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ORIGINAL ARTICLE

ASSOCIATION BETWEEN FUNCTIONAL CAPACITY AND HANDGRIP STRENGTH IN PEOPLE WITH DIABETES MELLITUS

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ABSTRACT
Objective: to investigate the association between handgrip strength and functional capacity in people with diabetes. Method: observational cross-sectional study with 168 participants seen at an outpatient clinic in Curitiba, Brazil, in 2019. Clinical, sociodemographic, and socioeconomic data were collected, and the following protocols were applied: World Health Organization Disability Assessment Schedule; Timed Up and Go; and dynamometry. For the analysis, multiple linear regression models were adjusted for the dependent variables related to functional capacity. Results: we observed mild disability, borderline functional mobility, and higher correlation between functional mobility scale and handgrip strength ($r=-0.384$; $p < 0.01$). Handgrip strength with other covariates explained less than 30% of the functional variability. Conclusion: these results contribute to the problem-solving of clinical practice in that they show that muscle strength and functional capacity should be considered in the evaluation of the patient in combination, making it clearer and more comprehensive.

DESCRIPTORS: Diabetes Mellitus, Muscle strength, Physical Functional Performance; International Classification of Functioning, Disability and Health; Ambulatory Care.

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INTRODUCTION

Diabetes Mellitus (DM) is a metabolic disorder, which triggers a series of progressive micro and macrovascular complications that, in the long term, affects the muscular system and functional capacity[1]. In Japan, a study comparing participants without and with Diabetes Mellitus 2 (DM2), enrolled in the Metabolic Medicine Department of two hospitals, showed a significantly worse balance ability in the group of people with diabetes, when compared to the group with healthy individuals, according to the execution time of the Timed Up and Go (TUG) test and other tests, and a significant association was found between balance ability, progression of diabetic microvascular complications and propensity to fall in all age groups[2].

Reduced functional capacity in people with diabetes was reported in the study by Dias et al[3], who found a positive association between dependence in both instrumental activities of daily living and basic activities of daily living, regardless of other variables[3,4]. This shows the need for tracking these limitations, since they can affect self-care and diabetes management.

An important component of functionality is the Handgrip Strength (HGS), which is considered a health indicator for being able to predict, through the upper extremity, the global muscular strength4, an important aspect of the functional capacity itself[3]. Studies have pointed out low HGS as an indication of cardiometabolic diseases, functional limitations and disabilities, besides inherent disorders of the musculoskeletal system [3,5]. Others have associated the incidence of DM to low levels of HGS and to different morbidities, besides being considered an important predictor of mortality, although the mechanisms of these relationships are still not well understood [2,4].

Dynamometry predicts functional capacity based on the assessment of muscle strength, i.e., considering only one important physical aspect of functionality, excluding, however, other factors such as cognition, self-care, life activities, mobility and interpersonal relationships that directly or indirectly impact functional capacity. For the study and evaluation of functionality in all its spheres, it is necessary to use several instruments, as observed in the study by Pinhal et al[7], when the functional decline over three years of 68 people with diabetes in Brazil was observed, guided by the International Classification of Functioning, Disability and Health (ICF).

Based on the knowledge that functionality includes biopsychosocial aspects[6], and that handgrip strength has been considered an indicator of global strength[4], even though it includes the physical component, there is a need to verify these relationships, to obtain a complete evaluation of functional capacity and thus optimize research and clinical practice, benefiting this population, because decisions can be made with an understanding of the individual's contextual factors. The contribution that is intended to be made is to expand the evaluation of functionality, making it more comprehensive and aligned with an expanded concept of health.

Thus, the aim of this study was to investigate the association between HGS and functional capacity in people with diabetes.

METHOD

Quantitative observational research was conducted according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist[8].

The study site was a hospital outpatient clinic that serves people referred from Basic Health Units (BHU), University Hospitals in the city of Curitiba and other regions of the state of Paraná. The participants were recruited randomly as they showed up at the reception desk of the outpatient clinic, and the reception sequence was organized by two receptionists who did not know the purpose of the study.

The study included 168 individuals aged 20 years or older, of both genders, and diagnosed with DM. Patients were excluded from the study if they had difficulty in responding to verbal commands or if they had records of cognitive deficit in their medical records, severe hearing and/or visual deficits, absence or deformity of the hands or chiropractors, and/or inability to get up from a chair and walk independently, with or without orthoses.

All study variables were tabulated with double entry, using the Epi Data Entry software. The main researcher of the study only applied the protocols, in a room of the outpatient clinic, as follows: evaluation form, World Health Organization Disability Assessment Schedule 2.0 (WHODAS 2.0), in its abbreviated version of 12 items; Timed Up and Go (TUG) with and without dual task association and measurement of HGS.

Data classification was established as: socioeconomic data: education, monthly income and occupational status; sociodemographic data: gender, age, age group, marital status and ethnic group; clinical and anthropometric data: subjective health perception, systolic and diastolic blood pressure, respectively, in mmHg: < 140 and < 90: normal and ≥ 140 and ≥ 90: hypertension[9], Body Mass Index (BMI): < 18.5: underweight; ≥ 18.5 and < 25 eutrophic; ≥ 25 and < 30: overweight; ≥ 30 and < 35 grade I obesity; ≥ 35 and < 40 grade II obesity and ≥ 40 grade III obesity, Abdominal Circumference (AC) in cm: recommended ≤ 102 in men and ≤ 88 in women[10], type, family history and time of DM, medication for DM control, medications other than those used for DM control, complications concerning DM, other diseases, episode of falling in the last year, smoking, alcoholism and physical activity.

The laboratory tests to survey glycemic control: glycated hemoglobin in %: < 6.5: controlled DM and ≥ 6.5: uncontrolled DM; fasting glucose in mg/dL: < 100 controlled DM and ≥ 100 uncontrolled DM[11] were considered the most recent measurements in the last four months of the respective tests.

The information on the evaluation form collected through an interview were sociodemographic and socioeconomic data, anthropometric data, and clinical data, subjective perception of health, systolic and diastolic blood pressure, family history of DM, episodes of falls in the last year, smoking, alcohol consumption, and physical activity. The clinical data type and duration of DM, DM control medication, medications other than those used for DM control, DM complications, other diseases, and laboratory tests were collected from the participants' medical records.

WHODAS 2.0 is considered the gold standard in the operationalization of the ICF and provides an indicator of global functioning. For this study, the 12-item version was chosen and applied through an individual interview. It contains two questions for the six domains of life addressed: self-care, mobility, cognition, participation, life activities, and interpersonal relationships. It uses a scale from one to five, in which one is considered without difficulties and five, complete difficulty, generating a final score from zero to one hundred, and the lower the score the better the functionality[12]. The application time ranged between five and twenty minutes.

Functionality was classified based on the ICF scale[13], in which: 0-4% infers no disability; 5-24%, mild disability; 25-49%, moderate disability; 50-95%, severe disability; and from 96-100%, complete disability.

The TUG test was applied in a closed environment within a doctor's office, and the participants performed the test once before being timed to familiarize themselves with the procedure, and there was a one-minute sitting interval before the start of each test[14].

In the first moment, the TUG was applied without associations; in the second moment, the TUG with the addition of cognitive activity; and in the third moment, the TUG associated with a motor activity. The participants were instructed not to lean on the arm of the chair to perform the test, to wear their usual shoes, and to hold their walking aid. Their backs were supported on the 46 cm highchair, and the arms were supported on the 65 cm highchair arms[15].

The instructions given were: "when you hear the word "go", you must get up and walk at your daily pace to the line marked with white crepe tape with a red x on the floor 3 meters away, turn around, return to the chair, and sit down again "[14]. The stopwatch was started immediately after the command of the word "go" and stopped after the contact of the volunteer's buttock with the seat of the chair[14].

In the TUG with cognitive task, the volunteers were stimulated to repeat during the test the phrase "Practicing physical activity is good for the body and mind" [15]. When the TUG was associated with the motor task, the participants were asked to simultaneously associate the action of transferring coins between two pockets when performing the TUG. Thus, during the entire course, the volunteers transferred 10 50-cent coins from their right pocket to their left pocket. The participants were dressed in an apron containing pockets in the appropriate sizes for each of them[15].

The lower the functional capacity, the longer the time required to complete the test. To perform the task, ten seconds or less is considered the time spent for independent people, from 11 to 20 seconds for people with partial dependence and over 20 seconds for total dependence[16].

To measure the HGS, a Jamar® hand-held mechanical dynamometer was used with the proper calibration to obtain a reliable measurement. Regarding the positioning of the participants, they were seated on a chair with their elbows at a 90° angle and their eyes horizontal. For each of the participants, the grip of the dynamometer was adjusted individually according to the size of the dominant hand and so that the rod closest to the dynamometer body was positioned over the second phalanges of the index, middle, and ring fingers. The recovery period between measurements was one minute, and the test was performed in three trials on the hand reported as dominant by the participant. The best score of the three attempts was used for statistical analysis[13], and the cut-off point used was 41.15 Kg/F[17].

The result (R^2), found in a pilot study, with the first 20 entries, was considered for the calculation of the sample size. The analysis was performed using the Gpower 3.1 software, and the statistical test (linear multiple regression) was selected, which indicated the number to find a significant correlation, using a power of 95% and an α of 0.01.

Data analysis was performed using the IBM SPSS Statistics 21.0 statistical package. Data were presented as means and standard deviations, or medians and 25%-75% interquartile ranges. The Shapiro-Wilk test was used to evaluate the distribution of the data. To evaluate the correlation between two quantitative variables, Pearson's linear correlation coefficients were estimated for the BMI and AC variables; and Spearman's coefficients were estimated for the variables age, number of other medications, duration of DM, number of DM complications, number of other diseases, number of falls in the last year, glycated hemoglobin, fasting glucose, weekly frequency of alcohol consumption, and physical activity.

For the multivariate analysis, multiple linear regression models were adjusted for each of the dependent variables related to functionality. The independent variables included in the models were the HGS and other variables of the clinical-epidemiological profile that obtained correlation in the Pearson or Spearman test and variables with theoretical ratios. These were included, one at a time, until the best fit was found, following the stepwise and hierarchical scheme. The significance level was 5%.

The general rule for interpreting the magnitude of the correlation effect for medical research according to Mukaka et al.[18] was used.

After approval by the ethics and research committee under opinion number 3,030,003, the study was conducted in the period from April to June 2019.

RESULTS

The steps of identification, screening, eligibility, and inclusion in the study are demonstrated in Figure 1.

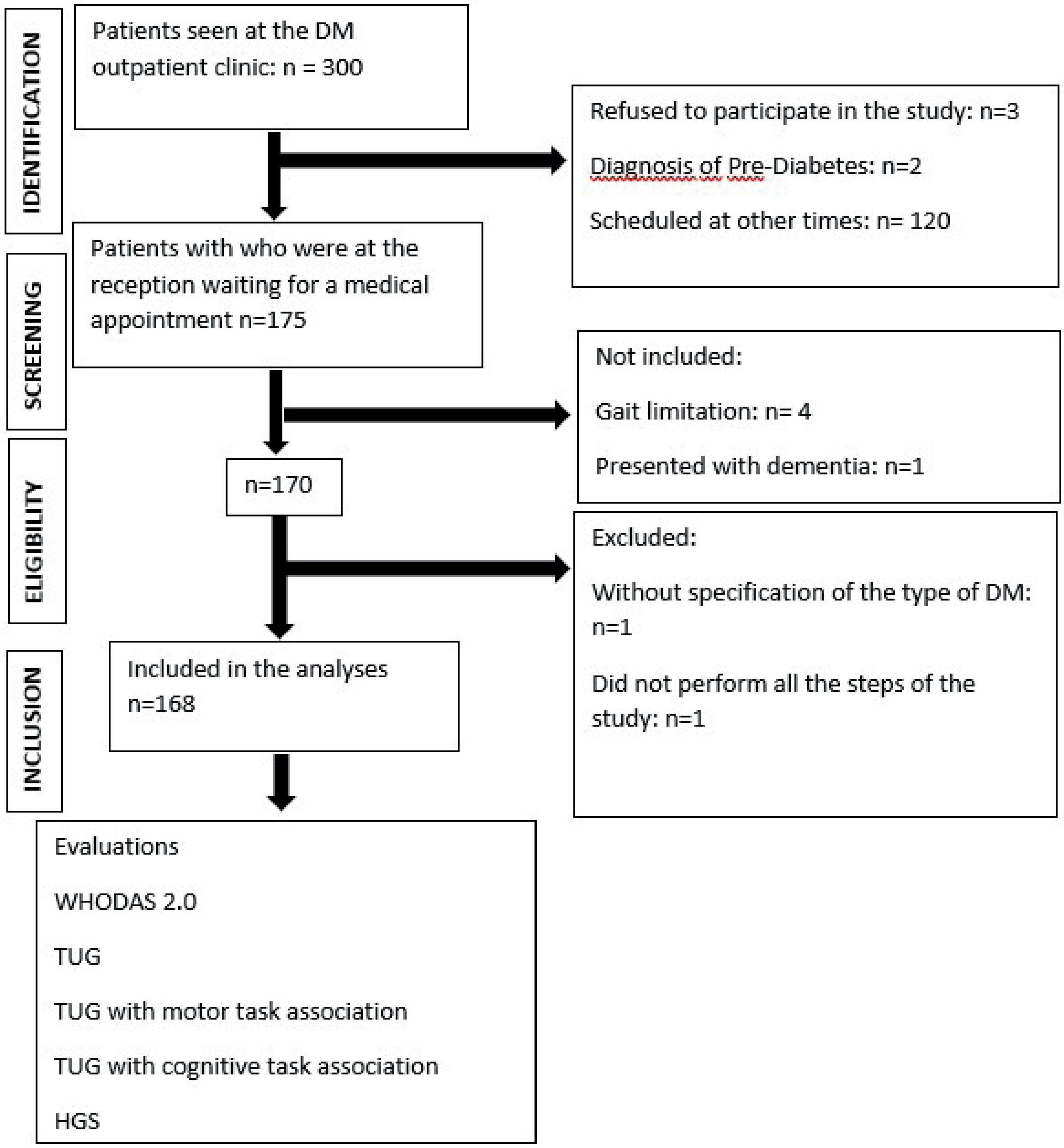

Figure 1 - Data collection following STROBE recommendation. Curitiba, PR, Brazil, 2019.
Source: the authors (2019).

A total of 168 people with diabetes participated in the study, of which: mean age 59.38 ±13.23 years; predominant age range between 60 and 79 years, 96 (57.1%) followed by between 40 and 59 years, 51 (30.4%), between 20 and 39 years, 16 (9.5%) and above 80 years, five (3%); and the minimum and maximum age found were 21 and 86 years, respectively. Ninety-three were female 93 (55.4%), white ethnic group 134 (79.8%), married life 110 (65.5%), level of education elementary school I, 56 (33.3%), retired 72 (42.9%), income from 1 to 3 minimum wages 133 (79.2%), and with subjective perception of good health 91 (54.2%).

The typical characteristics of the sample are shown in Table 1

Table 1 - General characteristics of the sample. Curitiba, PR, Brazil, 2019

Variables	Minimum	Maximum	Values
BMI (kg/m²)	18.80	50	31.05 ± 5.51
AC (cm)	61	140	104.55 ± 13.32
Systolic Blood Pressure (mmHg)	80	230	127.72 ± 19.31
Diastolic Blood Pressure (mmHg)	50	130	78.84 ± 11.4
DM time (months)	0	672	108 [60 – 204]
Quantity of complications DM	0	10	1 [0 – 2]
Quantity of other diseases	0	10	3 [2 – 5]
Number of medications in use	0	20	5.15 ± 3.41
Drinking (frequency per week)	0	7	0 [0 – 0]
Smoking (year/pack)	0	251.75	0 [0 – 10]
Physical activity (frequency per week)	0	7	0 [0 – 2]
Number of falls (last year)	0	10	0 [0 – 1]
HbA1c (%)	5.3	12.20	8.05 ± 1.74
Fasting Blood Glucose (mg/dL)	43	595	169.57 ± 81.19

Values shown as mean and standard deviation or median and interquartile range 25-75%.
Source: the authors (2019)

It could notice that 99 (59%) of the participants had degree of obesity, 49 (29.2%) were overweight, and 129 (77%) had AC above the recommended measurement. Although most participants diagnosed with hypertension, their blood pressure was adequate at the time of the research.

Of the total sample, 44% used oral medication associated with insulin therapy for DM control, most 106 (63.1%) denied a family history of DM, the median time of DM diagnosis was nine years, there was a significant gap between the minimum and maximum time of DM diagnosis (Table 1), 118 (70.2%) had at least one complication, the minimum and maximum number of complications were 1 and 10, respectively; the most frequent complications were cardiovascular 50 (29.8%), ophthalmologic 49 (29.2%), and circulatory 39 (23.2%). In addition to medication for glycemic control, participants used, on average, 5.15 ± 3.41 other medications.

Only 61 (33.6%) reported performing physical activity, the majority reported never having smoked 89 (53%), not being a drinker 155 (92.3%), and not having had any episodes of falls in the last year 118 (70.2%). They belonged to the etiological classification type 2 DM, 147 (88%), and 73 (44%) used oral medication associated with insulin therapy to control DM.

The individuals had mild disability level, reduced functional mobility and HGS on average, slightly decreased, considering the values for the Brazilian population, and the dependent variables did not adhere to normal distribution ($p<0.05$)[19] (Table 2). When the variable was stratified by gender and age group and categorized into adequate HGS and reduced HGS, adequate HGS was observed in most participants.

Table 2 - Characteristics of functionality and HGS. Curitiba, PR, Brazil, 2019

Variables	Values
WHODAS 2.0 (%)	16.67 [6.25 – 31.25]
TUG (s)	11.85 ± 4.92
TUG - motor task (s)	16.09 ± 7.36
TUG - cognitive task (s)	13.66 ± 5.93
HGS (kg/f)	32.85 ± 9.78

Source: the authors (2019).

Between self-reported functionality and the FPM and functional mobility with association of motor task versus FPM there were significant negative correlations, respectively (r = -0.296 and -0.343), but with biologically negligible effect magnitude. There was a significant negative correlation with weak effect magnitude between the TUG results without and with association of cognitive task and the FPM, respectively (r = -0.384 and - 0.52).

To verify which variables could explain the variability in functionality, multiple linear regression analysis was performed, considering its prerequisites. The analyses resulted in statistically significant models.

The HGS, the amount of DM complications, the weekly frequency of physical activity, the number of other diseases, and the amount of other medications in use insufficiently explained the variability of self-reported functionality of these individuals, only 14.1% (Table 3)

The percentage of variation of the dependent variable TUG that is elucidated by the set of independent variables explains 26.6% of the variability of functional mobility, with the dependent variable TUG with association of cognitive task 24.2% and 20.2% of the TUG with association of motor task, the HGS was the most significant variable in the models of TUG and TUG with association of motor task, age was the variable that best explained the variability in the model contemplating the TUG with cognitive task (Table 3).

Table 3 - Multiple linear regression models that best explained the variability of functionality. Curitiba, PR, Brazil, 2019

WHODAS	B	SE B	B	t	CI 95% for B
Constant	18.345	5.728		3.203**	7.020 - 29.670
HGS	-0.221	0.133	-0.134	-1.665+	-0.483 - 0.041
Complications of DM	2.337	0.809	0.232	2.888**	0.737 - 3.937
Physical activity	-0.455	0.550	-0.064	-0.827+	
Other diseases	-0.019	0.613	0.003	-0.032+	-1.231 – 1.192
Other medications	1.069	0.409	0.225	2.615**	0.261 – 1.876
TUG	**B**	**SE B**	**B**	**t**	**CI 95% for B**
Constant	7.274	1.722		4.225*	3.872 - 10.676
HGS	0.083	0.021	0.298	3.957*	-0.125 - 0.042
Age	0.057	0.016	0.268	3.536*	0.025 - 0.088
Other diseases	0.124	0.095	0.101	1.303+	-0.064 - 0.313
Other Medications	0.009	0.065	0.011	0.133+	-0.119 - 0.137
AC	0.020	0.015	0.098	1.302+	-0.010 - 0.050
Complications of DM	0.167	0.128	0.094	1.306+	-0.086 - 0.419
Falls	0.169	0.128	0.094	1.322+	-0.084 - 0.422
Cognitive TUG	**B**	**SE B**	**B**	**t**	**CI 95% for B**
Constant	9.660	1.599		6.040**	6.188 - 12.234
HGS	-0.106	0.027	-0.285	-3.976**	-0.138 - -0.036
Age	0.104	0.020	0.371	5.180**	0.062 - 0.138
Motor TUG	**B**	**SE B**	**B**	**t**	**CI 95% for B**
Constant	5.773	2.936		1.966	0.215 - 11.525
HGS	-0.103	0.036	-0.219	-2.842**	-0.166 - -0.27
Systolic Pressure	0.049	0.018	0.205	2.685**	0.015 - 0.085
AGE	0.070	0.028	0.202	2.511*	0.004 - 0.113
Other diseases	0.200	0.168	0.096	1.191	-0.133 - 0.513
Fasting Blood Glucose	0.007	0.004	0.121	1.644+	0.000 - 0.016

B and SE B: non-standardized coefficients; **β**: standardized coefficients; t: statistical significance test (*p≤0.05, +not significant; **p≤0.01); 95% CI: 95% confidence interval (lower bound/upper bound)19.

Source: the authors (2019).

The mean explanation of variability of the selected models was 21.3%, a low prediction value due to the magnitude of the standardized coefficients found, which are mostly classified as negligible, as stated by Mukaka et al.[18]

DISCUSSION

Investigating the associations of functional capacity with other elements may help in tracking functional limitations in this population. In the present study, an association between functionality and HGS was demonstrated. A significant negative association was observed between these variables, that is, the greater the disability and the time to perform the TUGs, the lower were the HGS values.

Proving the existing interaction between the FPM and functionality, with a moderate association when assessing functionality from the perspective of functional mobility with the performance of the cognitive task, and a weak association when assessed considering the individual's perception or by means of the physical test involving the other components of functionality and simulating the motor skills required in daily life.

Ramlagan et al.[20] in a population-based cross-sectional study in South Africa found similar results between self-reported functionality, assessed with the 12-item WHODAS 2.0, and HGS with the manual mechanical dynamometer in 3840 men and women over 50 years of age; according to the literature, this relationship would occur due to the physical inactivity that muscle weakness triggers[21].

The HGS is included in the components of Functions and Structures of the body according to the biopsychosocial ICF model[13]. Thus, factors that influence muscle strength can also influence functional capacity.

Investigating other factors that could influence this relationship, it was evident that, together, the HGS and other covariates were able to explain, significantly, less than 30% of the variability in the functionality of these individuals. These results can be justified by the amplitude of the biopsychosocial approach represented by WHODAS 2.0, where there is interaction among all ICF[13] components, which does not occur with dynamometry.

The above-mentioned reasoning is extended to functional capacity assessment tests such as the TUG without and with dual task association, because, although its demands are focused on dynamic balance and gait - domains of the ICF Body Function component - it also includes mobility, task performance, communication, learning and application of knowledge, domains of the Activity and Participation component, and can explain, in a broader way, the patient's functionality. This can be corroborated by studies[22,3] in which cognitive skills were determinant for walking, regardless of the behavior of the other motor variables.

Even though our results showed a weak correlation between functional mobility with and without the association of the motor task, the HGS was the variable that best explained the variability in these two models. This can be explained by the need for activation of muscle mechanisms to perform the test, and demonstrates the interaction of muscle strength, even if indirectly, with the Activity and Participation component of functionality.

Even though the HGS with the other independent variables explained a higher percentage of the variability in functional mobility compared to the percentage of self-reported functionality, this percentage was insufficient to consider the HGS, in isolation, and to be considered a predictor of functional capacity, as Wieczorek et al[23] warns in a study with community-dwelling elderly people in Brazil, when they found a weak, but significant correlation between HGS and functionality measured by the 6-minute walk test ($r = 0.324$) and the TUG ($r = - 0.385$).

Regarding the functional profile of the study participants, although the majority obtained a mild disability in the general WHODAS 2.0 score, 86.3% had some level of disability, agreeing with what was found in different studies that also assessed the functional capacity of this population and compared people with and without DM[25,26].

The participants in this study had a mean time of execution of the TUGs greater than 10, signaling deterioration in gait, greater risk of falling, and indicating reduced functional capacity, although when associated with the dual task by the walking test, the execution times were longer, especially when a motor task was added. The coordination between the upper limbs that the task required may justify this result.

Significant relationships were found between disability and functional mobility with polypharmacy and comorbidities associated with DM. These factors trigger a vicious cycle due to the presence of many diseases and the use of drugs to control them, and may have been contributing factors to the presence of disability and reduced functional mobility in this sample.

The research of Werfalli et al.[26] in southern Africa, related the greater disability measured by WHODAS 2.0 in people with diabetes, with the lower practice of physical activity and the greater number of chronic conditions, and pointed out that the score increased proportionally with age. Like our study, the number of complications and age were the variables that most explained the variability of self-reported functionality and cognitive TUG respectively, suggesting that, together, the DM and older age may potentiate the disabilities resulting from the disease.

It is observed in the literature that there are alterations in gait and cognition related to the aging process[22,27], a dual task associated with gait, which requires greater ability from both. When a cognitive task is added to the functional mobility test, the representation of daily life becomes more evident.

In the sample of the present study, most participants with severe disability presented four complications resulting from DM, with the three most frequent complications being cardiovascular, ophthalmic, and circulatory. According to the International Diabetes Federation [11], cardiovascular disease is the leading cause of death and disability in this population, and diabetic retinopathy, the leading cause of vision loss in adults aged 20-65 years. These data can and should be monitored by the outpatient clinic team for follow-up and evolution of the clinical picture of these complications, besides being the target of interventions directed at self-care and therapeutic conducts.

Cardiovascular complications were more present in the sample, due to the high rate of participants who have other NCDs besides DM, the lack of physical activity, as well as obesity and inadequate glycemic control. Studies point to these clinical, anthropometric, and lifestyle characteristics as risk factors for these complications, with a high correlation with mortality [11,26].

Reach, et al.[28] state that the limitations of developing care plans for individual patients can also mean poor education about DM. Thus, the diversity of complications and their different impacts may require the adoption of a person-centered care model, to know and thus conduct treatment in a comprehensive manner considering the particularities of the patients.

The limitations to be considered in this study are the correlation between functioning and the HGS analyzed in the general sample, without analyzing this association in the different age groups and gender, and the use of the 12-item WHODAS 2.0 instead of the 36-item version, which contemplates the individual associations of each domain of functioning.

CONCLUSION

The look at the individual, considering the internal and external elements that influence his autonomy and activities, requires a more comprehensive functional evaluation. Muscle strength is related to the components of body function and structure, but because it is associated with functional mobility, in this study it was also related to the component of activities and participation, so that functionality could be partially explained by HGS.

Although HGS has sparsely explained the variability in functionality of people with diabetes, in the multifactorial of the biopsychosocial model (WHODAS 2.0), the greater association between handgrip strength and functional mobility with the cognitive task highlights the influence of cognitive aspects for the evaluation of FPM, it is also possible to affirm that this test can be influenced by cognitive aspects that will always be present in life activities, thus demonstrating the importance of expanding the possibilities of assessing functionality.

These relationships highlight the complexity about the individual's functionality, and how necessary investigations are to clarify under which domains of functionality the HGS can be considered predictive. Thus, studies and evaluations focused only on specific characteristics of functioning do not predict it in all its spheres. For this reason, the HGS should not be used indiscriminately, without considering the patient's life context, since these two variables - muscle strength and functional capacity - must be considered in the patient's evaluation, making it clearer and more comprehensive to improve the resoluteness of the assistance conduct, for future studies and for clinical practice.

Thus, it is suggested for future studies, the investigation of the HGS with self-reported functionality using WHODAS 2.0 with the 36-item version and with the stratification of the different age groups and gender.

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