Health behaviour change considerations for weight loss and type 2 diabetes mellitus: Nutrition, physical activity and sedentary behaviour

***[1,2]Angel Marie Chater, [1]Lindsey Smith, [1]Louise Ferrandino, [1]Kev Wyld, [3,4]Daniel P Bailey**

[1]Centre for Health, Wellbeing and Behaviour Change, Institute for Sport and Physical Activity Research, Faculty of Education and Sport, University of Bedfordshire, Polhill Avenue, Bedford, MK41 9EA

[2]Centre for Behavioural Medicine, University College London, BMA House, Tavistock Square, WC1H 9JP

[3]Division of Sport, Health and Exercise Sciences, Department of Life Sciences, Brunel University London, Kingston Lane, Uxbridge, UB8 3PH

[4]Centre for Human Performance, Exercise and Rehabilitation, Brunel University London, Kingston Lane, Uxbridge, UB8 3PH

***Correspondence to:**

Professor Angel Marie Chater; Angel.chater@beds.ac.uk

Abstract (60 words)

Good nutrition, regular physical activity and low levels of sedentary behaviour are important to the prevention, management and treatment of obesity and type 2 diabetes mellitus (T2DM). Self-management requires individuals to have the capability to enact, opportunity to enable and motivation to perform relevant health behaviours. These behaviours, and the bio-psycho-social drivers of them, should be considered when working in the area of T2DM.

Key Points:

- Behaviour is essential in the prevention, management and treatment of type 2 diabetes, but cannot be achieved by simply telling people what to do.
- To adapt eating behaviour, physical activity and sedentary behaviour, individuals must have the capability to enact, opportunity to enable and motivation to perform (or avoid) the new behaviour. These components form the COM-B system and must all be present.
- Additional training to understand behaviour change and effective communication is needed to build capacity for health professionals to support individuals with T2DM.

Keywords: Diabetes, Eating behaviour, Physical activity, Sitting, Behaviour change

Word count: 2848

Introduction

An estimated 422 million adults worldwide[1], with 4.7 million of these in the UK[2], are living with diabetes, of which approximately 90% are Type 2 Diabetes Mellitus (T2DM). There has been a rise in T2DM over the last decade, directly correlating with increased rates of obesity[3,4,5]. Individuals living with obesity tend to have elevated levels of free fatty acids, which can cause muscular insulin resistance, impacting blood glucose control, leading to T2DM and its associated health complications[5]. Behavioural interventions to support weight loss, weight loss maintenance and diabetes self-management are therefore essential[6], with specific focus on nutrition, physical activity and sedentary behaviour.

Obesity, weight loss and type 2 diabetes mellitus

Weight loss, weight loss maintenance and blood glucose control are considered important targets in T2DM management[7,8]. Diabetes UK[9] recommends prioritising a sustained weight loss of ≥5% in individuals who are overweight for effective glycaemic control, although sustained weight loss of >7% is deemed optimal[7]. This degree of weight loss can reduce HbA1c (the measured amount of glucose level in the blood over 2-3 months) by 0.6-1.2%[10], while T2DM remission can be achieved in 86% of individuals who reduce their weight by >15 kg [11].

Weight loss with calorific deficit can positively influence glycaemic control in individuals with T2DM[12]. Improved blood pressure levels and reduction in diabetes-related medication can also be obtained via weight loss[13]. A low-energy liquid diet (for 3 months), followed by a period (2-8 weeks) of re-introduction to food used in the 'Counterweight-plus' programme[14], has been shown to put T2DM into remission in the DiRECT trial[11]. Significant weight loss (*M*=10.0kg; *SD*=8.0) was achieved, and diabetes remission was linked to the degree of weight loss maintained at 12 months[11].

Behaviour change is essential to the success of weight loss programmes, and central to the prevention, management and treatment of obesity[15]. However, it is important to note that obesity is not a behaviour[16]. It cannot be changed overnight, and it is not possible to directly influence weight loss unless an individual undergoes surgery to remove excess skin. Individuals living with obesity, also did not reach their weight status overnight, and were likely influenced by a multitude of bio-psycho-social factors[15]. These include genetics, thoughts, feelings and interactions with their physical and social environment. To support self-management, a focus must be placed on behaviours that can be directly influenced, rather than outcomes of behaviour. Engaging in any new behaviour, and/or changing old patterns of

behaviour is not as simple as following an instruction to do so. The underlying principles of behaviour and behaviour change must, therefore, be understood.

The importance of behaviour for the self-management of type 2 diabetes mellitus

Behavioural factors related to eating behaviour, increasing physical activity and reducing sedentary behaviour are important for the prevention and management of obesity[15,16] and have been shown to influence the risk of developing T2DM.[17,18] The first stage of treatment after diagnosis is usually recommendation for behaviour change in these areas, with the aim of improving glycaemic control[19]. If this is unsuccessful, medication is prescribed to support the individual with their glycaemic management[20]. All aspects of successful self-management of T2DM and treatment optimisation are, therefore, dependent on behaviour.

Human behaviour is, however, complex. Theoretical frameworks can help to enhance the likely success of interventions that aim to change behaviours such as healthy eating, physical activity, reducing sedentary behaviour or medication adherence[21]. The Behaviour Change Wheel[22] uses a system called COM-B designed to understand how Capability (e.g. knowledge and skill), Opportunity (e.g. social and environmental influence) and Motivation (e.g. confidence, identity, habit and emotion) interact to influence Behaviour through a behavioural diagnosis. The Theoretical Domains Framework (TDF)[23] helps to understand behaviour further, with a focus on the bio-psycho-social factors that influence behaviour, mapping them to COM-B. This helps separate potential ambiguity when using the COM-B system. For example, a barrier linked to Psychological Capability could be due to both a lack of Knowledge (a TDF domain linked to not knowing what to do or why) or poor Memory (a TDF domain linked to forgetting to do something). Each of these TDF domains would require a different Intervention Function. For example, 'Education' would be needed to increase 'Knowledge', or 'Enablement' to enhance 'Memory'. In turn, these would require different Behaviour Change Techniques (BCTs) when attempting to intervene to support behaviour change using a standardised taxonomy[24]. For example, giving information on health consequences would be used to increase knowledge; or prompts and cues to enable memory.

While individuals are often motivated to avoid the negative consequences of having diabetes, they do not always understand the impact of health behaviours on long-term outcomes[25]. In addition to knowledge, social opportunity (e.g. social support, cultural norms) and identity (e.g. in relation to body image) have been highlighted as barriers to healthful behaviors[25]. When considering approaches to use to support T2DM, a recent review of BCTs used within online self-management programmes found that 'feedback on behaviour', 'information on consequences of behaviour', 'problem solving' and 'self-monitoring' were instrumental in their

effectiveness[26]. Other work has shown the most common BCTs used are: 'prompts/cues', 'instruction on how to perform the behaviour', 'information about health consequences', 'restructuring the social environment', 'adding objects to the environment', 'social support (practical)', and 'goal setting (behaviour)'[27]. The HEAL-D intervention, targeted at an African and Caribbean population with T2DM in the UK, suggested the use of 'social support', 'social comparison', 'credible sources' and 'demonstration of behaviour' as key behaviour change techniques[25]. It is noted that certain BCT's may be effective for some individuals, but ineffective for others, dependant on factors such as personality, psychological state and general characteristics[28]. Interventions that include specific BCTs can significantly enhance physical activity and reduce HbA1c levels[29]. Moreover, using a higher number of BCTs has been found to be related to better weight loss outcomes[30]. More research is needed to identify not only the most common BCTs and volume used, but also the most effective BCTs to overcome COM-B barriers to self-management behaviours in those with T2DM.

Communication in the delivery of behaviour change techniques

Telling someone what to do will not be enough to change complex behaviours. Motivational interviewing (MI)[31,32] is an effective communication style for assisting with behaviour change in the management of T2DM. This includes increasing physical activity, consumption of fruit and vegetables and improving medication adherence, leading to reduced HbA1c[33]. Furthermore, MI has shown promise for improving dietary behaviours and weight loss. However, in a review of literature, fidelity of delivery was infrequently recorded[34]. Investment in MI training should be given to equip practitioners with the knowledge and skill to engage patients in the consultation process, resist telling them what to do, and allowing focus on what is desired and achievable in relation to behaviour change and outcomes. Furthermore, skill is needed to understand the patient's perspective, evoke a sense of empowerment, ensure that the client feels supported and that they have a plan going forward[35-39]. Effective consultations should use core communication skills to support behaviour change such as using the RULE (Resist the righting reflex; Understand your client's motivation; Listen to your client; Empower your client) and OARS (Open-ended questions, Affirmations, Reflective listening, Summaries), which can be linked to suitable BCTs[35-39]. The GROW (Goal, Reality, Options, Will/Way forward)[40] model is also useful from a health coaching perspective to guide conversations around nutrition, physical activity and sedentary behaviour with a natural start (goal) and finish (way forward)[35,39,41].

Eating behaviour and type 2 diabetes mellitus

A change to dietary intake is recommended as part of a personalised management plan for people living with T2DM. The aim of nutritional advice is to help manage glucose levels,

support weight loss and reduce the risk of CVD[9]. There is no evidence to suggest that one single dietary approach is most effective, however, consideration should be given to the amount and quality of carbohydrate within a dietary plan, as this is the primary determinant of glycaemia. Carbohydrate counting is considered an important approach for managing glycaemia but could have limited relevance for individuals who do not use insulin[42]. Meta-analyses have reported clinically small but significant reductions in HbA1c in response to low glycaemic index diets[43,44]. However, large RCTs have suggested low glycaemic index diets may be no more effective than standard diet education[45]. Dietary fibre can delay the digestion and absorption of glucose and increase satiety, which can help with weight loss. Intake of dietary fibre is associated with improved glycaemia and a lower prevalence of hypertension, obesity and metabolic syndrome in individuals living with T2DM[46,47] and should thus be considered when making changes to dietary behaviour.

There are a range of other dietary approaches that could be adopted to achieve health benefits in individuals living with T2DM, such as low-fat diets, low energy diets, Mediterranean and DASH (Dietary Approaches to Stop Hypertension) diets. The American Diabetes Association[48] and Diabetes UK[9] recommend the use of a Mediterranean diet or a DASH eating pattern to improve glycaemia, lipid profile and reduce the risk of CVD. Adopting a Mediterranean diet can result in significantly greater improvements in HbA1c than standard diabetes care[49]. Furthermore, following the DASH diet for 8 weeks can significantly reduce HbA1c, fasting glucose, body weight, blood pressure and lipids[50]. A healthcare professional with suitable expertise in nutrition should work with individuals to develop an effective and sustainable personalised plan based on these dietary guidelines and approaches to achieve the best possible outcomes. This could be achieved by enabling the development of capability, through enhancing knowledge of nutrition and skills for preparation; opportunity, though enabling social support and changes that may be needed to physical and social environments (e.g. what food is in the home/who else is influencing that environment); and motivation, in terms of encouragement, building confidence and strategies to overcome habitual and emotional eating patterns (e.g. finding alternative behaviours to eating when experiencing low mood). It should be recognised, however, that while capability (knowing what do to/how to do it) and motivation (wanting to do it/overcoming habit or emotion) are in the individual's control, opportunity is related to external factors such as social networks and environmental context and resources. Those who are living in food insecure households or without support from friends and family, have less opportunity to eat healthful foods, or even eat at all. This impacts on the individual's ability to manage their T2DM[51], potentially putting them at risk of adverse consequences.

Physical activity, sedentary behaviour and type 2 diabetes mellitus

Regular engagement in moderate-to-vigorous physical activity (MVPA) is a cornerstone strategy for effective management of T2DM[52]. Adults with T2DM should accumulate ≥150 minutes/week of MVPA or ≥75 minutes/week of vigorous physical activity spread over 3 days with no more than 2 consecutive days without activity. Additionally, resistance exercise should be performed 2-3 times/week on non-consecutive days[52]. Regular physical activity helps to manage glycaemia, reduce the risk of diabetes and CVD, and improve overall health, wellbeing and quality of life[53,54]. One of the most important adaptations to physical activity is increased glucose uptake into muscle and the liver. This occurs via insulin-dependent and non-insulin-dependent (i.e. mediated by muscular contractions) pathways, which can last for up to 48 hours after a single session of exercise[55]. Engaging in regular MVPA and resistance training can improve insulin sensitivity, HbA1c and lipid profile in the long-term, independent of weight loss[56,57]. Physical activity has been reported as one of the best non-pharmacological treatments for the control of T2DM[58]. However, adherence to regular physical activity in this population is low[59]. Engagement in physical activity should be encouraged in clinical practice and is the focus of the Sport England WeAreUndefeatable campaign, which targets those with long-term conditions such as T2DM[60].

Sedentary behaviour has now emerged as an independent risk factor for poor cardiometabolic health that should be considered in addition to physical activity[61]. Sedentary behaviour is defined as any waking behaviour characterised by a low energy expenditure whilst in a sitting, laying or reclined posture[62]. This behaviour is distinctly different to being physically inactive, which refers to an individual not meeting physical activity guidelines[62]. Individuals who engage in the highest amounts of sitting have a significantly increased risk of T2DM and CVD than individuals who sit the least[18]. Engaging in prolonged bouts of sedentary behaviour is adversely associated with cardiovascular health[63] and there is consistent evidence that breaking up sitting with 2-5 minutes of light or moderate-intensity walking every 20-30 minutes attenuates postprandial glucose responses[18,64,65]. Current evidence, therefore, suggests that adults with T2DM should reduce and break up sedentary time in addition to engaging in regular aerobic and resistance exercise[52].

Behavioural interventions aimed at increasing physical activity vary in terms of their content, implementation and effectiveness. A meta-analysis suggested that HbA1c improvements in participants with T2DM were greater in physical activity interventions that were underpinned by a theoretical model of behaviour change and were ≥6 months in duration[66]. There were also specific BCTs that appeared to be associated with clinically significant improvements in HbA1c, such as goal setting, time management, barrier identification/problem-solving, and

planning social support/social change [66]. Health professionals working in this area should aim to support capability, such as ensuring knowledge of physical activity guidelines and how often to break up sitting time, ways to prompt memory and strategies to plan to be more active and/or sit less. They could also support opportunity, by enabling individuals to identify who can help them and how they can change their environment to facilitate more activity and reduce sedentary behaviour. Finally, they can support motivation, by building confidence in the ability to be more active, while raising awareness of habitual behaviour and emotional factors that may be having a negative impact.

The use of apps in the management of Type 2 diabetes

Smartphone apps offer a convenient, flexible and cost-effective way in which interventions could be delivered to promote health behaviour change. This approach has the potential to reach a large proportion of the population with 78% of people in the UK having used a smartphone in 2018[67]. A number of studies have evaluated the effectiveness of health apps that enable people to self-manage their T2DM[68]. The majority of these apps allow the user to self-monitor and receive feedback on glucose levels, dietary intake, physical activity and sedentary behaviour. These behaviours are often targeted simultaneously within a single app and health coaching has often been provided remotely based on data recorded by the app[69,70]. A meta-analysis of interventions using mobile phone apps demonstrated their effectiveness for reducing HbA1c in adults with T2DM in the short (3-6 months) and longer-term (9-12 months)[71]. For health practitioners and patients with T2DM that are considering using these types of health and wellbeing apps, the National Health Service provides a library (several of which are designed for diabetes use) that have been deemed to be clinically safe and secure to use[72].

Apps that include BCTs such as ‘providing information’, ‘action planning’, ‘self-monitoring’, ‘goal setting’ and ‘reward’ have led to improvements in nutrition[73,74]. However, more research is needed to ascertain the efficacy of apps for changing dietary intake in T2DM. The combination of exergame apps with apps that self-monitor steps may not be effective for increasing physical activity levels[75], whereas apps using ‘goal setting’, ‘self-monitoring of behaviour’ and ‘feedback’ combined with a wearable activity tracker have significantly increased physical activity[76]. Apps that include ‘self-monitoring’, ‘feedback’ and ‘prompts/cues’ have been effective over short periods for reducing sedentary behaviour[77]. The MyHealthAvatar-Diabetes app was developed to reduce and break up sitting time, to in turn improve overall health and wellbeing in people living with T2DM[41]. This app used a range of BCTs, such as ‘goal setting’, ‘action planning’, ‘self-monitoring’, ‘feedback on behaviour’ and ‘prompts/cues’. In a feasibility trial[41], the MyHealthAvatar-Diabetes app was found to be

acceptable for use by adults with T2DM and showed preliminary efficacy for increasing the number of breaks in sitting per day and improving glucose tolerance and psychological wellbeing. The effectiveness of smartphone apps for managing glycaemia in adults with T2DM has been demonstrated, however, further research is required regarding their ability to improve dietary intake, physical activity and reduce sedentary behaviour in this population.

Conclusion

Health behaviours related to nutrition, physical activity and sedentary behaviour are important to the prevention, management and treatment of T2DM. Research highlights their role in weight loss, glycaemic control and metabolic health, however, human behaviour is complex, and simply being told what to do is often not enough for long term effective behaviour change. Self-management behaviours for T2DM require individuals to have the capability to enact, opportunity to enable and motivation to perform relevant behaviours. These aspects can be influenced by a multitude of factors such as knowledge, memory, environment, social support, cognitions, identity, habit and emotion. Using psychological theory can help to understand these determinants, while also highlighting to health professionals areas to target during consultation and intervention. Mobile apps hold potential to support behaviour change, and thus the self-management of T2DM at a wide-scale, and should be considered as part of a tailored treatment approach. Health care professionals would benefit from using behaviour change theory and effective communication skills to support self-management behaviours. Future work should develop training and build capacity in these areas.

References

1. World Health Organization. Diabetes: Key facts. 2020. Available at: https://www.who.int/news-room/fact-sheets/detail/diabetes (Accessed 14th June 2020).
2. Diabetes UK. Diabetes Prevalence 2019. 2020. Available at: https://www.diabetes.org.uk/professionals/position-statements-reports/statistics/diabetes-prevalence-2019 (Accessed 14th June 2020).
3. Phillips A. Optimising the person-centred management of type 2 diabetes. British Journal of Nursing. 2016 May 26;25(10):535-538.
4. Inzucchi SE, Bergenstal RM, Buse JB, Diamant M, Ferrannini E, Nauck M, Peters AL, Tsapas A, Wender R, Matthews DR. Management of hyperglycemia in type 2 diabetes, 2015: a patient-centered approach: update to a position statement of the American Diabetes Association and the European Association for the Study of Diabetes. Diabetes Care. 2015 Jan 1;38(1):140-149.
5. Yaturu S. Obesity and type 2 diabetes. Journal of Diabetes Mellitus. 2011 Nov 30;1(4):79-95.
6. Anderson JW, Kendall CW, Jenkins DJ. Importance of weight management in type 2 diabetes: review with meta-analysis of clinical studies. Journal of the American College of Nutrition. 2003 Oct 1;22(5):331-9.

7. American Diabetes Association. 7. Obesity management for the treatment of type 2 diabetes. Diabetes Care. 2017 Jan 1;40(Supplement 1):S57-63.
8. Hauner H. Managing type 2 diabetes mellitus in patients with obesity. Treatments in Endocrinology. 2004 Aug 1;3(4):223-32.
9. Diabetes UK (2018). Evidence-based nutrition guidelines for the prevention and management of diabetes. Available at: https://www.diabetes.org.uk/professionals/position-statements-reports/food-nutrition-lifestyle/evidence-based-nutrition-guidelines-for-the-prevention-and-management-of-diabetes (accessed 29 June 2020)
10. Franz MJ, Boucher JL, Rutten-Ramos S, VanWormer JJ. Lifestyle weight-loss intervention outcomes in overweight and obese adults with type 2 diabetes: a systematic review and meta-analysis of randomized clinical trials. Journal of the Academy of Nutrition and Dietetics. 2015 Sep 1;115(9):1447-63.
11. Lean, M. E., W. S. Leslie, A. C. Barnes, N. Brosnahan, G. Thom, L. McCombie, C. Peters, S. Zhyzhneuskaya, A. Al-Mrabeh, K. G. Hollingsworth, A. M. Rodrigues, L. Rehackova, A. J. Adamson, F. F. Sniehotta, J. C. Mathers, H. M. Ross, Y. McIlvenna, R. Stefanetti, M. Trenell, P. Welsh, S. Kean, I. Ford, A. McConnachie, N. Sattar and R. Taylor. Primary care-led weight management for remission of type 2 diabetes (DiRECT): an open-label, cluster-randomised trial. The Lancet. 2018 Feb 10;391(10120):541-51.
12. Gummesson A, Nyman E, Knutsson M, Karpefors M. Effect of weight reduction on glycated haemoglobin in weight loss trials in patients with type 2 diabetes. Diabetes, Obesity and Metabolism. 2017 Sep;19(9):1295-305.
13. Look AHEAD Research Group. Reduction in weight and cardiovascular disease risk factors in individuals with type 2 diabetes: one-year results of the Look AHEAD trial. Diabetes Care. 2007 Jun;30(6):1374.
14. Lean M, Brosnahan N, McLoone P, et al. Feasibility and indicative results from a 12-month low-energy liquid diet treatment and maintenance programme for severe obesity. Br J Gen Pract 2013; 63: e115–124.
15. Perriard-Abdoh S, Chadwick P, Chater A, Chisolm A, Doyle J, Gillison F, Greaves C, Liardet J, Llewellyn C, McKenna I, Moffat H, Newson L, Reid M, Scott K, Shearer R, Singh S, Snowden-Carr V. Psychological perspectives on obesity: Addressing policy, practice and research priorities. 2019. London: British Psychological Society.
16. Chater A. Psychological perspectives on obesity: policy, practice and research priorities British Psychological Society Blog 2020 May 7; Available at: https://www.bps.org.uk/blogs/guest/psychological-perspectives-obesity (Accessed 14th June 2020).
17. Zheng Y, Ley SH, Hu FB. Global aetiology and epidemiology of type 2 diabetes mellitus and its complications. Nature Reviews Endocrinology. 2018 Feb;14(2):88.
18. Bailey DP, Hewson DJ, Champion RB, Sayegh SM. Sitting Time and Risk of Cardiovascular Disease and Diabetes: A Systematic Review and Meta-Analysis. Am J Prev Med. 2019; 57(3): 408-416.
19. McGuire H, Longson D, Adler A, Farmer A, Lewin I. Management of type 2 diabetes in adults: summary of updated NICE guidance. BMJ. 2016 Apr 6;353:i1575.
20. Ripsin CM, Kang H, Urban RJ. Management of blood glucose in type 2 diabetes mellitus. American Family Physician. 2009 Jan 1;79(1):29-36.
21. McSharry J, Byrne M, Casey B, Dinneen SF, Fredrix M, Hynes L, Lake AJ, Morrissey E. Behaviour change in diabetes: behavioural science advancements to support the use of theory. Diabetic Medicine. 2020 Mar;37(3):455-63.

22. Michie S, Van Stralen MM, West R. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. Implementation Science. 2011 Dec 1;6(1):42.
23. Cane J, O'Connor D, Michie S. Validation of the theoretical domains framework for use in behaviour change and implementation research. Implementation Science. 2012 Dec 1;7(1):37.
24. Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, Eccles MP, Cane J, Wood CE. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. Annals of Behavioral Medicine. 2013 Aug 1;46(1):81-95.
25. Moore AP, Rivas CA, Stanton-Fay S, Harding S, Goff LM. Designing the Healthy Eating and Active Lifestyles for Diabetes (HEAL-D) self-management and support programme for UK African and Caribbean communities: a culturally tailored, complex intervention under-pinned by behaviour change theory. BMC Public Health. 2019 Dec 1;19(1):1146.
26. van Vugt M, de Wit M, Cleijne WH, Snoek FJ. Use of behavioral change techniques in web-based self-management programs for type 2 diabetes patients: systematic review. Journal of Medical Internet Research. 2013;15(12):e279.
27. Presseau J, Ivers NM, Newham JJ, Knittle K, Danko KJ, Grimshaw JM. Using a behaviour change techniques taxonomy to identify active ingredients within trials of implementation interventions for diabetes care. Implementation Science. 2015 Dec 1;10(1):55.
28. Cradock KA, ÓLaighin G, Finucane FM, Gainforth HL, Quinlan LR, Ginis KA. Behaviour change techniques targeting both diet and physical activity in type 2 diabetes: A systematic review and meta-analysis. International Journal of Behavioral Nutrition and Physical Activity. 2017 Dec;14(1):18.
29. Avery L, Flynn D, Dombrowski SU, Van Wersch A, Sniehotta FF, Trenell MI. Successful behavioural strategies to increase physical activity and improve glucose control in adults with Type 2 diabetes. Diabetic Medicine. 2015 Aug;32(8):1058-62.
30. Hankonen N, Sutton S, Prevost AT, Simmons RK, Griffin SJ, Kinmonth AL, Hardeman W. Which behavior change techniques are associated with changes in physical activity, diet and body mass index in people with recently diagnosed diabetes?. Annals of Behavioral Medicine. 2015 Feb 1;49(1):7-17.
31. Miller WR, Rollnick S Motivational interviewing: Helping people change. 2012. New York: Guilford press.
32. Rollnick S, Miller WR, Butler CC Motivational interviewing in health care. 2008 New York: Guilford Press.
33. do Valle Nascimento TM, Resnicow K, Nery M, Brentani A, Kaselitz E, Agrawal P, Mand S, Heisler M. A pilot study of a Community Health Agent-led type 2 diabetes self-management program using Motivational Interviewing-based approaches in a public primary care center in São Paulo, Brazil. BMC Health Services Research. 2017 Dec;17(1):32.
34. Ekong G, Kavookjian J. Motivational interviewing and outcomes in adults with type 2 diabetes: a systematic review. Patient Education and Counseling. 2016 Jun 1;99(6):944-52.
35. Chater A The power of language and emotion in specialist obesity services The European Health Psychologist, 2016; 18(5): 184-188.
36. Chater A Seven steps to help patients overcome a 'Fear of Finding Out - FOFO'. Nursing Standard, 2018: 33(1): 24-25.

37. Chater A Motivational Interviewing, Health Coaching and Behaviour Change. Enhancing communication skills for effective consultations. Training manual. 2015. Bedfordshire: SEPIA Health.
38. Chater A, Courtenay M Community nursing and antibiotic stewardship: the importance of communication and training. British Journal of Community Nursing. 2019;24(7): 338-342.
39. Howlett N, Jones A, Chater A Active Herts: Translating behavioural science into public health. Behavioural Science and Public Health, 2019;1(1): 29-39.
40. Whitmore J Coaching for performance: A practical guide to growing your own skills. 1995 London: Nicholas Brealey Publishing.
41. Bailey D, Mugridge L, Dong F, Zhang X, Chater A Randomised controlled feasibility study of the MyHealthAvatar-Diabetes smartphone app for reducing prolonged sitting time in Type 2 diabetes mellitus. Int. J. Environ. Res. Public Health 2020, 17, 4414; doi:10.3390/ijerph17124414
42. MacLeod, J., M. J. Franz, D. Handu, E. Gradwell, C. Brown, A. Evert, A. Reppert and M. Robinson (2017). "Academy of Nutrition and Dietetics Nutrition Practice Guideline for Type 1 and Type 2 Diabetes in Adults: Nutrition Intervention Evidence Reviews and Recommendations." Journal of the Academy of Nutrition and Dietetics 117(10): 1637-1658.
43. Brand-Miller J, Hayne S, Petocz P, Colagiuri S. Low-glycemic index diets in the management of diabetes: a meta-analysis of randomized controlled trials. Diabetes Care. 2003;26(8):2261-2267.
44. Thomas DE, Elliott EJ. The use of low-glycaemic index diets in diabetes control. Br J Nutr. 2010;104(6):797-802.
45. Visek J, Lacigova S, Cechurova D, Rusavy Z. Comparison of a low-glycemic index vs standard diabetic diet. Biomedical Papers. 2014 Apr 1;158(1):112-6.
46. Fujii H, Iwase M, Ohkuma T, et al. Impact of dietary fiber intake on glycemic control, cardiovascular risk factors and chronic kidney disease in Japanese patients with type 2 diabetes mellitus: the Fukuoka Diabetes Registry. Nutr J. 2013;12(1):159.
47. Velázquez-López, L., A. V. Muñoz-Torres, C. García-Peña, M. López-Alarcón, S. Islas-Andrade and J. Escobedo-de la Peña. Fiber in Diet Is Associated with Improvement of Glycated Hemoglobin and Lipid Profile in Mexican Patients with Type 2 Diabetes. Journal of Diabetes Research 2016: 2980406.
48. American Diabetes Association. Standards of Medical Care in Diabetes—2020 Abridged for Primary Care Providers. Clin Diabetes. 2020;38(1):10-38.
49. Esposito K, Maiorino MI, Bellastella G, Chiodini P, Panagiotakos D, Giugliano D. A journey into a Mediterranean diet and type 2 diabetes: a systematic review with meta-analyses. BMJ Open. 2015;5(8):e008222.
50. Azadbakht L, Fard NR, Karimi M, Baghaei MH, Surkan PJ, Rahimi M, Esmaillzadeh A, Willett WC. Effects of the Dietary Approaches to Stop Hypertension (DASH) eating plan on cardiovascular risks among type 2 diabetic patients: a randomized crossover clinical trial. Diabetes Care. 2011 Jan 1;34(1):55-7.
51. Chan J, DeMelo M, Gingras J, Gucciardi E. Challenges of diabetes self-management in adults affected by food insecurity in a large urban centre of Ontario, Canada. International Journal of Endocrinology. 2015; https://doi.org/10.1155/2015/903468
52. Colberg SR, Sigal RJ, Yardley JE, et al. Physical Activity/Exercise and Diabetes: A Position Statement of the American Diabetes Association. Diabetes Care. 2016;39(11):2065-2079.
53. Nicolucci A, Balducci S, Cardelli P, et al. Relationship of exercise volume to improvements of quality of life with supervised exercise training in patients with type 2

diabetes in a randomised controlled trial: the Italian Diabetes and Exercise Study (IDES). Diabetologia. 2012;55(3):579-588.
54. Wahid A, Manek N, Nichols M, Kelly P, Foster C, Webster P, Kaur A, Friedemann Smith C, Wilkins E, Rayner M, Roberts N. Quantifying the association between physical activity and cardiovascular disease and diabetes: a systematic review and meta-analysis. Journal of the American Heart Association. 2016 Sep 14;5(9):e002495.
55. Magkos F, Tsekouras Y, Kavouras SA, Mittendorfer B, Sidossis LS. Improved insulin sensitivity after a single bout of exercise is curvilinearly related to exercise energy expenditure. Clin Sci (Lond). 2008;114(1):59-64.
56. Bacchi E, Negri C, Targher G, et al. Both resistance training and aerobic training reduce hepatic fat content in type 2 diabetic subjects with nonalcoholic fatty liver disease (the RAED2 randomized trial). Hepatology. 2013;58(4):1287-1295.
57. Roberts CK, Hevener AL, Barnard RJ. Metabolic Syndrome and Insulin Resistance: Underlying Causes and Modification by Exercise Training. Compr Physiol. 2013;3(1):1-58.
58. Marteau T, Dieppe P, Foy R, Kinmonth AL, Schneiderman N. Behavioural medicine: changing our behaviour. BMJ 2006;332:437
59. Brugnara L, Murillo S, Novials A, Rojo-Martínez G, Soriguer F, Goday A, Calle-Pascual A, Castaño L, Gaztambide S, Valdés S, Franch J. Low physical activity and its association with diabetes and other cardiovascular risk factors: a nationwide, population-based study. PloS One. 2016;11(8).
60. Sport England. WeAreUndefeatable. 2019 Available at: https://weareundefeatable.co.uk/?fbclid=IwAR0B479gh0WSFK8Ji8t7d0pAfYXlmdn_2i-o9WJqGLTMKOn88clCBotdLtU (Accessed 14th June 2020).
61. Dempsey PC, Owen N, Yates TE, Kingwell BA, Dunstan DW. Sitting Less and Moving More: Improved Glycaemic Control for Type 2 Diabetes Prevention and Management. Current Diabetes Reports. 2016;16(11):114.
62. Tremblay MS, Aubert S, Barnes JD, et al. Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. Int J Behav Nutr Phys Act. 2017;14(1):75.
63. Bellettiere J, Winkler EAH, Chastin SFM, et al. Associations of sitting accumulation patterns with cardio-metabolic risk biomarkers in Australian adults. PloS One. 2017;12(6):e0180119.
64. Bailey DP, Locke CD. Breaking up prolonged sitting with light-intensity walking improves postprandial glycemia, but breaking up sitting with standing does not. J Sci Med Sport. 2015;18(3):294-298.
65. Bailey DP, Maylor BD, Orton CJ, Zakrzewski-Fruer JK. Effects of breaking up prolonged sitting following low and high glycaemic index breakfast consumption on glucose and insulin concentrations. European Journal of Applied Physiology. 2017;117(7):1299-1307.
66. Avery L, Flynn D, Van Wersch A, Sniehotta FF, Trenell MI. Changing physical activity behavior in type 2 diabetes: a systematic review and meta-analysis of behavioral interventions. Diabetes care. 2012 Dec 1;35(12):2681-9.
67. Statista. Smartphone adoption in the United Kingdom (UK) from 2011 to 2018. Available at: https://www.statista.com/statistics/271460/smartphone-adoption-in-the-united-kingdom-uk/ (accessed 2 August 2019).
68. Hou C, Carter B, Hewitt J, Francisa T, Mayor S. Do Mobile Phone Applications Improve Glycemic Control (HbA1c) in the Self-management of Diabetes? A Systematic Review, Meta-analysis, and GRADE of 14 Randomized Trials. Diabetes Care. 2016;39(11):2089-2095.

69. Karhula T, Vuorinen A-L, Rääpysjärvi K, et al. Telemonitoring and Mobile Phone-Based Health Coaching Among Finnish Diabetic and Heart Disease Patients: Randomized Controlled Trial. Journal of Medical Internet Research. 2015;17(6):e153-e153.
70. Orsama AL, Lahteenmaki J, Harno K, et al. Active assistance technology reduces glycosylated hemoglobin and weight in individuals with type 2 diabetes: results of a theory-based randomized trial. Diabetes Technol Ther. 2013;15(8):662-669.
71. Wu X, Guo X, Zhang Z. The Efficacy of Mobile Phone Apps for Lifestyle Modification in Diabetes: Systematic Review and Meta-Analysis. JMIR mHealth and uHealth. 2019;7(1):e12297-e12297.
72. National Health Service. NHS Apps Library. Available at: https://digital.nhs.uk/services/nhs-apps-library (accessed 27 March 2020).
73. Schoeppe S, Alley S, Van Lippevelde W, et al. Efficacy of interventions that use apps to improve diet, physical activity and sedentary behaviour: a systematic review. Int J Behav Nutr Phys Act. 2016;13(1):127.
74. Gilliland J, Sadler R, Clark A, O'Connor C, Milczarek M, Doherty S. Using a Smartphone Application to Promote Healthy Dietary Behaviours and Local Food Consumption. BioMed Research International. 2015;2015:841368-841368.
75. Cowdery J, Majeske P, Frank R, Brown D. Exergame Apps and Physical Activity: The Results of the ZOMBIE Trial. American Journal of Health Education. 2015;46(4):216-222.
76. Wang JB, Cadmus-Bertram LA, Natarajan L, et al. Wearable Sensor/Device (Fitbit One) and SMS Text-Messaging Prompts to Increase Physical Activity in Overweight and Obese Adults: A Randomized Controlled Trial. Telemedicine journal and e-health: the official journal of the American Telemedicine Association. 2015;21(10):782-792.
77. Arrogi A, Bogaerts A, Seghers J, Devloo K, Vanden Abeele V, Geurts L, Wauters J, Boen F. Evaluation of stAPP: a smartphone-based intervention to reduce prolonged sitting among Belgian adults. Health Promotion International. 2019 Feb 1;34(1):16-27.