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 risk of falls, mortality, and hospitalization in older adults.1,2 Thus, identifying older adults with functional performance “below norms” is the first step in 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 (IPTT-S) programme and we identified 775 older adults who reported no difficulty walking 100 metres, 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 multinomial robust linear regression models which included age, gender, and body height as independent variables. Pair-wise 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.

Results
Table 1 shows the sample characteristics. Overall, 95% reference ranges were 0.891-1.78 m/s for habitual gait speed and 4.7-28.9 s for 5-times sit-to-stand. 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 0.10 cm increase in height was associated with 0.07 m/s (95% CI, 0.030-0.109) higher functional gait speed. Furthermore, the estimated 95% prediction intervals tended 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://sgnht.shinyapps.io/iptt_project) 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 had tended to include the samples of older adults; hence, it is possible that the reported gender differences 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 expected faster performance for the gender differences can be explained, in part, by differences in body height performance reported in the literature2,4 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.

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-specific) cut-points is understandable from a 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 falls and gait-related 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 strictly 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, these 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 “belowaverage” values and to complement existing universal clinical cut-points for gait speed and sit-to-stand performance.

Acknowledgement
We thank the study participants, staff of the Senior Activity Centre, and Research Committees in the northern region of Singapore for their logistical and financial support. This study is funded by Singapore National Research Council (CSIRG1616127 and CSIRG16161031) and National Innovation Challenge on Active and Conditioned Ageing Grant (18WKHCRA1460417).

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