Reference ranges for gait speed and sit-to-stand performance in community-dwelling older adults with no mobility limitations

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Introduction

Gait speed and sit-to-stand tests are common and widely advocated tests of functional performance. Large cohort studies have shown that poor (slow) gait and sit-to-stand performance are associated with increased mortality, disability, and hospitalization in older adults[1]. Thus, identifying older adults with functional performance "below norms" is the first step to preventing adverse clinical outcomes. We aimed to, in older adults with no self-reported mobility limitations, (i) examine the associations of age, gender, and height with gait speed and sit-to-stand performance, and (ii) develop subgroup-specific reference ranges.

Methods

In this cross-sectional study, participants were obtained from The Individual Physical Proficiency Test for Seniors (IPPT-S) programme and we identified 775 older adults who reported no difficulty walking 100metres, climbing stairs, and rising from the chair. Gait speed and sit-to-stand performance were measured by the habitual 10-metre gait speed test and 5-times sit-to-stand test, respectively. To examine the associations of gait speed and sit-to-stand performance with participants' characteristics , we fitted separate Bayesian multivariable robust linear regression models which included age, gender, and body height as independent variables. Flat or weakly informative priors were specified for the model parameters. To avoid assuming linearity, we modelled age flexibly as a restricted cubic spline[2]. To generate the reference ranges, we computed 95% prediction intervals. All analyses were done using R software.

Table 1: Participant Characteristics

Variables	Women (n=569)	Men (n=206)	Combined (n=775)
Age (years)	62.0 **66.0** 71.0 (66.2 ± 6.2)	64.0 **67.0** 72.0 (68.2 ± 6.6)	62.0 **67.0** 71.0 (66.7 ± 6.4)
Height (m)	1.50 **1.53** 1.58 (1.54 ± 0.06)	1.61 **1.65** 1.69 (1.65 ± 0.06)	1.51 **1.56** 1.62 (1.57 ± 0.08)
Weight (kg)	50.1 **55.9** 62.5 (56.8 ± 9.9)	60.0 **66.5** 71.9 (66.6 ± 11.1)	51.9 **58.5** 66.6 (59.4 ± 11.1)
BMI (kg/m²)	21.4 **23.5** 26.2 (24.0 ± 4.0)	22.2 **24.2** 26.4 (24.4 ± 3.7)	21.7 **23.6** 26.3 (24.1 ± 3.9)
Gait Speed (m/s)	1.19 **1.34** 1.49 (1.34 ± 0.22)	1.19 **1.32** 1.51 (1.35 ± 0.26)	1.19 **1.34** 1.50 (1.34 ± 0.23)
Sit to Stand Pace (stands/30s)	14.1 **17.0** 20.5 (17.6 ± 5.1)	14.1 **16.7** 21.4 (18.0 ± 5.4)	14.1 **17.0** 20.8 (17.7 ± 5.2)
Sit to Stand Time (s)	7.3 **8.8** 10.6 (9.3 ± 2.9)	7.0 **9.0** 10.7 (9.1 ± 2.7)	7.2 **8.8** 10.6 (9.3 ± 2.8)

Continuous variables are summarized as 25th, **50th**, 75th percentiles (mean ± SD)

Table 2. Associations of age, gender, and body height with gait speed and sit-to-stand pace†

	Habitual Gait Speed (m/s)				Sit-to-Stand Pace (stands/30s)			
		Adjusted Difference	Probability of Effect Size* (%)			Adjusted Difference	Probability of Effect Size (%)	
Predictor	Comparison	Median (95% CrI)	Diff > 0	Diff > 0.05	Comparison	Median (95% CrI)	Diff > 0	Diff > 0.6
Age (years)	60 vs 70	0.09 (0.06 to 0.12)	>99.9	99.0	60 vs 70	3.4 (2.7 to 4.1)	>99.9	>99.9
Gender	Women vs Men	0.06 (0.01 to 0.10)	98.9	59.8	Men vs Women	1.9 (0.9 to 2.9)	>99.9	99.4
Height (m)	1.70 vs 1.60	0.07 (0.05 to 0.10)	>99.9	95.4	1.60 vs 1.70	0.9 (0.3 to 1.5)	99.9	83.9

† Results shown are from Bayesian regression models.
* Probability of posterior distributions exceeding 0, 0.05m/s (gait speed), and 0.6stands/30s (sit-to-stand pace). Credible intervals (CrIs) were based on the highest density interval of the posterior distribution.

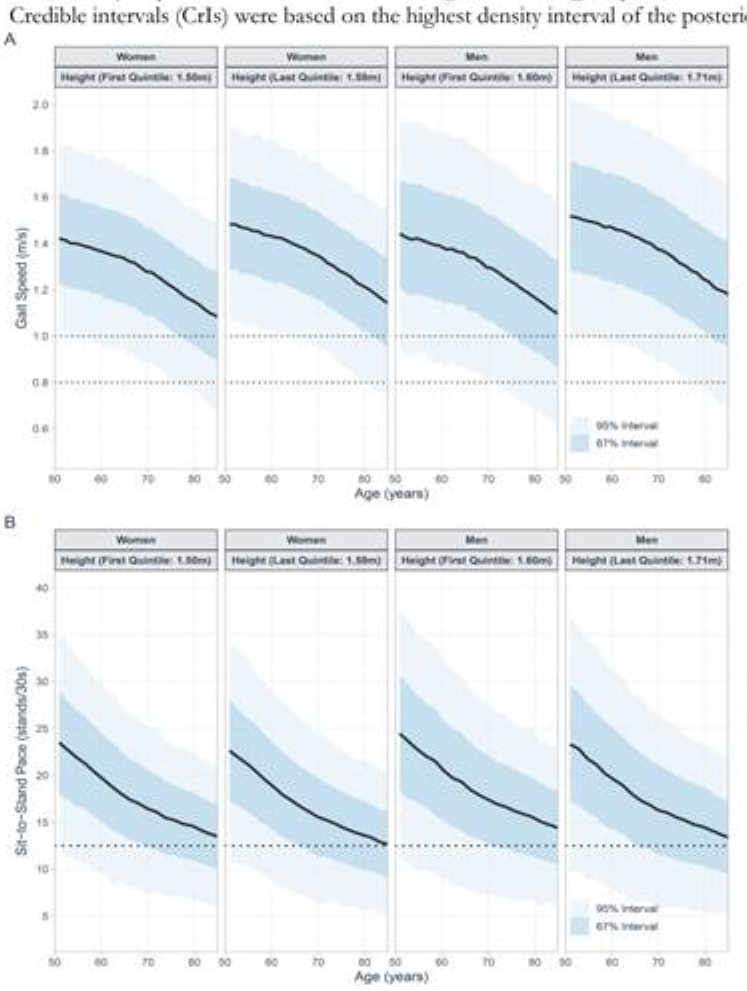

Figure 1 Habitual gait speed (A) and sit-to-stand pace (B) point estimates (solid lines) with 67% (darker band) and 95% (lighter band) reference intervals based on age, stratified by gender and by gender-specific quintiles (first and last) of body height. Reference interval values were extracted from a Bayesian robust linear regression model adjusted for age, gender, and body height. Horizontal dashed lines represent gait speed cutpoints (0.80m/s and 1.0m/s) and 5X sit-to-stand cutpoint of 12secs (or equivalently, 12.5stands/30sec). A web-based application is available for the interactive exploration of reference interval values at multiple covariate values (https://sghpt.shinyapps.io/ippts/).

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Results

Table 1 shows the sample characteristics. Overall, 95% reference range was 0.89-1.79 m/s for habitual gait speed and 7.4-27.9 stands/30s for sit-to-stand pace. Table 2 shows the associations of the independent variables with gait speed and sit-to-stand pace. Age had the highest posterior probability (>99%) of a meaningful association with both functional outcomes. Additionally, body height was strongly associated with gait speed: a 10-cm increase in height was associated with 0.07m/s (95%CrI, 0.05-0.10) faster gait speed. For sit-to-stand test, the lower reference range limits tended to be similar across gender and gender-specific height subgroups, owing to the associations of faster sit-to-stand pace with shorter height and male gender. Figure 1 shows the reference ranges of gait speed and sit-to-stand pace across age, stratified by gender and quintiles of body height. Because extensive tables of reference ranges are impractical, we created a web-based application (https://sghpt.shinyapps.io/ippts) to generate subgroup-specific reference ranges.

Discussion

Gait Speed

Contrary to several but not all previous studies, we did not observe a faster habitual gait speed in men than in women. To explain this, previous studies that showed gender differences have tended to include broader samples of older adults; hence, it is possible that the reported gender difference may reflect the general finding that physical disability is more prevalent in women than in men[2]. More subtly, the gender differences reported in previous studies could, at least partially, be a consequence of body height differences (Tables 1 and 2). Thus, taken together, our results indicate that body height may play a prominent role in influencing gait speed and potentially mediating the gender-gait speed association.

Sit-to-stand pace

Interestingly, given that men and women had comparable sit-to-stand performance in unadjusted analysis (Table 1), our results indicate that the explanation for the gender differences, or lack thereof, in sit-to-stand performance reported in the literature[4–8] may involve a complex interplay of factors. Specifically, although men, on average, may have greater muscle mass and density, this advantage is potentially offset by their taller stature, which demands greater muscular effort during the sit-to-stand task[9].

Implications

Our study has implications with regard to the setting of thresholds to define inadequate gait and sit-to-stand performance. Although the wish to adopt universal (age-, gender-, and stature-neutral) cut-points is understandable from clinical and practical perspectives, it should be viewed with caution as existing clinical cut-points were well within the 95% reference ranges (Figure 1). That said, we acknowledge that extensive tables of reference ranges are unwieldy for clinical care and mass screening efforts; hence, a web-based application was developed to more readily provide subgroup-specific reference ranges. Given the promotion and proliferation of automated functional assessments, future work should explore how personalized reference ranges could be incorporated into the relevant information technology systems.

Limitations

First, we studied older adults with no mobility limitations to provide complementary insights on what is — and, by corollary, what is not — adequate functional performance for different subgroups. Hence, our results are not directly comparable with those from population-based studies with broader inclusion criteria. Second, although we used a Bayesian regression-based method to optimize statistical power and robustness, the reference range estimates may be less precise for men due to the relatively smaller sample size.

Conclusion

In a large sample of mobile-intact older adults, reference ranges for gait speed and sit-to-stand performance differed meaningfully by age. Furthermore, gait speed was stature-dependent. Although requiring validation, our findings may be used to define subgroup-specific "below-range" values and to complement existing universal clinical cut-points for gait speed and sit-to-stand performance.

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