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# PHYSICAL ACTIVITY AND DIABETIC NEUROPATHIC PAIN IN TYPE 2 DIABETES

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**ABSTRACT**: Background: Diabetes mellitus T2DM is a leading health care challenge worldwide, and diabetic neuropathic pain (DNP) is one of the most common and severe complications of diabetes. Despite being a foundation of diabetes treatment, the relationship of physical activity with the painful axis of neuropathy is not well defined, and preliminary data are inconsistently reported. This study was conducted to assess the association of physical activity level and its pattern characteristics with the development of diabetic neuropathic pain in type 2 diabetes mellitus (T2DM) patients. The study was performed in the Ngoro Community Health Center (UPT Puskesmas), Mojokerto Regency, Indonesia, on patients registered in the Prolanis program for chronic disease management. We used a cross sectional observation design with patients with T2DM. Demographics, diabetes duration, profile of physical activity (type, frequency, duration) and the presence of DNP were obtained from structured interviews and standardized questionnaires. Additionally, a logistic regression analysis was conducted to identify predictors for DNP. There was good fit and high predictive ability of the statistical model. Duration of diabetes, type of physical activity, and frequency were significantly associated with increased odds of DNP. On the other hand older age, higher education level and more minutes of each physical activity session were negatively associated with DNP. Sex and a crude measure of total activity level did not make a significant contribution. Particular dimensions of physical activity, and not general aggregate categorization are associated with DNP. Patient-specific prescribed exercise regimens with exercise type, frequency, and duration are important in treating neuropathic pain in T2DM subjects. This research fills a significant gap by examining pain-specific outcomes and provides evidence that can be used to underpin more efficacious, non-pharmacological interventions of DNP in community health services.
**Keywords**: Diabetic neuropathic pain, medicine, physical activity, type 2 diabetes mellitus

## INTRODUCTION:

Diabetes mellitus is a long-term metabolic disorder that is marked by persistent high blood sugar levels due to the combined effect of genetic and environmental factors [1], [2]. The world is facing a substantial public health burden of diabetes and the International Diabetes Federation (IDF) has estimated that 589 mil- lion adults were diagnosed with diabetes in 2024 and this population is expected to increase to 853 million by 2050 [3], [4], [5]. This increasing prevalence is attributable to populations aging, urbanization, and an important decrease in the level of physical activity [6], [7]. With increasing prevalence of diabetes, the chronic complications of diabetes are also increasing and represent a significant risk for long term morbidity as well as mortality [7], [8], [9].

Of the numerous diabetic complications, diabetic neuropathy is the most prevalent, occurring in over 1/2 of type 1 and type 2 diabetic patients over their lifetime [10], [11], [12]. Diabetic neuropathy, a chronic condition of the nerves, may result in challenging neuropathic pain that affectseradically patients quality of life that interferes with sleep, normal activities, and livelihood [13], [14], [15]. This pain is described by patients in a number of ways, burning, tingling, electric shock like, and usually starts from the distal soles and toes and spread proximally in a classic stocking-like distribution [16], [17], [18]. Despite being highly prevalent and substantial in severity, diabetic lower limb neuropathic painful disorder still remains poorly controlled, which reveals a great need for efficient therapeutic alternatives [19], [20].

Management of type 2 diabetes mellitus (T2DM) has shifted to multidisciplinary strategies beyond medical treatment [21]. Physical exercise has long been regarded a key element in lifestyle modification with beneficial effects on metabolic control and general well-being [22], [23]. Exercise is known to improve the insulin sensitivity, glycemic control and it helps in weight management and prevention of both type i and type ii complications of diabetes [24], [25]. In theory, however, the neuroprotective effects of exercise on nerve health and function may be attributed to improved microcirculation, reduced level of oxidative stress, and systemic inflammation [26], [27]. Therefore, exercise is a powerful non-pharmacological resource for the overall T2DM treatment.

For all that, the overall advantages of the physical activity for diabetes are well probed, the association between pain and physical activity is another gray area in the literature. In contrast, some studies have supported a beneficial association; regular exercise decreases pain scales and enhances sensory results in DPN patients [28], [29]. Conversely, several well-designed studies reported negative or weak results [30], [31], [32], [33]. This comprises an anonymous Diabetologia trial and work that showed an increased motor function without changes in the intraepidermal nerve fiber density. [34], [35], [36], found that gait speed improved, but symptoms of neuropathy and tactile sensitivity remained unchanged. Sports medicine review conducted [37], [38], [39], reported evidence for fall-risk and ulcer prevention as being inconclusive, which is concurred underscore the need for improved pain-focused endpoints. This mismatch between positive correlations and null mixed results forms a credible paradox and a transparent research vacuum. To the best of our knowledge the available data has not thoroughly and specifically addressed the axis between physical activity and neuropathic pain other than functional or electrophysiological results. The challenge the authors find themselves against is to try to address this gap in a constructive and practical way, and for it to be a novel contribution that we are unaware of in any other location.

The objective of this report is to investigate the relationship of frequency of diabetic neuropathic pain with the level of physical activity in Type II DM patients. A deeper understanding on the impact of physical activity to prevent a major diabetic complication may be gained by studying this association. The implications of this research on a global scale are huge, as it may contribute to international guidance on T2DM care being im-proved and refined and lead to the creation of more effective, accessible non-pharmacologic strategies to improve quality of life for millions of people affected by dia-betic neuropathic pain throughout the world.

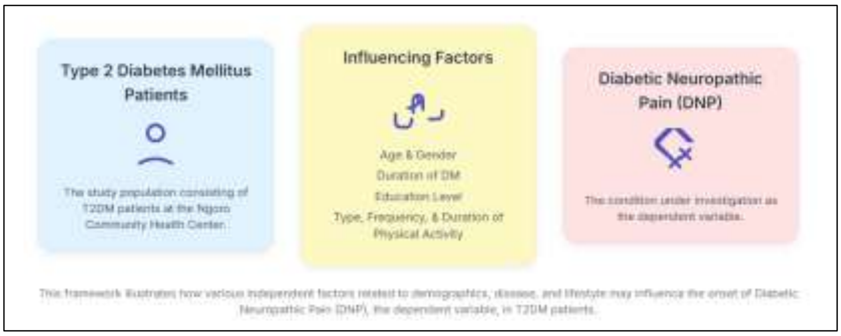


**FIGURE 1** Conceptual Model T2DM > DNP

## METHOD

***Study design and ethical approval***

The current study was planned as a cross-sectional observational analysis, ideally for exploring the interrelations of variables within one single point in time. This methodology provided an efficient means of 57217 gathering information on a select population, eliminating the need for long-term follow-up or intervention. The study protocol was completed in accordance with ethical standards and it's been approved by the Faculty of Medicine, Wijaya Kusuma University, Surabaya (No 96/SLE/FK/UWKS/2023), in which all procedures were performed in accordance with the ethical standard and that the participants were not violated morally, legally or physically. The research was conducted at Ngoro Community Health Center (UPT – PUSKESMAS) in Mojokerto Regency, where the study sample was available. The sample was non-random and included 70 T2DM (Type 2 Diabetes Mellitus) patients who joined the Prolanis. ProLanis is a health facility-based program that was developed by BPJS Kesehatan in collaboration with public Puskesmas to achieve an enhanced quality of life among people with chronic diseases through managing and accompanying the participants [40], [41]. One important and relatively unique aspect is that this program offered a captive and available cohort by identifying the individual with a recorded medical history of T2DM under regular scheduled health maintenance. There was a rigorous inclusion and exclusion criteria requirement for homogeneity as well as for the validity and reliability of research findings, in order to minimize confounding variables and increase the study's internal validity.

***Variables and Data Collection***

The factors in this study were with caution analysed in order to identify the potential risk factors for neuropathic pain in T2DM patients. The dependent variable or main outcome was the presence of diabetic neuropathic pain (as a categorical variable with two categories, "yes" or "no"). The independent variables examined included various demographic and lifestyle characteristics. These were conventional demographic factors (e.g., gender and age) and those not directly related to the DM manifestation (e.g., the duration of DM). To measure the lifestyle factors, types of physical activities, the frequency of each physical activity (such as rarely, sometimes, often, every day, and the duration of each physical activity (≤ 1 hour, 1-2 hours, 2-4 hours) were included as the variables. The last variable examined was the overall activity level - sufficient or low. Data for all of these variables were collected in a systematic mannerin the participants and originated from a combination of structured interviews and standardized questionnaires. This combination approach has mixed two methods to be self reported with consistent and clear perspectives and preliminated ambiguity and maximized data quality. The standardized questionnaire also ensured a uniform process, a necessity in a randomized testing and following the dogmas and tenders of a methodological stringency [42]. From the questionnaires and interviews, the raw data was transcribed into a computer for further statistical analyses.

***Statistical analysis***

All statistical analyses were performed in SPSS software. The dependent variable (diabetic neuropathic pain)was binary, in order to determine the risk factors of diabetic neuropathic pain, a logistic analysis was selected as the appropriate statistical approach. Logistic regression is a predictive modeling algorithm that is used when the Y variable is binary categorical. This approach models the probability of the dependent variable given the independent variable using the logit function, and performs better then linear models for categorical outcomes. Logistic regression results show the OR with confidence interval values representing the strength, as well as direction of association of a given independent with the odds of diabetic neuropathic pain. This method is well known in the epidemiological and health policy literature for being effective in risk analysis and in classification, as demonstrated in seminal works in the area [43]. It permits detailed exploration of what makes a significant contribution to the risk of developing DNP within the population of interest whereas still controlling for other independent variables in the model.

***Sample characteristics***

The characteristics of the study participants are presented in the table below as the frequency and percentage distribution according to important demographic and lifestyle factors. Demographic profile The sex ratio in the present sample was highly skewed, with nearly three-quarters of the sample (72.9%) being female. Most individuals (age) were 25-64 years old (68.6%) which reflects the younger age group in the active health center program with the minority of patients older than 65 years registered. The duration of DM emerged as another relevant feature, a considerable number of patients (71.4%) had experienced this for more than 5 years. Education levels among the respondents differed, and with high school accounting for the highest proportion (42.9%), followed by middle school. For physical activity, most participans did moderate exercise (45.7%), where the most common time of physical exercise was 1-2 hours (44.3%). In this respect, the results of this study are particularly interesting, since the sample indicated a moderate or low level of PA almost the same proportion of 51.4% and 48.6%. Finally, the former 55.7% of the subjects were diagnosed as NND diabetic neuropathic pain, upon which follows the logistic regression analysis later [42]. These descriptive statistics offer a base interpretation of the sample, that are necessary when interpreting the findings from inferential statistics.

TABLE 1 Table Characteristics of respondent

| Variables | Category | N | (%) |
|---|---|---|---|
| Dependent Variable | | | |
| DNP Incident | DNP | 39 | 55.7 |

| Variables | Category | N | (%) |
|---|---|---|---|
| | Non-DNP | 31 | 44.3 |
| Independent Variables | | | |
| Sex | Male | 19 | 27.1 |
| | Female | 51 | 72.9 |
| Age | 0-14 years old | 0 | 0 |
| | 15-24 years old | 0 | 0 |
| | 25-64 years old | 48 | 68.6 |
| | >65 years old | 22 | 31.4 |
| Education | Elementary School | 13 | 19 |
| | Junior High School | 22 | 31 |
| | Senior High School | 30 | 43 |
| | College | 5 | 7 |
| Duration of Diabetes Mellitus | < 5 years | 20 | 28.6 |
| | ≥ 5 years | 50 | 71.4 |
| Types of Physical Activity | Light Activity | 23 | 32.9 |
| | Moderate Aktivity | 32 | 45.7 |
| | Strenuous Activity | 15 | 21.4 |
| Frequency of Physical Activity | Rarely | 19 | 27.1 |
| | Sometimes | 19 | 27.1 |
| | Often | 16 | 22.9 |
| | Every Day | 16 | 22.9 |
| Duration of Physical Activity | < 1 Hour | 25 | 35.7 |
| | 1-2 Hours | 31 | 44.3 |
| | 2-4 Hours | 14 | 20 |
| | >4 Hours | 0 | 0 |
| Activity | Low Activity | 36 | 51.4 |
| | Adequate Activity | 34 | 48.6 |

## RESULT

### *Logistic regression model feasibility test*

According to the outcomes displayed on table 2, the logistic model adjusts well and present good explanatory quality. This can be seen from the -2 Log likelihood value of 31.542, showing a significant difference from the null model, thus the predictors in the model together make a meaningful contribution to predict the dependent variable. Also, two pseudo-R-squared measures were computed to estimate the amount of variation in the dependent variable that was accounted for by the model. The Cox & Snell R-Square of 0.603 indicates that about 60.3 per cent of the variance in DNP can be explained by independent variables taken together [44]. Most importantly, the Nagelkerke R-Square of.807 is a better and more easily interpreted estimate, meaning that the model accounts for a solid 80.7% of variance in the dependent variable. This is an very good result for this model, especially in the field of health policy, which focuses on highly complex and multifactorial conditions. The relatively large value of R-square reflects the strong predicting power of the included coefficients in particular age, duration of DM, education level, different items for physical activity in this story to predict diabetic peripheral neuropathy for study sample. The strong explanatory power implies that the factors we have chosen are not only associated but also important contributors to the observed variation in NP status among the T2DM patients in this study.

TABLE 2 Model Explanatory Power Measures

| Step | Log likelihood | Cox & Snell R Square | Nagelkerke R Square |
|---|---|---|---|
| 1 | 31.542 | 0.603 | 0.807 |

*Model prediction accuracy*

Table 3 shows the aorfs and auc of the logistic regression based on the report from the Hosmer and Lemeshow test that is essential to consider model goodness of fit. The measure tests whether the observed results are compatible with the results that would have been predicted "if the model were a good account of the data". annotated outputThe output indicates a value of 5.447 for the Chi-Sq statistic on 8 df. The corresponding significance level (Sig.) is 0.709. In literature, 0.05 is typically used as the threshold of significance for the Hosmer and Lemeshow test, if the p-value is greater than 0.05, this suggests there is no statistically significant difference between observed and predicted values i.e. our model fits well for the data. Since our calculated p-value of 0.709 is much larger than the standard alpha level of 0.05, we fail to reject the null hypothesis. So we may say the model fits the data satisfactorily [45]. This result is important to confirm, as it demonstrates the appropriateness of the logistic regression model to predict the risk of diabetic neuropathic pain and indicates that the predictions from the model are trustworthy and not different substantially from the actual observed data [46]. This validation to fit of the model further strengthens the validity of the subsequent results for the effect of individual independent variables on dependent variable.

TABLE 3 Hosmer and Lemeshow Test

| Step | Chi-Square | df | Sig. |
|---|---|---|---|
| 1 | 5.447 | 8 | 0.709 |

*Logistic regression analysis and hypothesis test*

Table 4 Classification table despite the moderate sample size, the classification table Table 4., is an important measure in assessing the predictive performance of the logistic regression model for patients having or not having DNP. The accuracy of the proposed model is 92.9% overall, which shows excellent confidence of the classification model. A closer look reveals that the model accurately predicted 37 of the 39 DNP observed cases with a classification rate of 94.9% for this group. This high sensitivity means that the model does a really good job predicting the patients that actually have the condition. Additionally, the model showed good predictive abilities for classifying non-DNP having DNP vs. not having DNP with 28 of the 31 cases being accurately predicted predictive accuracy of 90.3% . This high specificity suggests that the model is also good at correctly excluding people without the condition, so false positives are reduced. The both-balanced high accuracy and the large overall percentage clearly demonstrate that the independent variables tested in our study, which included demographical and life-style characteristics, offer an excellent model for the prediction of DN pain in the clinical range of this patient sample. The high predictive accuracy of the model is particularly relevant in a clinical setting, where a reliable non-invasive risk assessment tool would have a major impact on patient management.

TABLE 4 Accuracy of Logistic Regression Model

| Observed | | | DNP | Non-DNP | Percentage Correct |
|---|---|---|---|---|---|
| Step 1 | DNP Incident | DNP | 37 | 2 | 94.9 |
| | | Non-DNP | 3 | 28 | 90.3 |
| | Overall Percentage | | | | 92.9 |

Logistic Regression Analysis and Hypothesis Test

The results from the logistic regression model Table 5., offer important information regarding the determinants of the presence of DNP. The hypothesis testing sugest that most of the variables are statistically associated with the outcome. Duration of diabetes mellitus proved a very strong-predictor with a p = 0.012, and odds ratio 40.417. This result indicates that subjects living with DM for a long period of time are more than forty times more likely to develop DNP compared to those not living with DM, all else constant. The nature of the activity type was also found to have a significant and strong effect (p=0.009; OR=40.116), suggesting a qualitative activity type exists that dramatically increases the odds of DNP. On the contrary, age (p=0.026; OR=0.007) and time of physical activity (p=0.006; OR=0.010) presented an inverse significant association with DNP. However, this means that the older the patient and the longer the patient's physical activity, the lower the probability of suffering from DNP. Also, a significant correlation was found for educational level (p = 0.014; OR = 0.162), and frequency of physical activity (p = 0.038; OR = 7.163). The results imply that increased educational level is correlated with reduced likelihood of DNP and that an elevated frequency of exercise is associated with heightened likelihood. Sex (p=0.264) and total activity level (p=0.338) were not significantly associated based on critical values of 0.05. These results offer insight into the relationships among demographic, lifestyle, and clinical variables as part of their association with DPN pain.

## DISCUSION

No associations were identified between DNP status and sex or a combined overall physical activity composite, while age, diabetes duration, education level, and specific activity domains type/intensity, frequency, and session duration were associated with DNP in this cross-sectional sample of Prolanis-enrolled adults with T2DM. Supporting Information This multi-dimensional pattern is in line with the literature: the function e.g., gait, balance often improves and sometimes symptoms with exercise, but pain specific endpoints are still inconsistent between studies and reviews [37], [47], [48]. There is also prospective evidence indicating that even moderate leisure-time activity may be related to lower number of microvascular complications in T2DM, which supports a more detailed exposure measure other than "active/inactive" [49]. Collectively, our adjusted models support a multidimensional understanding of DNP in which demographic, clinical and behavioral factors interact.

The lack of a sex DNP relationship in this cohort mitigates expectations of uniform risk across sex and is in line with recommendations to expect diversity in neuropathy manifestation. Similarly, a global "sufficient" physical-activity variable was not related to DNP, whereas type/intensity, frequency, and session duration of component exposures were informative. This pattern reflects the literature: supervised aerobic, resistance, and multicomponent programs often improve balance, walking speed, and selected symptom scales [50], [51], while many trials and cohorts show small or context-specific effects on pain itself [30], [31], [33]. Positive findings that habitual exercise reduces pain scales (Fatolahi et al., 2025; Mao et al., 2025) thus coincide with other null or mixed findings, suggesting that the way in which activity is accruedmode, pace/cadence, and session length may be more critical for pain outcomes than meeting a uniform weekly threshold. Taken together, these data support use of an adequacy metric that moves away from binary measures toward behaviorally specific, granular, dosage recommendations that can be titrated and reassessed using pain-focused measures in the real-world clinic setting.

Older age was correlated with DNP in our cohort, reflecting cumulative metabolic and microvascular damage over the course of the diabetes experience and the lower burden of lifetime neuropathy in both type 1 and type 2 diabetes[10], [11], [12]. From a biological standpoint, longer duration of hyperglycemia and vascular impairment is likely to hasten axonal degeneration and subsequent small fiber loss, increasing the likelihood of painful symptoms appearing and being sustained with increasing age. Of importance, prospectively, any leisure-time physical activity is associated with reduced neuropathy risk and other microvascular complications in adults with T2DM, indicating prevention potential even at modest "low-dose" volumes that are realistic for older adults with T2DM [49]. These convergent findings underlie the arguments and provide support for age-adapted assessments of neuropathic pain via e.g., routine inquiry of distal burning/ tingling and sleep disruption and graded activity prescriptions which balance activity safety e.g., safe modes, conservative intensity progressions, clear guidelines on session frequency and duration with rigorous application of foot-risk precautions and footwear/foot-care recommendations that expand the emphasis already noted in current standard guidelines [14], [52]. In practice, this requires going beyond general "active not active" terminology and rather defining easy to reach amounts of activity that older adults can maintain and ensuring follow-up for the tracking of gains and adaptations for the future through pain specific measures.

Years of school was associated with DNP status in our sample, which is consistent with clinical advice that promotes the importance of health literacy to diabetes self-care and complication avoidance . Education can be targeted at making sure that patients actually understand what type of exercise they have been prescribed not just that it is multicomponent, but what types of activities and how frequently and for how long them and how to implement foot care precautions and symptom monitoring; such understanding is consistently associated with improved adherence and functional gains in the exercise literature [14], [37], [53]. operationally, a higher level of education may be indicative of better adherence to session format and progression, which might be associated to some extent to the benefit accrued in supervised interventions (e.g., improvements in gait speed and balance) even if pain-specific endpoints continue to be heterogeneous across trials [47]. On the other hand, low HL may be related to activity which is too generic or inconsistently performed, consistent with why the single straightforward "adequate vs low" classification was not associated with DNP in our sample while the dimensions of its components (*type, frequency, quantity*) were. To put these insights into practice, primary care should incorporate targeted education brief, structured counseling on session duration, safe intensity progression, footwear/foot-care routines, and when/how to report pain into routine visits and group programs, with periodic re-evaluation using pain-focused measures recommended by current reviews and guidelines [14], [36]. Behavioral education tailored in this way does not serve as an alternative to medical therapy but rather helps patients carry out exercise as it is prescribed, causing actual behavior to converge with regimens proven to enhance function and, in some investigations, decrease neuropathic symptom load [39].

There are multiple, biologically plausible pathways that combine and interact to predispose physical activity to reduce DNP risk and burden. Such studies have reported a marked improvement in insulin sensitivity and glycemic control with regular exercise which involves alleviation of glucose toxicity that drives neuroaxonal injury [24], [26], dampening of systemic inflammation and oxidative stress [26], [54], as well as improvement in microcirculation and endothelial function with potentially healthier peripheral nerve structure and signaling [25], [55]. These mechanistic advantages establish a logical biological substrate for the pattern of effects that have been seen across intervention syntheses: for instance, direct comparisons have revealed that supervised aerobic, resistance, and multicomponent programs all tend to enhance gait speed, balance, and focused measures of symptom severity in individuals with diabetic neuropathy, even if effects on the specific intensity of pain are not consistently replicated [17], [37], [56]. This nuance is reinforced by high-quality randomized trials, which demonstrate functional gains in some but without concomitant improvement that is specific to pain or small-fiber endpoints [57]. Collectively, the mechanistic clinical constellation provides support for prescriptive specificity in practice: combine mode (*aerobic + resistance*) with a defined dose frequency > session length and graduated progression, with the added use of foot-care precautions and protective footwear consistent with contemporary standards of care. Stated differently, rather than drawing from a single threshold for an activity guideline, clinicians should operationally define how activities are accrued i.e., modality, cadence, and session structure for susceptibility to the metabolic, vascular, and neurotrophics mechanisms most credibly associated with nerve health, followed by reassessment with pain-focused outcomes for dose individualiztion.

Broader implications and health recommendations. The implications of these findings are directly pertinent to public health and clinical care for T2DM, rather than generic recommendations, patients benefit from 'prescriptive' activity plans that specify mode aerobic, resistance, frequency, and duration of the session, along with foot-risk precautions for those with neuropathy [58], [59]. This level of granularity is compatible with reviews that have found that comprehensive or multicomponent programs can enhance gait, balance, and particular symptoms scales while effects on pain per se may differ thus, prescriptions should be titrated and reassessed according to pain-focused measures [47], [58], [60]. Large cohort evidence is also encouraging in identifying that even small amounts of leisure-time activity are beneficial for reducing microvascular complications in T2DM, which support moderate increment targets for patient in low amount baselines [49], [60], [61]. Operationally, these findings are a natural fit in Prolanis create stepwise protocols, apply them for example, add 2–3 sessions week of structured exercise, expand session length by corresponding amounts each month, couple resistance to aerobic work, match them to education about footwear foot checks, and monitor pain outcomes at discrete intervals. This will help improve metabolic control and functional capacity while trying to minimize the DNP burden on a large scale [17], [62], [63], [64].

The strong positive association we observe between diabetes duration and DNP is consistent with this has a higher prevalence of diabetes, and complications accrue at a younger age [3], [4], [8], [65]. Neuropathy is common throughout the diabetes span and is experienced by >50% of patients at some stage and so longer exposure to hyperglycemia could theoretically increase the likelihood of symptomatic pain [10], [11], [66]. Mechanistically, a prolonged state of hyperglycemia induces microvascular injury, oxidative stress and neuroinflammation leading to axonal degeneration and demyelination whereas exercise-related improvements in insulin sensitivity, endothelial function, and neurotrophic signaling counteract these pathways and thus provide a biologically consistent modulator of duration-based vulnerability [25]. That aside, prospective data at the population level link even only modest leisure-time activity to fewer microvascular complication, and trials and syntheses show im-pact for gait, balance, and selec-ted symp-tom scales and some-times pain mile-stones altho-ugh not always pain out-co-mes diarrheal, gingerol, leuko-cyte and plane-ing [29], [47], [49]. These lines together would support prevention of co-occurring cardiometabolic risks in early T2DM and physical activity targeting to mitigate the course from longer duration to neuropathic pain [67], [68].

In spite of the robust methodology and the relevant results, the present study is not without its shortcomings that need to be taken into account for result interpretation. The main one is the narrow range of the independent variables. Demographic and physical activity factors were considered, but there are numerous other variables that are well-recognized factors that would also influence DNP that were not entered dyslipidemia, hypertension, blood pressure, HbA1c, presence of other microvascular complications, for example. The lack of these important clinical factors suggests that the remaining confounding can not be adjusted for, which could limit the interpretability and generalizability of the model. And the questionnaire-only application approach in collecting the physical activity and other lifestyle factor data may cause recall bias and social desirability bias. The respondents may not remember their levels of activity correctly or may have given the answers they thought were more favorable. It is suggested that, for future research, a complete set of factors, including general clinical and biochemical indicators, should be considered and that objective measures of PA, e.g., accelerometers or physical performance tests, be utilized so that the reliability and validity of this relationship may be improved.

## CONCLUSION

The results of this research gave a complete insight to the features that are related to DNP in our patient population. We did not find an association between gender and PA in general, however, we observed a significant influence of age, diabetes duration, level of education, and those specific PAs metrics type, frequency, and duration in the overall sample. The ability of our logistic regression model to predict and fit the data well give confidence in these results. These findings emphasise the need for a multidisciplinary DNP management model, which does not only focus on glycaemic control, but also on lifestyle change and patient education. We suggest that in further research other clinical and biochemical variables including HbA1c, blood pressure and lipids are included to give a more global picture. Moreover, the objective assessment of physical activity will enhance the validity of future studies. These research findings may be used in public policy and clinical practice, especially programs such as Prolanis, to create specific interventions based on evidence for high-risk T2DM patients.

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**AUTHOR CONTRIBUTIONS**

Dr. Hj Andiani, M.Kes., as corresponding author, was solely responsible for study conceptualisation and design, data collection, statistical analysis, and writing the first to final draft of the manuscript. Dr Sulistiawati, dr., M.Kes. and Dr Lilik Djuari, dr., M.Kes. contributed to the study design and provided critical review from a public health perspective. Dr. Hanik Badriyah Hidayati, dr., Sp.S(K) provided clinical expertise in neurology to ensure accurate interpretation of pain data. Meanwhile, Prof. Dr. Kuntaman, dr., MS, Sp.MK(K) and dr. I Made Subhawa Harsa, M.Si. played a role in data analysis, methodological validation, and provided important feedback during the manuscript revision process. All authors have read and approved the final version of this manuscript.

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**DISCLAIMER**

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## REFERENCES

[1] M. V. Aayush *et al.*, "Redefining the pathogenesis of Gestational Diabetes Mellitus: The cumulative impact of endocrine disrupting environmental chemicals in key metabolic pathways," *Med. Hypotheses*, vol. 201, p. 111693, 2025, doi: https://doi.org/10.1016/j.mehy.2025.111693.

[2] A. P. Bravo-Garcia *et al.*, "Combined effects of time-restricted eating and exercise on short-term blood glucose management in individuals with Type 2 Diabetes Mellitus: The TREx study, a randomised controlled trial," *Diabetes Res. Clin. Pract.*, vol. 222, p. 112081, 2025, doi: https://doi.org/10.1016/j.diabres.2025.112081.

[3] Y. Cao, I. Widyahening, X. Sun, and S. Li, "Pathophysiology of type 2 diabetes: A focus on the metabolic differences among southeast Asian, Chinese and Indian populations and how this impacts treatment," *Diabetes, Obes. Metab.*, vol. n/a, no. n/a, Aug. 2025, doi: https://doi.org/10.1111/dom.70060.

[4] M. Bachar, "Sensitivity analysis for a delay mathematical model : the glucose-insulin model," *Front. Appl. Math. Stat.*, no. ii, 2025, doi: https://doi.org/10.3389/fams.2025.1562636.

[5] F. Geravand, E. Nasli-Esfahani, M. Montazer, M. Jalalzadeh, and L. Azadbakht, "Association of lipid composition with diabetic foot ulcer size and depth: a cross-sectional study on plant versus animal

oils, cholesterol, and omega fatty acids," *BMC Nutr.*, vol. 11, no. 1, p. 103, 2025, doi: 10.1186/s40795-025-01093-3.
[6] C.-F. Huang and C.-H. Wu, "Sarcopenic obesity in the Asia-Pacific region: Epidemiology, risk factors, and management," *Osteoporos. Sarcopenia*, vol. 11, no. 2, Supplement, pp. 40–49, 2025, doi: https://doi.org/10.1016/j.afos.2025.05.001.
[7] W. Lin *et al.*, "Global, regional and national burden of ischaemic heart disease attributable to high body mass index and low physical activity from 1990 to 2021," *Diabetes, Obes. Metab.*, vol. 27, no. 5, pp. 2561–2572, May 2025, doi: https://doi.org/10.1111/dom.16256.
[8] C. Dowling, L. Chu, Y. Etkin, and A. Oropallo, "Assessment and management of chronic venous, arterial, and diabetic wounds in older adults," *Semin. Vasc. Surg.*, 2025, doi: https://doi.org/10.1053/j.semvascsurg.2025.06.007.
[9] J. Gu and H. You, "Global and regional drivers of chronic kidney disease burden in older adults: The dominant role of high fasting plasma glucose and the rise of obesity in China," *Arch. Gerontol. Geriatr.*, vol. 139, p. 106006, 2025, doi: https://doi.org/10.1016/j.archger.2025.106006.
[10] S. James *et al.*, "Atypical complications and co-morbidities of type 1 diabetes in young adults," *J. Diabetes Complications*, p. 109158, 2025, doi: https://doi.org/10.1016/j.jdiacomp.2025.109158.
[11] H. Ward and A. S. Jawad, "Musculoskeletal Manifestations of Diabetes Mellitus – an update," *Clin. Med. (Northfield. Il).*, p. 100498, 2025, doi: https://doi.org/10.1016/j.clinme.2025.100498.
[12] I. S. F. Irwandy, F. Hawke, A. Coda, R. G. McGee, S. Birt, and A. Fellas, "Prevalence and Presentation of Lower Limb Neurovascular Complications in Children With Diabetes: A Systematic Review With Proportion Meta-Analysis," *Pediatr. Diabetes*, vol. 2025, no. 1, p. 7664860, Jan. 2025, doi: https://doi.org/10.1155/pedi/7664860.
[13] S. Handa, N. S. Khawaja, and J. R. Shaefer, "Diagnosis and Nonsurgical Management of Orofacial Pain," in *Oral and Maxillofacial Surgery*, 2025, pp. 1107–1130. doi: https://doi.org/10.1002/9781119842958.ch8.1.
[14] S. Barati *et al.*, "Curcumin as a promising therapeutic agent for diabetic neuropathy: from molecular mechanisms to functional recovery," *Diabetol. Metab. Syndr.*, vol. 17, no. 1, p. 314, 2025, doi: 10.1186/s13098-025-01884-5.
[15] M. Belayneh, S. Hejazi, B. Gagnon, and P. Hawley, "Methadone to treat chemotherapy-induced peripheral neuropathy (METACIN): study protocol," *Pain Manag.*, vol. 15, no. 5, pp. 235–243, May 2025, doi: 10.1080/17581869.2025.2494495.
[16] P. Bernier, L. Desjardins, M.-C. Charette, J. Harnois, É. Poirier, and K. Daigle, "The role of mental health nursing in pediatric hematology/oncology – Part 3: Evaluating feasibility, acceptability, and appreciation," *Can. Oncol. Nurs. J.*, vol. 34, no. 4, pp. 514–522, 2024, doi: 10.5737/23688076344514.
[17] D. Yildirim and D. Aras, "Evaluation of Complications, Peripheral Neuropathic Pain, and Sleep Quality in Patients With Diabetes Mellitus," *Brain Behav.*, vol. 15, no. 6, p. e70605, Jun. 2025, doi: https://doi.org/10.1002/brb3.70605.
[18] S. Madhu, D. K. N. Bhargavi, M. V. S. Ramprasad, S. Gautam, and S. Bhavana, "Accurate diabetic retinopathy segmentation and classification model using gated recurrent unit with residual attention network," *Biomed. Signal Process. Control*, vol. 102, p. 107348, 2025, doi: https://doi.org/10.1016/j.bspc.2024.107348.
[19] W. H. Almalki and M. S. Khan, "Burden of diabetes mellitus on health and economy of the Arab world: current situation and perspectives," *J. Public Health (Bangkok).*, 2025, doi: 10.1007/s10389-025-02448-7.
[20] L. Li *et al.*, "Network Meta-analysis of Randomized Controlled Trials Assessing Neuromodulation Therapies for Painful Diabetic Neuropathy," *Neurol. Ther.*, vol. 14, no. 4, pp. 1355–1382, 2025, doi: 10.1007/s40120-025-00759-1.
[21] E. Jian *et al.*, "The evolutionary relationship between sugar-sweetened beverages and type 2 diabetes mellitus since 1989," *Food Res. Int.*, vol. 219, p. 117009, 2025, doi: https://doi.org/10.1016/j.foodres.2025.117009.
[22] R. Srivastava and G. Singh, "Integrative Health: Combining Exercise, Lifestyle Changes, and Gut Microbiome for Metabolic Syndrome BT - Gut Health and Metabolic Syndrome: Optimizations with Microbiome Innovations," M. Nandave, R. Pati Pandey, and J. Upadhyay, Eds., Singapore: Springer Nature Singapore, 2025, pp. 107–131. doi: 10.1007/978-981-96-6246-3_6.
[23] F. Ahmed, M. T. Arshad, S. Maqsood, A. Ikram, and K. T. Gnedeka, "Gut-Brain Axis in Obesity: How Dietary Patterns Influence Psychological Well-Being and Metabolic Health?," *Food Sci. Nutr.*, vol. 13, no. 7, p. e70689, Jul. 2025, doi: https://doi.org/10.1002/fsn3.70689.
[24] K. G. Somisetty, G. B. Shetty, K. J. Sujatha, and P. Shetty, "Naturopathy and yoga-based interventions modify risk factors of peripheral neuropathy and improve nerve conduction among Type-2 Diabetes Mellitus patients," *J. Ayurveda Integr. Med.*, vol. 16, no. 4, p. 101147, 2025, doi:

https://doi.org/10.1016/j.jaim.2025.101147.
[25] A. Veluvali *et al.*, "Impact of digital health interventions on glycemic control and weight management," *npj Digit. Med.*, vol. 8, no. 1, p. 20, 2025, doi: 10.1038/s41746-025-01430-7.
[26] K. C. Anderson, J. Liu, and Z. Liu, "Interplay of fatty acids, insulin and exercise in vascular health," *Lipids Health Dis.*, vol. 24, no. 1, p. 4, 2025, doi: 10.1186/s12944-024-02421-5.
[27] S. Liu, J. Liu, Y. Wang, F. Deng, and Z. Deng, "Oxidative Stress: Signaling Pathways, Biological Functions, and Disease," *MedComm*, vol. 6, no. 7, p. e70268, Jul. 2025, doi: https://doi.org/10.1002/mco2.70268.
[28] J. Mao, A. Zhao, Y. Cai, and X. Liu, "Effects of traditional Chinese exercise on diabetes with neuropathy: A systematic review and meta-analysis," *J. Tradit. Chinese Med. Sci.*, vol. 12, no. 2, pp. 297–307, 2025, doi: https://doi.org/10.1016/j.jtcms.2025.03.009.
[29] S. Fatolahi, H. Agha-Alinejad, G. Hamidian, M. Molanouri Shamsi, E. Khalilzadeh, and M. L. Fernandez, "Effects of running and swimming on pain relief in male rats with type 2 diabetes-induced peripheral neuropathy," *Comp. Exerc. Physiol.*, vol. 21, no. 3, pp. 185–204, 2025, doi: https://doi.org/10.1163/17552559-00001103.
[30] E. Køhler, U. Dalgas, C. S. Buhl, and J. Brincks, "Content and effects of balance training in people with diabetic peripheral neuropathy – a systematic review and meta-analysis," *Physiother. Theory Pract.*, vol. 41, no. 5, pp. 1083–1094, May 2025, doi: 10.1080/09593985.2024.2391823.
[31] L. L. Määttä *et al.*, "Serum Neurofilament Light Chain and Structural and Functional Nerve Fiber Loss in Painful and Painless Diabetic Polyneuropathy," *Diabetes Res. Clin. Pract.*, vol. 223, p. 112098, 2025, doi: https://doi.org/10.1016/j.diabres.2025.112098.
[32] X. Lu *et al.*, "Cell-derived exosome therapy for diabetic peripheral neuropathy: a preclinical animal studies systematic review and meta-analysis," *Stem Cell Res. Ther.*, vol. 16, no. 1, p. 297, 2025, doi: 10.1186/s13287-025-04432-0.
[33] G. Koutsoflini, A. Lepouras, and C. Ridehalgh, "Mechanosensitivity during straight leg raise and slump neurodynamic tests in people with type 1 diabetes mellitus and diabetic peripheral neuropathy," *J. Man. Manip. Ther.*, pp. 1–8, 2025, doi: 10.1080/10669817.2025.2544285.
[34] B. Lindholm, R. Basna, H. Ekström, S. Elmståhl, and A. Siennicki-Lantz, "Gait Speed Reserve in the general population-based 'Good Aging in Skåne' cohort study—distribution and associated factors," *GeroScience*, vol. 47, no. 1, pp. 965–976, 2025, doi: 10.1007/s11357-024-01318-6.
[35] J. Nonnekes, E. Post, G. Imbalzano, and B. R. Bloem, "Gait changes with aging: an early warning sign for underlying pathology," *J. Neurol.*, vol. 272, no. 4, p. 257, 2025, doi: 10.1007/s00415-025-12995-4.
[36] L. Santamarina *et al.*, "Influence of photobiomodulation on sensory symptoms, balance, and gait speed in chemotherapy-induced peripheral neuropathy," *Support. Care Cancer*, vol. 33, no. 4, p. 355, 2025, doi: 10.1007/s00520-025-09405-w.
[37] A. Gracia-Sánchez, A. López-Pineda, R. Nouni-García, S. Zúnica-García, E. Chicharro-Luna, and V. F. Gil-Guillén, "Impact of Exercise Training in Patients with Diabetic Peripheral Neuropathy: An Umbrella Review," *Sport. Med. - Open*, vol. 11, no. 1, p. 75, 2025, doi: 10.1186/s40798-025-00863-4.
[38] S. Naghizadeh *et al.*, "Surgical Nerve Decompression at Lower Extremity for Diabetic Neuropathy: A Systematic Review and Meta-Analysis of Time-Dependent Pain, Sensory Recovery, Amputation, Ulcer Recurrence, and Balance," *World Neurosurg.*, vol. 199, p. 124114, 2025, doi: https://doi.org/10.1016/j.wneu.2025.124114.
[39] K. M. C. Talley and J. Thompson, "Lifestyle and behavioral interventions for urinary incontinence in frail older adults: An integrative review of recent evidence," *Continence*, vol. 13, p. 101749, 2025, doi: https://doi.org/10.1016/j.cont.2025.101749.
[40] E. Albert and A. Clare, "Impact of Work Demands on Burnout and Mental Health Among Frontline Nurses During COVID-19," *Saf. Heal. Med. Work.*, vol. 1, no. 3 SE-Articles, pp. 155–168, Oct. 2024, doi: 10.69725/shmw.v1i3.155.
[41] S. Conica, N. Browne, and R. Danyll, "Leveraging Machine Learning to Enhance Occupational Safety and Health in Hospital," *Saf. Heal. Med. Work.*, vol. 1, no. 2 SE-Articles, pp. 78–94, Jul. 2024, doi: 10.69725/shmw.v1i2.150.
[42] F. Shumayleh, R. Othman, and S. Waseem, "Patient Safety and Health Workforce Training: Identifying Curriculum Gaps and Development Needs," *Saf. Heal. Med. Work.*, vol. 1, no. 3 SE-Articles, pp. 111–126, Oct. 2024, doi: 10.69725/shmw.v1i3.152.
[43] P. Hooper *et al.*, "Canadian Ophthalmological Society evidence-based clinical practice guidelines for the management of diabetic retinopathy," *Can. J. Ophthalmol.*, vol. 47, no. 2, Supplement, pp. S1–S30, 2012, doi: https://doi.org/10.1016/j.jcjo.2011.12.025.
[44] S. Michiel, I. Moissact, and C. Sean, "REDECA Framework Enhancing Occupational Safety and Health Through Artificial Intelligence Applications," *Saf. Heal. Med. Work.*, vol. 1, no. 2 SE-Articles,

pp. 95–110, Jul. 2024, doi: 10.69725/shmw.v1i2.151.
[45] G. Lisa and E. Macle, "Exploring the Societal Impact of Death Anxiety on Mental Health Among Nurses: A Positive Psychology Perspective," *Saf. Heal. Med. Work.*, vol. 1, no. 3 SE-Articles, pp. 142–154, Oct. 2024, doi: 10.69725/shmw.v1i3.154.
[46] K. Lodhe L, A. Montes, and Z. D. Diallofd, "Workplace Bullying Among Senior Medical Staff in Africa: Prevalence, Impact, and Contributing Factors," *Saf. Heal. Med. Work.*, vol. 1, no. 3 SE-Articles, pp. 169–182, Oct. 2024, doi: 10.69725/shmw.v1i3.156.
[47] R. Oliveira, M. Monteiro-Soares, J. P. Guerreiro, R. Pereira, and A. Teixeira-Rodrigues, "Estimating Type 2 Diabetes Prevalence: A Model of Drug Consumption Data," 2024. doi: 10.3390/pharmacy12010018.
[48] H. Lestari and L. Nasrifah, "Assessment of Occupational Health and Safety Management System Implementation in General Hospital," *Saf. Heal. Med. Work.*, vol. 1, no. 2 SE-Articles, pp. 65–77, Jul. 2024, doi: 10.69725/shmw.v1i2.117.
[49] A. Kristensen-Alvarez *et al.*, "Long-term Outcomes of Prostatic Artery Embolisation: A Nationwide Prospective Cohort Study," *Eur. Urol. Focus*, 2025, doi: https://doi.org/10.1016/j.euf.2025.08.003.
[50] N. Cheirard and L. Gretha, "Advice for chief nurses on integrating LGBTQ+ inclusive practices into the healthcare system through centred qualitative exploration," *Saf. Heal. Med. Work.*, vol. 1, no. 3 SE-Articles, pp. 127–141, Oct. 2024, doi: 10.69725/shmw.v1i3.153.
[51] H. Van Tran, H. N. B. Tran, T. H. Ngo, and K. T. Nguyen, "Depression in type 2 diabetes mellitus: Prevalence, characteristics, associated factors, and treatment outcomes," *Endocr. Metab. Sci.*, vol. 16, p. 100194, 2024, doi: https://doi.org/10.1016/j.endmts.2024.100194.
[52] M. Faizun, M. Fanani, A. A. Subijanto, S. Anantanyu, F. Amalia, and A. Dwianto, "Optimizing the Health of Type 2 Diabetes Mellitus Patients with Islamic Approaches and Volunteers," *Qubahan Acad. J.* , vol. 4, no. 2, pp. 102–128, 2024, doi: 10.48161/qaj.v4n2a563.
[53] H. R. Devkota, B. Bhandari, and P. Adhikary, "Perceived mental health, wellbeing and associated factors among Nepali male migrant and non-migrant workers: A qualitative study," *J. Migr. Heal.*, vol. 3, p. 100013, 2021, doi: https://doi.org/10.1016/j.jmh.2020.100013.
[54] S. M. V Farid I, Suhartini R, "Optimizing Learning Management in Nursing Professional Education," Jul. 10, 2024, *Indonesia*. doi: 10.5281/zenodo.12654191.
[55] S. Zie, J., & Liang, "Mitigating Nurse Emigration: Strategies for Retaining South Africa's Healthcare Workforce," Jul. 10, 2024. doi: 10.5281/zenodo.12658998.
[56] L. Davalos *et al.*, "The Impact of Diabetes and Metabolic Syndrome Burden on Pain, Neuropathy Severity and Fiber Type," *Ann. Clin. Transl. Neurol.*, vol. 12, no. 7, pp. 1408–1417, Jul. 2025, doi: https://doi.org/10.1002/acn3.70072.
[57] A. A. K. Annadurai, S. Bhandary, S. G. Hegde, and J. Chatterjee, "Assembling a multiscale biomedical knowledge graph for explainable drug repurposing in rare diseases," *Netw. Model. Anal. Heal. Informatics Bioinforma.*, vol. 14, no. 1, p. 37, 2025, doi: 10.1007/s13721-025-00532-2.
[58] E. Lecce *et al.*, "Physiological mechanisms of neuromuscular impairment in diabetes-related complications: Can physical exercise help prevent it?," *J. Physiol.*, vol. n/a, no. n/a, Feb. 2025, doi: https://doi.org/10.1113/JP287589.
[59] T. Kumaresan, R. Ramya, S. Z. Beevi, M. Malini, V. Dineshbabu, and K. Saranya, "Deep Learning-Based Early Detection of Diabetic Retinopathy Using Fundus Images," *TPM - Testing, Psychom. Methodol. Appl. Psychol.*, vol. 32, no. S4, pp. 359–371, 2025.
[60] D. Gokul, M. Koushik, K. R. Karthik, V. Divya, B. Nisha, and G. Ramesh, "EFFECT OF COMPREHENSIVE CARE ON DIABETIC PATIENTS IN UHTC OF A TERTIARY CARE HOSPITAL IN TIRUVALLUR- AN OBSERVATORY-COMPARISON STUDY," vol. 32, pp. 43–51, 2025.
[61] M. A. Nurul Indana, "Effective Nursing Counseling Reduces Anxiety in Major Preoperative Patients," Jul. 10, 2024. doi: 10.5281/zenodo.12506554.
[62] M. G. Savelieff, M. A. Elafros, V. Viswanathan, T. S. Jensen, D. L. Bennett, and E. L. Feldman, "The global and regional burden of diabetic peripheral neuropathy," *Nat. Rev. Neurol.*, vol. 21, no. 1, pp. 17–31, 2025, doi: 10.1038/s41582-024-01041-y.
[63] A. Dovach, K. Al Saad, and L. Haliem, "Study Design and Baseline Characteristics of the Finerenone Trial in Slowing Kidney Disease Progression in Diabetic Patients," *Innov. Midwifery Child Heal. Pract.*, vol. 1, no. 2 SE-Articles, pp. 32–43, Jan. 2025, doi: 10.69725/imchp.v1i2.212.
[64] I. Dhevi, "ENHANCED ANTIDIABETIC AND ANTIOXIDANT POTENTIAL OF GREEN-SYNTHESIZED SELENIUM NANOPARTICLES USING MOMORDICA CYMBALARIA," vol. 32, no. 7, pp. 204–211, 2025.
[65] Y.-X. Yang *et al.*, "Artificial Intelligence-Empowered Multistep Integrated Radiation Therapy Workflow for Nasopharyngeal Carcinoma," *Int. J. Radiat. Oncol.*, vol. 122, no. 4, pp. 902–913, 2025, doi:

https://doi.org/10.1016/j.ijrobp.2024.11.096.
[66] N. Tianastia Rullyni, R. Rosauli Harianja, U. Dewi, V. Jayanti, Rahmadona, and Darwitri, "The Effectiveness of Postpartum Exercise Modules on Mothers Readiness to Perform Postpartum Exercises in Indonesia," *Innov. Midwifery Child Heal. Pract.*, vol. 1, no. 2 SE-Articles, pp. 44–56, Jan. 2025, doi: 10.69725/imchp.v1i2.218.
[67] M. W. Raja, D. M. Pushpavalli, M. Balamurugan, and K. Saranya, "Enhanced Med-Chain Security for Protecting Diabetic Healthcare Data in Decentralized Healthcare Environment Based on Advanced Crypto Authentication Policy," *TPM - Testing, Psychom. Methodol. Appl. Psychol.*, vol. 32, no. S4, pp. 241–255, 2025.
[68] S. Mabizela, E. Deacon, E. van Rensburg, and C. I. Bekker, "Protective factors in resilient South African youth with type 1 diabetes: A qualitative study," *African J. Prim. Heal. Care Fam. Med. Vol 17, No 1*, 2025, doi: 10.4102/phcfm.v17i1.4935.

APPENDIX A
Characteristics of Respondent

| Variables | Category | N | (%) |
|---|---|---|---|
| Dependent Variable | | | |
| DNP Incident | DNP | 39 | 55.7 |
| | Non-DNP | 31 | 44.3 |
| Independent Variables | | | |
| Sex | Male | 19 | 27.1 |
| | Female | 51 | 72.9 |
| Age | 0-14 years old | 0 | 0 |
| | 15-24 years old | 0 | 0 |
| | 25-64 years old | 48 | 68.6 |
| | >65 years old | 22 | 31.4 |
| Education | Elementary School | 13 | 19 |
| | Junior High School | 22 | 31 |
| | Senior High School | 30 | 43 |
| | College | 5 | 7 |
| Duration of Diabetes Mellitus | < 5 years | 20 | 28.6 |
| | ≥ 5 years | 50 | 71.4 |
| Types of Physical Activity | Light Activity | 23 | 32.9 |
| | Moderate Aktivity | 32 | 45.7 |
| | Strenuous Activity | 15 | 21.4 |
| Frequency of Physical Activity | Rarely | 19 | 27.1 |
| | Sometimes | 19 | 27.1 |
| | Often | 16 | 22.9 |
| | Every Day | 16 | 22.9 |
| Duration of Physical Activity | < 1 Hour | 25 | 35.7 |
| | 1-2 Hours | 31 | 44.3 |
| | 2-4 Hours | 14 | 20 |
| | >4 Hours | 0 | 0 |
| Activity | Low Activity | 36 | 51.4 |
| | Adequate Activity | 34 | 48.6 |