

Validity of self-reported exercise-induced sweating as a measure of physical activity among patients with coronary artery disease

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Summary

Background: In several epidemiological studies, self-reported exercise-induced sweating has been used as a measure of physical activity (PA). Among healthy subjects it is moderately well associated with other measures of PA and physical fitness, but its validity among patients with coronary artery disease (CAD) has not yet been established.

Methods: In a self-administered questionnaire, 233 patients undergoing coronary angiography replied to the question “In the past 4 weeks, how often have you exercised vigorously enough to work up a sweat?” Patients also gave the frequency and duration of different PA. We examined the association of the sweat frequency question with light (<4 metabolic equivalents [METs]), moderate (4.0–5.9 METs) and intense (>6 METs) PA, and tested the association with maximum exercise capacity.

Results: The frequency of self-reported exercise-induced sweating was significantly ($p < 0.001$)

associated with both moderate and intense PA. The correlation coefficient of moderate and intense PA with sweat frequency was $r = 0.34$ ($p < 0.001$), and $r = 0.44$ ($p < 0.001$) for the respective PA of >30 minutes' duration. The strength of the association between sweat frequency and caloric expenditure per time was similar (moderate and intense PA, $r = 0.43$, $p < 0.001$). There was a significant correlation between maximum exercise capacity measured in METs and sweat frequency ($r = 0.37$, $p < 0.001$).

Conclusions: These results suggest that for studies among patients with CAD, assessment of the frequency of self-reported exercise-induced sweating provides useful information regarding moderate and intense PA as well as physical exercise capacity.

Key words: physical activity, exercise test, questionnaire, assessment

Introduction

Physical activity (PA) is inversely related to several cardiovascular risk factors and cardiovascular mortality [1]. Assessment of PA therefore has an important bearing on most clinical or epidemiological studies of cardiovascular diseases. However, there are many patient characteristics to consider, and in practice a thorough compilation of data on all important lifestyle factors is often impossible. In these circumstances brief questions covering these risk factors would be helpful.

There is no gold standard for assessment of PA, and there are many different methods of assessment [2]. In several epidemiological studies of subjects without coronary artery disease (CAD), PA-associated sweating has been recorded as a measure of PA [3, 4]. In these studies sweating correlated with intense PA such as jogging and running, but also with walking [3, 4], generally con-

sidered non-vigorous PA [5]. Moreover, PA-induced sweating correlated moderately well with physical exercise capacity [3].

In subjects with coronary artery disease (CAD), data on the validity of PA-associated sweat frequency is sparse. In a recent study of patients with CAD, sweat frequency was a strong predictor of subsequent cardiovascular mortality [6], suggesting that the sweat frequency question may be valid. However, because patients with CAD may have different patterns of PA, it is not clear which dimensions of PA are covered by this question. We therefore assessed the association of the frequency of exercise-induced sweating with the frequency and duration of PA of varying intensity in patients with CAD. We also tested the relationship of sweating to maximum treadmill exercise capacity.

Methods

The study population consisted of 233 unselected non-emergency patients undergoing coronary angiography at Zurich University Hospital between October 2000 and March 2001. They were requested to complete a self-administered questionnaire for assessment of risk factors and quality of life. For PA we included an item requesting information on the frequency and duration of different PA in the past month, including slow walking (German: *spazieren*); brisk walking; gymnastics and strength training; fitness training such as aerobics and stationary bicycle training; jogging and running; cycling; swimming; ball games and other conditioning exercise. We classified slow walking as light PA (<4.0 metabolic equivalents [METs]), brisk walking and gymnastics/strength training as moderate (4.0–5.9 METs) and the other activities as intense PA (≥ 6.0 METs). Frequency categories were never/rarely, 1–3/month, 1/week, 2–4/week, 5–6/week and daily. Duration categories per exercise session were 5–10 min, 10–30 min, 30–60 min, 60–120 min and >120 min. We

assessed the sweat frequency with the question 'In the past month, how often did you exercise vigorously enough to work up a sweat?' with the same reply choices as for the other frequency questions. From the medical charts, patient characteristics and results of the routine treadmill exercise test were recorded.

Data analysis

We formed categories of low, moderate and intense PA and divided them into groups of >30 and <30 minutes' duration. From the frequency, duration and intensity of the reported episodes of PA we calculated the caloric expenditure of PA. Multiple regression, including calculation of partial correlation coefficients, was used to assess the association of each separate exercise group with sweating. Otherwise the associations were tested by the Spearman rank order correlation test. $P < 0.05$ was considered statistically significant.

Results

The baseline characteristics of the study population are given in table 1. The distribution of fre-

quencies of exercise-induced sweating and different PA are shown in table 2. The PA most often reported were slow walking (71%), cycling (31%) and brisk walking (29%). The average duration of these activities per session was 57, 38 and 28 minutes respectively.

The correlation coefficients between self-reported sweat frequency and the frequency of light, moderate and intense PA were $r = 0.04$ ($p = 0.61$), 0.20 ($p = 0.002$) and 0.32 ($p < 0.001$), and $r = 0.34$ ($p < 0.001$) for combined moderate and intense PA ($p < 0.001$). The correlation coefficients between sweat frequency and calories expended per time at the respective intensities were $r = 0.02$ ($p = 0.81$), 0.22 ($p = 0.002$), 0.37 ($p < 0.001$) and $r = 0.43$ ($p < 0.001$). Table 3 shows the independent association of sweat frequency with PA of varying intensity and duration. Moderate and intense PA of

Table 1

Baseline characteristics of the study population.

Characteristic	values \pm SD
N	233
Mean age (years)	63 \pm 10
Male sex	80%
Prior myocardial infarction	46%
Prior revascularisation	41%
Angina	52%
Heart failure	22%
Smoking (current/ever)	15%/62%
Hypertension	59%
Diabetes	22%
Hypercholesterolaemia	75%

Table 2

Frequency of exercise-induced sweating and different physical activities.

	rarely/ never	1–3/month	1/week	2–4/weeks	5–6/weeks	daily	mean duration of activity (min)*
Exercise-induced sweating	87 (38)	30 (13)	36 (15)	40 (17)	15 (6)	25 (11)	–
Light physical activity							
Slow walking	29 (13)	16 (7)	31 (14)	54 (25)	28 (13)	60 (27)	57
Moderate physical activity							
Brisk walking	165 (71)	11 (5)	18 (8)	11 (5)	13 (6)	15 (6)	28
Gymnastics/strength training	182 (78)	7 (3)	17 (7)	13 (6)	6 (3)	8 (3)	20
Intense physical activity							
Fitness training	199 (85)	5 (2)	10 (4)	12 (5)	2 (1)	5 (2)	21
Jogging/running	219 (94)	2 (1)	5 (2)	5 (2)	1 (0)	1 (0)	32
Bicycling	161 (69)	20 (9)	16 (7)	16 (7)	4 (2)	16 (7)	38
Swimming	181 (78)	26 (11)	12 (5)	7 (3)	5 (2)	2 (1)	24
Ball games	215 (93)	7 (3)	8 (3)	3 (1)	0	0	33
Other activities	214 (92)	4 (2)	9 (4)	1 (0)	0	5 (2)	53

* Among those engaging in the respective activities.

>30 minutes were significantly associated with sweat frequency, but not activities of <30 minutes. The mean frequency of PA-associated sweating

was 7.9+11.1 per month compared with 6.1+11.0 episodes of moderate and intense PA of >30 minutes per month ($r = 0.44$; kappa 0.36, both $p < 0.001$). The correlation coefficient of moderate and intense PA was significant among men and women and among patients aged >60 and <60 (all $p < 0.001$).

There was a significant association between PA-induced sweating and maximum exercise capacity measured in metabolic equivalents ($r = 0.37$, $p = 0.001$; $n = 103$). The correlation of maximum exercise capacity with the frequency of moderate and intense PA was 0.28 ($p = 0.009$), and 0.32 ($p = 0.003$) for the respective activity levels of >30 minutes' duration.

Table 3

Independent association of sweat frequency with physical activities of varying intensity and duration.

Intensity/duration classification	partial correlation coefficient	P-value
Low/<30 min	0.02	0.71
Low/>30 min	0.01	0.84
Moderate/<30 min	0.09	0.16
Moderate/>30 min	0.26	<0.001
Intense/<30 min	0.08	0.23
Intense/>30 min	0.34	<0.001

Discussion

Our results show that among patients with CAD the frequency of self-reported exercise-induced sweating correlates moderately well with the frequency of moderate and intense PA, particularly PA of >30 minutes' duration. Similarly, exercise-induced sweating correlates significantly with energy expenditure during moderate and intense PA but not light PA. Moreover, there is a significant association with maximum treadmill exercise capacity.

Our results in patients with CAD agree well with studies in healthy subjects showing that PA-induced sweating correlates significantly with moderate PA, such as brisk walking, and more intense PA [4]. Our data, however, show that this question misses brief PA of moderate and high intensity as well as light PA. Particularly slow walking, in which a large number of subjects engaged, did not correlate with the sweat question. This absence of correlation was expected, since the exercise intensity of slow walking is unlikely to induce sweating. Because there is evidence that the health benefit of PA depends strongly on the amount of PA, i.e. the total caloric expenditure per time [2], this single question may miss an important fraction of PA.

The relationship between sweat frequency and exercise capacity was moderate and less marked than in previous studies among healthy subjects [3]. Because of different criteria for termination of the routine treadmill exercise test, including silent ischaemia, the treadmill test in this setting is not a gold standard for peak exercise capacity. However, the correlation of sweat frequency with exercise capacity was higher than for the other measures of PA, indicating that the simple sweat question provides as much information on exercise capacity as a more detailed assessment of PA.

Despite the limitedness of the sweat question as a measure of PA, owing to its simplicity and the

reasonable correlation with other PA and with maximum exercise capacity, this question appears to be useful for assessment of PA in studies which do not have PA as the main focus. However, for other studies, as well as for advice to the individual patient, more information on the total PA status is required.

Our study has a number of potential limitations. The intensity of self-reported PA is not clear-cut, and thus misclassification between intensity levels is likely. Because this study involved a heterogeneous group of patients with symptoms of CAD, it is likely that the association between sweat frequency and other measures of PA, as well as with exercise capacity, was less close than in more homogeneous groups of patients with stable CAD. Because most patients underwent coronary revascularisation or changes in cardiovascular medication, we could not assess the test-retest reliability of the sweat frequency question in our study population.

In conclusion, among patients with CAD we found a significant association of self-reported sweat frequency with moderate and intense PA, particularly for activities of >30 minutes' duration. There was also a significant correlation with exercise capacity. If a more detailed assessment of PA is not possible in studies of patients with CAD, this simple question may be useful in estimating the level of physical activity.

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