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The Chinese (Mandarin) instructions of the 6-minute walk test: A validation study

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Background/Objective: To date, a validated Chinese (Mandarin) six-minute walk test (6MWT) translated instruction is not available. Translation of the Chinese 6MWT instruction is done in an *ad hoc* manner within the Chinese-speaking populations. This study aimed to develop a set of valid and reliable Chinese (Mandarin) instructions of the 6MWT.
Methods: Translation was performed from the original English instruction via the recommended "Process of translation and adaptation of instruments" by the World Health Organization to generate the Chinese instructions. The Chinese instructions were tested with 52 healthy adult participants for its validity. Each participant underwent three 6MWTs and a cardiopulmonary exercise test. Randomization allowed participants to undergo the walk test in both the original English and the new Chinese instructions. Face and content validity, intra-rater and inter-rater reliability of the Chinese instructions of the 6MWT were established through the translation process. Criterion validity was established by analyzing the results of the 6MWT and cardiopulmonary exercise test.
Results: Intraclass correlation coefficient for inter-rater reliability was excellent (ICC = 0.999, 95% confidence interval = 0.996–1.000). Similarly, the intra-rater reliability across the three raters was high (R1: ICC = 0.996, 95% confidence interval (CI) = 0.812–1.000; R2: ICC = 1.000, 95% CI = 0.994–1.000; R3: ICC = 1.000, 95% CI = 0.998–1.000). The 6-min walk distances collected from the Chinese and English instructed trials correlated positively with the maximal oxygen consumption ($r = 0.315$, $p = 0.023$; $r = 0.309$, $p = 0.026$).

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Conclusion: This is the first study to develop and validate the Chinese (Mandarin) instructions of the 6MWT, and the translation is as reliable and valid as the original English instructions.

Keywords: Six-minute walk test; Chinese translation; exercise test; outcome measures; validation.

Introduction

The six-minute walk test (6MWT) is a submaximal field test which measures the total distance an individual walks in 6 min, recorded as the six-minute walk distance (6MWD).[1] It is widely used to assess an individual's functional exercise capacity, treatment outcome, or as an indicator of morbidity and mortality across cardiopulmonary diseases.[1,2] The test is valid and reliable in both healthy and diseased populations such as chronic obstructive pulmonary disease, pulmonary fibrosis, heart failure, and amputations.[3–8] The 6MWT is simple, easy to conduct, and does not require any sophisticated equipment. Thus, it has an advantage over other comprehensive cardiopulmonary exercise tests (CPETs) in the clinical setting.

The American Thoracic Society (ATS) has established standardized English instructions for the 6MWT.[1] However, this has posed challenges to the non-English speaking populations worldwide in countries such as China, Taiwan, Hong Kong, and Singapore, where many of the people are Chinese speaking and may not comprehend the English instructions. The Chinese language is one of the most spoken languages, with approximately 1 billion speakers globally,[9] thus indicating the need for the Chinese instructions. To our knowledge, the instructions of the 6MWT are commonly translated by clinicians on an *ad hoc* basis. These translations, which are dependent on the linguistic ability of the clinicians, could lead to varied instructions from time to time between researchers and even within oneself, from one day to another.[10]

To date, no standardized and validated Chinese version of the recommended instructions for 6MWT has been published on any mainstream English scientific journal. Thus, we are establishing validated and standardized Chinese instructions with close adherence to the original English version. The establishment of this reliable and valid assessment tool would be of great value to countries with Chinese-speaking populations, in ensuring evidence-based practice in the clinical setting.

Methods

Study design

This was a translation and cross-sectional validation study to assess the feasibility of introducing standardized Chinese instructions for the 6MWT (6MWT-CHN). The study was carried out between August and November 2019 in the exercise laboratory at the Singapore Institute of Technology. Ethical approval (SIT-IRB Project Number: 2019089) was obtained from the Singapore Institute of Technology — Institutional Review Board, and all participants provided informed consent to participate in this study.

Development of the Chinese (Mandarin) instructions

We translated the 6MWT-CHN from the original 6MWT English instructions (6MWT-ENG)[1] while adhering to the process of translation and adaptation of instruments[11] recommended by the World Health Organization (WHO). In brief, two independent bilingual translators performed the forward translations independently. A panel comprising the researchers and the translators compared the two translations and formulated a consensus version. Twelve bilingual participants performed the backward translation of the consensus Chinese version to English. These 12 participants have no prior knowledge of the 6MWT and were not involved in the previous translation work. The backward translated instructions were reviewed for equivalence to the original instructions by another expert panel, which comprised experienced cardiopulmonary physiotherapists. The 6MWT-CHN was finalized after a pilot trial, which involved six healthy adult participants who fulfilled the inclusion and exclusion criteria.

Participants recruitments

The study recruited participants via convenience sampling if they met the inclusion and exclusion

criteria of our study. According to other cross-cultural adaptation studies,[12–19] a minimum sample size of 50 participants would provide adequate study power to observe validity and reliability. Considering the risk of missing datasets and dropouts, we supplemented an additional 20%, bringing the projected number of participants for recruitment to 60. The recruited participants were effectively bilingual and obtained at least a pass in both English and Chinese languages in the Singapore Primary School Leaving Examinations. Additionally, we only included participants between 21 and 60 years old and those without previous experience or knowledge of the 6MWT.

We excluded those with the presence of existing or past medical conditions that were contraindicated for physical activities as indicated by the Physical Activity Readiness Questionnaire for Everyone (PAR-Q+)[20] or contraindicated for the CPET following the American College of Sports Medicine (ACSM) standards.[21] We also excluded participants whose forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) were less than 80% and the FEV_1/FVC ratio less than 70% in the spirometry lung function test at the start of the study.[22] Subsequently, we randomized the participants into the English-Chinese-English (ECE) or Chinese-English-Chinese (CEC) group through a sealed envelope method (Fig. 1) to mitigate the impact of learning effects on the 6MWT results.

The 6MWT and the Bruce protocol treadmill test

The 6MWT was set up and conducted along a 30-m indoor walkway following ATS guidelines.[1] The participants walked back and forth the walkway for as far as possible within the 6-min duration. At every minute, the assessors gave standardized encouragement and recorded parameters such as Borg scale (0–10) of fatigue and dyspnea, heart

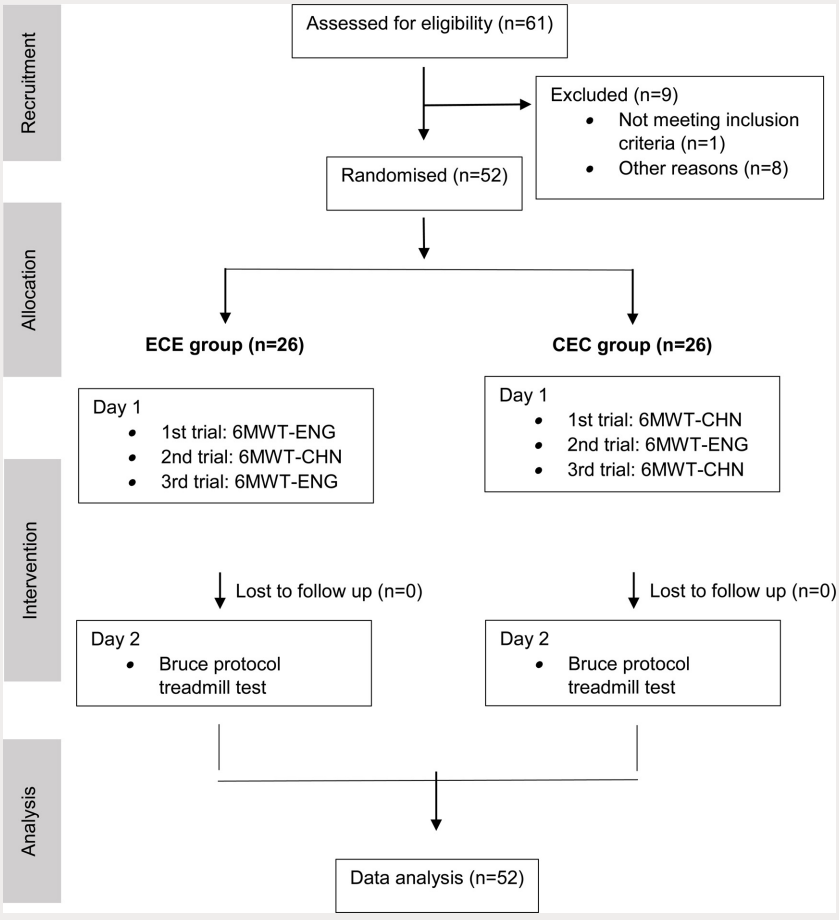

Fig. 1. Flow diagram of the validation study. ECE = English-Chinese-English; CEC = Chinese-English-Chinese; n = number; 6MWT-ENG = English instructions of the 6-min walk test; 6MWT-CHN = Chinese instructions of the 6-min walk test.

rate, and oxygen saturation (SpO_2) readings. The trials took place at 30-min intervals, ensuring that the participants' blood pressure, heart rate, and oxygen saturation returned to baseline before the next trial. At the end of 6 min, the 6MWD was recorded.

Before the validation study, a pilot study established intra-rater and inter-rater reliability among the three assessors. The six bilingual participants underwent five 6MWT trials on the same day using the instructions of the consensus version. Thereafter, participants in the validation study performed three trials of 6MWT on the same day and the CPET on the following day using the Bruce treadmill protocol (Fig. 2). Participants were instructed to exercise to maximal exhaustion while trained personnel monitored blood pressure, heart rate, and Borg scale of perceived exertion and analyzed the real-time electrocardiography.[23] At the end of the test, the relative maximum oxygen uptake (VO_2 max) was recorded for data analysis.

Statistical analysis

Statistical analysis was performed with IBM SPSS® Statistics Version 26.0 (IBM Corporation, Armond, New York, USA). The level of significance was set at $p < 0.05$ for all statistical analyses.

Reliability and validity of 6MWT-CHN

The intra-rater and inter-rater reliabilities of the 6MWT-CHN were analyzed via the intraclass correlation coefficients (ICCs), using average measures of two-way mixed effect and two-way random effect models, respectively, and Bland–Altman plots. A higher ICC value and a mean difference between paired measurements of raters closer to zero represent better reliability. Face and content validity were fulfilled during the translation process and content validity ratio was used as a quantitative measure.[24] Demographical data were tested for normal distribution using the independent *t*-test before analyzing the validation study results. Criterion validity was established by first identifying the best 6MWDs of the 6MWT-CHN and the 6MWT-ENG in each subject and subsequently analyzing the correlation between VO_2 max and the 6MWT-CHN results, as well as between VO_2 max and the 6MWT-ENG results using Pearson's correlation coefficient.

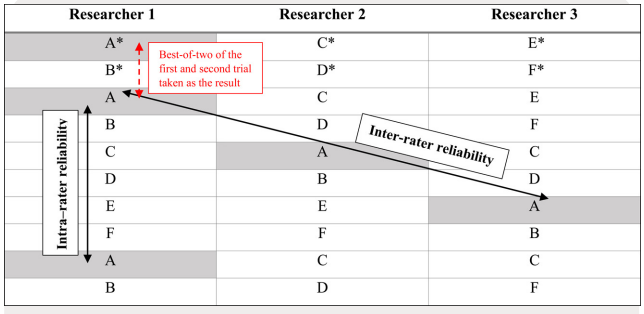

Fig. 2. Pilot study to determine intra-rater and inter-rater reliability. Alphabets A to F represent the six bilingual subjects. Asterisk "*" denotes the first trial for each subject. The best-of-two of the first and second trials was taken as the result for subsequent analysis. Subject A had been highlighted to illustrate how intra-rater and inter-rater reliability were measured.

Results

A total of 52 participants (32 males and 20 females) participated in the study. Table 1 presents the demographic data (age, body-mass index, spirometry results, and Chinese proficiency) of these participants.

Reliability

The 6MWT-CHN demonstrated high intra-rater reliability within each of the three raters (R1: ICC = 0.996, 95% confidence interval [CI] = 0.812–1.000; R2: ICC = 1.000, 95% CI = 0.994–1.000; R3: ICC = 1.000, 95% CI = 0.998–1.000). Similarly, the 6MWT-CHN demonstrated excellent inter-rater reliability (ICC = 0.999, 95% CI = 0.996–1.000) across the three raters involved (Table 2). Figure 3 illustrates the reliability data with Bland–Altman plots over repeated paired analyses between raters. Each of the dots on the Bland–Altman plot represents each of the six participants for the pilot study.

Validity

The face validity of the 6MWT-CHN was established with the rigorous translation process according to the WHO translation guidelines.[11] The subsequent panel review synonymously ascertained that the conceptual meaning of the 6MWT-CHN was accurate to the original with a content validity ratio of 1. Results from the validation study demonstrated that the 6MWDs of the

Table 1. Demographic of participants ($n = 52$).

	ECE ($n = 26$)	CEC ($n = 26$)	p-values
Age (years)	25.6 ± 9.06	26.1 ± 8.68	0.840
Gender			0.577
Male	15	17	
Female	11	9	
Body mass index (kg/m^2)	22.1 ± 3.59	22.8 ± 3.71	0.481
FEV_1/FVC ratio (%)	94.4 ± 7.68	92.3 ± 5.68	0.273
Relative VO_2 max (mL/min/kg)	40.3 ± 8.85	40.6 ± 9.47	0.910
Chinese language qualification			0.576
Junior college	8	7	
Secondary school	18	18	
Primary school	0	1	

Notes: Data are mean ± standard deviation unless otherwise noted. *Definition of abbreviations*: ECE = English-Chinese-English; CEC = Chinese-English-Chinese; n = number of participants; FEV_1 = ratio of forced expiratory volume in one second; FVC = forced vital capacity; VO_2 max = relative maximal oxygen consumption. Significance of p-values < 0.05.

Table 2. Inter-rater and intra-rater reliability of the Chinese version of 6MWT (6MWT-CHN).

6MWT-CHN		ICC	95% CI	p-values
Inter-rater reliability		0.999	0.996–1.000	0.000
Intra-rater reliability	Rater 1	0.996	0.812–1.000	0.000
	Rater 2	1.000	0.994–1.000	0.000
	Rater 3	1.000	0.998–1.000	0.000

Notes: *Definition of abbreviations*: ICC = intra-class coefficient; 95% CI = 95% confidence interval. Significance of p-values < 0.05.

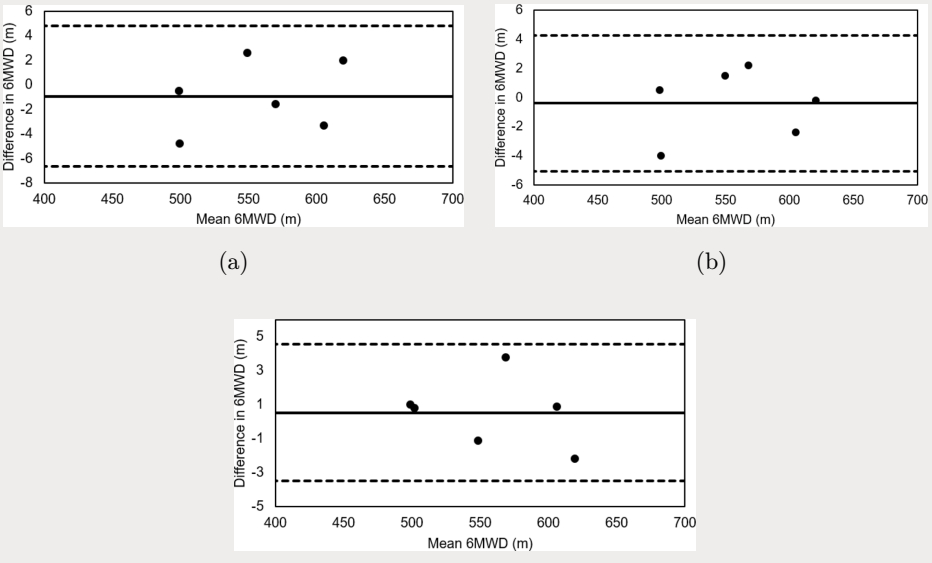

Fig. 3. Bland–Altman plots comparing the agreement of the three raters ([A] Rater 1 and 2, [B] Rater 1 and 3, [C] Rater 2 and 3). The differences in 6-min walk distance between raters are plotted against the mean scores. The straight line represents the mean difference between the two raters; dashed lines represent the 95% limits of agreement. 6MWD = 6-min walk distance; TEM = technical error of measurement; CV% = coefficient of variance.

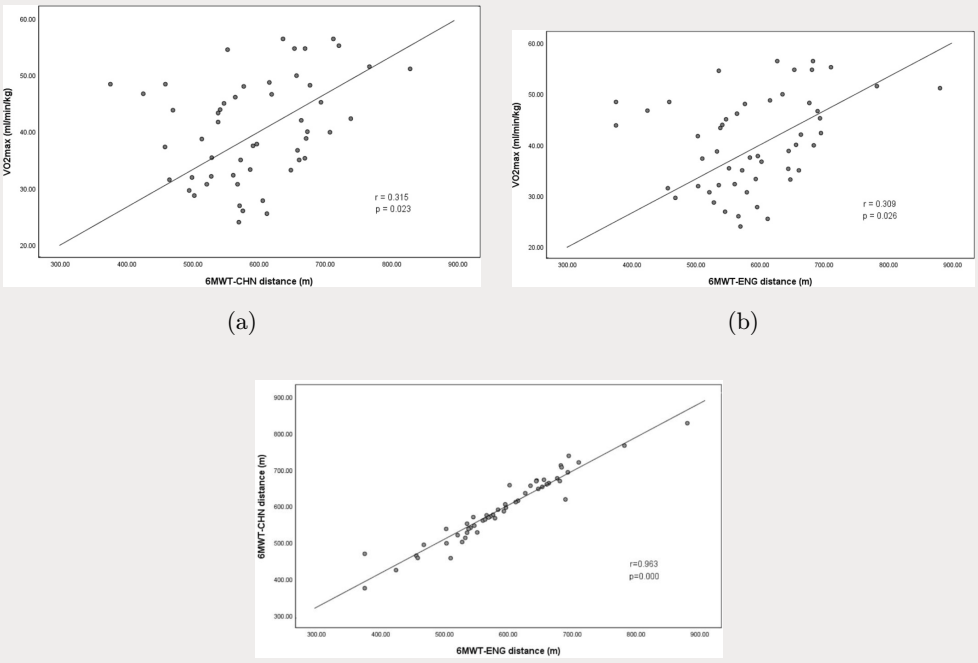

Fig. 4. Scatterplots of relative VO_2 max and 6MWDs of 6MWT-CHN and 6MWT-ENG ([A] VO_2 max and 6MWT-CHN, [B] VO_2 max and 6MWT-ENG, [C] 6MWT-CHN and 6MWT-ENG). VO_2 max = maximal oxygen consumption; 6MWT-CHN = Chinese instructions of 6-min walk test; 6MWT-ENG = English instructions of the 6-min walk test; r = Pearson's correlation coefficient; p = probability value.

6MWT-CHN (593 ± 91.5 m) and 6MWT-ENG (589 ± 94.5 m) had a weak positive correlation with the VO_2 max collected during the Bruce protocol treadmill test ($r = 0.315$, $p = 0.023$; $r = 0.309$, $p = 0.026$). Figure 4 illustrates the scatterplots to show the relationships between the relative VO_2 max (mL/min/kg), 6MWT-CHN distance (m), and 6MWT-ENG distance (m). The relationships of VO_2 max, 6MWT-CHN, and 6MWT-ENG were also highly similar ($r = 0.963$, $p = 0.000$), illustrating no difference between the instructions in the two languages and that 6MWT-CHN has good criterion validity.

Discussion

The 6MWT is a field test that measures submaximal exercise capacity. It is an outcome measure used to assess the effectiveness of interventions and to aid in exercise prescription. Although the CPET is the gold standard for exercise testing, field tests like the 6MWT are conducted more commonly in clinical settings as they are validated, easy to conduct, economic, and less time-consuming. It is also more applicable to patients with cardiopulmonary conditions who are easily fatigued. The ATS established a standardized set of instructions for the 6MWT in the English language in 2002. However, the English standardized instructions pose a challenge for the Chinese-speaking population worldwide. To the knowledge of the researchers, instructions of the 6MWT are usually translated into Chinese in an *ad hoc* manner without any documented standardizations[25–27] in the local clinical setting. The lack of standardization among assessors can alter the psychometric properties of the 6MWT since the test is only valid when conducted with standardized set-up and instructions.[1] Excessive or insufficient motivation can affect the distance an individual completes.[28] Therefore, our study aimed to develop and establish the validity and reliability of the Chinese version of the 6MWT instructions.

This is the first study to develop and validate a Chinese version of the 6MWT instructions against the gold standard measure of exercise capacity, the CPET. The study observed a rigorous process of forward and backward translation and reliability testing under WHO guidelines.[11] The panel of

researchers established the face and content validity of the 6MWT-CHN during the translational phase. Subsequently, the pilot study established intra-rater and inter-rater reliability, and the validation study established correlations of the 6MWT-CHN, 6MWT-ENG, and CPET. The 6MWT-CHN demonstrated acceptable psychometric properties. Our findings suggest that this instrument is a reliable and valid outcome measurement for the Chinese-speaking population. Intra-rater and inter-rater reliabilities of the 6MWT-CHN were excellent in healthy participants with ICC values ≥ 0.90. In addition, absolute reliability was excellent with precision and a small human error for measurements; % coefficient of variation $< 1\%$ and the technical error of measurement below the acceptable 5% mark. This resembles established literature on the 6MWT where the 6MWT has excellent reliability (ICC = 0.72–0.99) in people with pulmonary conditions.[8,29]

The 6MWT-CHN also showed a positive correlation with the CPET; the gold standard for exercise testing.[30] The 6MWT-CHN correlated well with the VO_2 max ($r = 0.315$, $p = 0.023$) and was comparable with the 6MWT-ENG ($r = 0.963$, $p = 0.000$). The high similarity in correlations between the VO_2 max and 6MWDs of 6MWT-ENG and 6MWT-CHN suggested strong agreement between the two 6MWT instruments and indicated the criterion validity of the 6MWT-CHN. The results of this study were comparable with published data on the validity of the 6MWT on healthy adults ($r = 0.54$–0.87),[31–33] healthy children ($r = 0.44$),[6] patients with pulmonary conditions ($r = 0.40$–0.80),[8] patients with heart failure ($r = 0.54$–0.69),[34] patients with diabetes mellitus ($r = 0.54$),[35] and patients with cancer ($r = 0.67$).[36]

Notwithstanding, we acknowledge that this is a limitation of our study. We considered several "gold standards" to test against the 6MWT-CHN/ENG during the inception of this study. However, given the nature of the 6MWT as a self-paced/self-limiting field test, there is no "gold standard" of another self-paced exercise test that is as widely established and used as the 6MWT-ENG. Therefore, we decided to test criterion validity against the CPET. The consistently weak positive correlations of the VO_2 max and 6MWT-CHN ($r = 0.315$, $p = 0.023$), with the VO_2 max and 6MWT-ENG ($r = 0.309$, $p = 0.026$), demonstrate the similar magnitude of positive correlations between the two versions of the 6MWT instructions with VO_2 max. The strong correlation between 6MWT-CHN and 6MWT-ENG proves the equivalency of the two sets of instructions. Hence, we extrapolated the establishment of criterion validity, given the mentioned conditions.

Despite the positive correlation of VO_2 max and 6MWD in our study, we acknowledge that the correlation was poor when compared with the established literature of the 6MWT in both healthy and diseased populations. We recognize that another major limitation of this study was the homogeneity of the participants. Despite a broad age criterion for the validation study, our participants were younger with a mean (SD) age of 25.9 ± 8.79 years. Selection bias may have persisted even with convenience sampling due to the enrollment procedure, which required a level of tech-savviness to navigate and complete the online questionnaire independently. Additionally, the older adults were either reluctant to perform the treadmill test or had existing comorbidities like high blood pressure and diabetes mellitus that did not meet the inclusion criteria of the PAR-Q+. As such, the reach of the study may have been hampered, and thus generalized results. Although the perceived understanding of the translation was well-received with the current participant group, the colloquial adaptation of a language may vary across different generations of individuals. Hence, future studies should recruit participants from varying backgrounds and age groups.

In addition, our pilot study for assessment of reliability had a small sample size of six participants, of whom all were healthy. These two factors could have contributed to the excellent intra-rater and inter-rater reliabilities and may not translate to individuals with existing morbidities. Although the sample size of our study was small compared with other studies, our study managed to generate significant results to affirm the similarity in conceptual terms of our translated instructions compared to the original English instructions. Nonetheless, the results of factor analysis should be interpreted with caution, and larger samples size can be evaluated in future studies.

Conclusion

This study developed and validated a Chinese version of the 6MWT instructions. The established reliability and validity of the 6MWT-CHN version

indicate that the psychometric properties are similar to the original English version. With this 6MWT-CHN version, clinicians can conduct the 6MWT in Chinese (Mandarin) while ensuring standardization. Further testing on the 6MWT-CHN in other patient populations may be warranted.

Acknowledgment

The authors would like to thank the participants who took precious time off to participate in this study to aid in the validation of the Chinese 6MWT instructions.

Conflict of Interest

The authors declare that they have no competing interests.

Author Contributions

V. Z.-Y. T. contributed to the execution of the study, analysis of the data, revision of the manuscript critically for relevant intellectual content and assembly to the manuscript; M. Q. L. and D. L.-W. W. contributed to the execution of the study, analysis of the data, and revision of the manuscript critically for important intellectual content; K. S. H., M. Y. C., C. C. Y., and M. T. Y. contributed to the conception and study design, revision of the manuscript critically for important intellectual content and final approval of the manuscript. All authors have read and approved the final version of the manuscript and agree with the order of presentation of the authors.

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