Original Article

Classifying gait patterns of older adults by movement control and biomechanical factors: validation by gait and physical performance measures

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Abstract

Background: While gait patterns of older adults with mobility problems vary, the patterns are rarely used to plan interventions. The purpose of this study was to establish concurrent validity of a clinically useful classification system using gait and physical performance measures. **Methods**: Community-dwelling male veterans (n=106; mean 76 ± 7.1) referred for mobility problems were videotaped for evaluation. Gait patterns have been classified using structured clinical observation and along movement control factors (consistent, inconsistent) & biomechanical factors (posture: usual, flexed, extended, crouched). Pair wise comparisons across various groups were performed to validate the gait classification using gait parameters (gait speed, step length, width and variability), lower extremity range of motion and muscle strength, physical function in ADL (Physical Performance Test, PPT) and gait abnormalities (GARS-M). **Results**: Consistent and inconsistent groups were different in gait speed (0.66 and 0.49m/s, respectively; p=0.003), step length (0.46 and 0.38m; p=0.008), step length variability (7.47% and 12.74%; p=0.043), the PPT (15.80 and 11.73; p<0.001) and GARS-M (5.83 and 10.66; p<0.001). Within both consistent and inconsistent groups, four groups defined by postural patterns, also differed in gait speed, step length, PPT and GARS-M scores (p<.05). **Conclusion:** Gait pattern classification based on movement control and biomechanical factors has good concurrent validity with respect to gait and physical performance measures of mobility.
Keywords: Physical Performance Test, Gait Rating Assessment Scale.

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INTRODUCTION

Gait is an extremely complex motor ability composed of a sequence of cyclical movements of the lower limbs that generate body movements. The modifications to the gait patterns among elderly people have not been completely clarified, but many studies on this subject have been published. One of the most consistent findings from these studies is that elderly people walk more slowly than young adults. This phenomenon has been interpreted by some authors as a compensatory strategy to ensure stability. On the other hand, this modification has been associated with structural changes to the locomotors system, such as reductions in muscle strength, which are considered to be specific changes caused by aging. In addition to reductions in this component, other kinetic and kinematic changes that influence gait speed have been found in the literature. In older adults, gait variability is related to future mobility disability[1] and falls.[2–4] Gait variability also is related to balance, mental and functional status, and limitations of quality of life.[2] A valid measure of gait variability may help clinicians identify older adults at risk for falls and mobility disability. The majority of research studies that have examined the importance of gait variability have used computerized technology-intensive techniques to quantify gait variability.[2,4–7] The Modified Gait Abnormality Rating Scale (GARS-M), a 7-item observational scale, is a qualitative measure designed to identify abnormalities of gait characteristics that are associated with the risk of falling in older adults.[8] Variability, an item of the GARS-M that is used to measure the inconsistency and arhythmicity of stepping, is relatively easy to administer and may be a low-cost alternative to the technology-intensive methods currently used to measure gait variability in clinical settings. The purpose of this study was to validate an observational rating of gait variability by comparison with gait variability determined from gait characteristics recorded (video-tape) and to determine the reliability and validity of measurements obtained with a seven-item modified version of the Gait Abnormality Rating Scale (GARSM), an assessment of gait designed on physical performance test PPT who predict risk of falling among community dwelling, frail older persons because of movement control and biomechanical factors

MATERIAL AND METHOD

Hundred and six community-dwelling, frail older veterans referred to the GEM Program team for evaluation from December 1991 through December 1993 participated. Participants in the study were veterans referred to the Geriatric Evaluation to assess and manage community-dwelling, frail older veterans. The target population for the GEM Program has been community-dwelling older veterans who are experiencing difficulty managing daily activities and responsibilities needed for community dwelling. Subject with age 63 years and older, independent in ambulation with a straight cane or no assistive device; Mini-Mental State Examination score of ≥24 were included in the study. Exclusion criteria were subjects with self-reported persistent lower-extremity pain, presence of a progressive motor disorder, such as multiple sclerosis or Parkinson disease, lower-extremity amputation; and presence of medical instability (defined as an acute illness or cardiovascular disease, not well controlled with medication; hospitalization for cardiac reasons in the preceding 6 months; major thoracic or joint surgery; or a myocardial infarction, stroke, or transient ischemic attack in the preceding 6 months) Veterans referred to the GEM Program who demonstrated the ability to follow verbal requests for movement or tasks, had sufficient strength of the ankle dorsiflexor and plantar-flexor muscle groups to move against gravity, and ambulated without assistive devices other than a straight cane participated. Because the population seen was predominantly male and because of the difficulty of obtaining a meaningful number of female veterans (in the time period indicated, only 1 female veteran was evaluated by the GEM Program team but was excluded from the analyses in the study), subjects were male veterans only. Characteristics of the subjects, including fall status, are presented in Table 1.

Gait Analysis

Determination of the GARS-M score involved using a standard camcorder for recording the subject walking at a self- selected pace on the smooth tile surface of the hallway of an outpatient clinic. Subjects walked past the camcorder, turned around, and walked back past the camera so that anterior, posterior, and lateral views from both sides of the subject could be recorded for scoring purposes.12 The distance walked was approximately 76 m (25 ft) in each direction, for a total distance of about 152 m (50 ft).Videotapes of the walks were replayed on standard video-monitoring equipment, allowing for repeated playback and slow-action and stop-action viewing of the walk rating system easy and quick to perform, as Wolfson et al noted in describing the development of the scale. Scoring from the videotape record also saves the time and energy of the frail older person during the clinical evaluation. The GARS is supposed to include variables that are intended to provide a description of gait associated with an increased risk of falling. The variables in the original GARS were variability of stepping and arm movements, guardedness (i.e., a lack of propulsion or commitment to stepping), weaving, waddling, staggering, percentage of time in the swing phase of the gait cycle, foot contact, hip range of motion (ROM), knee ROM, elbow extension, shoulder extension, shoulder abduction, arm-heel-strike synchrony, head held forward, shoulder held elevated, and upper trunk flexed forward. Each of the seven items of the GARS-M was scored on the criterion-based rating scale (0-3) reported for the original GARS" (Appendix, page 1002). In scale order, the GARSM consisted of the following items: (1) variability, (2) guardedness, (3) staggering, (4) foot contact, (5) hip ROM, (6) shoulder extension, and (7) arm- heel-strike synchrony. Gait characteristics were recorded as described by Wolfson et al and Cerny. The participants wore permanent markers attached with masking tape to the back of the heel of the shoe, with the tip of the marker just touching the floor, during a timed walk on a brown-paper walkway. Stride length and walking speed were determined from the measures of three central strides of the walk to avoid any acceleration or deceleration effects of initiating or stopping a walk. Nine item Physical Performance Test was performed to assessed upper fine motor function, upper coarse motor function, balance ,mobility ,co-ordination and endurance. The entire test take 5-10min.specifically ADL activities are :

1. Items of perceived minimal difficulty are writing a sentence ,stimulated eating and turning 360 degree
2. Items of moderate difficulty are lifting a book, putting on and removing a jacket, picking up a penny from a floor and walking 50 feet
3. The most difficult item is climbing a stairs

Data Analysis

The subjects' mean age was 76 years (SD=7.1, range=63-93), their mean height was 148.0 cm (SD=8.03, range= 115.5 160.6), and their mean weight was 80.6 kg (SD=15.40, range=48.2-119.1). No differences were noted for age. Intrarater and interrater reliability of the GARS-M scoring were determined by two statistical methods. Cohen's Kappa statistic (K) for determining proportion of non chance agreement as used to describe the extent of agreement for scores of each of the seven individual items. Total scores were considered aggregate data, and the reliability was described using the intraclass correlation coefficient (ICC)."' The total GARS-M score is a sum of the seven individual items, and the total score represents a rank ordering of risk for falling based on the number of gait abnormalities recognized and the severity of any abnormality identified. The rank ordering of the original GARS total score was previously demonstrated by the association of greater GARS scores with more abnormal gait. The ICC is an appropriate reliability coefficient for demonstrating the extent to which raters indicate similar rank orderings.' The Kappa was designed as an index of assessment, indicating the concordance between individual ratings, and loses the ordering information contained in a scale when used for ordered data." The ratings for the GARS- M by the three raters were compared using the Kappa statistic in three ways: determination of intrarater reliability (agreement between two trials of the same rater), determination of interrater reliability (agreement among three raters for the same trial), and analysis of individual item scores (agreement of scores for an item, by all raters, for both trials). The Kappa values for each of the seven gait variables rated were averaged into a generalized Kappazh cross the entire GARSM for the determinations of intrarater and interrater reliability.

RESULTS

Intrarater- reliability

Comparison of the individual scores for the seven items of the GARS-M by the same rater for two trials using the Kappa statistic yielded generalized Kappa values of agreement of .493, .583, and .676 for the three raters. The physical therapist rater (JMVS) who scored the GARS-M for the validity determinations in this study demonstrated a Kappa coefficient of agreement of ,676 for intrarater reliability. According to Landis and the Kappa values reported would be interpreted as an indication of moderate agreement (K=.41-.60) to substantial agreement (K= .61-30) . A Kappa value near zero is considered chance agreement. Very high Kappa values are frequently restricted, particularly with limited variability of the data."' Comparison of the first and second trial scores for each of the three raters yielded ICCs for intrarater reliability for the GARS-M total scores of .968, .950, and .984.(Table 1)

Interrater –reliability

Comparison of the three raters' individual scores for all seven GARS-M items yielded generalized Kappa measures of agreement for interrater reliability of .577 for the first trial and .603 for the second trial. Clinical experience in observational gait analysis may have been a factor influencing interrater reliability. The two more experienced physical therapists (raters 2 and 3) demonstrated higher interrater reliability for the first and second trials (K=.789 and .886) compared with the least experienced physical therapist (rater 1). The generalized Kappa values for the same comparison between the rater 1 and either of the other raters ranged from .417 to .457 for tbe four comparisons The ICCs for comparison of the GARS-M total scores for the three raters were .968 and .975 for the two trials. The ICCs for comparison of total GARS-M scores were highly reliable, regardless of the rater's clinical experience.(Table:2) The majority of the older adults (mean age=76 years, SD=7.1) participating in the present study were male, and walked slowly compared with the typical adult walking speed of 1.2 to 1.3 m/s[14] (Table 3). Participants stratified on the basis of stance time variability (VG-GM versus NVG-GM) did not differ by age, race, sex, cognitive status, total comorbidity score, or median score in each comorbidity domain. The numbers of participants reporting comorbid conditions were as follows: cardiac[7], neurologic[6], respiratory[13], musculoskeletal[29], general[14], cancer[14], diabetes[3], and visual[22]. Compared with older adults categorized into the NVG-GM group (with respect to stance time variability), older adults categorized into the VG-GM group walked more slowly and with shorter step length, greater step width, and longer stance time. The VG-GM and NVG-GM groups differed in gait variability, with step length and stance time variability being larger and step width variability being smaller for older adults in the VG-GM group than in the NVG-GM group (Table 3). With stance time variability as the gold standard and the observational rating as the diagnostic test to be evaluated, 6 validity indexes were calculated. Of 21 older adults with stance time variability, 17 were correctly identified by the observational rating of gait variability (sensitivity=81%). Of 19 older adults without stance time variability, 10 were correctly identified by the observational rating of gait variability (specificity=53%). The positive predictive value of the observational rating of variability was 65%; of the 26 older adults identified as having gait variability by the observational rating, 17 were in the VG-GM group. The negative predictive value of the observational rating of variability was slightly better, at 71%; of the 14 older adults identified as not having gait variability by the observational rating, 10 were in the NVG-GM group. The positive and negative likelihood ratios were 1.72 and 0.36, respectively. Compared with older adults classified into the NVG-GM group on the basis of stance time variability, older adults classified into the VG-GM group differed with regard to the GARS-M variability item score, with median scores of 1 (mean=0.95; range=0–2) and 0 (mean=0.53; range=0–2), respectively. The measurable difference in the stance time variability of the older adults corresponded to an observable difference in gait variability noted by a physical therapist rating the gait abnormality. A comparison of the GARS-M item and total scores for participants stratified on the basis of stance time variability illustrated differences in observed gait abnormalities for groups defined by values for stance time variability associated or not associated with mobility disability. Differences between the groups of older adults with regard to variability, guardedness, foot contact, and hip range of motion (GARS-M items 1, 2, 4, and 5) and total GARS-M scores were seen (Table 6). Consistent and inconsistent groups were different in gait speed (0.66 and 0.49m/s, respectively ;p=0.003), step length (0.46 and 0.38m; p=0.008), step length variability (7.47% and 12.74%; p=0.043), the PPT (15.80 and 11.73; p<0.001) and GARS-M (5.83 and 10.66; p<0.001). Within both consistent and inconsistent groups, four groups defined by postural patterns, also differed in gait speed, step length, PPT and GARS-M scores (p<.05).

Table 1: Interrater Reliability for the Modified Gait Abnormality Rating Scale (GARS-M) Generalized Across Individual Variable Scores and for the total GARS-M score

Raters	Trial	Individuals variable score/Observed agreement	K$^{a(Kappa)}$	Total GARS-M SCORE ICC^{b}
1 and 2	1	.610	0.417	0.932
1 and 2	2	.625	0.431	0.944
1 and 3	1	.644	0.457	0.974
1 and 3	2	.641	0.447	0.943
2 and 3	1	.861	0.789	0.951
2 and 3	2	.991	0.886	0.993
1,2 and 3	1	.721	0.577	0.968
1,2 and 3	2	.739	0.603	0.975

Kappa for individual variables averaged into generalized Kappa for the entire scale. ICC-Intra-class correlation coefficient.

Table 2: Reliability of scoring individual variables Modified Gait Abnormality Rating Scale(GARS-M)

Variable	Observed agreement	K
Variability	0.812	0.635
Guardedness	0.758	0.587
Staggering	0.471	0.490
Foot contact	0.641	0.451
Hip Range Of Motion	0.708	0.533
Shoulder extension	0.753	0.631
Arm-heel-strike synchrony	0.656	0.485

Comparison of 138 scores for each item (i.e three raters, two trial,106 participant.

Table 3: Characteristics of Gait of Older Adults Stratified on the Basis of Stance Time Variability

Characteristic	All participant(n =106)	VG-GM Group(n= 50)	NVG-GM Group(n=56)	p-Value
AGE(YEAR)	76.2(6.8)	75.2(6.4)	75.1(7.1)	0.27
MALE (%)	12(46)	10(34)	12(26)	0.36
COMORBID CONDITION number of domain range from (0-8)	3.18(1.7)	3.06(2.0)	3.31(1.4)	0.45
MMSE Score(range 0-30)	28.7(1.7)	28.1(1.8)	29.0(1.6)	0.06
GAIT				
Gait speedm/s	0.88(0.27)	0.71(0.19)	1.04(0.23)	< .0001
Step length m	0.51(0.12)	0.44(0.08)	0.59(0.10)	< .0001
Step width m	0.23(0.04)	0.24(0.03)	0.21(0.04)	.001
Stance time s	0.78(0.15)	0.87(0.15)	0.69(0.06)	<.0001
Gait variability SD				
Step length	0.03(0.01)	0.04(0.02)	0.03(0.01)	.048
Step width	0.03(0.010	0.03(0.01)	0.03(0.01)	.16
Stance time	0.04(0.03)	0.06(0.04)	0.03(0.010)	.001

Data are X(SD): VG-GM older adult with stance time variability(SD) of $\geq$0.0365 s (variable group), NVG-GM older adult with stance time variability (SD) of < 0.0365 s (non variable group)

Table 4: Summary of Physical Performance Test Nine Item and Seven Item Result

	NINE- ITEM	SEVEN- ITEM
NO.OF SUBJECTS	106	106
Mean score	23.7(2-35)	18.3(2-25)
Standard deviation	7.8	5.1
10th percentile score	12	11
25th percentile score	21	15
75th percentile score	29	22
90th percentile score	31	24

Table 5: Validity index for observation rating of variability for stance time variability group

Observational rating(by GARS-M item 1)	VG-GM Group(n=50)	NVG-GM Group(n=56)	TOTAL	Positive/Negative predictive value(%)
Variability item score 1-3(VG-GARSM)	17	09	26	65
Variability item score of 0(byNVG- GARSM)	04	10	14	71[b]
Total	21	19	40	
Sensitivity /Specipicity(%)	81	53[b]		
Positive/Negative likelihood ratio	1.72	0.36[b]		

[a]Data are reported as number of older adults, unless otherwise indicated. GARS-M=Modified Gait Abnormality Rating Scale; VG-GM=older adults with stance time variability (SD) of ≥0.0365 s (variable group); NVG-GM=older adults with stance time variability (SD) of <0.0365 s (nonvariable group); VG-GARSM=older adults with a GARS-M variability item score of 1, 2, or 3 (variable group); NVG-GARSM=older adults with a GARS-M variability item score of 0 (nonvariable group). [b]Number for specificity, negative predictive value, and negative likelihood ratio.

Table 6: Difference in Modified Gait Abnormality scale and Total score for stance Time Variability Group

GARS-M ITEM SCORE	VG-GM Group(n=50)	NVG-GM Group(n=56)	P
Variability: inconsistency and arhythmicity of stepping	1	0	0.05
Guardedness: head ,arms,trunk in front of base,hesitancy	1	0	0.009
Staggering: sudden, laterally directed,partial losses of balance	0	0	0.81
Foot contact:degree to which heal strike the ground	1	0	0.001
Hip Range Of Motion:degree of loss of hip ROM	1	0	0.001
Shoulder extension:decrease in shoulder ROM	2	1	0.957
Arm-Heel strike synchrony:contralateral arm and leg movement out of phase	0	0	0.611
Total GARS-M Score(range-0-21)	**6**	**3**	**0.001**

VG-GM=older adults with stance time variability (SD) of ≥0.0365 s (variable group), NVG-GM=older adults with stance time variability (SD) of <0.0365 s (nonvariable group).

CONCLUSION

Gait pattern classification based on movement control and biomechanical factors has good concurrent validity with respect to gait and physical performance measures of mobility. The variability and postures determined by observation of gait by the therapists can be used to quickly identify and classify older adults with mobility problems in clinical settings, allowing for possible targeted interventions for specific gait deficits. Further studies are warranted using gait analyzer to validate the gait and physical performance measures of mobility.

REFERENCES

1. Perry J. Análise de marcha: marcha normal. São Paulo: Manole; 2005. p. 8-43.
2. Judge J, Davis RB, Ounpuu S. Age-associated reduction in step length: testing the importance of hip and ankle kinetics. Gait Posture. 1995;3(2):81.
3. Hausdorff JM, Nelson ME, Kaliton D, Layne JE, Bernstein MJ, Nuernberger A et al. Etiology and modification of gait instability in older adults: a randomized controlled trial of exercise. J Appl Physiol. 2001;90(6):2117-29.
4. Lockhart TE, Woldstad JC, Smith JL. Effects of age-related gait changes on the biomechanics of slips and falls. Ergonomics. 2003;46(12):1136-60.
5. Crosbie J, Vachalathiti R, Smith R. Age, gender and speed effects on spinal kinematics during walking. Gait Posture. 1997;5:13-20.
6. Ferrandez AM, Pailhous I, Durup M. Slowness in elderly gait. Exp Aging Res.1990;16:(1-2)79-89.
7. Stolze H, Friedrich HJ, Steinauer K, Vieregge P. Stride parameters in health old women-measurement variability in a simple walkway. Exp Aging Res.2000;26(2):159-68.
8. Teixeira CS, Link DM, Ribeiro JK, Costa VP, Mota CB. Aspectos biomecânicos do caminhar em idosos. In: XVII Jornada Acadêmica Integrada. Anais Acadêmicos da Universidade Federal de Santa Maria (UFSM): Santa Maria; 2002.
9. Buchner DM, Larson EB, Wagner EH, Koepsell TD, de Lateur BJ. Evidence for a non-linear relationship between leg strenght and gait speed. Age Ageing. 1996;25(5):386-91.
10. Sipilä S, Multanen J, Kallinen M, Era P, Suominen H. Effects of strength and endurance training on isometric muscle strength and walking speed in elderly women. Acta Physiol Scamd. 1996;156(4):457-64.
11. Carvalho J, Soares JMC. Envelhecimento e força muscular: breve revisão. Revista Portuguesa de Ciências do Desporto. 2004;4(3):79-93.
12. Kerrigan DC, Todd MK, Della Croce U, Lipsitz LA, Collins JJ. Biomechanical gait alterations independent of speed in the healthy elderly: evidence for specific limiting impairments. Arch Phys Med Rehabil. 1998;79(3):317-22.
13. Berg KO, Wood-Dauphinee S, Williams JI, Gayton D. Measuring balance in the elderly: preliminary development of an instrument. Physiotherapy Canada. 1989;41:304-11.

14. Tinetti ME. Performance-oriented assessment of mobility problems in elderly patients. J Am Geriatr Soc. 1986;34(2):114-26.
15. Gomes GC. Tradução, adaptação transcultural e exame das propriedades de medida da escala "Performanced-Oriented Mobility Assessment" (POMA) para uma amostra de idosos brasileiros institucionalizados (tese de Mestrado). Campinas: Unicamp; 2003.
16. Miyamoto ST, Lombardi Junior I, Berg KO, Ramos LR, Natour J. Brazilian version of the Berg balance scale. Braz J Med Biol Res. 2004;37(9):1411-21.
17. Berg K, Norman KE. Functional assessment of balance and gait. Clin Geriatr Med. 1996;12(4):705-23.
18. Buchner DM, Hornbrook MC, Kutner NG, Tinetti ME, Ory MG, Mulrow CD et al. Development of the common data base for the FICSIT trial. J Am Geriatric Soc. 1993;41(3):297-308.
19. Province MA, Hadley EC, Hornbrook MC, Lipsitz LA, Miller JP, Mulrow CD et al. The effect of exercise on falls in the elderly patients: A preplanned meta-analisis of the FICST Trials. Frailty and injuries: Cooperative Studies of Intervention Techniques. JAMA. 1995;273(17):1341-7.
20. VanSwearingen JM, Paschal KA, Bonino P, Yang JF. The modified Gait Abnormality Rating Scale and recognizing recurrent fall risk of community dwelling, frail older veterans. Phys Ther. 1996;76(9):994-1002.
21. Salmela LFT, Faria CDC, Cassiano JGC, Tirdo MGA. Vale a pena viver: promovendo autonomia e qualidade de vida para idosos. Anais do encontro de extensão da Universidade Federal de Minas Gerais (UFMG): Belo Horizonte; 2004.
22. Portney LG, Watkins MP. Statistical Measures of Rehability. In: Foundations of clinical research: applications to practice. 2ª ed. New Jersey: Prentice Hall Health; 2000. p. 528-36.
23. Montero-Odasso M, Schapira M, Soriano ER, Varela M, Kaplan R, Camera LA et al. Gait velocity as a single predictor of adverse events in healthy seniors aged 75 year and older. J Gerontology A Biol Sci Med Sci. 2005;60(10):1304-9.
24. Pijnappels M, Bobbert MF, van Dieën JH. Changes in walking pattern caused by the possibility of a tripping reaction. Gait Posture. 2001;14(1)11-8.
25. Lord SR, Lloyd DG, Li SK. Sensori-motor function, gait patterns and falls in community-dwelling women. Age Aging. 1996;25(4):292-9.
26. Stalenhoef PA, Diederiks JP, de Witte LP, Schiricke KH, Crebolder HF. Impact of gait problems and falls on functioning in independent living persons of 55 years and over: a community survey. Patient Educ Coun. 1999;36(1):23-31.
27. Maciel ACC, Guerra RO. Prevalência e fatores associados ao déficit de equilíbrio em idosos. Rev Bras Ci Mov. 2005;13(1):37-44.
28. Lord SR, Sherrington C, Menz HB. Falls in older people: risk factors and strategies for prevention. Cambridge: Cambridge University Press; 2001.
29. Roger MA, Evans WJ. Changes in skeletal muscle with aging: effects of exercise training. Exerc Sport Sci Rev. 1993;21:65-102

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