Cognitive function and self-care in type 2 diabetes

Koula Asimakopoulou, Ali Tomlin, Alan Sinclair

Article points

1. Longitudinal and cross-sectional studies have provided concrete evidence that the risk of cognitive dysfunction increases as duration and complications of diabetes increase.
2. This paper reviews current literature on the relationship between cognitive function and diabetes self-management and presents a brief guide on how clinicians might assess cognitive function and diabetes self-care in primary care settings.

Key words

- Cognitive function
- Self-care
- Assessment tests

The extent to which diabetes is associated with cognitive dysfunction is a very topical issue (Strachan et al, 2008). Longitudinal and cross-sectional studies have provided concrete evidence that the risk of cognitive dysfunction increases as duration and complications of diabetes increase (Gregg et al, 2000; Fontbonne et al, 2001; Areosa and Grimley, 2002; Cukierman et al, 2005; Kumari and Marmot, 2005). Although physiological and metabolic parameters behind cognitive dysfunction are interesting in themselves (Stolk et al, 1997; Kumari et al, 2000; Grodstein et al, 2001; Knopman et al, 2001; Hassing et al, 2004; Gallacher et al, 2005), what is particularly relevant in terms of helping people self-manage their condition is the extent to which cognitive dysfunction in diabetes is associated with poor self-care behaviours. If cognitive dysfunction is associated with a decline in ability to self-care, clinicians might find knowing about this relationship useful in planning their consultations and offering additional support to people who may be at risk. This paper reviews current literature on the relationship between cognitive function and self-care and concludes with a practical guide on how to assess both of these in the primary care setting.

Although there has been much research both on self-care and on cognitive function in diabetes, the relationship between the two remains under-researched.

In one of the few studies in this area, Sinclair et al (2000) examined whether or not cognitive impairment is associated with changes in self-care behaviour and use of health and social services in a community-based case control study of older people with diabetes. Cognitive function was assessed using two global cognition measures, the Mini-Mental State Examination (MMSE; Folstein et al, 1975) and the Clock-Drawing Test (CDT; Shulman, 2000). Self-care was measured by recording the number of people who were solely responsible for self-medication and blood glucose (BG) monitoring and their attendance at a specialist diabetes clinic. Use of the CDT demonstrated that 65% and 72% of people with diabetes, respectively, placed the clock numbers and hands correctly, compared with 76% and 84% of controls. Elderly people with diabetes displayed a significant cognitive dysfunction that was

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associated with poorer abilities in diabetes self-management and greater dependency.

Asimakopoulou and Hampson (2002) argued that the lack of consensus over the cognitive functions and instruments that should be assessed and used in people with diabetes makes this area of research problematic. In their study, 51 people with type 2 diabetes completed a battery of cognitive tests and the Summary of Diabetes Self-Care Activities questionnaire (SDSCA; Toobert and Glasgow, 1994), but only a few associations between cognitive functioning and self-management were observed. This lack of association may be due to limited statistical power or the absence of a significant practical association between self-reported self-care and specific cognitive skills. One of the few significant associations that was found was the inverse relationship between self-reported memory problems and number of diabetes problem-solving strategies, although self-reported memory complaints were not a reliable indicator of objective cognitive function in the study. Better dietary self-management was predicted by better general and diabetes-specific abstract reasoning as assessed by the modified Wisconsin Card Sorting Test (Hart et al, 1998) and the Diabetes Problem-Solving Interview (Toobert and Glasgow, 1991), respectively. Better exercise self-management was predicted by better scores on a test of mental flexibility, the Serial Subtractions of 7s (Lezak, 1995), and generating more problem-solving strategies in the Diabetes Problem-Solving Interview was predicted by fewer subjective memory problems. This study assessed self-reported self-care through the SDSCA. In later work, however, Asimakopoulou and Hampson (2005) showed that the SDSCA can be prone to recall biases in people with diabetes.

Other studies have examined self-care on the basis of medication adherence and glycaemic control. Rosen et al (2003) examined the association between cognitive performance and adherence to prescribed medication, HbA_{1c} and missed appointments. Cognitive function was assessed using a variety of global and specific neuropsychological tests. Adherence to metformin was measured using pill bottle caps, which contained a microprocessor that recorded the date and times of bottle openings; the caps were placed on the patients' prescribed antihyperglycaemic medication. Medication adherence was independently associated with scores on the Stroop word test (a measure of attention and flexibility, Lezak, 1995) and with Trails B completion time (a measure of motor speed, visual scanning, attention and flexibility; Reitan and Wolfson, 1993) but, interestingly, neuropsychological performance was not associated with HbA_{1c} levels. Missed appointments were associated with impaired performance on the MMSE (Mini Mental State Exmination). The authors concluded that 'cognitive abilities should be considered when counselling patients concerning their adherence'.

More recently, Trimble et al (2005) assessed the ability of the CDT to predict problematic insulin administration skills in older adults with diabetes. Thirty individuals who had not used insulin before were taught to self-administer a sham insulin injection with an insulin pen using a standardised protocol. Injections were performed for 7 days, after which self-administration was re-tested. An abnormal CDT was significantly associated with more problems in learning to perform the sham injections (measured as those who were unable to correctly complete all steps of the protocol, or those who omitted all or part of a step), although a small number of people with a normal CDT also demonstrated major problems. The results were in line with other studies that noted the frequency of abnormal CDTs in older people (Sinclair et al, 2000) and the frequency of errors in older people self-administering insulin (Coscelli et

Page points

1. Better dietary self-management was predicted by better general and diabetes-specific abstract reasoning.
2. Better exercise self-management was predicted by better scores on a test of mental flexibility.
3. Cognitive abilities should be considered when counselling patients concerning their adherence.
4. Cognitive function may play a role in the control of diabetes.

al, 1992), and suggested that the CDT is a valuable predictor of potential problems with insulin administration skills in elderly individuals.

Finally, Munshi et al (2006) assessed the relationship between global cognitive function as measured by the MMSE, CDT and Clock in Box (CIB) tests, as well as glycaemic control, measured by HbA_{1c}, in older adults with diabetes. In total, 34% of people had low scores on the CIB and 38% had low scores on the CDT. Both CIB and CDT were superior at identifying those with cognitive dysfunction, compared with MMSE. CIB was more sensitive in predicting poor glycaemic control than CDT. Both clock tests were inversely correlated with HbA_{1c} levels, suggesting that cognitive function may play a role in the control of diabetes.

Table 1 summarises the tests the reviewed studies have used, the domains they measure and the reported main findings.

It thus appears that the few studies that have assessed diabetes self-management and cognition together tend to argue for a relationship between cognitive dysfunction and impaired self-care in people with diabetes. In order to help clinicians to identify and assist those who are less likely to be able to self-manage their diabetes, it is important to be able to assess whether or not cognitive impairment is associated with ability to self-care.

Assessing cognition and self-care in primary care settings: A practical guide

Variability in the way that cognitive function and self-management have been assessed is evidenced from the literature. Measures of cognition have included global (MMSE or CDT) or specific (Stroop or SS7) function tests, while measures of self-care have included self-report (SDSCA) and HbA_{1c} levels. Although self-reports of any health behaviour can be unreliable (Abraham and Hampson, 1996), HbA_{1c} as a measure of self-care (rather than glycaemic control) is also problematic as it can be affected by a myriad of factors that don't relate to self-care, including how aggressive a treatment regime is, sickness and stress. Despite these difficulties, we suggest some straightforward ways of assessing cognition and self-care in primary care settings.

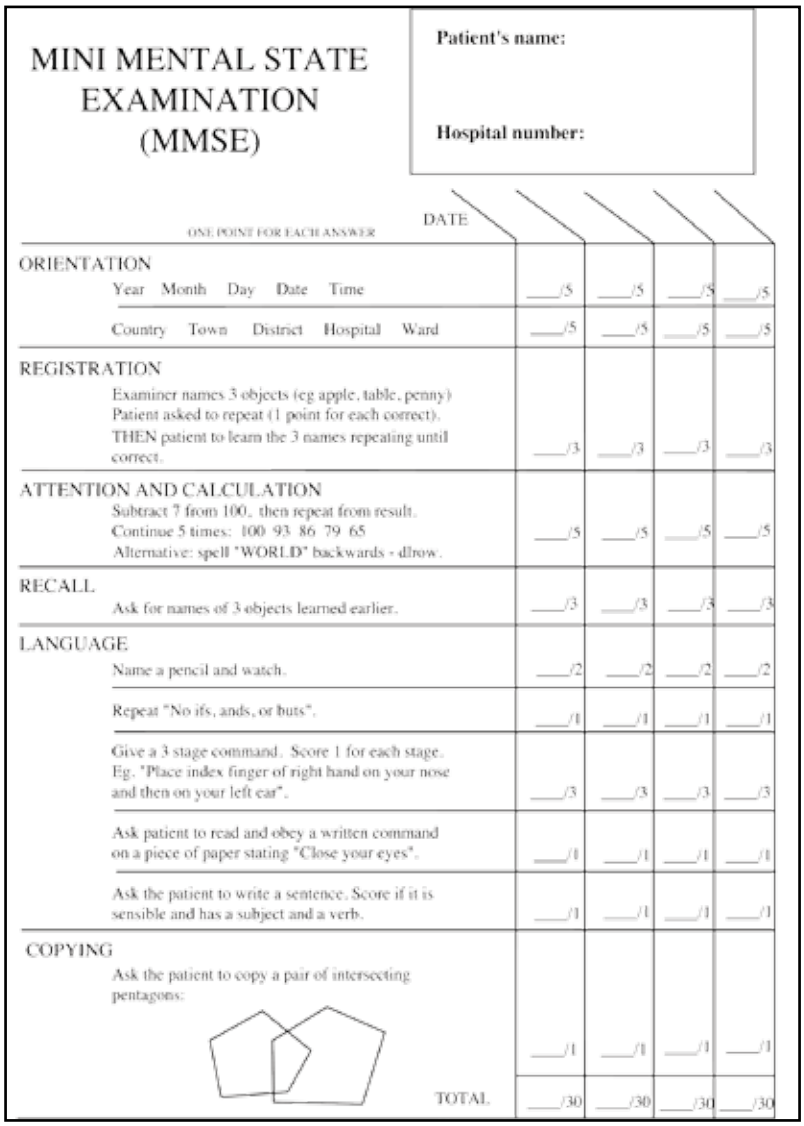
It has been argued that 'a strong background in neuropathology, neuroanatomy, basic neuropsychological principles, clinical and cognitive psychology' is needed before diagnostic cognitive testing is undertaken (Lezak, 1995). In light of this, we propose that some testing can take place by non-experts in neuropsychology, as long as the test results are used only as signs for further referral, rather than as diagnostic instruments.

Two global function tests that have been used successfully before with older people with diabetes are the MMSE and the Clock-Drawing Test. The former is the most widely used dementia screening tool, takes approximately 10 minutes to administer and consists of questions relating to attention, orientation, memory, calculation and language. It relies heavily

on language and, as such, would not be suitable for non-English speakers (although it is available in different languages). For example, individuals are, among other tasks, asked to tell the examiner the year, month, date, day and time and to spell the word 'world' backwards. They are also asked to name three objects that are in the examination room and, a few minutes later, unexpectedly recall them (Figure 1). Although a reliable indicator of moderate-to-severe cognitive impairment,

Table 1. A summary of the reviewed studies showing the cognitive tests they used, the domains they assessed and their main conclusions.

Author and main aim	Tests used	Domains measured	Main findings
Sinclair et al (2000) Assessed cognitive performance in elderly people with diabetes	Mini Mental State Examination (MMSE)	Global cognition – contains questions relating to attention, orientation, memory, calculation and language. MMSE is a reliable indicator of moderate-to-severe cognitive impairment – not sensitive enough to detect mild cognitive impairment	People displayed a significant excess of cognitive dysfunction that was associated with poorer abilities in diabetes self-management and greater dependency. The authors concluded that 'the CDT is a valuable predictor of potential problems with insulin administration skills in elderly individuals
	Clock Drawing Test (CDT)	Global cognition – executive function, planning, visuo-spatial ability, abstract reasoning and concentration. Might produce a large number of false positives	
Asimakopoulou and Hampson (2002) Assessed cognitive function and self-management in people with type 2 diabetes	Wisconsin Card Sorting Test (Hart et al, 1998)	Higher order cognitive processes/executive function – planning, response inhibition, abstract reasoning	Scores on the Wisconsin Card Sorting Test predicted better dietary self-management
	Serial Subtraction of 7s (Part of the MMSE) (Lezak, 2004)	Attention and calculation, mental flexibility	Better scores on this Serial Subtraction of 7s test predicted better exercise self-management
Rosen et al (2003) Assessed the medication adherence of people with type 2 diabetes	MMSE	See above	Missed appointments were associated with impaired performance on the MMSE
	Stroop Word Test (Lezak, 2004)	Attention and flexibility, executive function	Medication adherence was associated with scores on the Stroop and Trails B tests; however, neuropsychological performance was not associated with HbA_{1c} levels
	Trails B Completion Time (Reitan and Wolfson, 1993)	Motor Speed, visual scanning, attention, flexibility	The authors concluded that cognitive abilities should be considered when counselling people considering their adherence
Nishiwaki et al (2004) Assessed the validity of the CDT, in comparison with the MMSE, as a screening tool for cognitive impairment in the elderly	CDT	See above	The authors concluded that in isolation, the MMSE might not detect mild impairment while the CDT might detect a number of false positives but, used together, these tests can be reliable predictors of moderate-to-severe cognitive dysfunction
	MMSE	See above	
Trimble et al (2005) Assessed insulin administration skills in older adults with diabetes	CDT	See above	An abnormal CDT result was significantly associated with more problems in learning to perform sham injections
Munshi et al (2006) Assessed the relationship between cognitive function and glycaemic control in older adults with diabetes	MMSE (Folstein et al, 1975)	See above	Both clock test results were inversely correlated with HbA_{1c} levels (a measure of glycaemic control)
	CDT (Shulman et al, 2000)	See above	The authors concluded that cognitive function may play a role in the control of diabetes
	Clock In A Box (CIB)	A modified CDT – executive function, overall cognitive function	



MINI MENTAL STATE EXAMINATION (MMSE)

Patient's name:

Hospital number:

	DATE			
ONE POINT FOR EACH ANSWER				
ORIENTATION				
Year Month Day Date Time	____/5	____/5	____/5	____/5
Country Town District Hospital Ward	____/5	____/5	____/5	____/5
REGISTRATION				
Examiner names 3 objects (eg apple, table, penny) Patient asked to repeat (1 point for each correct). THEN patient to learn the 3 names repeating until correct.	____/3	____/3	____/3	____/3
ATTENTION AND CALCULATION				
Subtract 7 from 100, then repeat from result. Continue 5 times: 100 93 86 79 65 Alternative: spell "WORLD" backwards - dlrow.	____/5	____/5	____/5	____/5
RECALL				
Ask for names of 3 objects learned earlier.	____/3	____/3	____/3	____/3
LANGUAGE				
Name a pencil and watch.	____/2	____/2	____/2	____/2
Repeat "No ifs, ands, or buts".	____/1	____/1	____/1	____/1
Give a 3 stage command. Score 1 for each stage. Eg. "Place index finger of right hand on your nose and then on your left ear".	____/3	____/3	____/3	____/3
Ask patient to read and obey a written command on a piece of paper stating "Close your eyes".	____/1	____/1	____/1	____/1
Ask the patient to write a sentence. Score if it is sensible and has a subject and a verb.	____/1	____/1	____/1	____/1
COPYING				
Ask the patient to copy a pair of intersecting pentagons:	____/1	____/1	____/1	____/1
TOTAL	____/30	____/30	____/30	____/30

Figure 1. The Mini Mental State Examination (MMSE), downloaded from www.medicaleducation.co.uk/resources/Miniment.pdf

the MMSE is not sensitive enough to detect mild cognitive impairment. This may not necessarily be a problem as mild cognitive impairment is unlikely to be related to diabetes self-care activities in any significant way (Asimakopoulou and Hampson, 2002).

The Clock-Drawing Test is another popular measure that is quick and easy to administer. Participants are given a circle (4–10 cm in diameter), told that it represents a clock face and are instructed to 'put in the numbers so that it looks like a clock and then set the time to 10 minutes past 11'. The test assesses executive function and, in particular, abilities such as planning, visuo-spatial ability, abstract reasoning and concentration. The test can be scored in several ways (Shulman, 2000) although 4- (Death et al, 1993) and 5-point systems (Shulman et al, 1993) are probably the quickest and easiest. Using the latter, the individual's drawing is assessed from being perfect (scored 5) to showing inaccurate representation of 10 past 11 when the overall visuo-spatial organisation is good (scored 3), down to 0 for inability to make any reasonable representation of a clock (Shulman et al, 1993). Completed examples of the CDT using this severity scale are shown in Figure 2.

In their study of the validity of the CDT compared with the MMSE, Nishiwaki et al (2004) found that the CDT was better at detecting moderate/severe cognitive impairment than mild impairment. The test sensitivity was better for females and increased with age. Higher CDT scores were associated with higher mortality from cerebrovascular disease. The authors noted that in isolation, the MMSE might not detect mild impairment, while the CDT might produce a large number of false positives; used together however, it has been argued that these tests can be reliable predictors of moderate-to-severe cognitive dysfunction.

In terms of self-care, a revised version of the Toobert and Glasgow (1991) Summary of Diabetes Self-Care Activities measure is a reliable and valid way to assess self-care via self-report (Toobert et al, 2000). This brief questionnaire assesses, among other aspects of self-care, dietary behaviour, exercise, glucose monitoring and medication taking, in separate sections. It can be completed while the individual waits to be seen by their diabetes healthcare professional and can be scored very quickly (Toobert et al, 2000). Each section then provides a clear quantitative view of the individual's self-

care efforts over the past week. It is suggested that alongside HbA_{1c} readings, this measure may be used as a preliminary indicator of diabetes self-care areas that the person is struggling with and, as such, be instrumental in helping an informed discussion between clinicians and patients.

Conclusion

We have reviewed several studies examining whether or not there is a relationship between cognitive function and self-care in type 2 diabetes. In doing so, we have highlighted the variability in measures used to assess cognition and self-care and have proposed some straightforward tools that can be easily obtained and used in primary care to assess cognition and self-care. We have also noted that these tests are not meant to replace clinical judgement or offer a diagnosis. As they are fairly insensitive in detecting mild cognitive impairment, their usefulness with people who clinicians suspect might fall into this category is questionable. Assuming they are used ethically and alongside clinical opinion, research has shown that they can be useful indicators of people's cognitive functioning.

We conclude that there is evidence supporting a relationship between cognitive dysfunction and self-care in diabetes and, as such, clinicians may find it helpful to assess both of these in people with type 2 diabetes. Further work in determining the clinical relevance to diabetes self-care and overall medical management of both minor and moderate cognitive changes is needed. ■

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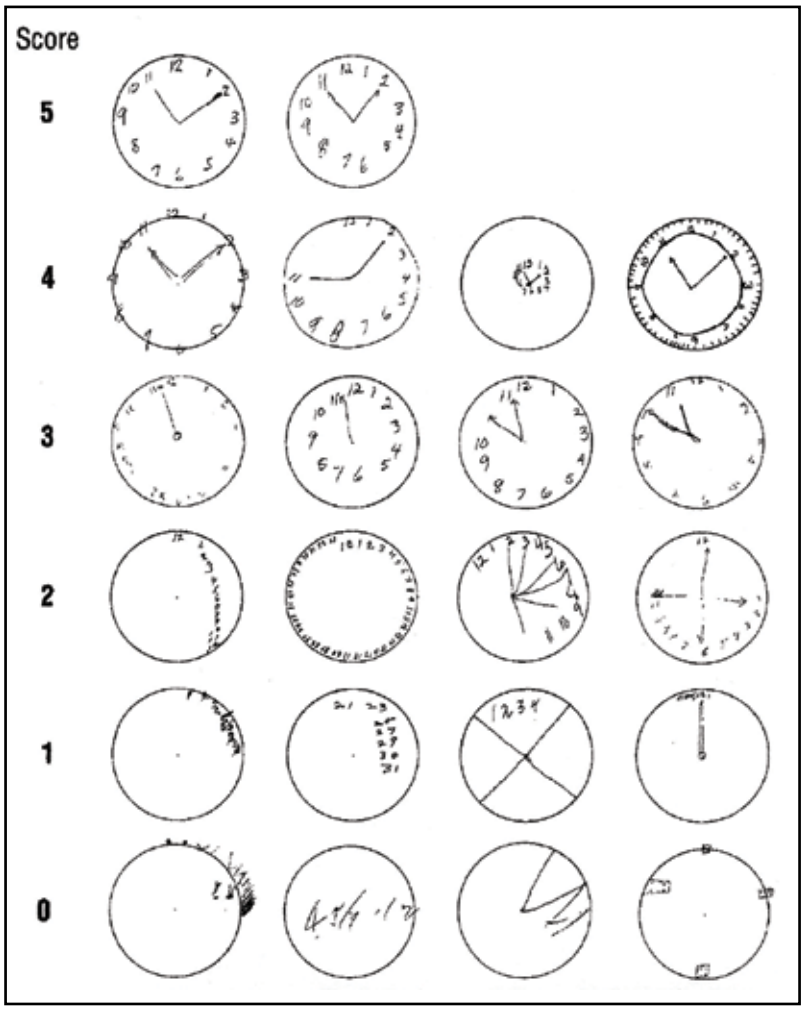

Figure 2. The Clock Drawing Test: Severity Scores from 5 to 0. Reproduced from Shulman (2000).

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