Effects of resistance training in people with Type II Diabetes Mellitus: systematic review

Efectos del entrenamiento de la fuerza en personas con Diabetes Mellitus Tipo II: revisión sistemática

Efeitos do treinamento de resistência em pessoas com diabetes mellitus tipo II. Revisão sistemática

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ABSTRACT

This Article Seeks analyzes the evidence provided by strength training, verifying its influence on Type II Diabetes Mellitus by using the existing literature on this subject of study. A systematic review was carried out following the PRISMA guidelines, where the main context was strength training in patients with Mellitus II. The search was carried out in Pubmed, Embase, and Scopus databases where 7 articles were selected. The findings consistently indicated that a well-structured strength training program gradually affected some markers that identify diabetes Mellitus II when performing interventions with strength training systems in a positive way. The authors recommend control-type studies with larger samples, if possible, to verify the incidence of training in the variables mentioned in this study.

Key words: Type II diabetes mellitus (DM2), Insulin, Glucose, HOMA-IR, Resistance training.

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RESUMEN

El presente artículo busca analizar las evidencias aportadas del entrenamiento de la fuerza comprobando su influencia en la Diabetes Mellitus tipo II utilizando la literatura existente sobre este objeto de estudio. Se realizo una revisión sistemática siguiendo las directrices PRISMA donde el principal contexto fue el entrenamiento de la fuerza en pacientes con Mellitus II, siendo buscados en bases de datos Pubmed, Embase y Scopus donde fueron seleccionados 7 artículos. Los hallazgos señalan consistentemente que el entrenamiento de la fuerza bien programado incide gradualmente en algunos marcadores que identifican la diabetes Mellitus II al realizar intervenciones con sistemas de entrenamiento de la fuerza de forma positiva. Los autores recomiendan estudios con muestras mayores en lo posible de tipo control para verificar la incidencia del entrenamiento en las variables mencionadas en este estudio.

Palabras Clave: Diabetes mellitus Tipo 2, Insulina, Glucosa, HOMA-IR, Entrenamiento de Fuerza.

RESUMO

Este artigo procura analisar as evidências fornecidas pelo treinamento de força, verificando sua influência no Diabetes Mellitus tipo II utilizando a literatura existente sobre este objeto de estudo. Foi realizada uma revisão sistemática seguindo as diretrizes PRISMA onde o principal contexto foi o treinamento de força em pacientes com Mellitus II, sendo pesquisada nas bases de dados Pubmed, Embase e Scopus onde foram selecionados 7 artigos. Os achados indicam consistentemente que o treinamento de força bem programado afeta gradualmente alguns marcadores que identificam o diabetes Mellitus II ao realizar intervenções com sistemas de treinamento de força de forma positiva. Os autores recomendam estudos do tipo controle com amostras maiores, se possível, para verificar a incidência de treinamento nas variáveis mencionadas neste estudo.

Palavras chave: Diabetes mellitus tipo II (DM2), Insulina, Glicose, HOMA-IR, Treinamento de força.

INTRODUCTION

Diabetes Mellitus is a chronic pathology that affects multiple organs and systems, causing a great impact on the life and well-being of people around the world, where a high prevalence has been observed, evidenced in the 2019 report in which a total of 462 million individuals suffer from this disease (Khan et al., 2020). To understand the importance of Diabetes Mellitus and the physiological changes it entails, it is necessary to know the glucose metabolism and its relationship with the other systems in the human body (Mendes et al., 2018), since an alteration implies modifications in the systems that intervene in the uptake, assimilation and degradation of carbohydrates (Conget, 2002), allowing some systemic dysfunctions that would imply alterations in the secretion of insulin and sensitivity to the action of this hormone (Kacerovsky-Bielesz et al., 2012). Diabetes has several types: DM1 is acquired genetically because the pancreas does not secrete insulin; DM2 is acquired through unhealthy habits, such as a sedentary lifestyle, and presents dysfunction in insulin secretion and decreased sensitivity (Rae-Dupree & Dupree, 2007).

The literature states that exercise plays a fundamental role in the management of insulin resistance, prediabetes and Diabetes Mellitus, especially DM2 (5–7), based on the above, we affirm that improving healthy lifestyles and reducing sedentary lifestyle are a key point to have control and prevention of DM2 and other comorbidities such as chronic non-communicable diseases (Colberg et al., 2010; Colberg & Sigal, 2011). Some authors state that exercise supervised by professionals and

performed progressively produces improvements in insulin sensitivity, blood glucose levels and lipid profile in people with DM (Brooks et al., 2007; Domínguez et al., 2016; Jiménez & Ramírez-Vélez, 2011; Misra et al., 2008); Certain studies that have analyzed the use of strength training in people with DM2 have shown changes in body composition due to the effects of training that are correlated with insulin sensitivity and glucose uptake (Kwon et al., 2010; Yaspelkis, 2006). The above is mediated by the increase in the transporter protein GLUT4, which is the largest glucose binder in skeletal muscle; this increase, which is achieved up to 100 times compared to rest, is directly related to the practice of exercise and strength training depending on its intensity and duration (Röckl et al., 2008; Richter, 2021). Taking the above into account, this systematic review focused on DM2 and its relationship with exercise, based on the specialized literature on the subject. The objective of our review article is to highlight the limited literature that discusses DM2 under the influence of strength training, taking into account the methods, factors, equipment and variables of the different studies consulted.

METHODS

This study was a systematic review of scientific articles on the topic of strength training and its impact on type II diabetes mellitus, which were evaluated using the PEDro scale (Bhogal et al., 2005), determining their methodological quality (Table 1). For its development, the PRISMA statement was used as a guide for the correct performance of the systematic review (Figure 1). In this section, the procedures for developing the methodology will be detailed step by step.

Search strategy and selection of studies

A literature search was conducted in English and Spanish between June and August 2020 in the Pubmed, Embase, and Scopus databases (1994-2020). The main MeSH terms used using the Boolean operators AND and OR were: [Resistance Training, Strength Training, Weight-Bearing Exercise Program, Weight-Bearing Strengthening Program] among others; [Diabetes Mellitus Type 2, Diabetes Mellitus, Adult-Onset, Diabetes Mellitus, Ketosis-Resistant, Diabetes Mellitus, Maturity-Onset, Diabetes Mellitus, Non-Insulin Dependent, Diabetes Mellitus, Non-Insulin-Dependent]. This systematic review was conducted according to the protocols according to the PRISMA review system (Figure 1).

Inclusion and exclusion criteria

Inclusion criteria included trials described as randomized, parallel, group or crossover designs, even if they did not report the methods for generating the random sequence or if they were not clear; that presented strength training as an exercise proposal in patients with DM2 older than 18 years, regardless of gender; and that measured the following variables: Hba1c, insulin, glucose, LDL-c, HDL-c and triglycerides (TG) as a result of training, whose intervention was at least 6 weeks (a month and a half).

The exclusion criteria adopted were studies with patients with DM1 and/or gestational DM, not randomized and whose exercise proposal did not include strength training, that in their evaluation some of the variables mentioned above were not included and that their intervention was less than 6 weeks.

Evaluation of methodological quality

The Physiotherapy Evidence Database (PEDro) scale was used to analyse the quality of the selected literature. The instrument allows the evaluation of the methodological quality of clinical designs, being used in a varied number of systematic and bibliographic reviews and developed by (Verhagen et al., 1998) based on the Delphi consensus techniques (Ayala & Baranda, 2013).

This scale is made up of 11 conditions, where positive values are scored with "1" and negative values with "0". Items between 2 and 9 refer to the internal validity of the methodology used and items 10 and 11 refer to the statistical treatment used by the authors (Table 1). Using this scale, we evaluate the quality of the studies, emphasizing the impact of strength on biochemical and body composition variables with pre-test and post-test designs from the selected literature.

Table 1

PEDro methodological evaluation scale.

#	Condition	Yes	No
1	The selection criteria were specified.	1	
2	Subjects were randomly assigned.	1	
3	The assignment was hidden.	1	
4	The groups were similar at baseline with respect to the most important prognostic indicators.	1	
5	All subjects were blinded.	1	
6	All therapists administering the therapy were blinded.	1	
7	All assessors measuring at least one key outcome were blinded.	1	
8	Measures of at least one of the key outcomes were obtained from more than 85% of subjects initially assigned to groups.	1	
9	Results were presented for all subjects who received treatment or were assigned to the control group, or when this could not be done, data for at least one key outcome were analysed on an “intention-to-treat” basis.	1	
10	Results of statistical comparisons between groups were reported for at least one key outcome.	1	
11	This study provides point and variability measures for at least one key outcome.	1	

RESULTS

Selection of literature

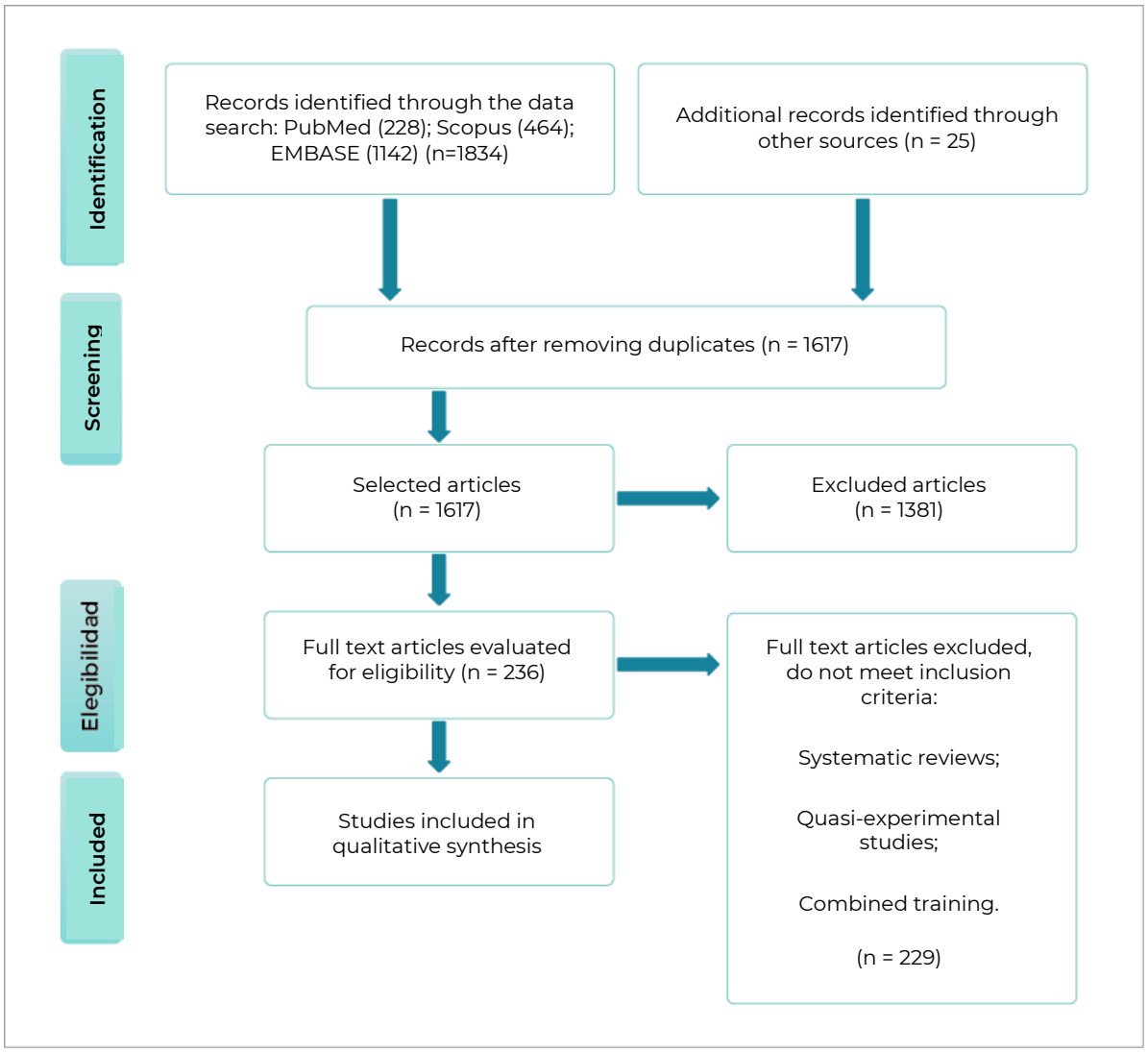
The procedures for selecting the literature used for this review resulted in seven articles that, in our opinion, meet the prerequisites established in the inclusion and exclusion criteria defined by the researchers. Of the selected documents (n = 7), four require payment and three are freely accessible. Most of the studies were carried out with people diagnosed with DM2, making up a total of 313 participants globally without taking into account sex. None of the groups presented dietary intervention, the minimum number of weeks of training was 6 weeks and a maximum of 24. The characteristics of each of the interventions are described in Table 3.

In the training routines in the included studies, improvements were obtained in some inherent parameters; Of all the studies mentioned, the interventions produced positive

changes translated into improvements ($p \leq 0.05$) in Hba1c (5 studies; 71.4%), Insulin (HOMA-IR: 3 studies; 42.8%), Glucose (4 studies; 57.1%), Ldl-c (3 studies; 42.8%), Hdl-c (2 studies; 28.5%) and TG (3 studies; 42.8%). We can reference the study presented by (Yang et al., 2017) where a better decrease was obtained in the group that worked with a percentage of 50% 1RM in the Hba1c parameter obtaining 7.4 and 6.7 and an effect size of (ES 3.53) cataloging as large effect as proposed by (Cohen, 1977). All studies included in this review were analysed (Figure 1). All included studies allow for comparison of the before and after of a strength intervention and its effects on the different biochemical and body variables of the participants.

Figure 1

PRISMA Search Flowchart.



All selected studies used strength training as the primary intervention; of the eight selected studies, five used % 1-RM load as a means of optimization, the remaining used time as a measure for the number of repetitions performed, and the others performed systematic increases from a repetition base.

Reliability of the selected studies

The studies in this review presented a range between 6 to 11 points with an average of 8.57 shown in Table 2. Within the studies, three articles presented 11 points (42.8%), two articles, 6 points (28.5%) and two articles with values between 7 and 8 each with 14.3%, respectively.

Table 2

Evaluation of the literature by PEDro methodological assessment scale.

Studies	1	2	3	4	5	6	7	8	9	10	11	Score
(Cauza et al., 2005)	yes	yes	no	yes	no	no	yes	yes	yes	yes	no	7
(Jorge et al., 2011)	yes	yes	yes	yes	no	no	no	yes	yes	yes	yes	8
(Kadoglou et al., 2012)	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	11
(Russell et al., 2017)	yes	no	no	yes	no	no	no	yes	yes	yes	yes	6
(Yang et al., 2017)	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	11
(Dadrass et al., 2019)	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	11
(De Lade et al., 2016)	yes	no	no	yes	no	no	no	yes	yes	yes	yes	6

Despite the variability of the data in some studies, most met the criteria proposed by the researchers, where it is evident that the major criteria of the methodological evaluation were: 1, 8, 9 and 10, being repetitive in the selected literature and where all the studies presented pre and post test intervention. All the studies presented eligibility criteria and the results met at least 85% of the measurements, yielding at least one key result in the participants, as well as a control treatment as a start or starting point in the research and the results show variability represented by the average and standard deviation.

Table 3

Main results of the included studies.

Authors	Participants	Intervention	Hba1c (%)	Insulin	Glucose (mg/dl)	Ldl-c (mg/dl)	Hdl-c (mg/dl)	TG. (mg/dl)
(Cauza et al., 2005)	43 participants	Pre Post	8.3±1.7** 7.1±0.2**	9.1±1.5±1.5* 7.2±1.2±1.2*	204±±16** 147±8± 8**	120±8±8** 106±8±8**	43±3±3* 48±2±2*	229±25±25** 150±15±15**
(Jorge et al., 2011)	48 participants	Pre Post	8.51±2.4 ±2.45 8.24±2.1	4.54±3.9 ±3.94 4.07±2.9 ±2.90	194.2±79.5*±79.53 166.1±60.5*±60.59	164.3±30.1* 153.0±25.5*	39.3±7.7* 34.7±3.6*	236.3±231.3* ±231.37 154.6±76.4* ±76.44 ± 64.46
(Kadoglou et al., 2012)	52 participants	Pre Post	7.4±0.4* 7.1±0.6*	3.97±1.8* ±1.86 2.79±0.4* ±1.01	169±27*±27 147±27*±27	155±26±26 145±17±17	51±15±15 50±12±12	159±60±60 135±68±68
(Dadrass et al., 2019)	48 participants	Pre Post	7.58±1.2 ±1.26 6.99±1.1±1.11	1.18±1.5 ±1.54 0.92±0.8 ±0.83	144.91±51±51.01 129.16±45.6±45.65	92.58±33.7* ±33.76 69.75±24.3* ±24.33	34.33±2.6±2.67 37.33±6.5±6.56	228.75±71.3* ±71.39 170.25±63.6* ±63.67
(De Lade et al., 2016)	43 participants	Pre Post	9.2±1.9±1.9* ±1.26 7.9±1.2*±1.26	13±14 6±4	174±92 129±46	106±51 83±8	45±3 45±3	128±97 136±172
(Russell et al., 2017)	17 participants	Pre Post	7.7±0.3* 7.3±03*	3.7±0.7±0.7 3.1±0.5±0.5	10.0±0.8±0.8# 8.7±0.6±0.6#	2.9±0.3±0.3# 2.6±0.2±0.2#	1.4±0.2±0.2# 1.2±0.1±0.1#	1.8±0.3±0.3# 1.4±0.2±0.2#
(Yang et al., 2017)	62 participants	Pre Post	7.4±0.2** ±0.3 6.7±0.2±0.2* *	9.79±0.6* 8.52±0.5*	9.79±0.6*$ 8.52±0.5*$	2.17±0.1# 2.25±0.16±0.1#	1.25±0.08±0.05 # 1.27±0.07±0.05 #	1.46±0.20±0.09# 1.40±0.08#

*Note: **=p≤0.001; *=p≤0.05; #=values in mmol/L; $= values in mIU/ml; Hba1c (Glycated Hemoglobin); Ldl-c (Low Density Lipoproteins); Hdl-c (High Density Lipoproteins); TG (triglycerides).*

The study with the greatest effect on all blood biochemical variables, especially in the lipid profile: Ldl-c (ES: 1.77); Hdl-c (ES: 1.98); and TG (ES: 3.88) was that of (Cauza et al., 2005) where improvement was observed mainly in glucose, in turn the study of Yang et al., (2017) was the one that most affected Hba1c (ES: 3.53).

Table 4

Characteristics of the interventions.

Authors	Type of exercise	Duration	Intensity
(Cauza et al., 2005)	Bench press, chest curl, shoulder press, pulldowns, bicep curls, triceps extensions, abdominal exercises, leg press, calf raises and leg extensions.	16 weeks (3x/week)	Sets of 10 to 15 repetitions. Systematic increase from 3 sets at the beginning of the program to 4, 5 and finally 6 sets per week at the end of the program.
(Jorge et al., 2011)	Leg press, bench press, lat pulldowns, seated row, shoulder press, abdominal push-ups, and knee push-ups.	12 weeks (3x/week)	NR
(Kadoglou et al., 2012)	Seated leg press, knee extension, knee flexion, chest press, lateral pulldown, shoulder press, biceps curl and triceps extension.	12 weeks (3x/week)	2-3 sets of 6-8 reps. 60-80% of 1-RM.
(Russell et al., 2017)	Leg press, lateral pulldown, chest press, weighted lunges, seated row, back fly, biceps curl, incline chest press, dumbbell shoulder press, leg extension, leg curl, dips, lateral shoulder raise, triceps extension, dumbbell deadlift and elbow curl; dumbbell crunches, medicine ball throw, leg raises, plank positions, burpees and weighted farmer's walk.	6 weeks (3x/week)	6 to 15 reps. 65-85% of 1-RM.
(Yang et al., 2017)	Dumbbell row, half squat, biceps curl, lateral raise, heel raise, hamstring curl, supine fly, triceps extension, abdominal flexion, and a core strengthening exercise.	RT1 group: 12 weeks. RT2 and RT3 group: 24 weeks.	RT1 Group: 2 sets of 10 to 15 reps. 50% of 1-RM. RT2 Group: 3 sets of 7 reps. 75% of 1-RM. RT3 Group: 2 sets of 15 reps. 50% of 1-RM.
(Dadrass et al., 2019)	Chest press, leg extension, leg curl, arm curl, push-up with knees on the floor, seated row, chest pulldown, military press, abdominal crunches with weights.	12 weeks (3x/week)	3 sets of 10 reps - 30 sec rest. Intensity: 55% of 1RM, (First month) 65% of 1RM (Second month), 75% of 1RM (Third month)
(De Lade et al., 2016)	Rowing, Squats, Bench Presses, Dumbbell Rows, Ankle Weighted Knee Extensions, Dumbbell Shoulder Press, Dumbbell Curls, Dumbbell Leg Extensions, Calf Raises, Triceps Push-Ups, and Sit-Ups.	Phase 1: 10 weeks 3x/week Phase 2: 10 weeks 3x/week	Circuit Method; 10-15 seconds rest Phase 1: 2 sets of 15 reps, week 3 3 sets. Phase 2: 2- sets of 12 reps.

NR= does not report; RM= Muscular Endurance.

The weekly training frequency was three days where each of the intervention groups performed the work with different loads according to their 1-RM; it should be noted that the groups that show significant differences perform work based on 50% of their 1-RM, so it could be inferred that there is no need to perform exercises with very high loads, where the number of series can be performed with values between 10-15 repetitions with a load of 50-59% of 1-RM, and gradually reach to perform series where between 8-10 repetitions are completed with a load of 70-84% of their 1-RM (Table 4).

DISCUSSION

In this systematic review document we have included only research that meets our inclusion criteria, especially the benefits of strength training in people suffering from diabetes mellitus 2 assessed by the results of blood variables and under the premises of the (Pan American Health Organization [PAHO], 2012) where it states that more than 342,603 people have died in 2016 and that in turn it produces sequelae at the ocular, renal, cardiac, cerebrovascular level and amputations in lower limbs.

Of the seven studies analyzed, the biochemical variable that presents the most differences in relation to a strength training system was Hba1c, where 5 studies presented significant differences and it seems that combined strength and resistance training systems such as those proposed by Yang et al. (2017) seem to be the most suitable for improving blood glucose levels (Pan et al., 2018, pp. 1-14), as well as insulin (ES: 2.32). Taking the above into account, our hypothesis is that exercises programmed for a minimum of 6 months produce positive effects on Hba1c (ES: 3.53). In addition to these results, the study by (Pinto et al., 2017) defines that there is a consensus that resistance training positively influences blood glucose levels, as well as a decrease in total body cholesterol (Moe et al., 2011).

Our findings show that the study that had the greatest impact on all blood variables was (Cauza et al., 2005), because it presented significant differences in all blood biochemical variables, identifying the largest effect size in the glucose variable (4.56), followed by TG (3.88), HDL (1.98) and LDL (1.77) respectively, so we propose that this training system is not only beneficial for a single variable, but rather for all in general in metabolic factors as well as their muscular function specifically in patients with Diabetes Mellitus 2 as long as it is controlled and directed by interdisciplinary groups (Da Silva & Grando, 2004). Strength work at 60% of 1RM demonstrated greater effectiveness, therefore work with these percentages with populations that present these pathologies is considered essential (Colberg et al., 2010; Hansen et al., 2012).

In our opinion and based on the evidence from the consulted literature, there are many investigations that evaluate the interventions of aerobic exercise on diabetes (Winnick et al., 2008), but there are few scholars who show the innumerable benefits of strength training on people with DM2, some of these studies show that strength training leads to clinical improvements, but not statistically relevant ones (Reid et al., 2010).

The authors state that there are limitations in the information that may lead to greater bias, due to the presence of a greater number of additional pathologies to DM2 in the population under study, where continued consumption of medications during the intervention was evident, as well as the low sample size in the studies, which is a limitation when making a better and more complete analysis.

CONCLUSION

The results based on the selected literature show that training for more than 16 weeks with loads of three sets and repetitions between 10 and 15 gradually affects blood biochemical variables, which translates into an improvement in patients with Type II Diabetes Mellitus. The analysis of the scientific studies carried out here shows the small number of investigations where the main intervention method is strength training with a representative sample size, as well as controlled and randomized studies where the intervening variables can be argued.

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