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Gait speed predictors and gait-speed cut-off score to discriminate asthma control status and physical activity in patients with asthma

Ismail Ozsoy *et al.*, Gait speed predictors and cut-off in asthma

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Short title: Gait speed predictors and cut-off in asthma

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ABSTRACT

Introduction: As a “vital sign” of health and functional capacity, gait speed is commonly used. However, there is insufficient evidence for possible determinants of gait speed in patients with asthma. The primary objective of the present study was to determine predictors of gait speed in patients with asthma. The second objective was to determine the cut-off point for the 4-minute Gait Speed (4MGS) to better discriminate asthma control status and physical activity in asthma.

Material and methods: Fifty-seven patients with asthma were included in this cross-sectional study. Demographic and clinic characteristics, pulmonary function, asthma control status (ACT, Asthma Control Test), dyspnea, gait speed (4MGS), physical activity

[International Physical Activity Questionnaire-Short Form (IPAQ-SF)] and activities of daily living were evaluated. Stepwise multiple linear regression analysis was used to investigate the possible predictors of gait speed. Receiver operating characteristic (ROC) curve analysis was used to determine whether usual gait speed had a discriminative value.

Results: The stepwise multiple regression analysis revealed that the ACT score and the IPAQ-SF score were significant and independent predictors of the 4MGS in patients with asthma explaining 40% of the variance in 4MGS ($p < 0.001$). The ROC curve showed a cut-off point of 1.06 m/s for the 4MGS for poorly controlled asthma and physical inactivity ($p < 0.05$).

Conclusions: Our findings indicate that asthma control status and physical activity can be independent predictors of gait speed in patients with asthma. In addition, gait speed may be discriminative to determine poorly controlled asthma and physical inactivity in patients with asthma.

Keywords: asthma, gait speed, physical activity

Introduction

Affecting around 300 million people worldwide [1], asthma is a chronic respiratory disease characterized by airway inflammation causing varying degrees of respiratory symptoms and expiratory airflow limitations [2]. In patients with asthma and other chronic lung diseases, the inability to achieve desirable physical activity levels deteriorates the quality of life [3]. Activity limitations in these patients stem from complex interactions between physiological, mechanical, and psychological mechanisms [3]. Impaired functional status is commonly reported in people with mild, moderate-to-severe, and difficult-to-control asthma [4, 5].

Gait capacity is a prominent determinant of functional status [6]. Precise integration of sensory, motor, and cognitive systems is essential for walking [7]. As a “vital sign” of health and functional capacity, gait speed is commonly used to measure mobility [7]. Lower gait speed represents the general degree of impairment, particularly in chronic respiratory diseases [8]. The 4-metre gait speed test (4MGS) can be used as a valid, reliable, and practical assessment of functional capacity in patients with asthma [9].

However, despite the prognostic significance of gait speed and the ease of measuring it in a reliable, precise and rapid way [9], there is insufficient evidence for possible determinants

of gait speed in patients with asthma. Therefore, the primary objective of the present study was to determine predictors of gait speed in patients with asthma. The second objective was to determine the cut-off point for the 4MGS to better discriminate asthma control status and physical activity in asthma.

Material and methods

Participants and study design

This study was designed as cross-sectional. A specialist (> 25 years of experience in asthma) made the diagnosis of asthma according to the Global Strategy for Asthma Management and Prevention (GINA) [10]. Inclusion criteria were as follows: being above 18 years of age; being under medical treatment for more than six months; clinical stability (i.e., no exacerbation or increase in medication for 30 days); and absence of any musculoskeletal and/or cardiovascular disease that might influence assessments. Individuals who were incapable of performing the test, those who had exacerbations during the assessment period; and patients diagnosed with other pulmonary disease(s) were excluded from the study.

The study was performed according to the guidelines of the Declaration of Helsinki. The study protocol was approved by X University Faculty of Health Sciences Ethics Committee (Report number: X). Informed consent was obtained from all participants included in the study.

Data collection

Demographic data and clinical characteristics of the participants were recorded.

Spirometric Assessment

A spirometer (Quark- SPIRO spirometer, COSMED, Roma, Italy) was used to evaluate pulmonary functions according to European Respiratory Society (ERS) and American Thoracic Society (ATS) guidelines [11]. The following parameters were measured and recorded: forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), and FEV1/FVC ratio.

Asthma Control Test (ACT)

The ACT was used to evaluate asthma control status. The test consists of five items scored on a range of 1–5. The highest score is 25 and indicates “perfectly controlled asthma”, and any score above 19 represents “well-controlled disease” [12].

Dyspnea Assessment

The Modified Medical Research Council (mMRC) Dyspnea Scale which quantifies disability attributable to breathlessness was used to assess dyspnoea [13].

4-Minute Gait Speed (4MGS)

The gait speed was determined using the 4MGS [14]. The participants were asked to walk at their normal speed along an 8-meter-long hallway, divided into three zones: acceleration zone (2 m), central “testing” zone (4 m), and deceleration zone (2 m). A stopwatch recorded the total time from the starting to the endpoint. The gait speed was calculated for each participant as “walking distance divided by time” [15]. The 4MGS was performed by two physiotherapists (> 10 years of experience). All measurements were performed by these two physiotherapists.

International Physical Activity Questionnaire-Short Form (IPAQ-SF)

The IPAQ-SF assesses physical activity level in terms of vigorous and moderate activities, and walking. To calculate scores, each activity duration is multiplied by its known metabolic equivalents (MET) [16]. The IPAQ-SF score < 600 MET min/week indicates physical inactivity [17].

London Chest Activity of Daily Living Scale (LCADL)

The LCADL assesses dyspnea originating from activities of daily living. Each of the 15 scale items is graded on a range of 0–5, in which lower scores indicate less difficulty in

performing ADL. We used the Turkish version of the LCADL, which is valid and reliable in obstructive lung disease [18].

Sample size

The minimum required sample size was calculated using G*Power Software (ver. 3.1.9.2, Düsseldorf, Germany). To our knowledge, the possible factors that influence the 4MGS have not been investigated in patients with asthma. Nevertheless, according to a previous study, the best equation ($R^2 = 0.131$) to predict usual gait speed in older adults included hip flexor strength, body mass, and gender [19]. Based on the afore-mentioned study, the minimum required sample size for multiple regression analysis (with eight predictors in the model) was 55 participants for the probability level of 0.05, anticipated effect size of 0.15, and statistical power level of 80%.

Data analysis

The IBM® SPSS® Statistics for Windows software (ver. 20.0; IBM Corp., NY, USA) was used to analyse the data. To check the normality of data distribution, visual (histograms, probability plots) and analytical methods (Skewness and Kurtosis tests) were used. Values were expressed as numbers for categorical variables and mean \pm standard deviation and median [interquartile range 25–75%] for continuous variables. Mann-Whitney U Test, Student t-test, and Chi-square test were used to compare the groups. To examine the correlation between the 4MGS and other study variables, the Pearson correlation coefficient was calculated. To identify variables that could best determine the 4MGS, we used stepwise multiple linear regression analysis and included the variables significantly correlated with the 4MGS (i.e., ACT, mMRC, IPAQ-SF, LCADL) in the regression model. In addition, receiver operating characteristic (ROC) curve analysis was used to determine whether usual gait speed had discriminative value for poorly controlled asthma ($ACT \leq 19$) and physical inactivity ($IPAQ-SF < 600$ MET min/week). The cut-off value of gait speed corresponding to optimal sensitivity and specificity was identified as the point on the ROC curve closest to the (0.1) point [20]. The level of significance was set at $p < 0.05$.

Results

Convenience sampling was used in the study. During the data collection period, 61 patients were interviewed, and 57 of them met the inclusion criteria were included in the study. Two patients did not volunteer to participate and two patient had a musculoskeletal problem.

Firstly, the ROC curve showed a cut-off point of 1.06 m/s for the 4MGS for poor controlled asthma and physical inactivity (Fig. 1). According to this cut-off value, the participants were divided into two groups. The demographic and clinical features of the participants are given in Table 1. There was no statistically significant difference with regards to demographic variables (except age) and spirometric values [FEV1/FVC, FEV1 (% pred), FVC (% pred)] between the patients who scored ≤ 1.06 m/s and > 1.06 m/s in the 4MGS ($p > 0.05$, Tab. 1). Those who scored ≤ 1.06 m/s in the 4MGS had lower scores on the ACT and the IPAQ-SF when compared to those who scored > 1.06 m/s ($p < 0.05$, Tab. 1). The mMRC and LCADL scores were higher in those who scored ≤ 1.06 m/s than those who scored > 1.06 m/s ($p < 0.05$, Tab. 1).

The 4MGS was significantly correlated with the ACT score ($r = 0.584$, $p < 0.001$), mMRC score ($r = -0.445$, $p = 0.001$), IPAQ-SF score ($r = 0.492$, $p < 0.001$), and LCADL ($r = -0.463$, $p < 0.001$) (Tab. 2).

The stepwise multiple regression analysis revealed that the ACT score and the IPAQ-SF score were significant and independent predictors of the 4MGS in patients with asthma explaining 40% of the variance in 4MGS ($p < 0.001$, Tab. 3). The regression equation formula was: **4MGS = 0.578 + (0.027 × ACT score) + (0.001 × IPAQ-SF score)** (Tab. 3).

Gait speed had a discriminative value for poorly controlled asthma with an area under the curve (AUC) of 0.80 ($p = 0.003$, 95% confidence interval 0.64–0.96). Gait speed of 1.06 m/s had a sensitivity of 90% and specificity of 70% to predict poorly controlled asthma in patients with asthma (Fig. 1. A). Gait speed had a discriminative value for physical inactivity with an AUC of 0.73 ($p = 0.004$, 95% confidence interval 0.59–0.86). Gait speed of 1.06 m/s had a sensitivity of 62% and specificity of 77% for the prediction of physical inactivity in patients with asthma (Fig. 1. B).

Discussion

To the best of our knowledge, the present study is the first to determine predictors of the 4MGS and identify a cut-off point to allow the 4MGS to be interpreted relative to impairment of asthma control status and physical activity. The study's main finding demonstrated that asthma control status and physical activity were independent determinants of the gait speed assessed by the 4MGS with explaining 40% of the variance in patients with asthma. In addition, we demonstrated that the gait speed of 1.06 m/s was a threshold to predict poorly controlled asthma and physical inactivity in this population.

The 4MGS is a practical, reliable, and valid tool to evaluate the functional capacity in patients with asthma [9]. Gait speed is frequently considered a functional "sixth vital sign" in the relevant literature [21].

The ACT is a simple self-report tool that can help the healthcare practitioner to recognise any improvements or deteriorations based on the level of asthma control [22]. It is reported that a higher level of regular physical activity is correlated with well controlled asthma [23]. A previous study showed a lower level of general health-related quality of life in patients with uncontrolled asthma compared to patients with the controlled disease [24]. In addition, our study showed that the ACT score has an impact on the 4MGS indicating that well controlled disease contributes to gait speed in patients with asthma.

Asthma adversely affects physical activity levels. Similarly, insufficient physical activity may worsen asthma outcomes [23]. There is an evidence-based relationship between higher levels of physical activity and less exacerbations, better overall asthma control, and less need for healthcare services [25]. Additionally, the association between functional exercise capacity and gait speed is shown [9]. Although the association between physical activity and gait speed is reported in patients with COPD [15], such a relationship has not been investigated in patients with asthma. We found that physical activity is a determinant of the 4MGS. This finding shows that physical inactivity can cause a limitation in gait speed in this population.

Gait speed was discriminative to determine frailty [26], poor exercise capacity [27, 28], physical inactivity [29], and health status [30] in elderly and cardiopulmonary diseases. To our knowledge, no other studies have introduced a threshold to predict poorly controlled asthma and physical inactivity in patients with asthma. However, our cut-off points slightly differ from the results of previous studies investigating the 4MGS. Karpman et al. [15] reported the gait speed of 0.8 m/s as a cut-off predicting poor exercise capacity in patients

with COPD. Likewise, the gait speed of 0.85 m/s was considered a threshold to predict physical inactivity in elderly [29]. The gait speed of 1 m/s is a cut-off for predicting the disease prognosis in older adults with heart failure [31]. Similarly, persons with walking speed above 1 m/s are independent in ADL, less likely to be hospitalized, and less likely to have an adverse event [21]. According to our results, a gait speed of 1.06 m/s is an indicator of poorly controlled asthma (sensitivity of 90% and specificity of 70%) and physical inactivity (sensitivity of 62% and specificity of 77%) in patients with asthma. We think that the different cut-off scores may be caused by the method and population differences in the studies. However, the results of our study being the first results on this subject will be a reference for future studies.

Due to the limitations of our study, the results should be interpreted with caution. First, including an age- and sex-matched healthy control group would enable us to compare the gait speed between the two groups and could provide a deeper understanding of whether the specified factors that impact the 4MGS are exclusively relevant to patients with asthma. Second, although the number of participants was higher than the minimum required sample size, the percentage of male participants was low; a fact that reduces the generalizability of our findings. Third, although our sample size was larger than the minimum required sample size, not enough to analyse asthma subgroups (for example well controlled, severe or moderate asthma) and clinical findings, which limits the generalizability of the results. Fourth, the use of self-reported questionnaires and the fact that it is a single-centered study are other limitations of our study. In this respect, there is a need for multicentre studies that include asthma subgroups and healthy controls.

Conclusions

To the best of our knowledge, this is the first study investigating the possible functional determinants of gait speed and its cut-off point to discriminate asthma control status and physical activity in asthma patients. Our findings indicate that asthma control status and physical activity can be independent predictors of gait speed in patients with asthma. In addition, gait speed may be discriminative to determine poorly controlled asthma and physical inactivity in patients with asthma.

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Conflict of interest

None declared.

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Table 1. Demographic and characteristic features

Variables	All participants (n = 57)	Gait speed ≤ 1.06 m/s (n = 34)	Gait speed > 1.06 m/s (n = 23)	P-value
Age (years)	52.89 ± 15.18	57.50 ± 14.91	46.08 ± 13.10	0.004^a
Sex (men/woman)	5/52	3/31	2/21	0.987 ^c
BMI [kg/m ²]	30.19 ± 6.02	30.73 ± 6.33	29.40 ± 5.58	0.421 ^a
FEV1/FVC	82.62 ± 8.75	82.40 ± 8.87	82.95 ± 8.76	0.827 ^a
FEV1 (%pred)	83.30 ± 18.45	80.62 ± 18.99	87.38 ± 17.25	0.195 ^a
FVC (%pred)	85.66 ± 18.98	83.21 ± 20.63	89.38 ± 15.89	0.252 ^a
ACT score	15.10 ± 4.93	12.97 ± 4.50	18.26 ± 3.74	< 0.001^a
mMRC score	2.00 [1.00–3.00]	2.50 [2.00–3.00]	1.00 [1.00–2.00]	0.002^b
4-m gait speed [m/s]	1.07 ± 0.28	0.89 ± 0.13	1.35 ± 0.21	< 0.001^a
IPAQ-SF (MET min/week)	755.61 ± 697.50	495.14 ± 431.52	1140.65 ± 836.19	< 0.001^a
LCADL score	34.12 ± 18.57	41.35 ± 18.34	23.43 ± 13.17	< 0.001^a

a: Student t Test; b: Mann-Whitney U Test; c: Chi-square Test. Data are presented as absolute or relative value, mean ± SD or median (interquartile range 25–75%).

ACT — Asthma Control Test; BMI — body mass index; FEV1 — forced expiratory volume in the 1st second; FVC — forced vital capacity; IPAQ-SF — International Physical Activity Questionnaire-Short Form; LCADL — London Chest Activity of Daily Living Scale; mMRC — modified Medical Respiratory Council.

p-values: comparisons between gait speed groups.

Bold values highlight statistically significant results.

Table 2. Correlations between gait speed and other outcomes

Variables (n = 57)	r*	P-value
BMI [kg/m ²]	-0.215	0.108
FEV1/FVC	-0.042	0.768
FEV1 (% pred)	0.195	0.163
FVC (% pred)	0.215	0.121
ACT score	0.584	< 0.001
mMRC score	-0.445	0.001
IPAQ-SF (MET min/week)	0.492	< 0.001
LCADL score	-0.463	< 0.001

*Pearson's product moment correlation coefficient.

ACT — Asthma Control Test; BMI — body mass index; FEV1 — forced expiratory volume in the 1st second; FVC — forced vital capacity; IPAQ-SF — International Physical Activity Questionnaire-Short Form; LCADL — London Chest Activity of Daily Living Scale; mMRC — modified Medical Respiratory Council.

Bold values highlight statistically significant results.

Table 3. Stepwise multiple linear regression model of gait speed

Variable	B	SE	Beta	p-value
Constant	0.578	0.095	—	< 0.001

ACT score	0.027	0.006	0.463	< 0.001
IPAQ-SF (MET min/week)	0.001	0.001	0.312	0.007

R = 0.65, R² = 0.42, adjusted R² = 0.40 (p < 0.001)

B — unstandardized regression coefficient; SE — standard error.

ACT — Asthma Control Test; IPAQ-SF — International Physical Activity Questionnaire-Short Form.

Bold values highlight statistically significant results.

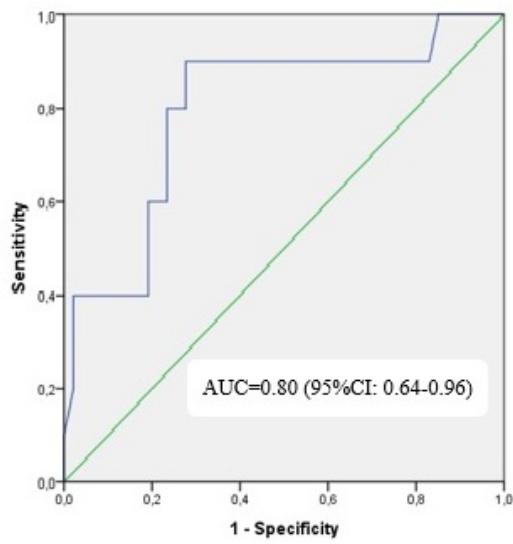
Figure Legends

Figure 1. Receiver operating characteristic curves for gait speed cut-off point to discriminate poor controlled asthma and physical inactivity in patients with asthma

A. Asthma Control Test (ACT) > 19 and ≤ 19: cut-off point = 1.06 m/s; sensitivity = 90%; specificity = 70%; area under the curve (AUC) = 0.80 (95% CI: 0.64–0.96); p = 0.003.

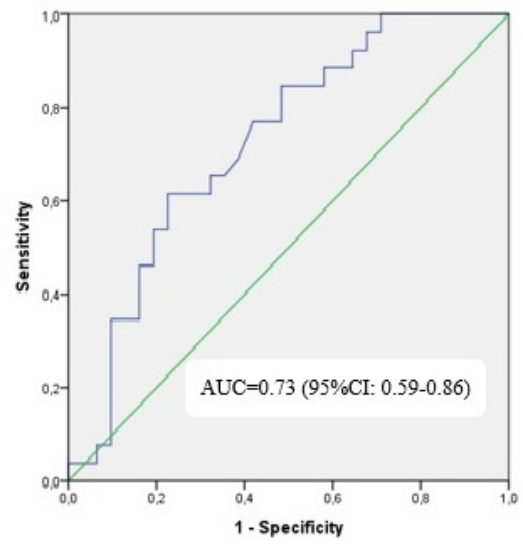
B. International Physical Activity Questionnaire-Short Form (IPAQ-SF) ≥ 600MET/min/week and < 600MET/min/week: cut-off point = 1.06 m/s; sensitivity = 62%; specificity = 77%; area under the curve (AUC) = 0.73 (95% CI: 0.59–0.86); p = 0.004.

ACT
>19 and ≤19



A

IPAQ-SF
≥600MET min/week and <600MET min/week



B