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A Comparative Case-Based Study on Age-Related Differences in Angular Velocity During Isokinetic Strength Assessments Based on Individual Capacity

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ABSTRACT

This study aims to elucidate the relationship between chronological aging and neuromuscular performance by comparing isokinetic strength parameters across different age groups. Specifically, it investigates how the individualized angular velocity settings during isokinetic knee extension and flexion exercises influence performance metrics such as peak torque, total work, and average power in both younger and older adults. The participants included individuals in their 20s and 60s, representing the early and late stages of adult musculoskeletal aging. Using an isokinetic dynamometer, measurements were collected at 10%, 40%, 70%, and 100% of each participant's maximum angular velocity.

The findings consistently demonstrated that the older group showed significantly reduced performance across all measured variables, implying a decline in skeletal muscle function with advancing age. This pattern was evident even after normalizing for individual capabilities, suggesting that intrinsic neuromuscular limitations become more pronounced with age. The implications of these findings are multifold: they reinforce the necessity for age-sensitive velocity modulation during resistance training and underscore the importance of personalized rehabilitation programs for elderly populations. Furthermore, this study provides foundational data for clinicians and exercise specialists seeking to optimize functional outcomes through velocity-specific interventions. Future research should incorporate larger samples and include electromyographic and metabolic markers to further elucidate the mechanisms driving age-related declines in isokinetic performance.

Keywords: *Angular velocity, age, isokinetic, strength*

1. INTRODUCTION

Isokinetic exercise, characterized by constant angular velocity against accommodating resistance, has long been established as a reliable modality for assessing and enhancing muscular strength across various populations. Its clinical and athletic utility stems from its ability to isolate muscle groups while precisely controlling mechanical parameters, particularly angular velocity. Historically, this method has been widely adopted in rehabilitation settings, sports science, and geriatric exercise protocols to evaluate muscular performance in a safe and controlled environment.

Notably, the effectiveness of isokinetic resistance training is heavily influenced by the velocity of joint movement, which in turn affects the recruitment pattern of muscle fibers. Higher angular velocities typically favor the activation of fast-twitch (Type II) muscle fibers, commonly associated with rapid force production and power development, which are more prominent in younger individuals [1]. In contrast, older adults, due to the natural degeneration of Type II fibers and decreased neuromuscular efficiency, may derive more benefit from training at slower velocities [2].

This notion is supported by prior studies. For example, Young et al. (1985) demonstrated that higher angular velocities resulted in greater torque production among younger women, while Aagaard et al. (1996) emphasized that slower velocities are more suitable for elderly individuals due to the safer loading and reduced joint stress [1,2]. Additionally, Marsh et al. (2006) confirmed that low-velocity strength training contributed significantly to maintaining lower limb functionality in older populations [3]. These studies collectively suggest that optimal angular velocity must be tailored not only to the individual's capacity but also to their age-related musculoskeletal profile.

Moreover, neuromuscular fatigue characteristics, as studied by Pincivero et al. (2004), show that angular velocity settings influence both immediate performance and post-exercise recovery. Brown and Weir (2005) further emphasized the necessity of velocity-specific programming in strength training, particularly in populations with varying muscular and neuromotor profiles [4,5].

Age-associated physiological changes, including sarcopenia, decreased anabolic hormone levels, and diminished motor unit recruitment, contribute to a significant decline in strength and power among older adults. Therefore, it is essential to explore how angular velocity, when calibrated to an individual's capacity, can mediate these age-related deficits. A more granular understanding of the interactions between age, angular velocity, and strength output may enable practitioners to implement more effective, personalized interventions.

This study seeks to address this gap by conducting a case-based analysis comparing young and older adults across multiple angular velocity conditions during isokinetic strength assessments. By integrating individualized capacity thresholds into the measurement protocol, this research aims to produce clinically relevant insights into the biomechanical and physiological adaptations associated with aging.

2. METHODS

This study employed a cross-sectional observational design to compare isokinetic strength performance between young and older adults under individualized angular velocity conditions. A total of six participants were recruited, consisting of three individuals in their 20s and three in their 60s, each group comprising one male and two females. All subjects were free from musculoskeletal or neurological conditions that might influence lower extremity performance, and they provided written informed consent prior to participation, in compliance with ethical research standards.

Each subject participated in a standardized warm-up protocol consisting of 3 minutes of moderate-intensity pedaling on a cycle ergometer set at 50 to 70 watts. This warm-up was designed to increase muscle temperature and facilitate neuromuscular readiness prior to isokinetic testing.

Participants were then seated in an isokinetic dynamometer chair (HUMAC NORM; CSMi, Stoughton, MA), with the thigh securely strapped to stabilize the femur. The alignment of the knee joint axis with the lever arm of the dynamometer was carefully verified to ensure consistent biomechanical positioning. Prior to strength testing, each participant's maximum voluntary angular velocity was determined through isotonic knee flexion and extension, performed without external resistance (0 Nm) across five maximal-effort repetitions. This measurement served as a baseline to establish four testing conditions based on percentage thresholds of the individual's maximum velocity: 10%, 40%, 70%, and 100%.

Subsequently, subjects performed three repetitions of isokinetic knee flexion and extension at each target angular velocity. The order of testing was randomized to control for potential fatigue or learning effects. Verbal encouragement and standardized rest periods were provided to maintain effort consistency.

Key biomechanical variables extracted from the dynamometer software included angular velocity (deg/sec), peak torque (Nm), total work (Joules), and average power (Watts). These outcomes were analyzed across velocity conditions to evaluate performance differences between age groups, with particular attention to how reduced movement speed and muscle force generation capacity manifest in older adults when matched for individual capabilities.

3. RESULTS

Participant characteristics are summarized in Table 1. The younger group had an average age of 22.0 ± 1.73 years, while the older group averaged 65.3 ± 4.62 years. Though baseline physical characteristics such as height, weight, and BMI were generally comparable, minor differences reflected age-related anthropometric trends (e.g., slightly higher BMI in older adults).

Table 1. General characteristics of the subjects

Mean(SD)		
	Elder	Youth
Male/Female	1/2	1/2
Age(years)	65.33(4.62)	22(1.73)
Height(cm)	167(7.79)	170.5(9.76)

Weight(kg)	70.23(1.27)	68.6(12.21)
BMI(%)	25.23(1.85)	23.43(1.54)

Table 2 presents performance outcomes under the four angular velocity conditions. At 100% of maximum voluntary velocity, the younger group consistently demonstrated higher torque output, greater total work, and significantly higher average power compared to the older group. This trend persisted across all conditions (70%, 40%, and 10%). For example, at 100% angular velocity, younger participants generated peak torque values averaging 55.1 Nm, while older adults achieved only 31.0 Nm. Similarly, average power outputs were 119 W in the younger group versus 50 W in the older group.

Table 2. Difference of biomechanics with individual isokinetic measurements

Mean(SD)				
	Angular velocity(Elder/Youth)	**Peak torque(Elder/Youth)**	**Total work(Elder/Youth)**	**Average power(Elder/Youth)**
100%	**333.3(40.83)/396.7(45.84)**	**31(1.65)/55.1(17.52)**	**30.1(3.45)/63.6(20.67)**	**50(6.6)/119(9.16)**
70%	**233.3(28.58)/277.3(31.93)**	**38.2(2.31)/79(20.28)**	**37.2(1.54)/78(18.84)**	**55.7(6.6)/130.9(53.3)**
40%	**133.3(16.33)/158.3(18.45)**	**58.8(2.98)/114.1(2.98)**	**52.9(5.05)/108.9(27.7)**	**57(11.4)/118.1(35.1)**
10%	**33.3(4.08)/39.3(4.5)**	**86.4(9.51)//146.1(33.66)**	**61.2(9.33)/120.2(26.14)**	**24(1.65)/46.4(15.32)**

Interestingly, even when angular velocity was reduced to 10% of maximum, performance disparities remained pronounced. This suggests that neuromuscular degradation associated with aging affects force generation regardless of movement speed. Although torque improved at slower velocities in both groups, the relative gap between groups was maintained, indicating fundamental physiological limitations in older muscle tissue.

These findings underscore the persistent impact of age on isokinetic strength capacity and highlight the importance of evaluating muscular function under a range of movement speeds rather than relying on a single-velocity paradigm.

4. DISCUSSION

This study sought to explore how aging affects isokinetic strength performance under angular velocity conditions individualized to each participant's maximum capability. The results provide compelling evidence that age-related declines in muscle performance are evident across a spectrum of movement speeds, reinforcing the hypothesis that aging compromises both force and power production, even when assessments are normalized for individual capability.

Previous literature has consistently identified sarcopenia as a critical factor contributing to muscular decline in older adults [6-8]. The loss of fast-twitch muscle fibers, reduced motor unit recruitment, and decreased neuromuscular coordination are well-established phenomena that collectively diminish force-generating capacity. The data from this study support these mechanisms, as older participants displayed lower torque and power outputs at all testing velocities.

Moreover, this study adds nuance to the current understanding of individualized velocity training. By assessing performance at multiple velocity thresholds, it becomes clear that even when accounting for individual capacity, the aging neuromuscular system lacks the adaptability and responsiveness of younger counterparts. This has important implications for designing strength training programs, especially for clinical populations. Low-velocity training may be more appropriate for older adults, not only due to safety considerations but also due to the physiological limitations in rapid force development.

The results also align with findings from Marsh et al. [3], who emphasized the utility of low-velocity resistance training in preserving function. Similarly, Brown and Weir [5] noted the importance of velocity specificity in optimizing training outcomes across age groups. Importantly, this study underscores that personalized angular velocity prescriptions should be a cornerstone of geriatric rehabilitation and exercise science interventions.

From a practical standpoint, these findings advocate for integrating isokinetic assessments into routine functional evaluations for older adults, particularly those at risk for frailty or mobility impairments. They also prompt further inquiry into how nutritional, hormonal, and neuromotor interventions might synergistically support strength gains in aging populations.

5. CONCLUSION

This case-based study provides clear evidence that aging significantly influences isokinetic strength performance, even when individual capacity is accounted for in the calibration of angular velocity. Across all velocity thresholds, older adults demonstrated reduced torque production, work output, and power generation compared to their younger counterparts. These discrepancies are consistent with the physiological realities of aging, including diminished neuromuscular responsiveness, reduced muscle mass, and a loss in the quality of motor unit recruitment.

The practical implications of these findings are significant. Clinicians and exercise specialists must consider individualized angular velocity profiles when designing resistance training or rehabilitation programs, particularly for elderly populations. Standardized protocols may fail to accommodate the nuanced physiological limitations present in older individuals. Instead, a tailored approach—considering the specific angular velocity at which an individual can safely and effectively exert force—will likely yield superior outcomes in terms of muscle function preservation, fall risk reduction, and maintenance of independence.

Furthermore, this study demonstrates the utility of capacity-based velocity scaling in biomechanical assessments. By setting relative percentages of maximum angular velocity, the data better reflects true performance limitations rather than being confounded by uniform velocity constraints.

Future research should aim to validate these findings in larger, more diverse cohorts and integrate complementary methodologies such as electromyography (EMG), balance testing, and hormonal profiling. Longitudinal studies examining how these parameters evolve over time with targeted interventions would also provide deeper insight into age-related functional decline and recovery potential.

Ultimately, these results reinforce the critical importance of velocity-specific, individualized, and evidence-based training paradigms in the promotion of healthy aging and functional longevity.

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