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ARTYKUŁ ORYGINALNY / *ORIGINAL ARTICLE*

Value of Duke treadmill score in predicting coronary artery lesion and the need for revascularisation

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Abstract

Background: Exercise electrocardiography is a long-standing method for the evaluation of coronary artery disease (CAD), and it remains the initial test for most patients who can exercise adequately with a baseline interpretable electrocardiogram. However, there is little information about the relationship between Duke treadmill test score (DTS) and severity of coronary artery lesion, as well as estimating the need for revascularisation.

Aim: The aim of the study was to ascertain whether the DTS could be an efficient parameter in choosing coronary revascularisation in different DTS groups.

Methods: Two hundred and fifty-eight (n = 258) patients had positive exercise testing for CAD and underwent coronary angiography. The patients were divided into three groups according to the DTS: low-risk (with a score of ≥ +5), moderate-risk (with scores ranging from –10 to +4), and high-risk (with a score of ≤ –11). Coronary angiography was done by the Judkins technique. A coronary lesion was considered significant when stenosis of the coronary artery was ≥ 70% and stenosis of the trunk was ≥ 50%. The SYNTAX score was determined.

Results: The study group included 258 patients with mean age 62.66 ± 9.6 years, and most of them were men (72.8%). Patients with high- and intermediate-risk DTS had the same SYNTAX score (16.35 ± 7.3, 15.09 ± 10.08 and 11.80 ± 9.88, respectively; p = 0.064) compared to low-risk DTS. A negative correlation between DTS and significant coronary artery stenosis (r = –0.181; p = 0.005), SYNTAX score (r = –0.173; p = 0.007), and cardiac revascularisations (r = –0.213; p = 0.001) were found. In multiple linear regressions to predict coronary revascularisation the SYNTAX score (B = 0.018; p = 0.0001), DTS (B = –0.014, p = 0.008) and previous myocardial infarction (B = –0.143; p = 0.047) were significant predictors.

Conclusions: The DTS alone is a useful tool in suspecting a significant coronary artery stenosis, but it is not accurate enough for revascularisation. Thus, by adding clinical information, its value may be maximised.

Key words: Duke treadmill score, SYNTAX score, exercise stress test, revascularisation, previous cardiovascular outcomes

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INTRODUCTION

Exercise testing is commonly used to predict coronary artery disease (CAD), the extent of coronary artery stenosis, and risk of cardiovascular outcomes in symptomatic patients. Exercise electrocardiogram (ECG) remains the least costly choice and is recommended in patients with suspected stable CAD with interpretable resting ECG [1]. However, its sensitivity and specificity is limited (67% and 71%, respectively) [2] compared to imaging stress tests. Also, it is less sensitive and specific for women [1]. Therefore, various scoring systems have been introduced to improve the specificity and sensitivity of the exercise ECG.

One of the most popular validated indexes, the Duke treadmill score (DTS), was originally a prognostic index;

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however, it became a diagnostic tool and proved to be a better predictor of CAD than ST-segment depression alone [3].

Use of DTS improves the diagnostic accuracy of exertional ST-segment depression [4] and has been noticed to add independent prognostic information to that provided by clinical data, coronary anatomy, and left ventricular function [5]. It has been shown that important information about coronary artery lesion complexity can be acquired by assessing DTS before invasive coronary artery testing [6].

There have been many studies in this field, and the diagnostic and prognostic value of DTS is quite well defined [2–9]. However, a possible limitation of earlier studies is that the results were obtained before the use of current medical therapies that significantly improve patient outcomes, such as statin therapy to appropriate low-density lipoprotein cholesterol (LDL-C) goals and perhaps lower blood pressure (BP) goals [10]. Our study evaluated DTS in a complex with coronary artery lesions, clinical data, and metabolic profile. Moreover, we considered the need for early revascularisation, which has not been analysed frequently.

The aim of the study was to ascertain whether the DTS could be an efficient parameter in choosing coronary revascularisation in different DTS risk groups.

METHODS

The study group comprised consecutive patients admitted between May 2014 and October 2016 to the Vilnius University Hospital Santariskiu Clinic in the Preventative Cardiology Department with chest pain and positive treadmill test. Patients with unstable angina pectoris, cardiomyopathy or congenital heart disease or other contraindications for exercise testing were excluded from analysis. Patients without exercise treadmill testing (ETT) or coronary angiography and with ETT with not interpretable ECG (left bundle-branch block, not known ST depression, pre-excitation) were also excluded from analysis. Informed consent was obtained from all patients.

Exercise treadmill testing

All patients underwent symptom-limited exercise testing according to the standard Bruce protocol test with standard ECG, BP, and heart rate measurements performed at prespecified time points according to relevant guidelines [11] and were exercised to the endpoints described in the original DTS study by Mark et al. [4].

Resting heart rate, BP, and 12-lead ECGs were recorded in the supine and upright positions before exercise. The target heart rate was determined according to the formula 0.85 × (220 – age). During each minute of exercise, heart rate, BP, and ECG were recorded.

Exercise testing was discontinued if exertional hypotension, malignant ventricular arrhythmias, or limiting chest pain was reported.

An abnormal exercise ST response was defined as follows: 1 mm of horizontal or down-sloping ST depression (J point ± 80 ms) or 1 mm of ST-segment elevation in leads without pathological Q waves (excluding aVR lead). Exercise-induced ST-segment deviation was coded to the nearest 0.25 mm for horizontal and down-sloping ST-segment depression and ST-segment elevation in a non-Q-wave lead.

Duke treadmill score

The equation for calculating the DTS is as follows: DTS = exercise time – (5 × ST deviation) – (4 × exercise angina). Exercise angina was assessed as one of three levels: 0, none; 1, non-limiting; and 2, exercise-limiting. The DTS was grouped into low-risk (with a score of ≥ +5), moderate-risk (with scores ranging from –10 to +4), and high-risk (with a score of ≤ –11) categories.

Coronary angiography

Coronary angiography was performed by the Judkins technique, using the standard Seldinger technique through a percutaneous femoral artery puncture. Each angiogram was analysed independently by experienced interventional cardiologists who were blinded to the patients' clinical data and to inclusion of participants in the study.

A coronary lesion was considered haemodynamically significant when stenosis of the coronary artery was ≥ 70% and stenosis of the trunk was ≥ 50%.

Each coronary lesion producing 50% diameter stenosis in vessels of 1.5 mm was scored separately and added together to provide the overall SYNTAX score, which was calculated prospectively using the SYNTAX score algorithm [12].

Statistical analysis

Continuous and normally distributed variables are presented as mean ± standard deviation (SD), while continuous variables with asymmetric distribution are presented as median with range values (min–max). The normality assumption for continuous variables was evaluated by the Kolmogorov-Smirnov test. Categorical data are presented as counts and percentages. The Spearman's correlation analysis was used to assess the correlation between DTS, ST-segment depression, and significant coronary artery stenosis, and coronary artery revascularisation, also for correlation between identified significant stenosis, coronary artery revascularisation, and previous cardiovascular events. Comparing risk factors between groups was done by using the Kruskall-Wallis test. The Mann-Whitney U test was used as a post hoc test after the Kruskal-Wallis test. A multiple linear regression was calculated to predict coronary revascularisation based on previous cardiovascular events, risk factors, max ST depression, SYNTAX score, and DTS.

Statistical analysis was performed by using SPSS 17.0. All p-values were two-tailed with a value ≤ 0.05 considered to be statistically significant.

RESULTS

The study group included 258 patients, with mean age 62.66 ± 9.68 years, and about two thirds were men (72.8%).

Table 1. Baseline characteristics

	All patients (n = 258)	Low-risk group (n = 67)	Moderate-risk group (n = 167)	High-risk group (n = 24)	P
Male sex	72.8%	83.6%	69.6%	50.0%	0.032
Age [years]	62.66 ± 9.6	60.82 ± 9.3	63.3 ± 9.6	68.8 ± 10.5	0.057
Body mass index [kg/m^2]	30.24 ± 4.43	31.0 ± 4.32	29.92 ± 4.49	30.24 ± 4.43	0.223
Diabetes	22.2%	20.9%	23.1%	14.3%	0.821
Hypertension	97.5%	100%	96.4%	100%	0.260
Hyperlipidaemia	95.1%	94%	96.4%	71.4%	0.01
Previous MI	54.3%	52.2%	56.2%	28.6%	0.328
Previous PCI	63%	61.2%	63.35	71.4%	0.855
Previous CABG	10%	3%	4.7%	0%	0.711
No previous cardiovascular events	29.6%	31.3%	29%%	28.6%	0.800
LDL-cholesterol	3.62 ± 1.25	3.29 ± 1.24	3.52 ± 1.24	3.62 ± 1.57	0.545
Triglycerides	1.76 ± 1.03	1.73 ± 1.04	1.79 ± 1.05	1.52 ± 0.30	0.786
Heart rate [bpm]	69.47 ± 11.73	67.0 ± 10.37	70.09 ± 12.09	78.0 ± 10.33	0.027
DTS [points]	1.23 ± 5.59	7.56 ± 1.70	–0.7 ± 3.98	–12.59 ± 2.88	0.0001
Exercise time [s]	6.27 ± 6.87	7.74 ± 8.66	5.69 ± 6.34	2.84 ± 5.42	0.0001
Max ST segment depression [mean]	0.659 ± 0.778	0.082 ± 0.269	0.83 ± 0.76	2.11 ± 0.63	0.0001
SYNTAX score [points]	14.22 ± 10.04	11.80 ± 9.88	15.09 ± 10.08	16.36 ± 7.37	0.064

Data are presented as mean ± standard deviation or percentage. CABG — coronary artery bypass graft surgery; PCI — percutaneous coronary intervention; MI — myocardial infarction; LDL — low-density lipoprotein; DTS — Duke treadmill score

Baseline subjects' characteristics by group are shown in Table 1.

Comorbid hypertension, CAD, and diabetes were seen in the same number of patients in all groups. Hyperlipidaemia was more frequent in the moderate-risk group than in the high-risk group (96.4%, 94.0% vs. 71.4%; p < 0.001).

A negative correlation between DTS and significant coronary artery stenosis (r = –0.181, p = 0.005), SYNTAX score (r = –0.173; p = 0.007), and cardiac revascularisations (r = –0.213; p = 0.001) was found. The correlation between SYNTAX score and TDS is shown in Figure 1. Furthermore, a positive correlation was found between maximum ST-segment depression in the ECG during exercise test, and significant coronary artery stenosis was observed during coronary artery angiography (r = 0.155; p = 0.016) as well as between ST-segment depression and cardiac revascularisation (r = 0.133, p = 0.038) or SYNTAX score (r = 0.154; p = 0.017).

Significant coronary artery stenosis was observed more often in patients of the high-risk group (85.7%) and more often in the moderate-risk group (71%) than in the low-risk group (50.7%; p = 0.005). Angiographic characteristics of patients are summarised in Table 2.

Therefore, lower-risk group patients were treated conservatively more often than moderate-risk group patients (p = 0.038) or high-risk group patients. In the low-risk group only 29.7% of patients were referred for revascularisation after coronary artery angiography, while in the moderate-risk group it was 52.3%, and in high risk group it was 50%. More detailed treatment modalities are shown in Table 3.

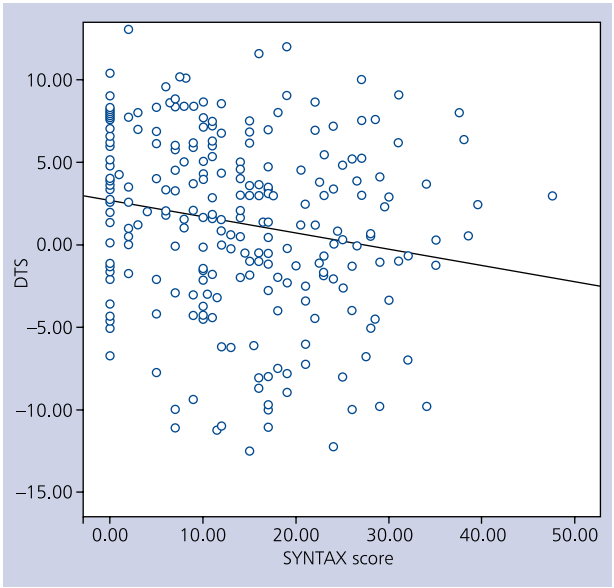

Figure 1. Correlation between Duke treadmill score (DTS) and SYNTAX score

The Duke treadmill test score of patients subsequently treated with cardiac revascularisation was significantly

Table 2. Characteristics of angiography results in study groups

Significant stenosis	All patients (n = 258)	Low-risk group (n = 67)	Moderate-risk group (n = 169)	High-risk group (n = 24)	P*
Right coronary artery	32.5%	28.4%	34.3%	28.6%	0.254
Left anterior descending artery	35.0%	23.9%	38.5%	57.1%	0.114
Right circumflex artery	29.6%	23.9%	30.8%	57.1%	0.154
Main artery	4.5%	3%	5.3%	0%	0.486

*P value by χ^2 test

Table 3. Treatment methods

	All patients (n = 258)	Low-risk group (n = 67)	Moderate-risk group (n = 169)	High-risk group (n = 24)	P*
Medical therapy	53.9%	70.1%	47.6%	50%	0.038
Percutaneous coronary intervention	36.6%	22.4%	42.3%	37.5%	
Coronary artery bypass grafting	9.5%	7.5%	10.1%	12.5%	

*P value by χ^2 test

($p < 0.001$) lower (0.08 ± 5.13) than in those treated conservatively (2.76 ± 5.12).

Previous cardiovascular events correlated with significant coronary artery stenosis ($r = 0.293$; $p = 0.001$), SYNTAX score ($r = 0.345$; $p = 0.0001$), and subsequent coronary artery revascularisation ($r = 0.220$; $p = 0.001$).

By analysing the patients who had prior cardiovascular events, we noticed that they were referred to coronary artery revascularisation 2.44 times more often than those who had no such anamnesis (odds ratio [OR] 2.442, 95% confidence interval [CI] 1.327–4.492). Patients in the low-risk group, who had cardiovascular events, had more than three-times higher probability (OR 3.103, 95% CI 0.787–12.238), and patients in the moderate-risk group had over two-times higher probability (OR 2.482, 95% CI 1.209–5.095).

By counting on multiple linear regression to predict coronary revascularisation (an adjusted sum of squares 12.262; mean square 3.066; $p = 0.001$), previous myocardial infarction (MI) (unstandardised coefficient $B = 0.143$, $p = 0.047$) and DTS (unstandardised coefficient $B = -0.014$, $p = 0.008$) were significant predictors. Other risk factors (gender, diabetes, hypertension, lipid profile) were excluded of the model because of their insignificant impact.

DISCUSSION

In this study, we could establish an important risk stratification role for the DTS in patients with known or suspected CAD and with or without previous revascularisation.

Using economical non-invasive techniques, like exercise ECG testing, develops a challenge to predict CAD in the growing number of patients with chest pain or at risk for CAD, and a challenge to decide which patients need and which do not need early revascularisation. The DTS, which is calculated from exercise ECG testing, traditionally a prognostic score, also was tested as a diagnostic score, and was shown to predict CAD better than the ST response alone [13].

There is little data about the relationship between DTS and haemodynamically significant coronary artery lesions, the extent of atherosclerosis, and its usefulness for revascularisations. This is also important in clinical practice for choosing a diagnostic and treatment method (invasive coronary angiography or non-invasive computed tomography coronary angiography). Shaw et al. [5] demonstrated that DTS was effective in diagnosing significant and severe CAD. They regarded CAD severity as the number of diseased arteries rather than the degree of stenosis of coronary arteries.

In the present study, a significant and negative correlation was demonstrated between DTS and SYNTAX score or significant coronary artery stenosis, and between DTS and cardiac revascularisation. Furthermore, there was a significant positive but weaker correlation between maximum ST-segment depression in the ECG during exercise test and SYNTAX score, as well as between ST-segment depression and cardiac revascularisation. These findings suggest that the use of DTS may add useful information and may help to create an early decision about the need for revascularisation.

Clinical history and physical examination can provide important prognostic information [1]. An important factor to consider is prior MI [13], symptoms and signs of heart failure [13, 14], and the pattern of occurrence (recent onset or progressive) and severity of angina, particularly if unresponsive to therapy [15–17]. However, this information is too complex to

be placed into a clinically useful event risk score for patients with CAD, or to instantly decide about the need for subsequent coronary artery revascularisation.

In this study, significant positive correlation was demonstrated between previous MI and subsequent coronary artery revascularisation. Also, we found that previous MI was a significant predictor of coronary artery revascularisation. These results suggest that not only use of DTS, but also use of additional clinical information, in this case previous MI, may help to make an early decision about the need for revascularisation.

The analysis of this data set has important limitations. Selection bias into our cohort may have been introduced by selecting patients from only one institution; however, our study population includes several patients with multiple cardiac risk factors: previous MI and revascularisations, and therefore is an adequately heterogeneous sample.

There may be a risk of circular logic using the treadmill result to predict cardiac outcomes (e.g. regarding the decision to perform percutaneous coronary intervention); however, the Cardiology Service did not routinely calculate the DTS and were therefore "blinded" to the numerical score, which is an objective criterion.

To avoid these limitations, future studies might benefit from a larger, consecutive sample taken from multiple hospital centres. Performance of DTS should be examined in a larger group of patients with various exercise ECG testing results.

CONCLUSIONS

In conclusion, the ETT remains a useful tool in suspecting the significance of coronary artery stenosis, and the test diagnostic value may be maximised by adding clinical information, which is encouraged. However, it is not enough to assess a risk group by DTS; clinical history should also be considered.

Conflict of interest: *none declared*

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Wartość wskaźnika Duke w teście wysiłkowym na bieżni w prognozowaniu zmian w tętnicach wieńcowych i konieczności rewaskularyzacji

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Streszczenie

Wstęp: Elektrokardiograficzna próba wysiłkowa to stosowana od wielu lat metoda oceny występowania i zaawansowania choroby wieńcowej (CAD). Jest ona nadal wykorzystywana jako wstępne badanie u większości osób, u których wyjściowy, możliwy do oceny zapis elektrokardiograficzny wskazuje, że mogą one podejmować aktywność fizyczną. Niewiele jest jednak dostępnych informacji na temat zależności między wartością wskaźnika Duke w próbie wysiłkowej (DTS) a nasileniem zmian w tętnicach wieńcowych i koniecznością wykonania rewaskularyzacji.

Cel: Badanie przeprowadzono w celu upewnienia się, czy DTS może być użytecznym parametrem w kwalifikowaniu do rewaskularyzacji tętnic wieńcowych.

Metody: U 258 pacjentów z dodatnim wynikiem próby wysiłkowej wskazującym na występowanie CAD wykonano koronarografię. Chorych podzielono na trzy grupy w zależności od wartości wskaźnika DTS: grupa niskiego ryzyka (wskaźnik Duke ≥ +5), grupa pośredniego ryzyka (wskaźnik Duke od –10 do +4) i grupa wysokiego ryzyka (wskaźnik Duke ≤ –11). Koronarografię przeprowadzono za pomocą techniki Judkinsa. Zmiany w naczyniach wieńcowych uważano za istotne, jeśli zwężenie tętnicy wieńcowej wynosiło ≥ 70%, a zwężenie pnia ≥ 50%. U chorych określono również wartość wskaźnika SYNTAX.

Wyniki: Średnia wieku w badanej grupie 258 chorych wynosiła 62,66 ± 9,6 roku, a odsetek mężczyzn (72,8%) był większy niż kobiet. W grupach wysokiego i pośredniego ryzyka wg DTS wartości wskaźnika SYNTAX (odpowiednio 16,35 ± 7,3; 15,09 ± 10,08 i 11,80 ± 9,88; p = 0,64) były podobne jak w grupie niskiego ryzyka wg DTS. Stwierdzono ujemną korelację między wartością wskaźnika DTS a istotnym zwężeniem tętnicy wieńcowej (r = –0,181; p = 0,005), wskaźnikiem SYNTAX (r = –0,173; p = 0,007) i rewaskularyzacją mięśnia sercowego (r = –0,213; p = 0,001). W liniowym modelu regresji wielokrotnej wskaźnik SYNTAX (B = 0,018; p = 0,0001), wskaźnik DTS (B = –0,014; p = 0,008) i przebyty wcześniej zawał serca (B = –0,143; p = 0,047) były niezależnymi czynnikami predykcyjnymi w prognozowaniu konieczności rewaskularyzacji tętnicy wieńcowej.

Wnioski: Stosowany samodzielnie wskaźnik DTS jest użytecznym narzędziem u osób z podejrzeniem istotnego zwężenia tętnicy wieńcowej, jednak nie jest dostatecznie dokładny w identyfikacji osób wymagających rewaskularyzacji. Aby zwiększyć jego wartość prognostyczną, należy go stosować w połączeniu z informacjami klinicznymi.

Słowa kluczowe: wskaźnik Duke, skala SYNTAX, próba wysiłkowa, rewaskularyzacja, wcześniejsze zdarzenia sercowo-naczyniowe

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