishing between functional performance capacities in older adults. Previous studies have demonstrated in older adults that isometric knee extension peak torque and RTD are effective discriminators of functional performance abilities[12-14]. However, because the performance measures used in these studies were limited to 10-m gait speed and timed up-and-go data[13,14], it remains unclear whether peak torque and RTD can effectively distinguish between functional differences in older adults according to their performance on a six-minute walk test. The six-minute walk test is different than other mobility assessments (i.e., 10-m gait speed, timed up-and-go test, etc.) in that it requires sustained walking over an extended period of time[15]. Nevertheless, despite being a longer duration event, the six-minute walk test still requires a certain level of muscle strength and power[4] and therefore, may also be influenced by maximal and rapid strength characteristics. Evidence suggests that older adults with low maximal and rapid strength use over 90% of their force-generating capacity to support and propel the body forward during walking[12]. Operating at such a capacity may contribute to fatigue[16,17], which could reduce one's ability to walk a long distance within a specific duration of time. Thus, based on these results[12,16] and given the importance of maximal and rapid strength to locomotor function, peak torque and RTD may be effective variables at determining six-minute walk distance in older adults.

Many locomotor-related movement tasks, including walking, require force application response times of less than 200 ms[18]. Consequently, RTD assessed over a short time period (≤200 ms) may be more functionally relevant and thus, a better discriminator of locomotor performances than peak torque, which often requires more than 300 ms to be achieved[19]. A number of studies have presented evidence in support of this hypothesis by demonstrating the superior capacity of RTD versus peak torque to distinguish between individuals with different gait speed and timed up-and-go performance abilities[13,14,20]. In addition, previous studies have shown that knee extension RTD characteristics calculated at early (100 ms), late (200 ms), and maximum (peak) phases of torque production were significantly associated with 10-m gait speed and 30-s sit-to-stand performances in older populations[13,21]. Although these findings reveal the capacity of RTD to predict functional performances assessed over a short distance (10 m) or duration (30 s), it has yet to be determined if RTD is an effective predictor of functional performance for a longer duration event, such as the six-minute walk test. Further research is needed to examine the relationships between six-minute walk distance and peak torque and RTD.

Numerous studies examining isometric peak torque and RTD have measured these variables using commercial isokinetic dynamometers or hand-held transducers[9,13,18,22]. Although these devices offer a useful means for quantifying real-time measurements of peak torque, they do not provide real-time calculation of RTD. Such calculation requires extensive offline analysis with data processing software. Recently, a novel strength testing device was developed called the Dynamo Torque Analyzer (Dynamo). The Dynamo consists of a load cell that can be affixed to existing equipment found in laboratories and clinics (i.e., isokinetic dynamometer, resistance training machine, treatment table or chair, etc.) and a microcomputer that records torque in newton-meters (Nm)[23]. Unlike previous transducers, the Dynamo automatically calculates and displays real-time measurements of peak torque and RTD. Consequently, it may be an attractive tool for evaluating isometric strength in older adults. Moreover, previous studies investigating the relationships between isometric strength and functional performance outcomes have only examined young and older men[24,25]. Additional research investigating isometric strength characteristics and walking performance ability in older women is needed. Thus, the purpose of the present study was to examine the efficacy of isometric knee extension peak torque and RTD characteristics to differentiate between functional status in older women who are able (higher functioning) versus those who are unable (lower functioning) to walk 550 m in six minutes. A secondary aim was to investigate the relationships between knee extension peak torque and RTD characteristics and six-minute walk distance. Based on the results reported by previous authors[13,21], we hypothesized that RTD would be a better discriminator and predictor of walking performance ability than peak torque.

Methods

Participants

Before data collection, an a priori power analysis was performed for a between-groups design. Using G*Power software (version 3.1.9.2; Heinrich Heine University, Düsseldorf, Germany) and effect sizes from relevant research[13], it was determined that a minimum of 20 participants were needed to achieve a statistical power of 0.80 at an alpha level of 0.05. Thus, 21 older women were recruited to participate in the present study. Participants were recruited from the local community via advertisements, flyers, and word of mouth. Of the 21 older women who were recruited, one was unable to perform the six-minute walk test, and thus, her data were excluded from the analyses. All subsequent analyses were performed on the data from the remaining 20 participants. Inclusion criteria consisted of participants who were healthy and between the ages of 60 and 75 years. Participants were excluded if they were unable to walk without an assistive device or had problems with the ankle, knee, or hip joints. No participant reported any current or ongoing neuromuscular diseases or musculoskeletal injuries to these areas. Consequently, all were eligible to participate.

The participants were classified into a "higher functioning" or "lower functioning" group according to their distance covered during a six-minute walk test. A distance of 550 m

Table 1. Mean ± SD values for age, height, body mass, and six-minute walk distance.

Variable	Higher Functioning	Lower Functioning
Age (years)	66.60 ± 4.20	67.60 ± 4.43
Height (cm)	159.45 ± 2.91	159.32 ± 8.03
Body Mass (kg)	66.78 ± 6.99	68.29 ± 6.76
Walk Distance (m)	627.43 ± 49.34*	492.56 ± 42.33

**Significant difference (P<O.O5O) between the higher and lower functioning groups.*

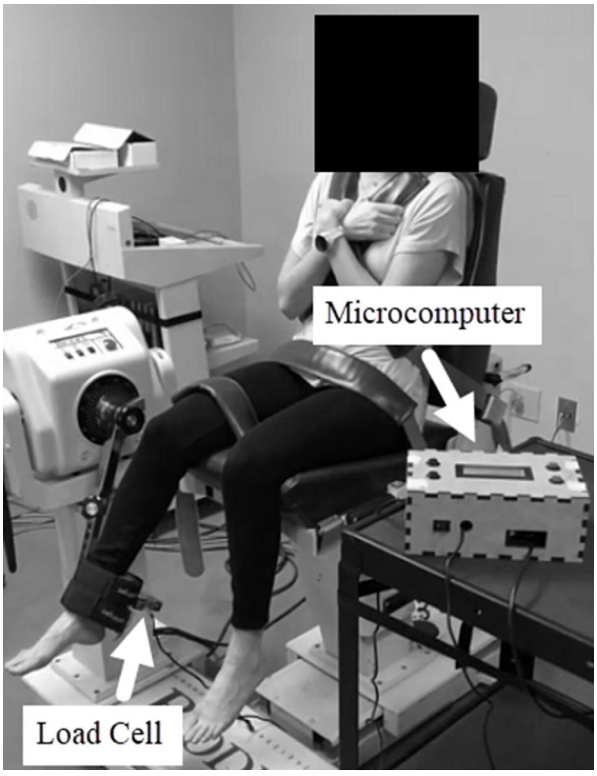

Figure 1. A participant performing an isometric knee extension maximal voluntary contraction using the Dynamo. The Dynamo consists of two functional components: a load cell and a microcomputer.

during the six-minute walk test has been reported and used as a cutoff for distinguishing between functional status in older adults and other clinical populations[26,27]. Based on this criterion, of the 20 participants in our study, 10 were identified as higher functioning (≥550 m) and 10 were identified as lower functioning (<550 m). The demographic data for these participants are presented in Table 1. This study was approved by the university's institutional review board for human subject's research, and each participant signed and completed an informed consent document and health history questionnaire.

Experimental Design

This study used a cross-sectional research design to investigate isometric knee extension peak torque and RTD characteristics as discriminators and predictors of six-minute walking performance ability in older women. Participants reported to the laboratory for a single visit where they performed three isometric knee extension MVCs followed by a six-minute walk test. The six-minute walk test was performed after the MVCs to avoid the potential effects of fatigue on the peak torque and RTD measurements.

Isometric Knee Extension

Isometric knee extension MVCs were performed on the right leg using the Dynamo, as described previously[23] (Figure 1). The Dynamo consisted of a microcomputer and a load cell (200 kg capacity) that was attached to the ankle pad of a lever arm fastened around the participant's lower leg. The lever arm was connected to the input axis of an isokinetic dynamometer (Biodex System 3, Biodex Medical Systems Inc., Shirley, NY) which was aligned with the axis of rotation of the knee joint. For each MVC, participants sat on the dynamometer chair in an upright position with restraining straps placed over the shoulders, waist, and thigh. All MVCs were performed at a knee joint angle of 60° below the horizontal plane[23]. This joint angle was chosen because previous research has shown that knee extension torque at 60° of flexion is more strongly correlated with functional tasks than knee extension torque at other positions[28]. Prior to the MVC assessments, participants performed a standardized warm-up of three submaximal isometric knee extension muscle actions at approximately 75% of their perceived maximal effort. Following the submaximal contractions, each participant performed three isometric knee extension MVCs with one minute of recovery between each trial[29]. For all MVCs, participants were verbally instructed to push "as hard and fast as possible" for a total of 3-4 s and strong verbal encouragement was given throughout the duration of the contraction.

Data Processing

During each MVC, the scaled force signal from the load cell was sampled at 1000 Hz and processed automatically by the Dynamo. A torque signal (Nm) was derived by multiplying

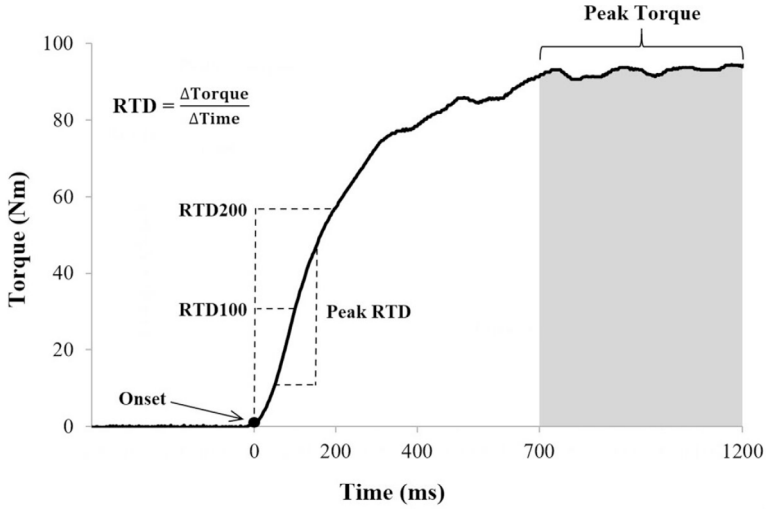

Figure 2. Example of a processed torque signal derived from the Dynamo during an isometric knee extension maximal voluntary contraction. The torque signal produced during the contraction was used to measure isometric peak torque and rate of torque development (RTD) characteristics. Isometric peak torque was calculated as the highest mean 500 ms epoch. RTD was calculated as the linear slope of the torque signal at time intervals of 0-100 (RTD100) and 0-200 (RTD200) ms from onset. Peak RTD was calculated as the highest slope value for any 100 ms epoch that occurred over the initial 200 ms of the torque signal.

the force signal (N) from the load cell by the limb length (m) for each participant[23]. Limb length was measured as the distance from the lateral knee joint to the lateral malleolus of the ankle (positioned over the load cell) and was entered into the Dynamo's microcomputer prior to the MVC assessments. The torque signal was gravity corrected and low-pass filtered with a zero-phase lag, fourth-order Butterworth filter at a cutoff frequency of 150 Hz[9]. All subsequent analyses were conducted on the filtered and gravity-corrected torque signal.

Isometric peak torque was calculated as the highest mean 500 ms epoch (Figure 2). RTD was calculated as the linear slope of the torque signal (Δtorque/Δtime) at early and late time intervals of 0-100 (RTD100) and 0-200 (RTD200) ms from contraction onset (Figure 2)[22]. Maximum RTD (Peak RTD) was calculated as the highest slope value for any 100 ms epoch that occurred over the initial 200 ms of the torque signal (Figure 2). The contraction onset for the Dynamo was set at 1.0 Nm[9]. Isometric peak torque, Peak RTD, RTD100, and RTD200 were calculated and displayed by the Dynamo at the conclusion of each trial and were normalized to body mass.

Unsteady baseline torque resulting from either pre-tension or countermovement can adversely influence RTD[30]. A unique feature of the Dynamo is its ability to detect unsteady baseline torque. The Dynamo's microcomputer evaluates unsteady baseline torque by computing the baseline slope prior to contraction onset using methods similar to those described previously[9]. If unsteady baseline torque was detected prior to contraction onset, a warning was displayed by the microcomputer at the end of the trial. Contractions with unsteady baseline torques as indicated by the Dynamo were always discarded, and additional MVCs were performed until three knee extension contractions presented acceptable data. Of the three MVCs performed, the MVC with the highest peak torque value was selected for further analysis.

Six-Minute Walk Test

The six-minute walk test was performed in accordance with the procedures described by the American Thoracic Society[31], in which participants walked back and forth between two markers set 30 m apart (60 m per lap). Participants were instructed to walk as fast as possible, without running, at a pace that they could maintain for six minutes. No participants had to stop or rest during the test. Only one six-minute walk test was performed, and no warm-up period before the test was permitted. The primary investigator timed the walk with a stopwatch and used a mechanical counter to count the number of laps completed. Standardized words of encouragement (i.e., "you are doing well," "keep up the good work") were given at 30-s intervals, and participants were informed of the remaining time left at each minute mark. The total distance covered (m) at the end of six minutes was recorded and used to separate the participants into higher (≥550 m) or lower (<550 m) functioning groups.

Statistical Analyses

We inspected data for normality using the Shapiro-Wilk test. Outliers were defined as values that exceeded 2.2 times the interquartile range away from the first and third quartiles[32]. Independent samples *t*-tests were used to compare demographic characteristics, six-minute walk distance, peak torque, and RTD variables between the higher and lower functioning groups. Cohen's *d* effect sizes[33] and percent differences (%Δ) were calculated for each between-

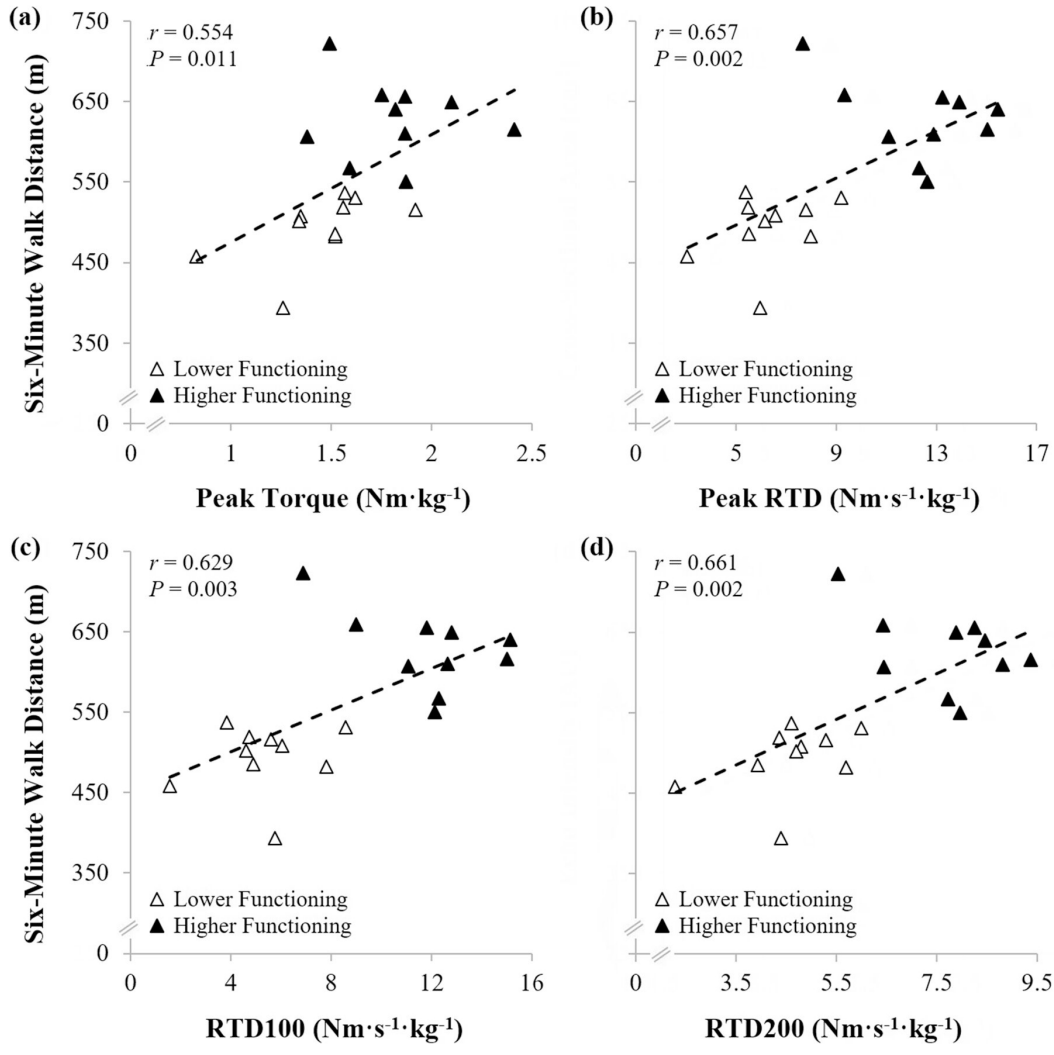

Figure 3. Relationships between six-minute walk distance and isometric knee extension (a) Peak Torque, (b) Peak RTD, (c) RTD100, and (d) RTD200.

group comparison. Pearson correlation coefficients (*r*) were calculated to examine the relationships between six-minute walk distance and peak torque and RTD variables. Multiple regression analysis (stepwise model) was used to determine which variables were the best predictors of six-minute walk distance. Discriminant analysis was used to establish peak torque and RTD thresholds for identifying functional group membership. All statistical analyses were performed using IBM SPSS Statistics Version 26.0 (SPSS Inc., Chicago, IL), and an alpha level of $P<0.050$ was used to determine statistical significance.

Results

No outliers were identified, and all data were confirmed as being normally distributed. Mean and standard deviation (SD) values for demographic characteristics and six-minute walk distance are presented in Table 1. There were no significant differences between the higher and lower functioning groups for age ($P=0.610$, $d=0.24$, %Δ=1.5%), height ($P=0.963$, $d=0.02$, %Δ=0.1%), or body mass ($P=0.629$, $d=0.22$, %Δ=2.3%). Six-minute walk distance was significantly greater for the higher compared to the lower functioning groups ($P<0.001$, $d=1.64$, %Δ=21.5%). Table 2 shows the means, SDs, *P* values, Cohen's *d* effect sizes, and percent differences between groups for isometric peak torque and RTD variables. The higher functioning group exhibited significantly greater peak torque, Peak RTD, RTD100, and RTD200 compared to the lower functioning group ($P\leq0.011$, $d\geq1.08$), with larger differences occurring for RTD characteristics (%Δ=39.9-54.9%) than peak torque (%Δ=20.3%).

Significant positive relationships were observed between six-minute walk distance and peak torque ($r=0.554$,

Table 2. Means ± SDs, P values, Cohen's d effect sizes, and percent differences (%Δ) between groups for isometric peak torque and rate of torque development (RTD) variables.

Variable	Higher Functioning	Lower Functioning	*P value*	*d*	%Δ
Peak Torque ($Nm•kg^{-1}$)	1.82 ± 0.30*	1.45 ± 0.28	0.011	1.08	20.3%
Peak RTD ($Nm•s^{-1}•kg^{-1}$)	12.35 ± 2.43*	6.32 ± 1.71	<0.001	1.63	48.8%
RTD100 ($Nm•s^{-1}•kg^{-1}$)	11.88 ± 2.49*	5.36 ± 1.97	<0.001	1.63	54.9%
RTD200 ($Nm•s^{-1}•kg^{-1}$)	7.69 ± 1.20*	4.62 ± 1.03	<0.001	1.60	39.9%
**Significant difference (P<0.050) between the higher and lower functioning groups.*					

Table 3. Discriminant analysis statistics for identifying functional group membership.

Variable	Threshold	Sensitivity %	Specificity %
Peak Torque ($Nm•kg^{-1}$)	1.58	80	80
Peak RTD ($Nm•s^{-1}•kg^{-1}$)	9.27	100	90
RTD100 ($Nm•s^{-1}•kg^{-1}$)	8.80	100	90
RTD200 ($Nm•s^{-1}•kg^{-1}$)	6.22	100	90

P=0.011, Figure 3a), Peak RTD (*r*=0.657, *P*=0.002, Figure 3b), RTD100 (*r*=0.629, *P*=0.003, Figure 3c), and RTD200 (*r*=0.661, *P*=0.002, Figure 3d). For the multiple regression analysis, isometric peak torque, Peak RTD, RTD100, and RTD200 were entered as predictor variables into the stepwise model. The model revealed that RTD200 was the single best predictor of the distance covered during the six-minute walk test (R^2=0.437, *P*=0.002), with peak torque, Peak RTD, and RTD100 explaining no further unique variance.

Discriminant analysis revealed thresholds of 1.58 $Nm•kg^{-1}$ for peak torque and 9.27, 8.80, and 6.22 $Nm•s^{-1}•kg^{-1}$ for Peak RTD, RTD100, and RTD200, respectively. The thresholds for the RTD variables demonstrated excellent sensitivity (100%) and specificity (90%) for identifying functional group membership. All discriminant analysis statistics for peak torque and RTD variables are shown in Table 3.

Discussion

In this study, the higher functioning group exhibited significantly greater peak torque, Peak RTD, RTD100, and RTD200 compared to the lower functioning group, with larger differences occurring for RTD characteristics than peak torque (Table 2). There were significant positive relationships between six-minute walk distance and peak torque and RTD characteristics (Figure 3). Multiple regression analysis indicated that RTD200 was the single best predictor of the distance covered during the six-minute walk test. Moreover, the thresholds for the RTD variables in the discriminant analysis demonstrated excellent sensitivity and specificity for identifying functional group membership (Table 3).

The greater peak torque and RTD characteristics observed in the present study for the higher compared to the lower functioning women demonstrated the efficacy of these measurements at distinguishing between groups based on six-minute walk distance. Previous studies have reported similar findings in older adults regarding the effectiveness of isometric peak torque and RTD variables to discriminate between functional performance abilities[12-14]. For example, Berryman et al.[14] showed that older adults who were able to walk 10 m at a faster speed were also able to produce greater isometric peak torque and RTD of the knee extensors than age-matched slower individuals. It was hypothesized that because the faster walkers exhibited greater peak torque and RTD values than the slower walkers, maximal and rapid strength may be important determinants of 10-m gait speed in older populations[14]. Similar to gait speed, the six-minute walk test, despite being a longer duration event, requires a certain level of muscle strength and power[4] and therefore, may also be influenced by maximal and rapid strength characteristics. Evidence suggests that older adults with lower maximal and rapid strength use a greater percentage of their force-generating capacity to successfully ambulate over ground[12]. Operating at a greater capacity contributes to the early onset of fatigue[16,17], which in turn, may reduce one's ability to walk faster and cover a longer distance within a specific duration of time[15]. The results of the present study add support to the importance of maximal and rapid strength in regard to the distance covered during a six-minute walk test, given that this was the parameter used to separate participants into higher or lower functioning groups. Because walking utilizes many lower-extremity muscles, including those surrounding the knee joint[16,34], it is possible that knee extension peak torque and RTD characteristics may be effective parameters at determining walking performance abilities in older adults.

A key finding of this study was that the differences in RTD characteristics (39.9-54.9%) between the higher and lower functioning groups were larger than the difference

in peak torque (20.3%). This finding is consistent with that of Morcelli et al.[13] who reported larger differences for knee extension RTD (36.2%) than peak torque (14.5%) between slow and fast walkers. Collectively, these findings highlight the importance of rapid strength and suggest that RTD may be a better variable than peak torque at differentiating between walking performance abilities in older adults. Many locomotor-related movement tasks, including walking, involve rapid, repetitive muscle actions of the knee extensors[18]. During normal walking, knee extensor muscle activity begins in terminal swing and rapidly increases to peak amplitude early in the loading response, requiring force to be generated within approximately 150 ms[18,35]. Because the time required to achieve maximal force is typically greater than 300 ms[19], rapid strength characteristics (0-200 ms) of the knee extensors may be more functionally relevant than maximal strength for walking-related tasks in older adults. Therefore, the possibility of greater functional relevance between rapid strength and walking performance ability may explain why larger differences in RTD characteristics were observed between the higher and lower functioning groups in the present study.

Poorer performance on the six-minute walk test may be due to lower rapid strength capacities. Previous authors have suggested that the inability to produce torque rapidly is a limiting factor in the performances of walking-related tasks[18] and that lower rapid strength may lead to a decreased ability to walk faster[13] and/or cover long distances in a timely manner[36]. Our findings would support these hypotheses given the significant positive relationships (r=0.629-0.661, Figure 3b-d) between knee extension RTD characteristics and six-minute walk distance in the older women. In addition, the present findings showed a significant relationship between six-minute walk distance and peak torque (r=0.554, Figure 3a). Although these findings highlight the potential for peak torque to predict performance on the six-minute walk test, multiple regression analysis revealed that the single best predictor of six-minute walk distance was RTD200 (R^2=0.437). The superior predictive capacity of RTD200 versus peak torque may be due to the aforementioned greater functional relevance of rapid strength as it pertains to the fast and forceful muscle actions required to perform important walking-related tasks. Previous research has shown that RTD of the knee extensors was a more effective variable than peak torque at predicting 10-m gait speed in older adults[13]. The results of our study extend these findings by demonstrating that knee extension RTD may also be a better predictor than peak torque of the distance covered during a six-minute walk test.

The thresholds for the RTD variables in our discriminant analysis showed 100% sensitivity (ability to correctly identify those who were lower functioning) and 90% specificity (ability to correctly identify those who were higher functioning) (Table 3). These sensitivity and specificity statistics were higher than those for peak torque (80%), which supports our previous assertion that the ability to generate torque rapidly may be a better discriminator of functional performance ability in older adults than maximal strength. In this study, isometric RTD values were substantially lower in the older women who were unable to walk 550 m during the six-minute walk test. Because 550 m is considered the approximate walking distance required for successful community ambulation[5], the inability to cover such a distance in a timely manner may contribute to a lack of functional independence and confidence in community level participation[15]. Thus, in light of this and given the high sensitivity and specificity observed for the RTD thresholds in the discriminant analysis, isometric RTD may be an effective measure at identifying older adults who are at risk for functional decline.

Research suggests that differences in RTD may be attributed to several factors including changes in connective tissue stiffness[37], type II fiber area[38], and muscle activation characteristics[39]. Because age-related changes in RTD are believed to be influenced by factors that include muscle size and strength[40], the smaller RTD values we observed in the lower functioning group may be a result of impairments in these physiological mechanisms. Consequently, training programs aimed at increasing the size and strength of the lower-body musculature may be beneficial for improving RTD as well as mobility in older adults with low functional status. Futures studies investigating the effects of muscle strength and hypertrophy training on rapid strength characteristics and walking ability in lower-functioning older adults are needed to further examine these findings.

Commercial devices, such as isokinetic dynamometers and hand-held transducers, are commonly used to measure isometric peak torque and RTD characteristics[9,13,18,22]. To calculate RTD with these devices, offline analysis of the torque signal using data processing software is required. Because analyzing the torque signal offline can be a time-consuming task, this method of RTD calculation may not be feasible in certain research or clinical situations where rapid data analysis is required for immediate RTD results. In contrast, the Dynamo device used in our study automatically calculates and displays early, late, and maximum RTD parameters immediately after an isometric contraction. To our knowledge, the Dynamo is the first device capable of calculating and displaying real-time measurements of isometric RTD. The present findings provide support that RTD measurements from the Dynamo may be particularly useful at differentiating between functional status in older women. Given the potential importance of rapid strength to locomotor-related movement tasks, physical therapists and other practitioners may want to consider using Dynamo measurements of RTD in their current test battery. These measurements may provide practitioners with an additional evaluation tool to help in identifying older adults who are at a high risk for functional performance deficits.

A limitation of this study was the small sample size. Although significant differences in peak torque and RTD characteristics were still observed between the higher and lower functioning groups, these results need to be confirmed in a larger sample. Another limitation of this study was the

examination of healthy older women. Although this can be viewed as a major strength since our results are not influenced by orthopedic limitations or neuromuscular diseases, we do acknowledge that the present findings may not be generalizable to other populations.

In summary, our findings showed that the higher functioning women exhibited greater isometric knee extension peak torque and RTD characteristics than the lower functioning women, with larger differences occurring between groups for RTD than peak torque. These findings suggest that knee extensor muscle strength, and in particular RTD, may be an effective measure at differentiating between functional status in older women. An interesting finding of this study was the significant positive relationships between six-minute walk distance and isometric RTD characteristics. Because the best predictor of six-minute walk distance was RTD200, the present findings provide support that the ability to generate torque rapidly (0-200 ms) may play an important role in the distance covered during a six-minute walk test in older adults. The thresholds for the RTD variables in the discriminant analysis demonstrated high sensitivity and specificity, and therefore, may be used as indices to identify older adults with low functional performance abilities. A novel aspect of the present study was the utility of the Dynamo. The ability of the Dynamo to provide real-time measurements of isometric RTD that are highly discriminatory of functional differences in the elderly may make it an attractive evaluation tool for purposes of assessing the lower-body performance capacities of older adults in both laboratory and field-based settings.

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