

Article

Self-Reported Physical Activity Among Individuals with Diabetes Mellitus in Germany—Identifying Potential Barriers and Facilitators

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Abstract

Background/Objectives: Physical activity is a cornerstone of diabetes mellitus (DM) management and is strongly recommended in the American Diabetes Association (ADA)'s guidelines. This study aims to investigate the self-reported physical activity levels of individuals with DM in Germany, as well as the barriers and facilitators they encounter. **Methods:** Individuals with type 1 DM (T1DM) and type 2 DM (T2DM) were asked to fill out an online questionnaire that was partly based on the International Physical Activity Questionnaire (IPAQ). **Results:** The questionnaire was completed by 338 persons with either T1DM (57.1%) or T2DM (42.9%) (females: 56.2%, males: 42.0%, gender diverse persons: 1.8%) of all age groups (at least 18 years). In total, 80.5% of respondents were aware of the current physical activity recommendations. Among the respondents, 58% reported meeting the recommendations for endurance-type physical activity, while only 30.5% reported meeting those for strength training. The three most frequently cited barriers to physical activity were lack of time, lack of motivation and current state of health. Supporting factors included coverage of costs, availability of exercise programs in close proximity to the patient's home and target group specific exercise programs. **Conclusions:** The results imply that many individuals with DM in Germany do not meet ADA's physical activity recommendations, especially considering that self-reports often overestimate actual behavior. In particular, the actual number of individuals who regularly engage in strength training may be too low. There is a clear need to better communicate the benefits of different forms of physical training and to provide physical activity programs aligned with patients' individual needs.

Keywords: type 1 diabetes mellitus; type 2 diabetes mellitus; ADA; adherence; questionnaire



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1. Introduction

Diabetes mellitus (DM) is a growing global health problem [1]. As of 2024, around 589 million people worldwide are affected by the disease, and this number is projected to rise further in coming years for both type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus (T2DM) [2,3]. In Germany, at least 8.9 million people are living with DM [4]. The disease is often accompanied by a variety of comorbidities and secondary

complications [5–7]. This results in a substantial economic burden [8,9]. Regular physical activity positively influences multiple health outcomes in individuals with DM, for example improvements in insulin sensitivity, glycemic control, cardiovascular health as well as mental well-being [10–18]. Lifestyle interventions may even induce remission of T2DM [19,20]. Among others, the underlying mechanisms include a long-term reduction in inflammation and oxidative stress [21–28]. Given the tremendous health benefits associated with physical activity, it is strongly recommended for all patients with DM to reduce sedentary behavior and be as physically active as possible [29,30].

The American Diabetes Association (ADA) recommends individuals with DM to engage in at least 150 min of moderate endurance-type physical activity per week, or 75 min of more intense physical activity for younger or physically fit persons. Additionally, the ADA recommends strength training on two to three non-consecutive days per week [29]. The German Diabetes Association (DDG) incorporated the ADA's recommendations into its current practice guidelines [30].

Studies in other countries, e.g., (rural) South Africa, Ireland, Iran, Saudi Arabia, Portugal or Qatar show that people with diabetes often fail to meet the recommended levels of physical activity [31–36]. To our knowledge, there are no recent studies about (self-reported) physical activity among individuals with diabetes in Germany. To address this research gap, this study aims to assess awareness of the ADA's physical activity recommendations among persons with DM and adherence to those guidelines. Furthermore, perceived barriers to physical activity as well as facilitators that might be relevant for coaching individuals with DM should be captured [37,38].

2. Methods

2.1. Study Design

In this cross-sectional study, an online survey was conducted via the “Soscisurvey” platform (<https://www.soscisurvey.de>, first accessed on 17 February 2024) between 17 February 2024 to 14 April 2024. The survey was promoted through social media (Facebook, Instagram). Furthermore, 902 interest groups (diabetology practices, diabetes centers, self-help groups, etc.) were contacted by email. The research team used contact lists provided by the DDG. Additional contacts were identified through an internet search. The survey was also promoted on “SurveyCircle.com” (first accessed on 28 February 2024), a platform where researchers support each other by participating in surveys. Eligibility criteria for participation in the present survey included being at least 18 years old and having a diagnosis of DM.

2.2. Ethical Approval

The survey was conducted in accordance with applicable data protection regulations and the Declaration of Helsinki. All responses were collected anonymously. The study has been approved by the internal Ethics Committee of the IST University of Applied Sciences Düsseldorf (No. IR1605IST233).

2.3. Survey

Following questions on sociodemographic factors (age, sex, education level, living situation), participants were asked about their diabetes diagnosis, awareness of physical activity guidelines, adherence to these guidelines, physical activity behavior as well as perceived barriers and facilitators. Questions to assess participants' weekly physical activity levels were based on the World Health Organization (WHO)'s International Physical Activity Questionnaire (IPAQ) [39]. Additional questions on weekly strength training

were included due to its importance in DM management [30,40,41]. Questions addressing barriers and facilitators were adapted from previous studies [32,42–53].

2.4. Statistics

Descriptive data analysis was carried out using IBM SPSS 29.0.2.0. Where frequencies are reported as percentages, the exact number of valid responses is provided in brackets. If two numbers are shown in brackets separated by a slash, the first number indicates the number of responses and the second refers to the total number of participants.

Further analyses were conducted using R (version 4.4.2). A linear mixed-effects (LME) model was applied to examine the relationship between weekly Metabolic Equivalent of Task (MET) minutes and a range of sociodemographic, medical and behavioral factors, while accounting for regional variation. Weekly MET minutes were computed by weighting self-reported moderate and vigorous endurance activity using standard MET conversion factors (moderate: ×4; vigorous: ×8).

The model included the following fixed effects: sex, age group, education level, place of residence, diabetes type, and the presence of comorbidities (yes/no). Additionally, behavioral predictors were incorporated: occupational physical activity was classified as intensive, moderate, sedentary, or no information based on type of work. Transport-related physical activity was assessed metrically as the number of active transport trips per week. Motivation to be physically active was measured through self-reported discipline levels (very, rather, less, not at all disciplined). Dichotomous indicators (yes/no) were also included to indicate whether participants had received physical activity recommendations from various sources: general practitioner, diabetes education programs, internet, printed materials (e.g., magazines), or other channels.

To account for potential regional differences in the level of physical activity, a random intercept for federal state was included in the model, allowing for variation in baseline activity levels across different regions. The model was estimated using restricted maximum likelihood (REML) to obtain unbiased variance estimates. Degrees of freedom and *p*-values for the fixed effects were calculated using Satterthwaite’s approximation. Results are presented as estimated marginal means with standard deviations and *p*-values, with statistical significance set at *p* < 0.05. Model diagnostics, including residual plots, were reviewed to assess heteroscedasticity and the normality of residuals. Participants with missing data in any of the modeled variables were excluded using listwise deletion (*n* = 196 complete cases).

3. Results

A total of 556 questionnaires were collected, of which 218 were excluded for the following reasons: insufficient completion (less than 80%) (*n* = 89), missing diabetes diagnosis or no information on diabetes type (*n* = 116), any indication of a DM type other than T1DM or T2DM (*n* = 13). Finally, 338 questionnaires were analyzed. The respondents’ demographic data are presented in Table 1.

Table 1. Demographic data.

Females: 56.2% (<i>n</i> = 190) Males: 42.0% (<i>n</i> = 142) Gender diverse persons: 1.8% (<i>n</i> = 6)	All Participants (<i>n</i> = 338)	Type 1 DM 57.1% (<i>n</i> = 193)	Type 2 DM 42.9% (<i>n</i> = 145)
Age (years)			
18–39	24.0% (<i>n</i> = 81)	38.3% (<i>n</i> = 74)	4.8% (<i>n</i> = 7)
40–59	35.8% (<i>n</i> = 121)	37.8% (<i>n</i> = 73)	33.1% (<i>n</i> = 48)
60+	40.2% (<i>n</i> = 136)	23.8% (<i>n</i> = 46)	62.1% (<i>n</i> = 90)

Table 1. *Cont.*

Education level			
No school-leaving certificate	0.9% (n = 3)	0	2.1% (n = 3)
Lower secondary school	5.3% (n = 18)	3.1% (n = 6)	8.3% (n = 12)
Secondary school	12.8% (n = 43)	10.0% (n = 19)	16.6% (n = 24)
A-level	7.4% (n = 25)	7.9% (n = 15)	6.9% (n = 10)
Completed vocational training	33.3% (n = 112)	35.1% (n = 67)	31.0% (n = 45)
Bachelor or Master craftsman	15.5% (n = 52)	16.8% (n = 32)	13.8% (n = 20)
Master or diploma	23.5% (n = 79)	25.7% (n = 49)	20.7% (n = 30)
Doctorate	1.2% (n = 4)	1.6% (n = 3)	0.7% (n = 1)
Living situation			
Village (<5000 inhabitants)	35.2% (n = 119)	32.6% (n = 63)	38.6% (n = 56)
Small town (up to 20,000)	18.6% (n = 63)	14.0% (n = 27)	24.8% (n = 36)
Urban area (up to 100,000)	21.0% (n = 71)	23.3% (n = 45)	17.9% (n = 26)
Large city (>100,000)	25.1% (n = 85)	30.1% (n = 58)	18.6% (n = 27)
Diagnosis (years ago)			
<5 years	20.4% (n = 69)	17.1% (n = 33)	24.8% (n = 36)
5–9 years	11.2% (n = 38)	5.2% (n = 10)	19.3% (n = 28)
10–14 years	18.0% (n = 61)	10.9% (n = 21)	27.6% (n = 40)
15–19 years	11.8% (n = 40)	11.9% (n = 23)	11.7% (n = 17)
>20 years	38.5% (n = 130)	54.9% (n = 106)	16.6% (n = 24)
Secondary diseases			
Yes	36.6% (n = 123)	29.2% (n = 56)	46.5% (n = 67)
No	63.4% (n = 213)	70.8% (n = 136)	53.5% (n = 77)

3.1. Knowledge of ADA's Physical Activity Recommendations

Among all respondents (n = 338), 80.5% (n = 272) reported being aware of existing physical activity guidelines for persons with DM (among those with T1DM: 86.0% [n = 166/n = 193], those with T2DM: 73.1% [n = 106/n = 154]). Study participants were also asked where they received information about these physical activity recommendations. Multiple responses were allowed, and the most frequently cited sources were medical practices and DM education courses (Table 2).

Table 2. Most reported sources where patients receive information about physical activity recommendations.

Sources of Information	All Participants (n = 279)	Type 1 DM (n = 168)	Type 2 DM (n = 111)
Medical practice	53.8% (n = 150)	46.4% (n = 78)	64.9% (n = 72)
Diabetes education course	42.7% (n = 119)	42.9% (n = 72)	42.3% (n = 47)
Internet	24.4% (n = 68)	26.8% (n = 45)	20.7% (n = 23)
Magazines/Journals	18.3% (n = 51)	21.4% (n = 36)	13.5% (n = 15)

Multiple answers possible.

Other reported sources of information included work (n = 12), self-help groups (n = 9), and rehabilitation programs (n = 3). The recommendations are fully comprehensible for 81.5% of respondents (n = 269), mostly comprehensible for 16.1% (n = 53), mostly not comprehensible for 1.8% (n = 6), and not comprehensible for 0.6% (n = 2). Among the participants, 75.9% (n = 245) deemed the recommended volume of physical activity to be appropriate, 19.5% (n = 63) considered it too high and 4.6% (n = 15) too low.

3.2. Attitudes Toward Physical Activity

Study participants were asked about their (dis)agreement with several statements (Table 3). Most individuals with DM agreed that they themselves are responsible for planning and performing physical activities and that regular physical activity can positively influence DM. Most respondents with DM stated that they do not need qualified support in planning and performing physical activities.

Table 3. Agreement with statements on physical activity.

Statements	All Participants	Type 1 DM	Type 2 DM
Physical activity is part of my diabetes therapy	43.9% (n = 126/ n = 287)	42.1% (n = 67/ n = 159)	46.1% (n = 59/ n = 128)
Physical activity should be part of my diabetes therapy	67.1% (n = 192/ n = 286)	62.9% (n = 100/ n = 159)	72.4% (n = 92/ n = 127)
I can positively influence diabetes through physical activity	78.5% (n = 226/ n = 288)	73.0% (n = 116/ n = 159)	85.3% (n = 110/ n = 129)
I would like to receive more information about physical activity as part of my diabetes treatment	34.8% (n = 100/ n = 287)	34.6% (n = 55/ n = 159)	35.2% (n = 45/ n = 128)
I am responsible for planning and performing physical activities	89.6% (n = 258/ n = 288)	94.3% (n = 150/ n = 159)	83.7% (n = 108/ n = 129)
I need qualified support in planning and performing physical activities	24.4% (n = 70/ n = 287)	20.1% (n = 32/ n = 159)	29.7% (n = 38/ n = 128)
I am willing to finance participation in exercise programs myself	53.2% (n = 151/ n = 284)	52.2% (n = 82/ n = 157)	54.3% (n = 69/ n = 127)

3.3. Adherence to ADA's Physical Activity Recommendations

Most respondents stated that they always or mostly fulfil the ADA's recommendations for endurance-type physical activity (Table 4).

Table 4. Adherence to ADA recommendations for endurance-type physical activity.

Recommendations	All Participants	Type 1 DM	Type 2 DM
Always or mostly met	58.0% (n = 188)	60.7% (n = 111)	54.6% (n = 77)
Rarely met	33.0% (n = 107)	29.5% (n = 54)	37.6% (n = 53)
Never met	5.6% (n = 18)	7.1% (n = 13)	3.5% (n = 5)
I don't know	3.4% (n = 11)	2.7% (n = 5)	4.3% (n = 6)

3.3.1. Self-Reported Engagement in Endurance Training

Participants were asked about the time they spend on endurance training per week (Table 5).

Table 5. Self-reported time respondents spend on endurance training per week (in minutes).

Intensity	All Participants	Type 1 DM	Type 2 DM
Moderate	114 ± 139 (n = 278)	132 ± 159 (n = 152)	92 ± 107 (n = 126)
Intense	42 ± 79 (n = 260)	52 ± 95 (n = 148)	29 ± 48 (n = 112)

3.3.2. Self-Reported Engagement in Strength Training

The recommendation to engage in strength training at least two days a week is met by only a minority of all respondents with DM according to their own information (Table 6).

Table 6. Adherence to ADA recommendations for strength training.

Recommendations	All Participants	Type 1 DM	Type 2 DM
Met	30.5% (n = 90)	27.4% (n = 45)	34.4% (n = 45)
Not met	69.5% (n = 205)	72.6% (n = 119)	65.6% (n = 86)

3.4. Sports Diary

The majority of respondents (89.1%) do not maintain a sports diary (n = 270/n = 303). Only 7.3% of participants with T1DM (n = 12/n = 165) and 2.9% with T2DM (n = 4/n = 138) reported that they regularly keep a sports diary.

3.5. Changes in Physical Activity Level Since DM Diagnosis

When asked about changes in their level of activity since diagnosis, 30.8% ($n = 92$) of all respondents stated that they are more active, 13.0% ($n = 39$) are less active, and 56.2% ($n = 168$) are as active as before their diagnosis.

Among participants with T1DM, 26.1% ($n = 42$) reported being more active, 13.7% ($n = 22$) less active, and 60.2% ($n = 97$) as active as before their diagnosis. In persons with T2DM, 36.2% ($n = 50$) said they are more active, 12.3% ($n = 17$) are less active, and 51.4% ($n = 71$) are as active as before their diagnosis.

3.6. Influence of Sociodemographic, Health-Related and Behavioral Factors on Calculated MET-Minutes per Week

The LME analysis, which included 188 participants (i.e., complete cases with no missing data), estimated a residual variance of 211,140,024 MET minutes, with a residual standard deviation of 14,531. After adjusting for demographic, health-related and behavioral factors, as well as regional differences, the results revealed that occupational physical activity had the strongest association with weekly MET minutes. The marginal R^2 of the model was 0.150, indicating that the fixed effects explained approximately 15.0% of the variance in MET minutes. The conditional R^2 was 0.597, suggesting that the full model, including both fixed and random effects (federal state), accounted for 59.7% of the total variance.

Compared to participants engaged in physically intense occupations, those involved in moderately physical work reported significantly higher estimated MET minutes (estimate = 38,805; SD = 6866, $p < 0.001$), while no significant difference was observed for participants with sedentary occupations ($p > 0.05$).

Regarding sociodemographic and medical factors, sex, age group, and the presence of comorbidities did not reveal statistically significant effects on MET minutes ($p > 0.05$). However, diabetes type showed a significant effect: participants with T2DM reported significantly fewer MET minutes compared to those with T1DM ($p = 0.019$).

Education level, however, showed some variation. Participants with a *Hauptschule* degree (lower secondary education) reported an average of 712 MET minutes per week (SD = 979). Compared to the reference group without any school-leaving qualification, they accumulated significantly fewer MET minutes ($p = 0.032$). No significant differences were observed for other education levels compared to the reference group ($p > 0.05$).

As for environmental and behavioral factors, participants residing in urban areas did not accumulate significantly more MET minutes than those in rural areas ($p > 0.05$). The source of physical activity recommendations also did not have a significant impact on MET minutes ($p > 0.05$). Transport-related activity and self-reported motivation levels also did not significantly influence the amount of MET minutes ($p > 0.05$).

These findings suggest that occupational physical activity is the most relevant factor influencing weekly MET minutes, while level of education and diabetes type may also play a role.

3.7. Barriers to and Facilitators of Physical Activity

Among the potential barriers to physical activity, the three most frequently mentioned ones by individuals with T1DM and T2DM were lack of time, lack of motivation and state of health (excluding diabetes-related complaints) (Table 7). Social circumstances refer to lack of a training partner or social support. Fear of negative health consequences includes, for example, fear of hypoglycemia or injuries.

Table 7. Barriers to physical activity.

Barriers	All Participants (n = 297)	Type 1 DM (n = 164)	Type 2 DM (n = 133)
Lack of time	52.2% (n = 155)	58.5% (n = 96)	44.4% (n = 59)
Lack of motivation	44.1% (n = 131)	40.9% (n = 67)	48.1% (n = 64)
Lack of fun	14.5% (n = 43)	17.1% (n = 28)	11.3% (n = 15)
Bad weather	24.9% (n = 74)	18.9% (n = 31)	32.3% (n = 43)
Financial reasons	7.7% (n = 23)	9.1% (n = 15)	6.0% (n = 8)
Social circumstances	12.1% (n = 36)	11.6% (n = 19)	12.8% (n = 17)
Distance to sport facilities	7.7% (n = 23)	10.4% (n = 17)	4.5% (n = 6)
Advice from physician to not engage in physical activity	1.3% (n = 4)	1.8% (n = 3)	0.8% (n = 1)
Fear of negative health consequences (e.g., hypoglycemia, injuries)	13.1% (n = 39)	19.5% (n = 32)	5.3% (n = 7)
DM itself and secondary diseases	5.1% (n = 15)	6.7% (n = 11)	3.0% (n = 4)
State of health (except diabetes-related issues)	31.3% (n = 93)	22.6% (n = 37)	42.1% (n = 56)

Multiple answers possible.

Other barriers mentioned (in the free text field) included, for example, fully booked sport courses (n = 1), acute infections (n = 3), relocation and adjusting to a new place of residence (n = 1) or high level of physical activity at work (n = 1) and shift work (n = 1).

Participants were also asked about factors that could enhance their level of physical activity. The results, presented in Table 8, indicate that the most frequently cited facilitators among the respondents were coverage of costs, availability of exercise programs in close proximity to the patient's home and target group specific exercise programs.

Table 8. Facilitators of physical activity.

Facilitators	All Participants (n = 284)	Type 1 DM (n = 158)	Type 2 DM (n = 126)
Coverage of costs (by health insurance company)	66.5% (n = 189)	65.2% (n = 103)	68.3% (n = 86)
Integration of physical activity into the workday (activity during breaks, sport during work)	38.4% (n = 109)	48.7% (n = 77)	25.4% (n = 32)
Advertisements of healthy living	17.3% (n = 49)	13.3% (n = 21)	22.2% (n = 28)
Availability of exercise programs in close proximity to the patient's home	62.3% (n = 177)	59.5% (n = 94)	65.9% (n = 83)
Target group specific exercise program	51.8% (n = 147)	53.8% (n = 85)	49.2% (n = 62)
Digital services	15.1% (n = 43)	17.1% (n = 27)	12.7% (n = 16)

Multiple answers possible.

Other facilitators mentioned (in the free text field) included, for example, education in diabetes practices (n = 1), childcare while exercising (n = 1), personal training equipment (n = 1), subsidy from the employer for, e.g., Urban Sports Club or Wellpass (flexible membership for gyms) (n = 1) and having a training partner (n = 1).

In a next step, we explored the types of sports the participants would be most likely to engage in regularly. Respondents were asked to rate these on a 5-point scale (1 = not like to engage in, 5 = very much likely to engage in). Table 9 presents the percentage of respondents who would like to engage in (4) or would very much like to engage in (5) the given type of sport. Among those with T1DM, the most popular sports activities included cycling, hiking and walking/Nordic walking. For individuals with T2DM, the top three sports mentioned were cycling, swimming and hiking (Table 9).

Table 9. Sports individuals with DM would like to or very much like to engage in.

Sports	All Participants	Type 1 DM	Type 2 DM
(Nordic) Walking	49.0% (n = 124/ n = 253)	49.3% (n = 68/ n = 138)	48.7% (n = 56/ n = 115)
Running	29.6% (n = 76/ n = 257)	33.3% (n = 48/ n = 144)	24.8% (n = 28/ n = 113)
Hiking	59.5% (n = 160/ n = 269)	64.7% (n = 97/ n = 150)	52.9% (n = 63/ n = 119)
Cycling	68.8% (n = 183/ n = 266)	66.0% (n = 97/ n = 147)	72.3% (n = 86/ n = 119)
Swimming	50.4% (n = 132/ n = 262)	41.5% (n = 61/ n = 147)	61.7% (n = 71/ n = 115)
Dancing	37.9% (n = 96/ n = 253)	46.3% (n = 68/ n = 147)	26.4% (n = 28/ n = 106)
Cross-country skiing	20.6% (n = 48/ n = 233)	26.3% (n = 36/ n = 137)	12.5% (n = 12/ n = 96)
Fitness training in the gym	37.6% (n = 102/ n = 271)	34.2% (n = 52/ n = 152)	42.0% (n = 50/ n = 119)
Yoga/Pilates	34.7% (n = 86/ n = 248)	39.2% (n = 56/ n = 143)	28.6% (n = 30/ n = 105)
Thai Chi	21.7% (n = 49/ n = 226)	19.5% (n = 25/ n = 128)	24.5% (n = 24/ n = 98)
Coordination exercises	39.4% (n = 100/ n = 254)	39.9% (n = 57/ n = 143)	38.7% (n = 43/ n = 111)
Aqua gymnastics	37.7% (n = 98/ n = 260)	31.3% (n = 46/ n = 147)	46.0% (n = 52/ n = 113)

Multiple answers possible.

4. Discussion

The primary aim of this study was to assess the level of adherence of individuals with T1DM and T2DM who reside in Germany to the ADA's physical activity recommendations, and to investigate possible barriers and facilitators.

Among all participants, 58% stated that they usually or always meet the ADA's physical activity recommendations (respondents with T1DM: 60.7%, with T2DM: 54.6%). On average, and based on self-reported data, respondents spend around 114 min per week on moderate-intensity endurance training and 42 min on intense endurance training. However, there was substantial variation in reported durations. Furthermore, only 30.5% of patients performed strength training exercises at least two days per week as recommended by the ADA.

The most commonly reported barriers to physical activity for individuals with T1DM and T2DM were lack of time, lack of motivation and poor state of health. The coverage of costs, availability of exercise programs in close proximity to the patient's home, as well as target group specific exercise programs were frequently mentioned facilitators.

4.1. Self-Reported Physical Activity

Our findings are similar to the findings of previous studies, which show relatively low adherence among patients with DM to physical activity guidelines [31–36].

One limitation is that self-reported physical activity levels are often overestimated. Finn et al. [32] examined adherence to physical activity guidelines among individuals with T1DM in Ireland using both objective measurement methods (accelerometry) and subjective assessments based on the IPAQ. While 97% of participants fulfilled the recommendations based on self-reports, only 32% did so according to the objective accelerometer data. This highlights a potential discrepancy between subjective perception and objective measure-

ment of physical activity and must also be taken into consideration when interpreting the results of our study [54,55].

4.2. Self-Reported Engagement in Endurance and Strength Training

Physical activity is strongly recommended for persons with DM. Both endurance and strength training have been shown to have beneficial effects for individuals with DM, e.g., on glycemic control [30,40,56,57]. A combination of endurance and strength training is also strongly recommended for persons with DM [58,59]. The participants in our study showed a preference for endurance training, while strength training seems to be less popular, despite its positive effects on muscle mass and glucose homeostasis. According to their self-report, only one-third of respondents met the ADA's recommendations (performing strength training twice a week). This highlights an urgent need to better communicate the positive effects of strength training and to find solutions for making strength training more attractive for patients with DM. Although most respondents were aware of the beneficial effects of exercise (T1DM: 73.0%; T2DM: 85.3%), many failed to adequately translate it into practice.

The most popular sports among persons with DM in Germany were cycling, hiking, swimming and (Nordic) walking. This is an encouraging finding, because these physical activities have a low impact on joints, which is relevant given that many individuals with diabetes are overweight and suffer from osteoarthritis [60]. All of these sports involve simple movements, can be easily integrated into daily routines and have significant health benefits for patients with DM [61–64].

4.3. Barriers and Facilitators

Similar barriers and facilitators to physical activity, as identified by participants in our study, have also been reported in other studies involving patients with DM [42,44]. The barrier lack of time can be addressed through time-efficient training methods such as high-intensity interval training, if suitable for the patient [65,66]. Furthermore, the integration of physical activities in patients' daily routines can be a useful approach. Citing poor state of health as a reason for inactivity can be addressed through tailored exercise programs that consider secondary diseases and physical disabilities. In this regard, individuals with DM residing in Germany can participate in diabetes-specific sports courses (rehabilitation sport), which are free of charge and can be prescribed by a physician. Another option is training in certified fitness centers. The DDG, in collaboration with several partners, has developed a quality certification for fitness facilities that have experienced diabetes coaches, emergency management protocols and high standards of patient care. Home-based training may also be a strategy to improve health outcomes in persons with DM [67–69]. Exercising at home is not only time efficient but also cost-effective. However, several studies have shown that supervised training is more effective than unsupervised home-based exercise [70]. Supervised exercise is recommended for many patients with DM for safety reasons. German health insurance providers cover the costs of both rehabilitation sport programs and digital health applications (DIGAs). However, for such digital exercise programs to be effective, the user must have a certain affinity for apps. Another option for saving costs is engagement in simple sports that do not require much equipment, such as walking or Nordic walking.

4.4. Knowledge Versus Behavior and Implications for Practice

In our study, 80.5% of respondents reported being aware of the existence of physical activity guidelines. Clearly, there is a gap between knowledge and behavior, as not all of them manage to translate the recommendations into practice. Therefore, it is essential to develop practicable solutions and closely examine the support systems in place.

The most frequently mentioned sources of information were medical practices and diabetes training courses, highlighting the important roles of physicians and medical staff in counseling individuals with DM [71]. Physicians and diabetes care teams should actively inform patients about the benefits of physical activity and encourage them to increase their activity levels. Unfortunately, medical staff are often not adequately qualified to provide effective guidance on physical activity [72]. “Movement experts” should therefore be employed or existing medical staff should be trained accordingly. Diabetes teams need to be better informed about available resources, such as the aforementioned rehabilitation sport programs, certified fitness centers or DIGAs.

To reach or sustain the desired behavior (being physically active), patients must find it enjoyable [73–76]. It is therefore important to address individuals’ needs and existing barriers, and support them in finding a suitable form of physical activity.

4.5. Limitations

The present study has several limitations. A selection bias may be present, as individuals already interested in physical activity might have been more inclined to participate. In addition, the questionnaire was primarily distributed through digital media, potentially excluding older adults who may have lower digital literacy. As already mentioned, reliance on self-reported data is a significant limitation, as participants may have overestimated their activity level or reported a higher activity level due to social desirability. In addition, it remains a limitation that the questionnaire has not been validated in its entirety. Another limitation is that a sample size calculation has not been performed *a priori*. It is also a limitation that many participants were not included in the LME model due to the fact that participants with missing data in any of the modeled variables were excluded from the analysis.

5. Conclusions

The present study provides new insights into the self-reported physical activity behavior of people with diabetes in Germany. Although 80.5% of respondents residing in Germany are aware of the current physical activity guidelines, only 58% reported meeting the ADA recommendations for endurance-type physical activity. This highlights a clear knowledge-behavior gap. This gap appears even wider for strength training, with just 30.5% of participants meeting the recommended levels. To effectively address the most commonly cited barriers, there is an urgent need for highly motivating, tailored, time-efficient and free of charge physical activity programs. Comprehensive individual counseling by exercise specialists should be incorporated into the German Disease Management Program (DMP) “Diabetes mellitus” to reach as many patients as possible.

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Institutional Review Board Statement: Following a thorough review by the university’s internal ethics committee, it was determined that the study fully complies with the ethical guidelines of the German Research Foundation (DFG), the recommendations of the German Psychological Society (DGPs), and the principles of the Declaration of Helsinki. The data collection is based exclusively on anonymized questionnaire responses, without any physical interventions or procedures exceeding everyday experiences of discomfort or burden. No physical or psychological risks were identified for

the participants. The respondents do not belong to any particularly vulnerable group, and the content of the questions is not expected to cause emotional distress, stress reactions, or other impairments. Moreover, participation does not entail any foreseeable social, legal, or professional risks. Participation in the survey is informed and voluntary, and the study is conducted in full compliance with all applicable data protection regulations. The survey platform used ensures complete anonymization of the data at the point of collection through appropriate technical safeguards. Considering these conditions, the university's internal ethics committee hereby informally confirms the ethical approval of the study. A formal ethics vote is not required.

Informed Consent Statement: Informed consent was obtained from all subjects involved in this study.

Data Availability Statement: Data are available from the corresponding author upon reasonable request due to privacy reasons.

Conflicts of Interest: C.B. reports relationships with Abbott, Novo Nordisk and Lilly. The companies had no role in the design of the study, in the collection, analyses or interpretation of the data, in the writing of the manuscript or in the decision to publish the results.

Abbreviations

The following abbreviations are used in this manuscript:

ADA	American Diabetes Association
DDG	German Diabetes Association
DIGA	Digital health application
DM	Diabetes mellitus
IPAQ	International Physical Activity Questionnaire
LME	Linear mixed-effects
MET	Metabolic equivalent of task
REML	Restricted maximum likelihood
T1DM	Type 1 diabetes mellitus
T2DM	Type 2 diabetes mellitus
WHO	World Health Organization

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