Cognitive Functioning and Self-Management in Older People With Diabetes

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Abstract

The extent to which diabetes is responsible for cognitive dysfunction in older people continues to be investigated. Research is also being conducted to better understand why people with diabetes find self-management of their illness a challenge and to develop behavioral interventions to help older people improve their diabetes self-management. There is little research combining these two issues, that is, whether the level and type of cognitive impairment associated with diabetes affects people's self-management. In this article, we review the evidence for deficits in cognitive functioning in older people with diabetes (predominantly type 2) and consider the implications for diabetes self-management.

Case-control and epidemiological studies comparing cognitive functioning of older people with and without diabetes have yielded inconsistent findings. However, one may draw the broad conclusion that there is some evidence of decline in more complex aspects of cognitive function, such as verbal memory, learning, and psychomotor efficiency. Cognitive functioning is probably also adversely affected by age, illness duration, glycemic control, and the presence of other co-morbid conditions. People with diabetes are at increased risk for dementia. This research is limited by lack of consensus on cognitive measures across studies and small sample sizes limiting power to detect differences. We summarize the findings from our study relating cognitive functioning to self-management behaviors for older people with type 2 diabetes, in which we found only a few associations.

On the basis of the available evidence, we conclude that the cognitive impairment associated with relatively uncomplicated type 2 diabetes in older adults is unlikely to adversely affect self-management of the illness.

Since the early 1920s, it has been recognized that conditions characterized by abnormalities in the supply of glucose to the brain, such as diabetes, are likely to affect cognitive performance.[1] To date, the precise mechanism by which diabetes may cause cognitive dysfunction is unclear.[2] Also unclear is the extent and type of cognitive impairment associated with diabetes as distinct from impairment associated with other conditions frequently seen in older people with diabetes.[3] Moreover, the implications of any such cognitive deficits for diabetes self-management activities are yet to be established.

In this article, we evaluate the evidence on cognitive functioning in older people with diabetes with respect to five key issues: age, illness duration, glycemic control, dementia, and other co-morbidities. The majority of studies have included people with type 2 diabetes, although some have included people with type 1 diabetes. We also examine whether deficits in cognitive functioning adversely impact diabetes self-management activities for this age group.

The evidence includes contradictory findings about the cognitive impairment associated with diabetes in older people, and therefore the implications for self-management are not always clear. In addition, there has been remarkably little research that directly addresses the possible impact of cognitive impairment on self-management. However, despite these limitations, we will draw some preliminary conclusions.

Are older people with diabetes more likely to be cognitively impaired than older people without diabetes?

Research on cognitive functioning in older people with type 2 diabetes is

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dominated by case-control studies, in which people with diabetes are compared to people without (and usually matched on some potentially confounding variables) on a battery of cognitive tests. One problem with the majority of these studies is their relatively small sample size, which limits their power to detect significant differences. A few epidemiological studies involving much larger samples have also been carried out.[4–8] However, these have often used only brief and relatively crude measures of cognitive functioning. Within each type of study, the evidence generated has been inconsistent.

There are two main reasons for this lack of consensus. First, older people with diabetes usually also have other medical conditions that impair cognitive functioning, such as hypertension and cardiovascular disease. Therefore, identifying the independent contributions of diabetes and of other conditions presents a challenge for researchers.[9,10] Second, there is a lack of consensus over the cognitive functions that ought to be assessed, as well as the instruments that should be used. As a result, no two studies have used the identical test battery.

Cognitive functions that have been studied have included both simple and more complex processes. Studies of simple reaction time and visual and auditory attention tasks typically suggest that these functions are not affected by type 2 diabetes.[11] However, performance of more complex cognitive tasks, such as those assessing abstract reasoning, verbal memory, and mental flexibility, has often been shown to be impaired in people with type 2 diabetes compared to people without the illness.[12–14]

In contrast, some studies have found very little[10,15] or no[16–18] cognitive impairment in either simple or complex cognitive tasks in older people with type 2 diabetes. These latter studies have been particularly well-controlled in terms of matching participants on several potentially confounding factors (such as pre-morbid IQ and existence of other conditions likely to impair cognitive function, such as hypertension and depression). The importance of control and matching to avoid the possibility of wrongly attributing cognitive impairment to type 2 diabetes rather than to other co-morbid conditions has been recently stressed.[10]

We conclude that older people with type 2 diabetes are more likely to have some cognitive impairment compared to people without the illness. However, such impairment is probably limited to relatively complex cognitive processes (such as verbal memory and psychomotor efficiency) and may be attributable to other conditions that often accompany diabetes and that are likely to interfere with cognitive functioning. The precise extent and severity of cognitive impairment is unlikely to be established until a consensus is achieved on the cognitive functions that should be routinely assessed and on the precise battery of cognitive tests that is likely to be sensitive enough to detect these cognitive changes.

Cross-cutting these methodological problems are a number of factors that may themselves influence the degree of cognitive impairment associated with diabetes. The effects of these variables will be considered in turn below.

Age

It is well established that impairments in cognitive functioning are often seen with advancing age but that such a decline is not an all-or-nothing phenomenon. That is, age does not seem to affect all areas of cognition and all older adults in the same way.[19,20] For example, it is generally accepted that over-learned, well practiced, familiar cognitive skills (i.e. ones relying on crystallized intelligence) are likely to be spared, whereas activities requiring reasoning and complex problem solving (i.e., fluid intelligence) may well be affected by the aging process.[21] Nevertheless, cognitive deficits have been observed in cross-sectional studies of younger,[22] middle-aged,[14,15] and older[23] adults with diabetes. Consequently, it could be concluded that increasing age is not associated with level or type of cognitive impairment in older people with diabetes.

However, closer examination of specific cognitive functions indicates that some cognitive abilities are affected by age to a greater extent than others. For example, Ryan and Geckle's study[15] of relatively young older adults with diabetes (mean age 51 years) showed that some psychomotor slowing was present but that learning, memory, and problem solving were unaffected. Psychomotor slowing was assessed by a combination of cognitive tests that included the Digit Vigilance[24] test measuring sustained attention, the Digit Symbol[25] test measuring visual attention and learning, and the Embedded Figures[26] test measuring visuospatial analysis without a motor response. The work of Cosway et al.[18] found no evidence of cognitive impairment in a relatively youthful group of people with diabetes (mean age 57 years).

Older people (over 65 years of age) with the illness, on the other hand, are generally found to be impaired in learning and verbal memory as well as in psychomotor functioning.[10,23,27] Ryan and Geckle[28] proposed that learning and memory impairments in older adults with type 2 diabetes may be the result of "a synergistic interaction between diabetes-related metabolic derangements and the structural and functional changes occurring in the central nervous system that are part of the normal aging process" (p. 308). Therefore, we conclude that with increasing age, people with diabetes are more likely to be prone to diabetes-associated memory and learning difficulties than to declines in other areas of cognitive functioning. They are also likely to have some slowing of psychomotor functioning.

Illness Duration

It seems reasonable to expect that increased illness duration is associated with increased cognitive impairment because of the brain's increased exposure to metabolic abnormalities. Research provides some support for this view. Both cross-sectional and prospective studies have reported a positive association between diabetes duration and extent of cognitive decline, with longer illness duration being related to greater cognitive dysfunction.[5,8,18] In one recent prospective study,[29] it was suggested that diabetes duration >15 years carries a 57–114% greater risk of major cognitive decline compared to people without diabetes. Others[30] have also found a relation-

ship between long diabetes duration (17 or more years) and cognitive decline, but only for patients on insulin. In contrast, the same study reported no association between short illness duration (~6 years) and cognitive functioning for patients on oral hypoglycemic agents (OHAs).

On the basis of these studies, we suggest that people with longer diabetes duration and more complicated diabetes (as indicated by their treatment with insulin) may be at a greater risk of cognitive impairment than are people with diabetes of shorter duration.

Glycemic Control

Hyperglycemia is known to predispose for cognitive impairment.[31] However, studies do not provide a clear answer as to whether better glycemic control may be related to better cognitive functioning. Some studies have found a positive relationship between glycemic control and cognitive functioning.[4,12,32,33] For example, it has been reported that both short-term (fasting plasma glucose) and long-term (hemoglobin A_{1c}) indices of glycemic control are predictive of cognitive functioning.[13] Others,[7,8,34] however, have failed to find any evidence to support a relationship between cognitive performance and glycemic control.

The evidence from intervention studies is suggestive of cognitive functioning improvements with improved glycemic control. In these studies, the intervention is intended to improve glycemic control, which in turn should result in improved cognitive functioning. Such interventions have usually relied on intensive therapy rather than self-management and have followed patients for 6 weeks to 6 months. The work of Gradman et al.,[35] for example, demonstrated the beneficial effects of this type of intervention, with improvements in verbal memory and learning associated with improvements in glycemic control. However, attention (as measured by the Paced Auditory Serial Addition Task[36] and Trail Making[37] among other tests) and perceptual motor function (as assessed by reaction time and finger tapping tests[38]) did not improve with glycemic control.

In summary, although the health benefits of good glycemic control are undisputed, a strong link between enhanced glycemic control and better cognitive functioning is yet to be established.

Dementia

Type 2 diabetes has been associated with an increased risk of developing dementia or Alzheimer's disease. Large prospective studies[39–41] have provided strong evidence that older people with diabetes are at a significantly higher risk of developing all types of dementia and Alzheimer's disease. Although the exact pathogenic mechanism is unclear, it has been proposed[41] that diabetes doubles the risk of developing dementia and that this is particularly true for people controlling the illness with insulin rather than OHAs. From this evidence, we conclude that type 2 diabetes increases the risk of developing serious cognitive impairment such as dementia or Alzheimer's disease.

Other Conditions

People with diabetes often also have other medical conditions that may affect cognition either in their own right or in interaction with diabetes. For example, it is well-established that hypertension is associated with cognitive decline.[42] In people with diabetes, hypertension has been found to interact with the illness and result in impairments in visual organization and memory processes.[5] Specifically, the Framingham Study[5] reported that people with type 2 diabetes and hypertension were at greater risk for cognitive impairment than their normotensive counterparts. Peripheral neuropathy in people with diabetes has also been found to be related to poor cognitive performance.[12] Autonomic neuropathy is likely to be associated with greater cognitive decline in people with diabetes, but the effect is limited to visual memory.[43] In contrast, a relationship has been found between cognitive impairment and distal symmetric polyneuropathy in people with type 1 diabetes,[44] but this relationship has not been replicated in younger people with type 2 diabetes.[22]

These findings suggest that the greater the number of co-morbid conditions likely to impair cognitive functioning and the higher the level of diabetes-related complications, the greater the risk of cognitive impairment.

In conclusion, there is evidence for cognitive decline in older adults with diabetes. The areas most likely to be affected by diabetes are those of verbal memory, learning, and psychomotor efficiency, although given the lack of methodological consensus in the field, replication of these findings in large prospective studies is imperative. Furthermore, older people, those who have had diabetes longer, those with poorer glycemic control, and those who have other related conditions may be at greater risk of impaired cognitive functioning.

Does impaired cognitive functioning affect diabetes self-management in older people?

The above review suggests that there may be modest cognitive deficits associated with diabetes among the elderly. Therefore, health care providers for older people with diabetes should be aware of the possibility that their elderly patients are more likely to have cognitive deficits compared to elderly people without diabetes. All older people are at risk for cognitive deficits, but older people with diabetes are probably at increased risk.

Self-management is the term used for patient-centered diabetes care in which it is recognized that patients are responsible for carrying out the day-to-day activities that form most of the diabetes regimen.[45–47] The treatment of diabetes is predominantly behavioral. People with diabetes are expected to take medication (pills and/or insulin), test their blood glucose, exercise, eat a healthy diet, inspect their feet, carry diabetes identification, go for health checks, stop smoking, and on and on. All the verbs in the previous sentence indicate expected behaviors that people with diabetes must initiate and maintain on a daily basis.

The recognition of the central role of people with diabetes in their own care is exemplified in the increasing emphasis on patient empowerment in diabetes care.[48,49] In addition to providing medical care, health care professionals facilitate and support self-management behaviors.

Discussions of diabetes self-man-

agement note the special problems that exist for children and adolescents with diabetes but typically do not single out older adults as a group in need of particular attention.[47,50] Moreover, although studies of cognitive impairment associated with diabetes often include a comment on the implications for self-management behaviors,[51] there has been surprisingly little research on this issue. We have only been able to locate one study other than our own that specifically addressed whether cognitive deficits associated with diabetes in older people impair self-management.

Sinclair et al.[52] assessed 396 people with diabetes (5% had type 1 diabetes) and 393 without diabetes who were matched for sex and age. All participants were at least 65 years old. Two tests of cognitive function were used: the Mini Mental State Examination[53] (MMSE) and the Clock Drawing Test.[54] The MMSE is a widely used screening measure for dementia, and a score of 23 or less out of 30 is an indication of impairment. In the Clock Drawing Test, participants are presented with a circle and asked to draw in the numbers of a clock face and to draw in hands to show a specific time. This task calls on a number of cognitive abilities, such as memory, planning, and understanding instructions.

The participants with diabetes significantly under-performed on both tests compared to participants without diabetes, indicating a modest cognitive impairment. Self-management of diabetes was assessed by asking whether participants were solely responsible for their medication and for monitoring blood glucose. The diabetes group was divided into those scoring 23 or less on the MMSE versus those scoring 24 or more. The low scorers were significantly less likely to be responsible for these two aspects of their diabetes management than were the high scorers. Moreover, the low scorers were more likely to have been recently hospitalized, to require help with self-care generally, to be living in an institution, and to have lower scores on a measure of activities of daily living. These findings indicate that people with diabetes who have cognitive impairment indicative of dementia are less likely to be performing certain self-management behaviors.

Although not reported, it is likely that a comparable analysis of the control group would have shown similar results, that is, that those scoring 23 or less on the MMSE were less independent than were those scoring 24 or higher. Dementia is a threat to independent living, and people with diabetes who also have dementia will be less able to carry out self-management activities.

Screening for dementia is a sensible precaution for older diabetes patients. Those showing signs of dementia on a simple measure such as the MMSE should be referred for a more thorough neuropsychological assessment.

Similarly, screening for depression is recommended when cognitive impairment is suspected. The incidence of depression is higher among people with diabetes,[55] and depression is associated with poorer cognitive functioning[21] and poorer self-management.[56] Reducing depression may result in improvements on cognitive tasks and self-management behaviors.[57]

Our research[10] has focused on whether more minor cognitive impairment would be associated with poorer diabetes self-management. Past research on cognitive functioning, as described above, has used batteries of tests to detect relatively small impairments in specific areas of functioning that together may not lead to poor performance on a screening test such as the MMSE. Would these relatively small impairments have clinical significance in terms of impaired self-management? If there were no discernible impact on self-management, then these small changes in cognitive functioning would have no implications for patient-centered diabetes management, and this would be reassuring for older people with diabetes.

In our study,[58] 51 people with type 2 diabetes completed a battery of cognitive tests and measures of diabetes self-management. Their mean age was 61.5 years (SD = 10.4 years), and 22 were women. The majority (73%) were taking OHAs; only 22% were taking insulin. Participants were not excluded if they had other health conditions that may have affected their cognitive functioning, such as heart disease or hypertension. However, they were excluded if they had a documented history of dementia or a major psychiatric disorder including clinical depression. In this way, we intended to study a fairly typical sample of older people with diabetes but without dementia who may be contending with other common diseases of old age.

The cognitive test battery included Digit Symbol,[25] forward and backward digit symbol span,[25] Logical Memory Stories A and B,[59] serial subtraction,[21] Trail Making A and B,[37] the Modified Wisconsin Card Sorting Task,[60] a word stem completion task,[58] and the Subjective Memory Questionnaire.[61] Diabetes self-management was assessed by the Summary of Diabetes Self-Care.[62,63] This self-report questionnaire measures diet, exercise, glucose testing, and medication-taking over the past month. Higher scores for each domain indicate higher levels of the self-management behavior. We also administered the Diabetes Problem Solving Interview,[64] which assesses the number and quality of strategies generated for each of a series of diabetes self-management problems.

Only a selection of the results will be reviewed here, but the main finding was a lack of association between the measures of cognitive functioning and self-management. In multiple regression analyses after controlling for age, pre-morbid IQ, and depression, better dietary self-management was predicted by better scores on the modified Wisconsin Card Sorting Task and on the Diabetes Problem Solving Interview. Better exercise self-management was predicted by better scores on the serial subtraction task (counting backward by sevens). Generating more problem-solving strategies in the Diabetes Problem Solving Interview was predicted by fewer subjective memory problems. The quality of the diabetes problem-solving strategies was predicted by one of the tests of logical memory (Logical Memory Story B). Better implicit memory was associated with less self-monitoring of blood glucose. These were the only associations between the measures of cognitive functioning and the self-management measures after controlling for confounding variables.

These findings suggest that the cog-

nitive functioning of people with uncomplicated type 2 diabetes is, in large part, not associated with their level of diabetes self-management. These findings should be interpreted with caution, however, because of the modest power to detect significant associations in these analyses given the small sample size. However, if more significant associations could be detected in more powerful studies, the question would remain whether these relatively small effects are of clinical significance.

Of particular interest among the few significant associations we observed was the inverse association between the measure of subjective memory and the number of diabetes problem-solving strategies generated. People who believe their memory to be poor were less able to generate problem-solving strategies. This finding suggests that people with diabetes who believe themselves to have memory problems may have difficulty with those aspects of diabetes self-management that require them to think up solutions to everyday problems posed by their condition. Patients may complain about their poor memory to their health care providers, and, although subjective memory complaints were not a reliable indicator of cognitive impairment in our study, these complaints may be a warning sign that patients' ability to cope creatively with diabetes problems is reduced.

Conclusions

Based on the small amount of research to date, it would appear that cognitive impairment below the threshold for detection by dementia screening is not associated with clinically significant impairment on self-management tasks. With due caution, older diabetes patients can be reassured that even if diabetes is associated with some modest cognitive decline, this decline in itself is unlikely to endanger their ability to self-manage their illness.

References

[1]Miles WR, Root HF: Psychologic tests applied to diabetic patients. *Arch Intern Med* 30:767–777, 1922

[2]Gispen WH, Biessels G-J: Cognition and synaptic plasticity in diabetes mellitus. *Trends Neurosci* 23:542–549, 2000

[3]Stewart R, Liolitsa D: Type 2 diabetes mellitus, cognitive impairment and dementia. *Diabet Med* 16:93-112, 1999

[4]Kalmijn S, Feskens EJM, Launer LJ, Stijnen T, Kromhout D: Glucose intolerance, hyperinsulinemia and cognitive function in general population of elderly men. *Diabetologia* 38:1096–1102, 1995

[5]Elias PK, Elias MF, D'Agostino RB, Cupples LA, Wilson PW, Silbershatz H, Wolf PA: NIDDM and blood pressure as risk factors for poor cognitive performance. *Diabetes Care* 20:1388–1395, 1997

[6]Scott RD, Kritz SD, Barrett CE, Wiederholt WC: The association of non-insulin-dependent diabetes mellitus and cognitive function in an older cohort. *J Am Geriatr Soc* 46:1217–1222, 1998

[7]Fontbonne A, Berr C, Ducimetiere P, Alperovitch A: Changes in cognitive abilities over a 4-year period are unfavorably affected in elderly diabetic subjects. *Diabetes Care* 24:366–370, 2001

[8]Grodstein F, Chen J, Wilson RS, Manson JE: Type 2 diabetes and cognitive function in community-dwelling elderly women. *Diabetes Care* 24:1060–1065, 2001

[9]Strachan MWJ, Deary IJ, Ewing FME, Frier BM: Is type II diabetes associated with increased risk of cognitive dysfunction? *Diabetes Care* 20:438–445, 1997

[10]Asimakopoulou KG, Hampson SE, Morrish NJ: Neuropsychological functioning in older people with type 2 diabetes: the effect of controlling for confounding factors. *Diabet Med* 19:311–316, 2002

[11]Meuter F, Thomas W, Gruneklee D, Gries FA, Lohmann R: Psychometric evaluation of performance in diabetes mellitus. *Horm Metab Res* 9 (Suppl.):9–17, 1980

[12]Perlmuter LC, Hakami MK, Hodgson-Harrington C, Ginsberg J, Katz J, Singer DE, Nathan DM: Decreased cognitive function in aging non-insulin-dependent diabetic patients. *Am J Med* 77:1043–1048, 1984

[13]Reaven GM, Thompson L, Nahum D, Haskins E: Relationship between hyperglycemia and cognitive function in older NIDDM patients. *Diabetes Care* 13:16–21, 1990

[14]Biessels G-J, ter Braak EWMT, Erkelens DW, Hijman R: Cognitive function in patients with type 2 diabetes mellitus. *Neurosci Res Comm* 28:11–22, 2001

[15]Ryan CM, Geckle MO: Circumscribed cognitive dysfunction in middle-age adults with type 2 diabetes. *Diabetes Care* 23:1486–1493, 2000

[16]Mattlar CE, Falck B, Ronnemaa T, Hyyppa M: Neuropsychological cognitive performance of patients with type II diabetes. *Scand J Rehab Med* 17:101–105, 1985

[17]Atiea JA, Moses JL, Sinclair AJ: Neuropsychological function in older subjects with non-insulin-dependent diabetes mellitus. *Diabet Med* 12:679–685, 1995

[18]Cosway R, Strachan MWJ, Dougall A, Frier BM, Deary IJ: Cognitive function and information processing in type 2 diabetes. *Diabet Med* 18:803–810, 2001

[19]Salthouse TA: *Theoretical Perspectives on Cognitive Aging.* Hillsdale, N.J., Erlbaum, 1991

[20]Tun P, Nathan DM, Perlmutter LC: Cognitive and affective disorders in elderly diabetics. *Clin Geriatr Med* 6:731–746, 1990

[21]Lezak MD: *Neuropsychological Assessment.* Oxford, UK, Oxford University Press, 1995

[22]Dey J, Misra A, Desai NG, Mohapatra AK, Padma MV: Cognitive function in younger type II diabetes. *Diabetes Care* 20:32–35, 1997

[23]U'Ren RC, Riddle M, Lezak MD, Bennington-Davis M: The mental efficiency of the elderly person with type II diabetes mellitus. *J Am Geriatr Soc* 38:505–510, 1990

[24]Lewis RF, Rennick PM: *Manual for the Repeatable Cognitive-Perceptual-Motor Battery.* Clinton, Mich., Axon, 1979

[25]Weschler D: *WAIS-R Manual.* New York, The Psychological Corp., 1981

[26]Ryan CM, Morrow LA, Bromet EJ, Parkinson DK: Assessment of neuropsychological dysfunction in the workplace: normative data from the Pittsburgh Occupational Exposures Test Battery. *J Clin Exp Neuropsychol* 6:665–679, 1987

[27]Worrall G, Moulton N, Briffett E: Effect of type II diabetes mellitus on cognitive function. *J Fam Pract* 36:639–643, 1993

[28]Ryan CM, Geckle M: Why is learning and memory dysfunction in type 2 diabetes limited to older adults? *Diabetes Metab Res Rev* 16:308–315, 2000

[29]Gregg EG, Yaffe K, Cauley JA, Rolka DB, Blackwell TL, Narayan KMV, Cummings SR: Is diabetes associated with cognitive impairment and cognitive decline among older women? *Arch Intern Med* 160:174–179, 2000

[30]Jagusch W, Cramon DYV, Renner R, Hepp KD: Cognitive function and metabolic state in elderly diabetic patients. *Diabetes Nutr Metab* 5:265–274, 1992

[31]Perlmuter LC, Anderson KS, Fan X, Tabanico F: Does cognitive function decline in type II diabetes? *Diabetes Spectrum* 10:57–62, 1996

[32]Meneilly GS, Cheung E, Tessier D, Yakura C, Tuokko H: The effect of improved glycemic control on cognitive functions in the elderly patient with diabetes. *J Gerontol* 48:M117–M121, 1993

[33]Naor M, Steingruber HJ, Westhoff K, Schottenfeld-Naor Y, Gries AF: Cognitive function in elderly non-insulin-dependent diabetic patients before and after inpatient treatment for metabolic control. *J Diabetes Comp* 11:40–46, 1997

[34]Lowe LP, Tranel D, Wallace RB, Welty TK: Type II diabetes and cognitive function. *Diabetes Care* 17:891–896, 1994

[35]Gradman TJ, Laws A, Thompson LW, Reaven

GM: Verbal learning and/or memory improves with glycemic control in older subjects with non-insulin-dependent diabetes mellitus. *J Am Geriatr Soc* 41:1305–1312, 1993

[36]Gronwall DMA: Paced auditory serial addition task: a measure of recovery from concussion. *Percept Motor Skills* 44:367–373, 1977

[37]Reitan R, Davison L: Validity of the trail making test as an indicator of organic brain damage. *Percept Motor Skills* 8:271–276, 1958

[38]Reitan R, Davison L: *Clinical Neuropsychology: Current Status and Applications.* New York, John Wiley, 1974

[39]Katzman R, Aronson M, Fuld P, Kawas C, Brown T, Morgenstern H, Frishman W, Gidez L, Eder H, Ooi WL: Development of dementing illnesses in an 80-year-old volunteer cohort. *Ann Neurol* 25:317–324, 1989

[40]Leibson CL, Rocca WA, Hanson VA, Cha R, Kokmen E, O'Brien PC, Palumbo PJ: Risk of dementia among person with diabetes mellitus: a population-based cohort study. *Am J Epidemiol* 145:301–308, 1997

[41]Ott A, Stolk RP, van Harskamp F, Pols HAP, Hofman A, Breteler MMB: Diabetes mellitus and the risk of dementia. *Neurology* 53:1937–1942, 1999

[42]Blumental JA, Madden DJ, Pierce TW, Siegel WC, Appelbaum M: Hypertension affects neurobehavioral functioning. *Psychosom Med* 55:44–50, 1993

[43]Zaslavsky LMA, Gross JL, Chaves ML, Machado R: Memory dysfunction and autonomic neuropathy in non-insulin-dependent (type 2) diabetic patients. *Diabetes Res Clin Pract* 30:101–110, 1995

[44]Ryan CM, Williams TM, Orchard TJ, Finegold DN: Psychomotor slowing is associated with distal symmetrical polyneuropathy in adults with diabetes mellitus. *Diabetes* 41:107–113, 1992

[45]Clement S: Diabetes self-management education. *Diabetes Care* 11:239–240, 1995

[46]Glasgow RE, Eakin EG: Issues in diabetes self-management. In *The Handbook of Health Behavior Change.* Shumaker SA, Schron EB, Ockene JK, McBee WL, Eds. New York, Springer, 1998, p. 435–461

[47]Glasgow RE, Fisher EB, Anderson BJ, LaGreca A, Marrero D, Johnson SB, Rubin RR, Cox DJ: Behavioral science in diabetes. *Diabetes Care* 22:832–843, 1999

[48]Anderson RM, Funnell MM, Butler PM, Arnold MS, Fitzgerald JT, Feste CC: Patient empowerment: results of a randomized controlled trial. *Diabetes Care* 18:943–949, 1995

[49]Anderson RM, Funnell MM: *The Art of Empowerment.* Alexandria, Va., American Diabetes Association, 2000

[50]Snoek FJ, Skinner TC (Eds.): *Psychology in Diabetes Care.* Chichester, UK, John Wiley, 2000

[51]Moorodian AD, Perryman K, Fitten J, Kavonian G, Morley JE: Cortical function in elderly non-insulin dependent diabetic patients. *Arch Intern Med* 148:2369–2372, 1988

[52]Sinclair AJ, Girling AJ, Bayer AJ: Cognitive dysfunction in older subjects with diabetes mellitus: impact on diabetes self-management and use of care services. *Diabetes Res Clin Pract* 50:203–212, 2000

[53]Folstein MF, Folstein SE, McHugh PR: Mini-mental state. *J Psychiatr Res* 12:189–198, 1975

[54]Shuhnan KI, Shedletsky R, Silver IL: The challenge of time: clock-drawing and cognitive function in the elderly. *Int J Geriatr Psychiatry* 1:135–140, 1986

[55]Anderson RJ, Freedland KE, Clouse RE, Lustman PJ: The prevalence of comorbid depression in adults with diabetes. *Diabetes Care* 24:1069–1078, 2001

[56]Hampson SE, Glasgow RE, Strycker LA: Beliefs versus feelings: a comparison of personal models and depression for predicting multiple outcomes in diabetes. *Brit J Health Psychol* 5:27–40, 2000

[57]Rubin RR, Peyrot M: Psychosocial problems and interventions in diabetes. *Diabetes Care* 15:1640–1657, 1992

[58]Asimakopoulou KG: Cognitive Function in Type 2 Diabetes: Relationship to Diabetes Self-management. PhD thesis. Guildford, Surrey, UK, University of Surrey, 2001

[59]Weschler D: *Weschler Memory Scale-Revised Manual.* San Antonio, Tx., The Psychological Corp., 1987

[60]Hart RP, Kwentus JA, Wade JB, Taylor JR: Modified Wisconsin Sorting Test in elderly normal, depressed and demented patients. *Clin Neuropsychologist* 2:49–56, 1988

[61]Bennett-Levy J, Powell GE: The Subjective Memory Questionnaire: an investigation into the self-reporting of "real life" memory skills. *Brit J Soc Clin Psychol* 19:177–188, 1984

[62]Toobert DJ, Glasgow RE: Assessing diabetes self-management: the Summary of Diabetes Self-Care Activities questionnaire. In *Handbook of Psychology and Diabetes.* Bradley C, Ed., Chur, Switzerland, Harwood Academic, 1994, p. 351–375

[63]Toobert DJ, Hampson SE, Glasgow RE: The Summary of Diabetes Self-Care Activities measure: results from 7 studies and a revised scale. *Diabetes Care* 23:943–950, 2000

[64]Toobert D, Glasgow RE: Problem solving and diabetes self-care. *J Behav Med* 14:71–86, 1991

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