Injection Technique: Development of a Novel Questionnaire and User Guide

Katharine D. Barnard-Kelly,1,2 Edward Mahoney,3 Leah Baccari,3 Teresa Oliveria,3 Stanislav Glezer,3 Lori Berard,4 and Didier Morel3

1Bournemouth University, Dorset, U.K.; 2BHR Limited, Hampshire, U.K.; 3BD, Franklin Lakes, NJ; 4Nurse Consultant, Winnipeg, Canada

OBJECTIVE | Approximately 200 million people worldwide use injectable therapies as part of diabetes management. There appears to be a significant gap between insulin injection technique recommendations and injection practice for many. We aimed to develop and validate a novel, brief, self-administered injection technique assessment questionnaire.

RESEARCH DESIGN AND METHODS | An iterative codesign process was conducted. Focus groups and interviews with adults (or parents of children) with type 1 or type 2 diabetes and health care providers (HCPs) elicited views and refined the tool for broader distribution to the target audience. Questions addressed ease of understanding; relevance; included items and potential missing questions; feelings about diabetes; and any discomfort or judgment felt when completing the tool. A user guide was developed with cognitive interviewing performed to ensure relevance, acceptability, readability, and understanding. Statistical analyses included propensity score matching to identify a subset of the Worldwide Injection Technique Questionnaire with similar characteristics. Boruta feature selection, Cramér’s V, and multiple correspondence analysis were conducted.

RESULTS | HCPs and 16 people with diabetes participated in the initial focus groups and interviews. Questions were reported as clinically relevant, simple to complete, “about the right length,” relevant, and easy to understand. A total of 267 participants completed the survey reviewing the questionnaire. A further 16 participants underwent cognitive interviews. The complete resource was then reviewed by another 23 people with diabetes as a final check for completeness and usability. Statistical analyses demonstrated high validity and reliability.

CONCLUSION | This novel resource is clinically relevant, acceptable, and easy to use as both a clinical tool and a self-assessment tool for people using injectable therapies for diabetes.

It is estimated that >1 million people in the United Kingdom use injectable therapies to treat diabetes, projected from a 2010 estimate of 800,000 by Pledger et al. (1). Injection technique is an important factor in determining the efficacy of insulin and other injectable therapies in diabetes. Incorrect injection technique can lead to problems with absorption, leading to unpredictable blood glucose levels, including hypoglycemia and hyperglycemia. According to Pledger et al. (1), a correct subcutaneous injection technique is one that reliably delivers medication into the healthy subcutaneous space without leakage and with minimal discomfort. However, there appears to be a significant gap between insulin injection technique recommendations and current injection practice for many patients (2).

Recent guidelines on injection technique were published as part of the American Diabetes Association’s (ADA’s) Standards of Medical Care in Diabetes—2020 (3) and in a 2018 publication from Trend UK titled “Injection Technique Matters: Best Practice Guidelines to Support Correct Injection Technique in Diabetes Care” (4). The latter is divided into three distinct sections covering 1) the delivery of insulin and glucagon-like peptide 1 (GLP-1) receptor agonist therapy, 2) challenges of insulin and GLP-1 receptor agonist delivery, and 3) sharps safety. In addition to this document, there is a companion six-page guide for injection users detailing the importance of good injection technique and how to achieve it. An accompanying website provides a plethora of data on various aspects of injecting supported by videos; however, each of these resources relies on the

Corresponding author: Katharine D. Barnard-Kelly, katharinebarnard@bhrlltd.com

This article contains supplementary material online at https://doi.org/10.2337/figshare.13237364. https://doi.org/10.2337/ds20-0054

©2021 by the American Diabetes Association. Readers may use this article as long as the work is properly cited, the use is educational and not for profit, and the work is not altered. More information is available at https://www.diabetesjournals.org/content/license.
Despite many previous studies assessing gaps in injection technique (5–7), the approach to such assessments has been variable and not validated, making the interpretation of their findings challenging. Surveys relating to this topic can be burdensome and have sometimes included as many as 70 questions, which makes them difficult to use for assessment in real-world clinical settings (5). As a result, there is a lack of understanding on the part of health care providers (HCPs) regarding injection technique gaps that may exist in their practices, thereby limiting their ability to identify and implement corrective measures to close these gaps for their patients.

The aim of this study was to develop and validate a novel, brief questionnaire and user guide assessing injection technique for people with diabetes who use injectable therapies.

**Research Design and Methods**

**Participants**

Individuals (or parents of children) with type 1 or type 2 diabetes were invited to participate. In addition, HCPs working in adult or pediatric diabetes services were also included. Recruitment strategies included the social media sites Twitter and LinkedIn, as well as the TCOYD (Taking Care of Your Diabetes), Diabetes UK, and DRWF (Diabetes Research and Wellness Foundation) nonprofit organizations. Ethics approval was received from Bournemouth University’s institutional review board before study initiation. To meet inclusion criteria, patient participants had to have either type 1 or type 2 diabetes and be using any form of injectable therapy.

**Study Procedures**

The questionnaire was initially developed by HCPs based on best-practice evidence pertaining to injection technique. It then underwent a rigorous process of codesign evaluation, refinement, and psychometric analysis. Focus groups and interviews were conducted with HCPs and people with diabetes to elicit views on the initial draft questionnaire. Revisions were made to the initial questionnaire in line with feedback from the focus groups and interviews. Then, the revised questionnaire was surveyed by potential users to determine acceptability and relevance. Further revisions were made after this survey to address core issues succinctly. Next, cognitive interviewing was conducted with HCPs and people with diabetes to ensure that the questionnaire was understandable and relevant and that it used appropriate language. Finally, a second survey was sent to a much broader population of people with diabetes to ensure the relevance and acceptability of the final questionnaire and user guide targeted to the target audience (Supplementary Appendix St).

**Focus Groups and Interviews**

The acceptability, relevance, and readability of the initial questionnaire was assessed in a series of focus groups and one-on-one interviews with HCPs and people with diabetes. Participants were asked to review the questionnaire and provide views on the questions asked and whether anything was missing that they felt should be present. They were also asked to assess the utility of the questionnaire for self-administered and clinical use and to provide their preferences for how results should be presented.

**Surveys**

The questionnaire was included in a broader survey in which participants were also asked about their demographics, comorbidities, and diabetes-related complications. They were also asked whether they had received injection technique training and, if so, what take-home messages they remembered. Additionally, the survey solicited their views on the utility of the questionnaire. Participants were also asked for further feedback on whether the questions were easy to understand, any questions were perceived to be unimportant, anything was missing, any changes might be useful, or anyone might have trouble completing the questionnaire, and they were asked their preference for an electronic or paper format.

A second survey was electronically distributed to HCPs and people with diabetes that include the second version of the questionnaire and its instructions, as well as a user guide showing how to interpret results, a color-coded grid highlighting good technique practices, examples of technique practices associated with some concerns, and examples with serious concerns. In addition, the Forum for Injection Technique (FIT) guidelines (8) were paraphrased to conform to Language Matters guidelines (9) and included, along with a 12-step diagram showing the best-practice injection technique process.

**Statistical Analyses**

Statistical analyses were performed with R software, v. 3.6.2 (10). No formal sample size or statistical power calculations were performed before the study.

**Descriptive statistics**

The demographic and clinical characteristics of participants, as well as answers to the questionnaire and survey,
were summarized using descriptive statistics, including counts and percentages for categorical variables and means, SDs, 95% CIs, medians, interquartile ranges, minimums, and maximums for continuous variables.

Survey analysis

Relationships between demographics, clinical characteristics of participants, and answers to the revised questionnaire (second version) were investigated for bivariate association using Cramér’s V and for multivariate association using multiple correspondence analysis (MCA). Tally and graphical summary were extended beyond those provided as descriptive statistics following findings from the Cramér’s V. Questions were reformatted for MCA to simplify interpretation. Active variables were priming (yes, no, sometimes), checking that injection site is clean (yes, no), injection site (one-hot encoded as abdomen, arm, buttocks, thigh), rotation of injection site (yes, no), needle length (4 mm, 5 mm, 6 mm, 8 mm, other), needle insertion into the skin (straight, angle), reuse of needle (no, sometimes, yes), presence of lipohypertrophy (yes, no), and injection into lipohypertrophy (not relevant, no, sometimes, yes). Supplementary qualitative variables were sex, duration of diabetes, prior injection technique education (yes, no), comorbidities (yes, I don’t know, no), type of treatment (insulin, other, mix), device type (pen, syringe, both, other), and diabetes type (type 1, type 2). Supplementary quantitative variables were age, duration of injectable treatment, and A1C. Using its first two dimensions, the MCA was then used to observe patterns related to the origin of the data and generate broader observations about the dataset.

Questionnaire validation

Propensity score matching was used to identify a subset of the Worldwide Injection Technique Questionnaire (ITQ WW) dataset corresponding to participants from the same countries (the United Kingdom and the United States) matching the survey characteristics using age, sex, diabetes type, diabetes duration, and A1C. This analysis was performed using the matchit package in R.

The questions present in the two surveys were identified and, after applying a reformatting similar to the one applied for the survey analysis, the matched survey data and ITQ WW data were combined and used as input in an MCA. Active variables were questions common to the newly developed ITQ and the ITQ WW: injection site, rotation of injection site, needle length, needle insertion into the skin, needle reuse, presence of lipohypertrophy, and injection into lipohypertrophy. Supplementary qualitative variables were source (survey, ITQ WW), sex, diabetes duration, device type, and type of diabetes. Supplementary quantitative variables were age, duration of injectable therapy, and A1C. Using its first two dimensions, the MCA was then used to observe patterns related to the origin of the data and generate broader observations about the dataset.

Cognitive Interviewing

After making revisions to the second version of our questionnaire based on feedback from the second survey, further participant interviews were conducted with people with diabetes and HCPs. The focus of these interviews was to review the questionnaire and user guide for their ease of use and acceptability, to assess the usefulness of the included FIT guidelines and diagram, and to understand whether people would prefer a paper version of the entire resource versus an electronic version.

Results

Three hundred and twenty-eight individuals participated in at least one phase of the study. Five HCPs and 16 people with diabetes took part in the initial focus groups and interviews, and a further 10 HCPs and six people with diabetes participated in the cognitive interviews. A total of 267 participants completed the survey, 77% with type 1 diabetes and 23% with type 2 diabetes. An additional 23 people with diabetes reviewed the final survey as a check of completeness and usability.

Focus Groups and Interviews

The HCPs reported that the questions were clinically relevant and simple to complete. The people with diabetes reported the tool to be “about the right length,” and that the questions were relevant and easy to read and follow. Adding “sometimes” to response options was felt to be beneficial to more accurately reflect real-life diabetes management, along with including a clarification of medication type (i.e., listing the different types of insulin and noninsulin medications). Overall, participants felt that the questionnaire would be a useful tool to help people using injectable therapies refresh their injection technique for optimal dosing.

Survey

Demographic characteristics and descriptive statistics of survey participants are shown in Tables 1 and 2. A total of 267 participants completed the survey, of whom 156 (60%) were female and 104 (40%) were male. A total of 208 had type 1 diabetes, 51 had type 2 diabetes, and 8 responded “other” but did not state a type of diabetes or stated both type 1 and type 2 diabetes. The mean age of participants was
The mean duration of injectable therapy was 16.5 years (range 1 month to 70 years). The mean A1C for participants who reported their latest A1C (n = 235) was 7.25% (range 5–12.2%). A total of 198 participants (74%) did not have diabetes-related complications, 62 (23%) reported having had complications, and 6 (2%) did not know.

The most commonly cited complications were retinopathy (n = 25), neuropathy (n = 16), and chronic kidney disease/nephropathy (n = 8). A total of 109 participants (41%) reported having comorbidities.

Most participants (n = 258) reported taking insulin injections to treat their diabetes, with others using an injectable GLP-1 receptor agonist. The majority of participants (217 [82%]) reported using pen injection devices, 13 (5%) used syringes and pens, 16 (6%) used syringes only, 18 (7%) used pens with timers that record the dose and time of delivery. A total of 108 participants (41%) administered five or more injections per day, 82 (31%) took four daily injections, 18 (7%) took three per day, 15 (6%) took two per day, 19 (7%) took once-daily injections, 7 (3%) took once- or twice-weekly injections, and 15 (6%) took less than one injection per week.

Table 3 shows participants’ injection sites, needle lengths, and technique of needle insertion into the skin.

Participants’ responses to questions specifically about their injection technique are summarized in Table 4. A total of 257 participants (97%) reported that these questions were eyes to understand. The eight participants (3%) who answered “no” to this question reported not knowing what “air shot” or “priming” meant. A total of 232 participants (90%) felt that the number of injection technique questions was about right, 19 (7%) thought there were too few of these questions, and 7 (3%) thought there were too many. The vast majority of participants (243 [95%]) said they would prefer an electronic version of the injection technique questionnaire compared with 14 (5%) who expressed a preference for a paper version. This finding was unsurprising given that the survey was distributed electronically via social media and nonprofit networks.

Fewer than half of participants (123 of 266 responses) reported never having reused their pen/syringe needles during the past 2 weeks. A further 71 participants reported reusing their needles “a few times,” 51 reported reusing needles “most times,” and 21 said they did so “all of the time.” Most, however, reported never injecting into lumps, bumps, or pits under their skin (121 of 153 responses), whereas 30 said they had done so “a few times” over the past 2 weeks. One respondent each reported doing so “most times” and “all of the time.”

Only half of participants (133 [50%]) reported having received any injection technique training from a HCP or online. Of these, 101 (76%) had type 1 diabetes, 29 (22%) had type 2 diabetes, and 8 (3%) reported “other” or gave no response. Approximately one-third of participants (87 [33%]) said they had received no training, and the remaining 46 participants (17%) said they did not know or could not remember. A total of 328 individual take-home messages were provided, and these included 63 unique topics. Table 5 shows the six most common take-home messages from the 133 free-text responses.
Participants were asked to state their top three take-home messages from the education they had received. Only 23 participants (17.3%) were able to recall three messages, 52 (39.1%) recalled two messages, 38 (28.6%) recalled one message, and 19 (14.3%) could not recall any messages. Among the participants who received training on injection technique, there were significant variations in their responses regarding the most important take-home messages recalled. Within several of the themes, there was some discrepancy within recall of the messages (e.g., there was disagreement as to how often to change needles, with most participants stating that needles should be changed after each injection, but others stating that needles should be changed daily or more often).

The data also reveal several differences among the most common take-home messages when broken down by duration of diabetes or by type of diabetes. Participants who had had diabetes for ≤5 years recalled an average of two key take-home messages, whereas those who had had diabetes for ≥5 years recalled an average of 1.78. Among participants who had a shorter duration of diabetes, a higher proportion mentioned changing needles (43% of participants with a diabetes duration of 0–5 years vs. 24% of those with a duration ≥5 years) and priming/air shots (30% of those with a duration of 0–5 years vs. 14% of those with a duration ≥5 years). The difference in the average number of key themes recalled among participants with type 1 diabetes (1.86) and type 2 diabetes (1.76) was slight; however, there were some differentiations in terms of which themes they recalled. More participants with type 1 diabetes reported reusing needles, and rotating injection sites was fairly similar between diabetes type (90% of participants with type 1 diabetes vs. 92% of those with type 2 diabetes). A higher percentage of participants with type 2 diabetes mentioned holding the needle in the skin before removing it (38% of participants with type 2 diabetes vs. 25% of those with type 1 diabetes).

Survey Validation

A subset of 250 participants from the survey dataset had data for age, sex, and diabetes type. Applying propensity
score matching identified a subset of 250 participants to the ITQ WW from the United Kingdom or United States with similar enough characteristics to the survey participants. Table 6 shows the basic characteristics of these two datasets. The match was considered satisfactory to proceed through the validation step.

The first step of the analysis was to visually display the individuals from the two datasets using the first two dimensions of the MCA to observe whether a specific pattern could be associated with the data source. As can be seen in Figure 1, no pattern could be seen distinguishing individual participants in the current survey from individual participants in the ITQ WW.

Combining the current survey and ITQ WW matched datasets before running the MCA also permitted the observation of trends on the two combined datasets as if they were a single source of information. Figure 2 shows the most interesting of these trends. Figure 2A shows the association of not rotating sites, having observed lipohypertrophy, and injecting into lipohypertrophy (yes and sometimes). Figure 2B shows the rotation of injection site matching the pattern of people injecting only in the abdomen (C) versus in the arm (D), buttocks (E), or thigh (F).

Discussion

The number of people globally using injectable therapies in their daily diabetes self-management continues to grow. Injection technique is an important factor in determining the efficacy of insulin and other injectable therapies in diabetes (5–7). To this end, guidelines exist regarding proper injection technique, including within the ADA’s Standards of Care (3). Despite this guidance, however, there appears to be a significant gap between injection technique guidelines and current injection practice for many people. It may be that the guidelines are simply too long and detailed to be easily digestible. Such complicated guidelines would be inconsistent with messages that diabetes self-management should not be a job in and of itself, but rather should be achievable within the confines of otherwise busy lives. We conducted a rigorous, stepwise development process of a novel, brief injection technique assessment to fill this gap.

As demonstrated, the distributions of participants from the survey and from the U.K./U.S. subset of the ITQ WW were not different, which suggests very little difference in the way participants answered questions that

| Injection site          |          |
|-------------------------|----------|
| Tummy/lower abdomen     | 237 (89.1) |
| Legs/thighs/hips        | 177 (66.3) |
| Upper buttocks          | 91 (34.2)  |
| Back of arm             | 65 (24.4)  |

| Needle length, mm*     |          |
|------------------------|----------|
| 4                      | 162 (60.9) |
| 5                      | 38 (14.3)  |
| 6                      | 41 (15.4)  |
| 8                      | 14 (5.2)   |
| 12                     | 1 (0.4)    |
| Other/don’t know       | 10 (3.8)   |

| Needle insertion technique |          |
|---------------------------|----------|
| Inject straight down      | 169 (63.5) |
| Inject at an angle        | 31 (11.7)  |
| Use the pinch-up technique| 66 (24.8)  |

Data are n (%). *Of 266 responses.

| Question                                             | Responses, n | Yes, n (%) | No, n (%) | Sometimes, n (%) |
|------------------------------------------------------|--------------|------------|-----------|-----------------|
| Do you prime your pen/syringe before injecting?      | 264          | 183 (69.3) | 48 (18.2) | 33 (12.5)       |
| When priming your pen/syringe (sometimes call doing an air shot), if you do not see a drop of liquid appear, do you replace the needle before injecting? | 258          | 132 (51.2) | 77 (29.8) | NA: 49 (19.0)*  |
| Do you hold the needle in your skin for 5 seconds after pressing the button? | 264          | 205 (77.7) | 22 (8.3)  | 37 (14.0)       |
| Do you check your injection site for cleanliness/redness/bumps before injecting? | 266          | 205 (77.1) | 61 (22.9) | –               |
| Have you noticed any lumps, bumps, or pits under your skin near injection sites that have lasted more than a day? | 265          | 95 (35.8)  | 170 (64.2) | –               |
| Do you rotate your injection sites with each injection? | 266          | 241 (90.6) | 25 (9.4)  | –               |

NA, not applicable. *Participants said this item did not apply to them.
TABLE 5 Six Most Common Education Take-Home Messages Reported by Participants

| Message                                      | n (%)  |
|----------------------------------------------|--------|
| Injection sites                              | 99 (74)|
| Need to hold pen in after injection          | 40 (30)|
| Need to always change needle after use       | 34 (26)|
| Need to do an air shot/prime the pen/syringe | 26 (20)|
| Correct angle of injection                   | 17 (13)|
| Proper hygiene for injection area            | 12 (9)|

Data are n (%).

were included in both the current survey and the ITQ WW. This finding validates that our survey with its limited number of questions seems to provide information similar to that obtained from the longer ITQ WW questionnaire. As data collection continues from ongoing and future studies, these associations are expected to reflect what our new ITQ will show once it is run on a larger dataset.

The results of our study show that injection technique was variable among survey participants. Of particular concern were the large numbers of participants who reported not priming their injection device before injecting (48 [18%]), reusing their needles (143 [54%]), and injecting into lumps, bumps, or pits under their skin (32 [20%] of 153 answering).

Grassi et al. (7) conducted a survey of 346 people with diabetes from northern Italy who had been injecting insulin for a minimum of 4 years. Their results show similarly poor technique, with the authors noting that most physician visits involve discussions about blood glucose control and insulin dose adjustment, but very little time is spent looking at ways to improve injection technique.

Data from the U.K. National Diabetes Audit (15) show consistently poor glycemic outcomes, with only 30% of people with type 1 diabetes and 67% of those with type 2 diabetes achieving target A1C. Widespread poor injection technique is likely to play a role as a contributing factor in this suboptimal glycemic control. While HCPs have a duty to teach their patients correct injection technique at the initiation of injectable therapy, this role of course relies on HCPs possessing up-to-date knowledge and skills in best practice injection technique themselves. Our study demonstrates that people with diabetes are not exhibiting these skills and that HCPs are not transferring these skills to their patients.

TABLE 6 Summary Statistics for Matched Datasets From the Injection Technique Survey and the ITQ WW

| Characteristic                  | Survey Cohort (n = 250) | ITQ WW Cohort (n = 250) |
|---------------------------------|-------------------------|-------------------------|
| Age, years                      |                         |                         |
| Mean                            | 46.92                   | 45.45                   |
| 95% CI                          | 44.80–49.04             | 42.64–48.26             |
| Median                         | 47.00                   | 49.00                   |
| SD                              | 17.01                   | 22.55                   |
| 25%, 75% quantiles             | 32.75, 60.00            | 26.75, 64.00            |
| Minimum, maximum               | 2, 80                   | 6, 85                   |
| Sex, n (%)                      |                         |                         |
| Female                          | 150 (60.0)              | 141 (56.4)              |
| Male                            | 100 (40.0)              | 109 (43.6)              |
| Diabetes type, n (%)            |                         |                         |
| Type 1                          | 201 (80.4)              | 173 (69.2)              |
| Type 2                          | 49 (19.6)               | 77 (30.8)               |
| Diabetes duration, n (%)        |                         |                         |
| 0–6 months                      | 4 (1.6)                 | 0 (0.0)                 |
| 6–12 months                     | 8 (3.2)                 | 11 (4.4)                |
| 1–3 years                       | 33 (13.2)               | 21 (8.4)                |
| 4–5 years                       | 12 (4.8)                | 16 (6.4)                |
| ≥5 years                        | 193 (77.2)              | 202 (80.8)              |
| A1C, %                          |                         |                         |
| Mean                            | 7.24                    | 7.96                    |
| 95% CI                          | 7.09–7.39               | 7.85–8.08               |
| Median                         | 7.00                    | 8.00                    |
| SD                             | 1.18                    | 0.91                    |
| 25%, 75% quantiles             | 6.50, 7.71              | 7.47, 8.60              |
| Minimum, maximum               | 5, 12.2                 | 5.6, 11                 |
Although our study used a rigorous and stepped approach including both qualitative and quantitative methodology, it is not without limitations. Recruitment via diabetes organizations and via social media channels enabled a broad reach, which was reflected in the diversity of the participants. However, it could be argued that the online delivery of the survey may have excluded potential participants who lacked access to a computer or the Internet. Further research will be required to determine the uptake and impact of the novel resource we developed.

**Conclusion**

Our results indicate that this novel injection technique assessment questionnaire is a reliable and valid measure. The questionnaire is brief, with only nine items, making it feasible to complete quickly in busy outpatient clinics or as a stand-alone tool self-administered at home. The user guide is succinct, visually sensitive, and informative. In short, this validated novel, brief questionnaire and user guide are clinically relevant, acceptable, and easy to use, both as a clinical resource and a self-assessment tool for people using injectable therapies for diabetes.

**ACKNOWLEDGMENTS**

The authors thank all of their participants as well as TCOYD, which helped with recruitment and review of the documents.

**FUNDING**

This project was supported by an unrestricted research grant from BD.

**DUALITY OF INTEREST**

K.D.B.-K. has received research support from BD. E.M., T.O., S.G., L.Ba., and D.M. are employees of and stock shareholders in BD. L.Be. has received consulting fees from BD Canada, Eli Lilly, MontMed Canada, Novo Nordisk, and Sanofi. No other potential conflicts of interest relevant to this article were reported.

**AUTHOR CONTRIBUTIONS**

K.D.B.-K. led the research project and wrote the first draft of the manuscript. E.M., L.Ba., T.O., and S.G. reviewed the manuscript and contributed to the discussion. L.Be. was an advisor to the project, reviewed results, and contributed to manuscript writing. D.M. conducted statistical analyses and contributed to manuscript writing. K.D.B.-K. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
FIGURE 2  MCA. First two dimensions showing A) categories for active questions and color-coded (no in orange, yes in blue), B) rotate injection site, C) injection site abdomen, D) injection site arm, E) injection site buttocks, and F) injection site thigh.
REFERENCES

1. Pledger J, Hicks D, Kirkland F, Down S. Importance of injection technique in diabetes. J Diabetes Nurs 2012;16:160–165
2. Patil M, Sahoo J, Kamalanathan S, et al. Assessment of insulin injection techniques among diabetes patients in a tertiary care centre. Diabetes Metab Syndr 2017;11(Suppl. 1):S53–S56
3. American Diabetes Association. 9. Pharmacologic approaches to glycemic treatment: Standards of Medical Care in Diabetes—2020. Diabetes Care 2020;43(Suppl. 1):S98–S110
4. Trend UK. Injection Technique Matters: Best Practice Guidelines to Support Correct Injection Technique in Diabetes Care. Available from www.trend-uk.org. Accessed 20 March 2020
5. Frid AH, Hirsch LJ, Menchior AR, Morel DR, Strauss KW. Worldwide injection technique questionnaire study: population parameters and injection practices. Mayo Clin Proc 2016;91:1212–1223
6. Misnikova IV, Gubkina VA, Lakeeva TS, Dreval AV. A randomized controlled trial to assess the impact of proper insulin injection technique training on glycemic control. Diabetes Ther 2017;8:1309–1318
7. Grassi G, Scuntero P, Trepiccioni R, Marubbi F, Strauss K. Optimizing insulin injection technique and its effect on blood glucose control. J Clin Transl Endocrinol 2014;1:145–150
8. FIT U.K. The UK Injection and Infusion Technique Recommendations. 4th ed. Available from https://www.fit4diabetes.com/files/4514/7946/3482/FIT_UK_Recommendations_4th_Edition.pdf. Accessed 3 June 2020
9. NHS England. Language Matters: Language and Diabetes. Available from https://www.england.nhs.uk/wp-content/uploads/2018/06/language-matters.pdf. Accessed 13 November 2020
10. Foundation R. The R project for statistical computing. Available from https://www.R-project.org. Accessed 13 August 2020
11. Cramér H. Mathematical Methods of Statistics. Princeton, NJ, Princeton University Press, 1946
12. Pagès J. Multiple Factor Analysis by Example Using R. London, U.K., Chapman & Hall, 2014
13. Rosenbaum PR, Rubin DB. The central role of the propensity score in observational studies for causal effects. Biometrika 1983;70:41–55
14. Olima A, Govindasamy P. Propensity scores: a practical introduction using R. J Multidiscip Eval 2015;11:68–88
15. NHS Digital. National Diabetes Audit 2018–19 short report 1. Available from https://digital.nhs.uk/data-and-information/publications/statistical/national-diabetes-audit/report-1-care-processes-and-treatment-targets-2018-19-short-report. Accessed 20 March 2020