**TITLE:** Barriers to Exercise in Adults with Type 1 Diabetes and Insulin Resistance

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**ABBREVIATIONS**

T1D, Type 1 diabetes; QoL, quality of life; eGDR, estimated glucose disposal rate; IR, insulin resistance; BMI, body mass index; HbA1c, haemoglobin A1c; BAPAD-1, Barriers to Physical Activity in T1D scale; RCT, randomised controlled trial; MVPA, moderate-to-vigorous physical activity; SF-36, 36-item short form questionnaire; Cls, confidence intervals; METs, Metabolic equivalents

**KEY MESSAGE**

* The presence of insulin resistance is associated with lower physical activity levels and greater barriers to physical activity in individuals with type 1 diabetes (T1D).
* T1D individuals with IR reported that glycaemic factors, specifically hypoglycaemia, are the greatest salient barriers to exercise, whereas those without IR found non-diabetes related factors as the main salient barriers to exercise.

**ABSTRACT**

**Objective:** To explore attitudes to exercise and quality of life (QoL) in adults with type 1 diabetes (T1D) with and without insulin resistance (IR).

**Design:** We pooled baseline pre-treatment data from a subset of T1D individuals from two randomised controlled trials (RCT). Estimated glucose disposal rate (eGDR), a validated surrogate marker of IR, was calculated using an established formula to classify individuals according to IR status with a cut-point of <6mg/kg/min for the determination of IR. Self-reported barriers to exercise were obtained using a validated questionnaire, the *Barriers to Physical Activity in T1D (BAPAD-1)*. In addition, QoL was determined using the *36-item short form (SF-36)* questionnaire. Differences between dichotomised variables were assessed using independent t-tests, Mann-Whitney U tests or Fisher’s exact tests. Linear regression was employed to explore the association of eGDR with BAPAD-1 and QoL scores, with sequential adjustment for potential confounders.

**Results:** Of 85 individuals included, n=39 were classified as having IR. The mean BAPAD-1 total score was higher for individuals with IR (IR 3.87±0.61 vs. non-IR 2.83±0.55; P<0.001). The highest exercise barrier scores for individuals with IR were risk of hypoglycaemia (5.67±1.26) and risk of hyperglycaemia (5.23±1.20), whereas the highest scoring exercise barrier scores for non-IR individuals were non-diabetes related; low level of fitness (3.91±1.26) and physical health status excluding diabetes (3.67±1.48) were ranked highest. QoL scores were comparable between groups (P>0.05).

**Conclusions:** Risk of hypoglycaemia was the greatest barrier to exercise in T1D individuals with IR, whereas non-diabetes related barriers to exercise were more salient in T1D individuals without IR.

**KEYWORDS**

Physical activity, type 1 diabetes, insulin resistance, attitudes to exercise, quality of life.

**INTRODUCTION**

Regular participation in physical activity reduces the risk of developing insulin resistance (IR), metabolic syndrome, and progression to overt type 2 diabetes (T2D)1. In individuals with type 1 diabetes (T1D), regular physical activity also improves features of metabolic syndrome including IR2 and lowers the risk of long-term health complications3. A recent large cross-sectional survey of 18,028 adults with T1D, reported that ~60% of individuals with T1D did not achieve the recommended physical activity levels of ≥150-minutes of moderate-to-vigorous physical activity (MVPA) per week3 a finding which supports some4,5 but not all previous studies6. Previously, fear of hypoglycaemia and a lack of knowledge about managing diabetes around exercise have been reported as salient barriers to exercise7-9, but it has yet to be established if these perceived barriers differ between those with and without IR. Furthermore, T1D has been consistently shown to be associated with reduced quality of life (QoL)10,11 and exercise12 and IR13 have been identified as important mediating factors.

IR is highly prevalent within the T1D population and that IR is a strong independent risk factor for diabetes complications14-16. Although individuals with T1D are more prone to insulin resistance than non-diabetes individuals17, participating in physical activity improves insulin sensitivity18,19. Given the health benefits associated with physical activity, T1D individuals with IR are likely to greatly benefit from regular participation in physical activity. However, little is known about the attitudes to physical activity or QoL in T1D individuals with associated IR. Existing research has principally focussed on T1D as a single clinical entity when considering attitudes and barriers to exercise and QoL7,9,20,21. In the general population, obesity is associated with lower physical activity levels and poorer QoL22, suggesting that some barriers to exercise and QoL outcomes are weight-specific. Furthermore, IR is generally associated with increased insulin dose requirements and poorer glycaemic control in T1D23, which, increase the burden of disease24. As such, it is possible that individuals with T1D and IR may have greater barriers to physical activity than T1D individuals without IR. To the best of our knowledge, however, no research has explored whether attitudes towards physical activity in T1D individuals are mediated by IR and how it affect QoL.This information is important for the future design of individualised and patient-centred physical activity interventions that target T1D individuals at high risk of complications. Therefore, the aim of this study was to explore attitudes to exercise in T1D individuals with and without IR, while also investigating the impact on QoL.

**METHODS**

## Study population

We pooled data from two randomised controlled trials (RCTs; Clinical trial registrations: ISRCTN40811115; NCT05231642) each of which received ethical approval from local National Health Service Research Ethics Committees (REC reference: 17/NE/0244; 21/WA/0381). Briefly, ISRCTN40811115 was an RCT investigating the impact of omega-3 supplementaiton on glycaemic control in T1D, and NCT05231642 was an RCT investigating exploring interpersonal postprandial glucose responses in T1D. In both RCTs, participants were recruited from the Yorkshire, Humber, and North East Regions of the United Kingdom both in-clinic and through Univeristy-led advertisments, and written informed consent was obtained from all participants. We used used baseline pretreatment data only from both RCTs. In the present analysis we included 85 participants that met inclusion criteria as described previously25,26 including classical presentation of T1D, aged 18-50 years, diabetes duration of ≥5-years, treated on a stable (>12-months) basal-bolus insulin regimen delivered through multiple daily injections or continuous subcutaneous insulin infusion. None of the study participants had clinically established diabetes-related complications.

## Data Collection and Study Procedures

We performed cross-sectional analyses using baseline pre-treatment data across each RCT. Clinical information obtained included age, sex, body mass index (BMI), haemoglobin A1c (HbA1c), hypertension status, insulin regimen, and estimated glucose disposal rate (eGDR), and self-report physical activity levels. Participants were defined as hypertensive if blood pressure was ≥140/90mmHg; they had a pre-existing diagnosis of hypertension or were prescribed antihypertensive drugs. Participants were classified by IR status using eGDR – a validated surrogate marker of IR – formulated using BMI, HbA1c, and hypertension status; *eGDR* *= 19.02 – (0.22 X BMI [kg/m2) – (3.26 X HTN) – (0.61 X HbA1c [%])*, whereby HTN is hypertension (1 = yes, 0 = no)27; patients were informed about their IR status after the completion of research procedures.

We assessed self-reported attitudes to exercise using the validated Barriers to Physical Activity in T1D (BAPAD-1) questionnaire28,29, which has been described in detail previously29-31. In summary, the BAPAD-1 scale consists of 11 equally weighted diabetes-specific items, with answers coded on a 7-level rating scale ranging from extremely unlikely to extremely likely to keep representing the likelihood of individuals from practicing regular physical activity during the next 6 months29,31.

QoL was determined using the 36-item short form questionnaire (SF-36)32 – a tool which has previously been validated in individuals with diabetes33. The SF-36 assesses both physical and mental domains in eight multi-items scores: physical functioning, limitations due to physical problems, social functioning, bodily pain, general mental health (psychological distress and well-being), limitations due to emotional problems, vitality (energy and fatigue), and general health perceptions. All domains contribute differently to the scoring for both measures34. Scores from different domains were converted and aggregated using a scoring key, to obtain a score indicating a range from low to high QoL.

**Statistical analysis**

Descriptive information for each variable was calculated and assessed for normality. Normally distributed variables are reported as (mean±SD), non-normally distributed variables are reported as median (IQR), and categorical variables are reported as frequency (%). β-coefficients with confidence intervals (CIs were presented where appropriate. The cohort was stratified according to eGDR into IR status with a cut-point of <6mg.kg.ml for the determination of IR, as reported previously35. Continuous variables were examined using independent t-tests for normally distributed variables and Mann-Whitney U tests for non-normally distributed variables, and categorical variables were used for Fisher’s exact tests. Linear regression was employed to investigate the association between eGDR and, BAPAD-1 and QoL (SF-36) questionnaires, respectively, with sequential adjustment for confounders (age, sex, diabetes duration, exercise participation levels) using the sub-scores for each domain. Data analysis was performed using SPSS (IBM SPSS Statistics, version 28), with statistical significance accepted at a p-value <0.05.

**RESULTS**

The clinical characteristics of the cohort stratified by IR status are presented in (**Table 1).** A total of 85 individuals (n=39 with IR and n=46 without IR) were included in the analysis. Individuals with IR were more likely to be older with a longer duration of diabetes, higher total daily insulin dose, an increased prevalence of hypertension, and lower levels of exercise participation (P<0.05, **Table 1**).

The mean BAPAD-1 total score was higher for individuals with IR (IR 3.87±0.61 vs. non-IR 2.83±0.55; P<0.001; **Table 2**). The highest exercise barrier scores for IR were risk of hypoglycaemia (IR 5.67±1.26), risk of hyperglycaemia (IR 5.23±1.20), presence of diabetes (IR 4.46±1.27) and loss of diabetes management (IR 4.33±1.83). The highest scoring exercise barrier scores for non-IR were not diabetes related with low level of fitness (3.91±1.26) and physical health status excluding diabetes (3.67±1.48) listed as the most salient barrier in non-IR **(Table 2)**. **Table 3** presents the unadjusted and adjusted associations between IR status and BAPAD-1 subscales. Significant associations were observed between eGDR and BAPAD-1 subscales (i.e. loss of control over your diabetes, risk of hypoglycaemia, fear of hurting yourself, fear of suffering a heart attack, presence of diabetes, and risk of hyperglycaemia (p<0.05) **(Table 3)**; The strongest association was for risk of hypoglycaemia in unadjusted and adjusted models (Model 1: β= -0.817; Model 2: β= -0.733; Model 3: β= -0.709, P<0.001) (Table 3). These associated remained robust following adjustment for age, sex, diabetes duration and exercise participation, except fear of being tired and a low level of fitness in model 2 and model 3, and weather conditions in model 2 (P>0.05) (Table 3). Further, significant associations were observed between fear of being tired, a low level of fitness, and weather conditions with eGDR. Location of a gym subscale was not significant with eGDR (P>0.05) **(Table 3).**

The mean SF-36 subscale scores are presented in **Table 4**. No differences were observed across any physical or mental components of the SF-36 when assessing the cohort stratified by IR status. **Table 5** presents the unadjusted and adjusted associations between eGDR and SF-36 subscales. No significant associations were observed in SF-36 subscales and eGDR following unadjusted and adjusted models for age, sex, length of diagnosis, and exercise participation, with the exception of emotional problems which was significantly associated with eGDR following sequential adjustment **(Table 5)**.

**DISCUSSION**

This is the first study to explore attitudes to exercise and QoL in T1D individuals with and without IR. We found that T1D individuals with IR report lower exercise participation levels and greater barriers to exercise than their counterparts without IR. Furthermore, we found that main barriers to exercise differ between T1D individuals with and without IR. Specifically, in our cohort diabetes-specific factors, fear of hypoglycaemia, was the most salient barrier to exercise in T1D individuals with IR, whereas fitness and non-diabetes-specific physical health were the greatest barriers to exercise in T1D individuals without IR; this has still been the case after adjusting for age, gender and diabetes duration.

In the present study, fear of hypoglycaemia had the strongest association with eGDR. Findings from other studies, including those employing the BAPAD1 have demonstrated that fear of hypoglycaemia is a salient barrier to exercise in individuals with T1D7,9. Hypoglycaemia is a common occurrence in response to exercise in individuals with T1D, and this can be difficult to predict, avoid, and manage. Previous studies have reported that the frequency of hypoglycaemia outside the context of exercise ranges from 42 to 91 events per patient year in adults with T1D, with ~12% of individuals experiencing at least one episode of severe hypoglycaemia per year36,37. Data regarding the prevalence of exercise-induced hypoglycaemia in T1D is limited largely to laboratory-based studies which varies depending on the nature of exercise and the treatment strategies employed38, although no single exercise modality or treatment strategy is fully protective. The finding that individuals with IR reported glycaemic factors, specifically hypoglycaemia, as more salient barriers to exercise, than individuals without IR could be related to greater exposure to exercise-induced dysglycaemia given that exercise participation levels were on average lower in individuals with IR. However, the association between glycaemic-related barriers to exercise and eGDR remained robust following adjustment for exercise participation levels. Importantly, the association between eGDR and subscales of the BAPAD1 scale suggests that this tool captures general aspects related to T1D, and it is therefore possible that individuals able to navigate exercise barriers are also better equipped to manage weight, diabetes control and blood pressure. Whereas, individuals without IR outlined non-glycaemic factors, specifically fitness and physical health status, as salient barriers to exercise than individuals with IR could be related to the stabilisation of their blood glucose levels. Notably, moderate exercise participation levels were on average higher in individuals without IR.

In the present study, we did not observe differences in QoL between T1D individuals stratified by IR status. QoL is consistently reported to be lower in individuals with T1D as compared to the general population 10,11,39, as is the presence of IR in the general population13. As such, the finding that IR in T1D is not associated with further decrements in QoL was unexpected. This may be due to the relatively conservative sample size40. Qol scores are summed where a higher score indicates a higher QoL41. Importantly, when comparing the Qol data normalised to a general population with the present study in T1D, the overall physical health (PCS) domain and mental health (MSC) domain values for SF-36 were lower than those reported for the general population42,43. Furthermore, our data have shown that T1D individuals with IR had lower QoL scores in each domain compared with insulin resistant individuals IR in other work 44. Of interest, the association between the emotional problems subscale and eGDR became significant following sequential adjustment, which warrants further investigation, particularly as this is at odds with the other subscales.

In addition to being the first piece of work investigating the effects of IR on barriers to exercise in T1D, this study has a number of strengths to be highlighted. First, we employed validated questionnaires to assess attitudes to exercise and QoL. Second, sampling came from a relatively broad and representative population of T1D individuals, although our population excludes individuals with established diabetes complications. Third, we utilised eGDR – a robust and validated surrogate measure of IR, which has previously been shown to be a strong predictor of diabetes complications as well as mortality27, although we acknolwdge that this is an indirect assessment of IR. Therefore our T1D individuals with IR represent a high-risk subpopulation that require targeted intervention. However, this study is not without limitations and these should be acknowledged. Given the cross-sectional design of our study, it is not possible to infer causation from our findings. Whereas it is possible that lower exercise participation levels may be a contributing factor to the development of IR, it is also likely that the presence of IR may impact exercise participation. Although we did not assess our patients’ understanding of IR, our anecdotal oberservations however are that this is generally poorly understood within the context of T1D and rarely discussed in routine diabetes practice. Our patients were not informed of their IR status prior to completion of the questionnaires. As such, we spectualte that it is unlikely that awareness of IR influenced questionnaire responses. From our reporting methods, it was not possible to objectively assess exercise participation levels in this study, and therefore our findings are based upon self-report data. Lastly, having pooled data from two previous RCTs and thus we cannot exclude the potential for selection bias, and therefore real world studies are needed in a larger group of people and involving different ethinic groups to ensur generalisability of our findings.

**CONCLUSION**

Individuals with T1D and IR participate in lower levels of exercise and present with greater perceived barriers to exercise than T1D individuals without IR. Risk of hypoglycaemia was the greatest barrier to exercise in T1D individuals with IR, whereas non-diabetes related barriers to exercise are more salient in T1D individuals without IR. However, there was no effect in the Qol domains of the SF-36 between IR groups. As such, individual centered physical activity interventions should be designed that consider and account for differences in exercise attitudes in specific subpopulations of T1D individuals.

**AUTHOR DISCLOSURES**

A.M.A., M.D.C., M.H., M.A.Z., R.A.A., J. B., have no conflicts of interest to disclose in relation to this work.

**AUTHOR CONTRIBUTIONS**

A.M.A performed the statistical analysis and searched, contributed to the selection of the references, and involved in the manuscript creation. M.H., M.A.Z., R.A.A., J.B., critically appraised the work and were involved in editing of the final manuscript. M.D.C collected the data, performed searches, contributed to the selection of references, was involved in editing the final manuscript, and had overall oversight of the work. All authors have reviewed and approved the final manuscript.

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**Table 1**. Characteristics of the study population stratified by IR status

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **IR status** |  |
|  | **All data** | **IR**  | **non-IR**  | **P-value** |
| **n** | 85 | 39(46) | 46(54) | - |
| Age (years) | 28.60±5.44 | 30.66±4.99 | 26.86±5.23 | **<0.001a** |
| Sex Male (%) | 43(51) | 22(56) | 21(46) | 0.22c |
| BMI (kg/m2) | 26.52±3.36 | 28.21±3.21 | 25.09±2.79 | **<0.001a** |
| HbA1c (mmol/mol) | 60.96[13.3] | 67.15[22.16] | 56.43[9.10] | **<0.001b** |
| HbA1c (%) | 7.73[1.22] | 8.29[2.03] | 7.32[0.83] | **<0.001b** |
| Length of Diagnosis (years) | 16.27[2.90] | 19.17[12.94] | 14.58[11.38] | **0.003b** |
| Hypertensive (%) | 44(51.80) | 39(100) | 5(10.90) | **<0.001c** |
| Bolus Insulin Aspart (%) |  54(63.50) | 23(59) | 31(67.40) | 0.282c |
| TDD (IU) | 45[8] | 46[9] | 42[7] | **<0.001b** |
| No exercise (%) | 38(45) | 28(72) | 10(22) | **0.004c** |
| Moderate exercise (%) | 32(38) | 13(33) | 19(41) | 0.298c |
| Vigorous exercise (%) | 15(18) | 9(23) | 6(13) | 0.178c |
| Normally distributed variables are reported as mean±SD; non-normally distributed variables are reported as median [IQR]; categorical variables are reported as frequency (%). a = Independent t-test; = bMann-Whitney U test = cFisher’s exact test. **BMI**, Body Mass Index; **HbA1c**, Haemoglobin A1c; **TDD**: total Daily Insulin Dose Requirements |

**Table 2.** Barriers to physical activity in T1D individuals stratified by eGDR (IR status)

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **IR status** |  |
|  |  **All data** | **IR** | **non-IR** | **p-value** |
| 1. Loss of control over your diabetes | 3.49±1.71 | 4.33±1.83 | 2.78±1.24 | **0.004a** |
| 2. Risk of hypoglycaemia | 4.24±1.78 | 5.67±1.26 | 3.02±1.15 | **<0.001c** |
| 3. Fear of being tired | 1.81±0.93 | 1.97±1.06 | 1.67±0.79 | 0.138c |
| 4. Fear of hurting yourself | 1.92±0.97 | 2.08±0.96 | 1.78±0.96 | 0.355c |
| 5. Fear of suffering a heart attack | 2.61±1.57 | 3.49±1.72 | 1.87±0.93 | **<0.001c** |
| 6. A low level of fitness | 4.08±1.31 | 4.28±1.36 | 3.91±1.26 | 0.849c |
| 7. Presence of diabetes | 3.80±1.40 | 4.46±1.27 | 3.24±1.27 | **0.005c** |
| 8. Risk of hyperglycaemia | 4.14±1.63 | 5.23±1.20 | 3.22±1.35 | **<0.001c** |
| 9. Physical health status excluding diabetes | 3.51±1.41 | 3.31±1.34 | 3.67±1.48 | 0.659c |
| 10. Weather conditions | 3.49±2.38 | 3.87±1.15 | 3.17±3.04 | **0.008c** |
| 11. Location of a gym | 2.76±1.14 | 2.87±1.08 | 2.67±1.19 | 0.730c |
| **Standardised total score** | 3.31±0.77 | 3.87±0.61 | 2.83±0.55 | **<0.001b** |
| Normally distributed variables are reported as mean±SD; non-normally distributed variables are reported as median and IQR; categorical variables are reported as frequency (%). a = Independent t-test; = bMann-Whitney U test = cFisher’s exact test. |

**Table 3.** Association between eGDR and BAPAD-1 subscales

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Model 1** |  **Model 2** |  | **Model 3** |
|   | **β (95% CI) p-value** | **β (95% CI) p-value** | **β (95% CI)** | **P-value** |
| **eGDR** |  |  |  |  |  |  |
| 1. Loss of control over your diabetes | -0.629(-1.13 to -0.65) | **<0.001\*\*\*** | -0.522(-0.96 to -0.52)  | **<0.001\*\*\*** | -0.498(-0.92 to -0.49) | **<0.001\*\*\*** |
| 2. Risk of hypoglycaemia | -0.817(-1.29 to -0.95) | **<0.001\*\*\*** | -0.733(-1.19 to -0.81)  | **<0.001\*\*\*** | **-**0.709(-1.16 to -0.78) | **<0.001\*\*\*** |
| 3. Fear of being tired | -0.220(-1.13 to -0.02) | **0.044\*** | -0.165(-0.91 to -0.05) | 0.077 | -0.126(-0.82 to -0.16) | 0.183 |
| 4. Fear of hurting yourself | -0.291(-1.26 to -0.21) | **0.007\*\*** | -0.278(-1.15 to -0.25) | **0.003\*\*** | -0.268(-1.12 to -0.24) | **0.003\*\*** |
| 5. Fear of suffering a heart attack | -0.568(-1.16 to -0.61) | **<0.001\*\*\*** | -0.471(-0.99 to -0.48) | **<0.001\*\*\*** | -0.446(-0.96 to -0.43) | **<0.001\*\*\*** |
| 6. A low level of fitness | -0.281(-0.91 to -0.13) | **0.009\*\*** | -0.115(-0.58 to 0.15) | 0.249 | -0.174(-0.69 to 0.04) | 0.082 |
| 7. Presence of diabetes | -0.461(-1.14 to -0.46) | **<0.001\*\*\*** | -0.341(-0.90 to -0.28) | **<0.001\*\*\*** | -0.335(-0.89 to -0.27) | **<0.001\*\*\*** |
| 8. Risk of hyperglycaemia | -0.710(-1.29 to -0.83) | **<0.001\*\*\*** | -0.601(-1.11 to -0.69) | **<0.001\*\*\*** | -0.581(-1.08 to -0.66) | **<0.001\*\*\*** |
| 9. Physical health status excluding diabetes  | 0.148(-0.12 to 0.63) | 0.176 | 0.220(0.07 to 0.69) | **0.019\*** | 0.262(0.15 to 0.76) | **0.004\*\*** |
| 10. Weather conditions | -0.237(-0.46 to -0.03) | **0.029\*** | -0.177(-0.37 to -0.01) | 0.061 | -0.188(-0.38 to -0.01) | **0.043\*** |
| 11. Location of a gym | -0.094(-0.67 to -0.26) | 0.392 | -0.111(-0.63 to 0.16) | 0.237 | -0.083(-0.57 to 0.22) | 0.374 |
| Model 1 unadjusted; Model 2 adjusted for age, sex, length of diagnosis; Model 3 adjusted for age, sex, duration of diabetes , and exercise participation. \*Significant association at p<0.05); \*\* significant association at p<0.01); \*\*\*significant association at p<0.001). |

**Table 4.** Quality of life (QoL) scores for T1D patients stratified by eGDR (IR status)

|  |
| --- |
|  **IR status** |
|  | **All data** | **IR**  | **non-IR** | **P-value** |
| 1. PF-NBS | 48.00(20.00) | 52.00(20.00) | 43.00(20.25) | 0.733b |
| 2. RP-NBS | 44.00(27.00) | 48.00(25.00) | 39.00(29.00) | 0.423b |
| 3. BP-NBS | 42.00(22.00) | 42.00(21.00) | 38.00(22.00) | 0.919b |
| 4. GH-NHS | 41.02±11.64 | 41.46±12.36 | 40.65±11.13 | 0.752a |
| 5. VT\_NBS | 43.75±12.20 | 44.08±12.95 | 40.48±11.67 | 0.823a |
| 6. SF-NBS | 42.00(30.00) | 42.00(30.00) | 39.50(25.00) | 0.520b |
| 7. RE\_NBS | 46.00(31.00) | 49.00(28.00) | 37.00(28.75) | 0.054b |
| 8. MH-NBS | 46.00(23.00) | 46.00(21.00) | 43.00(23.00) | 0.527b |
| 9. PCS  | 43.81±11.63 | 43.67±11.69 | 43.93±11.69 | 0.916a |
| 10. MCS  | 40.82±14.74 | 42.85±15.77 | 39.11±13.75 | 0.247a |
| Normally distributed variables are reported as mean±SD; non-normally distributed variables are reported as median and IQR; and categorical variables are reported frequency %. a = Independent t-test; = bMann-Whitney U test = cFisher’s exact test. |
| **PF,** physical functioning; **RP**, role limitation due to physical health; **BP,** Bodily pain; **GH**, general health; **VT**, vitality; **SF**, social functioning; **RE**, role limitations due to emotional problems; **MH**, mental health; **PCS,** physical component summary; **MCS,** Mental component summary.  |

**Table 5.** Association between eGDR (IR Status) and Quality of Life (QoL) in T1D

|  |  |  |  |
| --- | --- | --- | --- |
|   | **Model 1**  | **Model 2**  | **Model 3**  |
|   | **β (95% CI)**  | **p-value**  | **β (95% CI)**  | **P-value**  | **β (95% CI)**  | **P-value**  |
| **eGDR**  |
| 1. PF-NBS2. RP\_NBS3. BP\_NBS4. GH\_NBS5. VT\_NBS6. SF\_NBS7. RE\_NBS8. MH\_NBS9. PCS10. MCS | 0.003(-0.04 to 0.05)-0.006(-0.05 to 0.03)0.003(-0.04 to 0.04)-0.005(-0.05 to 0.04)0.009(-0.04 to 0.05)0.000(-0.04 to 0.04)-0.024(-0.06 to 0.01)-0.003(-0.04 to 0.04)0.009(-0.04 to 0.06)-0.012(-0.05 to 0.02)  | 0.8930.758 0.8800.8330.6990.9880.1530.8620.6920.495 |  -0.001(-0.03 to 0.04) -0.007(-0.04 to 0.03) -0.006(-0.04 to 0.03) -0.017(-0.06 to 0.02) 0.001(-0.04 to 0.04) -0.014(-0.05 to 0.02) -0.029(-0.06 to -0.001)   -0.018(-0.05 to 0.02) 0.007(-0.03 to 0.05) -0.025(-0.06 to 0.001) |  0.962 0.694 0.765 0.396 0.953 0.379 **0.043\*** 0.286 0.715 0.112 |  -0.002(-0.04 to 0.04)  -0.010(-0.04 to 0.03) -0.010(-0.05 to 0.03) -0.023(-0.06 to 0.02) -0.004(-0.05 to 0.04) -0.022(-0.06 to 0.01) -0.032(-0.06 to -0.003) -0.022(-0.06 to 0.01) 0.004(-0.04 to 0.05) -0.031(-0.06 to 0.002) |  0.923 0.584 0.615 0.239 0.828 0.195 **0.032\*** 0.220 0.847 0.062 |
| Model 1 unadjusted; Model 2 adjusted for age, sex, length of diagnosis; Model 3 adjusted for age, sex, length of diagnosis, and exercise participation. \*Significant association at p<0.05); \*\* significant association at p<0.01); \*\*\*significant association at p<0.001).  |

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