Validity of the methods evaluating the association between psychosocial stress and diabetes incidence and/ or control

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Abstract

Aims: Assessment of psychosocial stress remains a major obstacle in understanding its association with diabetes. We examined the validity of methods used to measure psychosocial stress in relation to diabetes incidence and control.

Methods: 125 studies of psychosocial stress and diabetes published between 1983 and 2017 were evaluated. Evaluation included the stress type definition, study's design, methodology of stress assessment and diabetes outcomes (incidence and/or control).

Results: An association between stress and diabetes outcomes was found in 89% of studies. Prospective designs were commonly employed (38%), followed by cross-section designs (18%). More studies (64%) focused on psychosocial stress than sleep disorder related stress (22%). More studies explored diabetes incidence as an outcome (74%) than diabetes control (22%). The most common measure for stress assessment was a self-administered questionnaire (64%), followed by physiological indicators (7%). An analysis of the validity of the measures used, indicates that 67% of the studies used valid measures, with self-administered questionnaires exhibited a similar validity as other tools. Interestingly, the validity of tools used to evaluate sleep disorders severity was generally higher than those used to evaluate psychosocial stress.

Conclusion: The majority of studies evaluating the association between anteceding stress and diabetes outcome applied valid measures.

Introduction

Despite the wide use of the word 'stress' in research, there is still no clear accepted definition of the term 'stress' [1]. A careful examination of the scientific uses of stress indicates that stress is often equated with stressors (e.g., social and occupational factors), with responses or physiological manifestations (e.g., sleep disorders, cortisol levels), with cognitions and emotions (e.g., rumination, anxiety) [2] and even with specific behaviors (e.g., smoking, reckless driving). Thus, when assessing the association between 'stress' and various outcomes, it is necessary to understand how 'stress' was measured and whether these measures are valid.

It is widely accepted that psychosocial stress can disrupt glycemic control and can act as a trigger for diabetes onset [3,4]. However, the vagueness and multitude of stress definitions and measures, makes it difficult to assess and quantify the stress-diabetes association. For example, some studies focus on self-administered questionnaires (which are usually adapted from previous studies), asking respondents to report past or present occupational [5] or childhood experiences [6]. Such self- administered questionnaires are easy to use, can be distributed to large populations and their cost is modest. However, as indicated above, they reflect different constructs, and therefore assessing their validity is important. Other studies have used physiological indicators such as cortisol levels to predict diabetes [7]. These indicators may be objectively measured, yet their validity may also be questionable, as they may be indicators of common morbidity rather than reflecting a response to a stressful situation.

Given the varied definitions and measures described above, it is clear that we need to gain a better understanding of the definitions, measures, and study designs used in order to assess the stress-diabetes association. Doing so may inform future research as well as enhance our understanding of past studies.

Validity is defined as the extent to which an empirical measure adequately reflects the real concept under consideration; namely does it measure what it is supposed to measure. A correlation equal or greater than 0.5 between questionnaire, for example, and another valid acceptable method of measurement is needed in order to establish the validity for each intended interpretation [8]. Hence, to better understand which measures should be used to assess the stress- diabetes association, we should assess the validity of the measures commonly used.

Methods

In 2016, an expert committee appointed by the Israeli national diabetes council (The Rapoport committee) concluded that a strong link exists between pre-existing psychosocial and sleep- related stress and the incidence and/or deteriorated glycemic control of type 1 and 2 diabetes. This work adds to the original report by examining the validity of the stress assessment methods employed in the studies reviewed by the Rapoport committee.

The analysis of medical literature included in this study was approved by Shamir Medical Center review board and all methods were carried out in accordance with the relevant guidelines and regulations.

Studies analyzed: Hundred and twenty- five papers were analyzed (see appendix) and divided into three groups according to the effect of the measured stress on diabetes: diabetes control, type 1 diabetes incidence or type 2 diabetes incidence (studies addressing more than one category, i.e., both control and incidence were listed under a single category). It is important to emphasize that the term "incidence" refers to prospective studies whereas in other types of studies (such as retrospective), the measured outcome is in fact diabetes prevalence. However, and for ease of reading, the term "diabetes incidence" is used uniformly in group names instead of "diabetes incidence or prevalence"

The collected data included: date and source of publication, type of stress: psychosocial stress (e.g., stressful life event) or physical stress (e.g., bungee jump); stress measurement method (questionnaire, medical interview, sleep lab, etc.), validity of the stress measurement method and study conclusion. Twenty-eight studies examined the association between sleep disorder related stress secondary to poor sleep quality and/or reduced sleep hours and diabetes control and/or incidence. These studies used either objective measures (such as polysomnography) or self-administered questionnaires.

Setting the criteria for measurement validation: The presence or absence of preexisting validation was the key factor confirming the validity of the stress assessment method used in each study. The following classification system was used to determine measurement validity:

(A) Measures were coded *valid* if they used previously validated questionnaires such as the 10 items Perceived Stress Scale (PSS-10) by Cohen [9], the Job Content Questionnaire (JCQ) by Karasek [10], Hopkins Symptom Checklist-90 (SCL-90) [11] or if stress-related sleep disorders measures were used such as Epworth Sleepiness Scale (ESS) [12] and Pittsburgh Sleep Quality Index (PSQI) [13]. Studies using biochemical stress markers such as cortisol and norepinephrine, data from polysomnography [14] or actigraphy [15] as well as self-reported number of sleep hours were also considered valid.

(B) Measures were coded *partially valid* if they used modified validated questionnaires without further validation or combined valid questionnaires with modified ones.

(C) Measures were defined *not valid* if the questionnaires used were not subjected to validity testing or if the study lacked details regarding the type of questionnaire used. Likewise, a study that established sleep related stress simply by asking the subject's spouse if he snores, for example, was defined as invalid.

Statistical analysis

We compared the distribution of the validity criteria across the study designs, outcomes and other characteristics. All statistical analyses were carried out with Graph Pad software. Fisher's exact test was used to compare categorical values. P values less than 0.05 were considered significant. Odds ratio were calculated manually, using Haldane-Anscombe correction for zero-cells [16]. When comparing groups of studies based on the outcomes, three categories of outcomes were considered: diabetes control, type 1 diabetes incidence and type 2 diabetes incidence. Such comparisons were performed in a pairwise manner, i.e., between two groups of studies at a time, yielding three p-values that were then tested against Bonferroni-adjusted alpha level of 0.016 (0.05/3). Because the focus of this study was to characterize the studies that used valid method in order to measure stress, in most comparisons, partially valid and non-valid studies were grouped together and compared against valid studies.

Results

Details of the 125 analyzed studies appear in **table 1**. Most studies used validated questionnaires and supported an association between the measured stress and diabetes.

In the 125 studies examined, the outcomes used were diabetes control (30 studies, 24%), type 2 diabetes incidence (74 studies, 59%), and type 1 diabetes incidence (21 studies, 17%).

Table No. 1- studies characteristics:

		Diabetes outcome				
		(A) Diabetes control N = 30 (24%)	(B) Type 2 diabetes incidence N = 74 (59%)	(C) Type 1 diabetes incidence N = 21 (17%)		Total n = 125 (%)
Validity of the stress measures	Valid measures	25 (83%)	51 (69%)	8 (38%)	A:B P = 0.1517 A:C **P = 0.0013** B:C P = 0.0202	84 (67%)
	Non valid measures	3 (10%)	14 (19%)	11 (52%)	A:B P = 0.3829 A:C **P = 0.0013** B:C **P = 0.0042**	28 (22%)
	Partially valid measures	2 (7%)	9 (12%)	2 (10%)	A:B P= 0.5045 A:C P = 1.00 B:C P = 1.00	13 (10%)
Stress definition-Type of stress	Psychosocial	17 (57%)	42 (56.7%)	21 (100%)	A:B P = 1.00 A:C **P = 0.0003** B:C **P = 0.0001**	80 (64%)
	Physical	0 (0%)	0 (0%)	0 (0%)	A:B P = 1.00 A:C P = 1.00 B:C P = 1.00	0 (0%)

		Diabetes outcome				
	Psychosocial & Physical	1 (3%)	16 (22%)	0 (0%)	A:B P = 0.0211 A:C P = 1.00 B:C P = 0.0188	17 (13.6%)
	Psychosocial & Sleep	0 (0%)	1 (1.3%)	0 (0%)	A:B P = 1.00 A:C P = 1.00 B:C P = 1.00	1 (0.8%)
	Sleep	12 (40%)	15 (20%)	0 (0%)	A:B P = 0.0492 A:C **P = 0.0006** B:C P = 0.0363	27 (21.6%)
stress measurement method	Self -administered questionnaire	12 (40%)	53 (72%)	15 (71%)	A:B P = 0.0036 A:C P = 0.0453 B:C P = 1.00	80 (64%)
	Physiologic (sleep-lab, actigraphy, etc.)	6 (20%)	2 (2.7%)	1 (5%)	A:B **P = 0.0068** A:C P = 0.2168 B:C P = 0.5317	9 (7.2%)
	Medical interview	0 (0%)	2 (2.7%)	3 (14%)	A:B P = 1.00 A:C P = 0.0639 B:C P = 0.07	5 (4%)

		Diabetes outcome				
	Self-report	1 (3%)	4 (5.3%)	0 (0%)	A:B P = 1.00 A:C P = 1.00 B:C P = 0.5724	5 (4%)
	Other†	2 (7%)	4 (5.3%)	1 (5%)	A:B P = 0.6043 A:C P = 0.6060 B:C P = 1.00	7 (5.6%)
	Combination‡	9 (30%)	9 (12%)	1 (5%)	A:B P = 0.0439 A:C P = 0.0335 B:C P = 0.4499	19 (15.2%)
Study design	Prospective	7 (23%)	35 (48%)	6 (29%)	A:B P = 0.0284 A:C P = 0.7499 B:C P = 0.1428	48 (38.4%)
	Retrospective	4 (13%)	6 (8%)	2 (10%)	A:B P = 0.4689 A:C P = 1.00 B:C P = 1.00	12 (9.6%)
	Cross section	5 (16.6%)	17 (23%)	0 (0%)	A:B P = 0.6002 A:C P = 0.0693 B:C P = 0.0197	22 (17.6%)

		Diabetes outcome				
	Case control	2 (7.1%)	7 (9%)	9 (42%)	A:B P = 1.00 A:C P = 0.0041 B:C P = 0.0011	18 (14.4%)
	Interventional/ Randomized	5 (16.6%)	0 (0%)	0 (0%)	A:B P = 0.0015 A:C P = 0.0693 B:C P = 1.00	5 (4%)
	Meta-analysis	5 (16.6%)	8 (11%)	0 (0%)	A:B P = 0.5140 A:C P = 0.0693 B:C P = 0.1928	13 (10.4%)
	Review	2 (7.1%)	1 (1%)	3 (14%)	A:B P = 0.1991 A:C P = 0.6370 B:C P = 0.0328	6 (4.8%)
	Case report	0 (0%)	0 (0%)	1 (5%)	A:B P = 1.00 A:C P = 0.4118 B:C P = 0.2211	1 (0.8%)
Conclusions	Association was found between the measured stress and diabetes	28 (93%)	66 (89%)	17 (80%)	A:B P = 0.7201 A:C P = 0.2144 B:C P = 0.2144	111 (89%)
	No association was found between the measured stress and diabetes	2 (7%)	8 (11%)	4 (20%)		14 (11%)

(A)Comparison between diabetes control group to type 2 diabetes incidence group

Diabetes outcome
(B) Comparison between diabetes control group to type 1 diabetes incidence group
(C) Comparison between type 2 diabetes incidence group to type 1 diabetes incidence group
† List of other measurements used to measure stress and the number of studies using each measure: Living at a war zone: 1; Using antidepressants:1 ; Score:1 ; Unknown:1; Medical record:1; Psychological intervention: 1;Trier Social Stress Test: 1.
‡ List of combination of measurements used in studies and the number of studies employing each combination: Questionnaire + Subject interview: 7; Physiologic + Questionnaire: 5; Questionnaire + Self-report: 3; Subject interview + Other: 1; Actigraphy + Self-report: 1; Sleep diary + Wrist actigraphy: 1; Questionnaire + Medical record: 1.

Proportion of valid studies across the three diabetes outcomes (*i.e., diabetes control, type 1 diabetes incidence, type 2 diabetes incidence)*: The comparison was performed using three pairwise Fisher's exact tests. After applying a Bonferroni correction on the resulting p-values, the only difference that remained significant is the higher proportion of valid studies (versus partially and non-valid studies) in the diabetes control group compared with type 1 diabetes incidence group (OR: 8.125, corrected p-value = 0.0038).

Type of stress across the three diabetes criteria

The comparison was performed using three pairwise Fisher's exact tests, applying Bonferroni correction as previously described. The analysis revealed a higher percentage of studies that examined psychosocial stress only in the type 1 diabetes incidence group, compared with diabetes control group (OR = 33, corrected p = 0.0009) and type 2 diabetes incidence group (OR = 32, corrected p = 0.0003).

Study findings across the three diabetes criteria

The comparison was performed using three pairwise Fisher's exact tests. After applying a Bonferroni correction on the resulting p-values, we found no statistically significant difference in the findings of studies among the three diabetes criteria; most studies concluded an association between the measured stress and diabetes outcome.

Study findings across the three validity criteria: The comparison was performed using three pairwise Fisher's exact tests. After applying a Bonferroni correction on the resulting p-values, we found no statistically significant difference in the conclusions of studies that used valid measures as compared to partially valid measures (OR: 1.34, corrected p-value = 1.98) and non-valid measures (OR: 0.56, corrected p-value = 2.16), and studies that used partially valid measures compared to non-valid measures (OR: 0.42, corrected p-value = 1.74). Among the three validity criteria groups, most studies concluded association between the measures stress and diabetes, as shown in Fig. 1.

Proportion of valid studies according to type of stress: Fisher's exact test indicated a significantly higher proportion of studies used a valid measure (versus partially and non-valid measure) in the sleep-disorder related stress group compared to studies in the psychosocial stress group (OR: 4.47, p = 0.01. subgroup analysis indicated no significant difference in the proportion of studies using valid measures among the three diabetes criteria subgroups, as shown in **table 2.**

Table No 2 – Proportion of valid studies according to type of stress

			psychosocial stress only	**sleep disorder related stress only**	
Total		Studies using valid measure	45	23	**P = 0.010**
		Studies using partially and non -valid measure	35	4	
Subgroups	stress & diabetes control	Studies using valid measure	12	12	P = 0.058
		Studies using partially and non -valid measure	5	0	
	stress & type 2 diabetes incidence	Studies using valid measure	25	11	P = 0.533
		Studies using partially and non -valid measure	17	4	
	stress & type 1 diabetes incidence	Studies using valid measure	8	0	P = 1.000
		Studies using partially and non -valid measure	13	0	

Use of questionnaires according to type of stress

Fisher's exact test indicated a more prevalent use of questionnaires as the sole stress measuring method in studies that measured psychosocial stress compared with studies that measured sleep related stress (OR = 7.53, p = 0.0001, also shown in **table 3**. A subgroup analysis showed this phenomenon holds truth for studies of type 2 diabetes incidence and diabetes control (OR = 5.5, P = 0.009; OR = 15.7 P = 0.008 respectively). For studies of type 1 diabetes, however, no significance could be attained, as no studies dealt with sleep-related stress.

Table No 3 – Use of questionnaires according to type of stress

			psychosocial stress only	sleep disorder related stress only	
Total		Studies using Questionnaire only as the stress measuring method	58	7	**P = 0.0001**
		Studies using other types of stress measuring method	22	20	
Subgroups	stress & diabetes control	Studies using Questionnaire only as the stress measuring method	10	1	**P = 0.008**
		Studies using other types of stress measuring method	7	11	
	stress & type 2 diabetes incidence	Studies using Questionnaire only as the stress measuring method	33	6	**P = 0.009**
		Studies using other types of stress measuring method	9	9	
	stress & type 1 diabetes incidence	Studies using Questionnaire only as the stress measuring method	15	0	P = 1.000
		Studies using other types of stress measuring method	6	0	

Proportion of valid studies according to the stress measurement method

Fisher's exact test indicated no significant difference in the proportion of studies using valid measures (versus partially and non-valid measure) between studies that used questionnaires only as the stress measuring method compared to studies that used other type of stress measurement method (OR = 0.58, p = 0.366).

Proportion of valid studies according to study design

Fisher's exact test indicated no significant difference in the proportion of studies using valid measures (versus partially and non-valid measure) between studies with prospective design compared to studies with other design, i.e., retrospective design, cross-section design, etc. (OR = 0.82, p = 0.695).

Discussion

This work evaluated for the first time the validity of the various methods used in order to measure stress in studies examining the association between antecedent psychosocial stress and diabetes incidence and/or glycemic control. In most of the publications the method of measuring stress was valid and in accordance with published quality parameters in other domains. Thus, as far as evaluation and quantification of stress these studies seem to be valid and devoid of methodological flaws regardless of their conclusions. It should be emphasized that most of the valid studies (89%) found a positive association between the measured stress and diabetes and in most studies (67%) that demonstrated an association between psychosocial stress and diabetes, the method of measuring stress was valid. No significant difference was found in the validity and/or conclusions of prospective studies versus studies with other designs. The same holds for studies that used questionnaires versus studies using other methods. In addition, no statistically significant difference was found in the validity of studies that concluded that there is an association between diabetes incidence/control and those concluding that there is no association. The only exception was a higher percentage of valid studies that examined sleep-related stress versus studies that examined psychosocial stress. The reason for this difference is unclear. It may result from the fact that most psychosocial stress and diabetes studies used questionnaires as a single tool while only a minority of sleep disorder related stress studies used questionnaires. In addition, usage of questionnaires was significantly higher in the psychosocial stress studies of both diabetes control and type 2 diabetes incidence subgroups, while the difference in validity was not statistically significant between these subgroups (tables 2, 3). In addition, psychosocial stress often involves sleep disorders and vice versa [17,18], hence the two antecedents are not independent of each other, and any distinction between these two common forms of stress is rather artificial and may be misleading.

Taken together, these data underscore the strong linkage between antecedent psychosocial and sleep-related stress and diabetes as well as the valid methodology of stress evaluation in that regard.

It should be noted that most studies that used objective quantifiers for stress measurement such as sleep laboratory methods focused for on a relatively small group of participants, whereas prospective cohort studies that followed up to hundreds of thousands subjects for many years across a large geographical area [6,19-20] used self-reported questionnaires for obvious reasons. The latter is a widely accepted, inexpensive, does not require the physical presence of enrolled subjects and maybe used uniformly within a wide range of population. However, employment of a questionnaire for measuring psychological stress is not free of limitations. For example, when measuring work related stress, the level of stress that was determined at the time of first completing the questionnaire may change over the years, even if there was no significant change in work characteristics or other external sources of stress. Nyberg et al [21] examined the effect of work-related psychosocial stress on BMI. Indeed, 58% of subjects classified as a "high stress" group at baseline were classified as a "low stress" group after a follow-up period and 11% that were classified as non-stressed at work, were reclassified after follow-up as experiencing high levels of work related stress. In addition, focusing only on work related stress may not take into account the possible relationship between stress at work and life habits such as smoking, harmful dietary habits, and lack of exercise that may affect diabetes incidence and/or control, nor do they take into account external sources of stress (e.g., fear of terror) [22]. However, most studies examining objective outcomes usually control for health habits. Considering the advantages and disadvantages mentioned above, and in the absence of a more accurate, widely available methodology, self-administered stress questionnaires became a commonly accepted tool for assessing psychosocial stress in relation to various common organic diseases including diabetes, myocardial infarction and stroke [23-25].

Conclusion

our analysis demonstrates that most studies evaluating the association between antecedent psychosocial stress and diabetes incident and/or control used validated self- administered questionnaires or equally qualified other methodologies of assessment. The results of these studies regardless of their conclusions are therefore acceptable and valid.

Limitations

This work included only the publications in the database used by the committee appointed by the Israeli National Diabetes Council in 2016. Later relevant studies that may have changed the results of this work were not included.

Statements And Declarations

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S.S researched data and wrote the manuscript. No relevant conflicts of interest to disclose.

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Figures

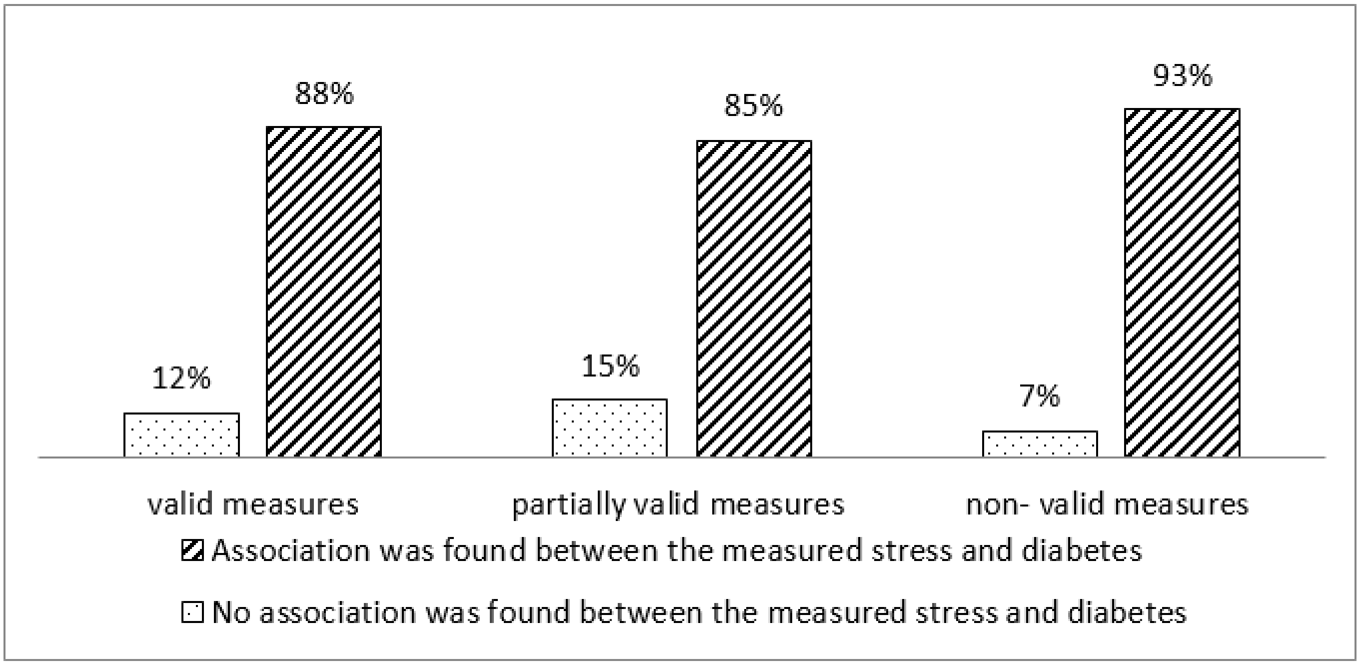

Figure 1

Conclusions of studies according to validity of stress measurement method used.

Supplementary Files

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