THE RELATIONSHIPS BETWEEN PHYSICAL CAPACITY AND BIOMECHANICAL PLASTICITY IN OLD ADULTS DURING LEVEL AND INCLINE WALKING

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INTRODUCTION

Compared to young adults, old adults exhibit a distal-to-proximal redistribution of joint contributions to support phase mechanics of level walking. This age-associated biomechanical plasticity was quantified by DeVita & Hortobagyi (2000), who reported that hip and ankle joint contributions to total positive work were 16% and 73%, respectively for healthy, young adults and 44% and 51%, respectively for healthy, old adults [1]. Age-associated biomechanical plasticity has also been reported during incline walking. However, while young adults increased both hip and ankle joint torques during incline walking, old adults increased hip but not ankle joint torques [2] suggesting the magnitude of biomechanical plasticity may be task dependent.

Biomechanical plasticity is well established in healthy, old adults. However, not all adults age in a healthy and robust manner; old adults have a wide variation in physical capacity. Understanding the relationship between biomechanical plasticity and physical capacity in old adults may shed a brighter light on age-related declines in neuromuscular function and may lead to improved exercise and rehabilitation strategies for old adults. There is some indication that low- compared to high-capacity old adults exhibit increased magnitudes of biomechanical plasticity [3-5]. Based on these comparisons, we hypothesized that as physical capacity declines, age-associated biomechanical plasticity increases in magnitude. We also hypothesized that the magnitude of biomechanical plasticity would increase during incline compared to level walking; i.e. in the more difficult task.

The purpose of this study was to quantify the relationships between physical capacity and biomechanical plasticity in old adults during level and incline walking.

METHODS

Data were collected on 32 old (22 female; age = 74.7 ± 4.4 yr.) individuals. Written informed consent approved by the IRB of East Carolina University was obtained from all participants.

Physical capacity was measured using the Short-Form Health Survey Physical Component (SF-36 PC) score. Kinematic and GRF data for the pelvis and right leg were collected using motion capture (120 Hz, Qualisys AB) and force platforms (960 Hz, AMTI). Participants completed 5 successful trials of walking at self-selected speeds over level ground and up a 10° incline ramp.

Kinematic and GRF data were filtered using second-order low pass Butterworth digital filters with cut-off frequencies of 6 & 45 Hz. Joint torques and powers were calculated using an inverse dynamics approach (Visual 3D, C-Motion). To define biomechanical plasticity, we created ratios of support phase hip extensor to ankle plantarflexor peak torques, angular impulses, peak positive powers, and positive work in both level and incline gaits.

Pearson product correlation coefficients were computed between SF-36 PC scores and the four biomechanical plasticity ratios during both walking gaits ($p < 0.05$). In the cases where significant corresponding relationships existed during level and incline walking, 95% C.I.s of regression slopes were computed and compared to determine differences in the magnitude of plasticity in level and incline walking.

RESULTS AND DISCUSSION

During level walking, significant positive relationships were observed between physical capacity and hip/ankle peak torque, angular impulse, peak positive power, and positive work ratios (Figure

1). During incline walking, significant positive relationships were observed between physical capacity and hip/ankle peak torque, angular impulse, and peak positive power ratios. No significant differences were observed in the magnitude of biomechanical plasticity between level and incline walking (i.e., the beta weights were statistically identical between gaits).

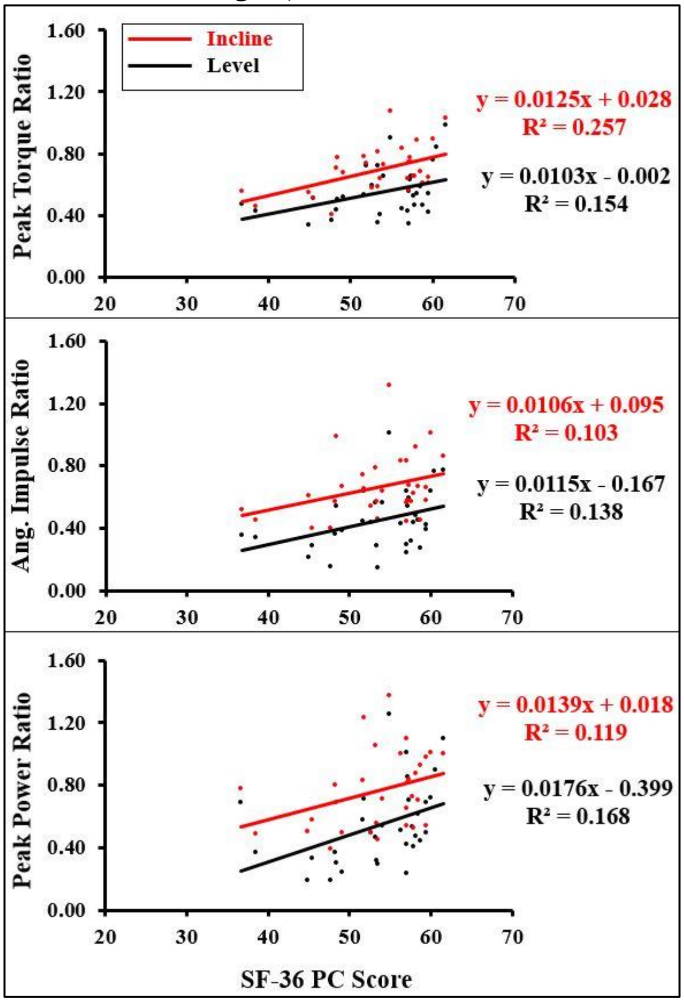

Figure 1: Correlations between SF-36 PC scores and biomechanical plasticity ratios and regression equations for each relationship.

Previous comparisons of high and low-capacity [3], strong and weak [4], and active and sedentary [5] old adults suggested an increased magnitude of biomechanical plasticity in low- compared to high-capacity old adults. Because of this, we hypothesized that an inverse relationship exists between physical capacity and age-associated biomechanical plasticity. Our results do not support this hypothesis. In fact, we report significant positive relationships between physical capacity and biomechanical plasticity during both level and incline walking. Positive relationships between plasticity ratios and self-selected walking speeds during level and incline walking suggest that biomechanical plasticity is an adaptation made by higher-capacity old adults to maintain better walking performance (Table 1). However, it should be noted that the magnitude of the relationships between biomechanical plasticity and physical capacity were moderate at best.

CONCLUSION

Positive relationships exist between physical capacity and biomechanical plasticity during level and incline walking gait. Incline walking does not appear to increase the per unit magnitude of biomechanical plasticity per unit increase in physical capacity.

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Table 1: Pearson Correlation Coefficients (r) between biomechanical plasticity ratios and self-selected walking speeds during level and incline walking. Significant r-values are highlighted by **bold** font ($p < 0.05$).

Pearson Correlation Coefficients				
Plasticity Ratios	Self-Selected Level Walking Speed		Self-Selected Incline Walking Speed	
	r-value	r^2	r-value	r^2
Peak Torque	**0.518**	0.268	**0.453**	0.205
Angular Impulse	**0.353**	0.125	0.272	0.074
Peak Power	**0.352**	0.124	0.293	0.086
Work	0.087	0.008	0.007	0.000