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Lipid profile in people with Down syndrome: a literature review

Eloise Werle de Almeida[1], Márcia Greguol[1]

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[1]Departamento de Educação Física, Centro de Educação Física e Esporte, Universidade Estadual de Londrina (UEL) – Londrina (PR), Brasil.

Corresponding author
eloisewalmeida@gmail.com

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Abstract

Backgroung: People with Down syndrome (DS) may present changes in the lipid profile. The objective of this research was to collect data from the literature on the lipid profile and the effect of exercise on this variable of people with DS. Five databases were searched (MedLine, Lilacs, EBSCO Host, Web of Science and PsycInfo) using terms related to the research objectives. At the end of the searches, 15 articles were included in the review. Five studies verified changes in the lipid profile and high incidence of dyslipidemias, with the most frequent changes being low HDL and elevated triglycerides. Two studies investigated the effect of intervention with exercise and counseling for health-friendly practices and found improvement mainly in HDL after the intervention period. Thus, the lipid profile should be investigated in people with DS and the practice of physical exercises can be used to control these variables.

Keywords: Lipid profile, Down syndrome, Physical exercise, Literature review.

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Authors summary

Why was this study done?
Down syndrome involves a number of morphological and functional characteristics that require specific care. For this care to be managed, it is important to systematize information about the health of this population. The number of professionals working with people with DS is increasing and they still need subsidies to make this performance increasingly specific to the needs of disabilities. In this sense, we performed the literature review so that we could gather information from the literature on the lipid profile of people with DS, since these data are relevant to the health of this population.

What did the researchers do and find?
We gather data from the literature on the lipid profile and the effect of exercise on this variable of people with DS. Five databases were searched (MedLine, Lilacs, EBSCO Host, Web of Science and PsycInfo) using terms related to the research objectives. At the end of the searches, 15 articles were included in the review.
From the analysis of the studies included in this review, it is possible to perceive that a high portion of the population with DS presents negative results of the lipid profile. Also, important relationships between abdominal fat accumulation and lipid profile were found. Excess abdominal fat is associated with higher total cholesterol, LDL and triglycerides and lower HDL cholesterol. Finally, it was verified that both the practice of recreational physical activities and regular and systematized physical exercises seem to benefit the lipid profile, specifically the HDL cholesterol of people with DS.

What do these findings mean?
It was possible to notice that people with Down syndrome have negative results related to their lipid profile, and even though some studies seek to understand what interferes in these variables, there is still little research investigating these data.
Also, it is known that in people without disabilities, the practice of physical exercises can have benefits for the lipid profile. However, little research has verified the effects of exercise for the population with Down syndrome.
Therefore, in general, the results indicate the need to further investigate the effects of exercise on the behavior of the lipid profile of people with Down syndrome, so that an increasingly active lifestyle is stimulated among this population, and so that the benefits brought by the practice of physical exercises are manifested in the maintenance of positive health among these individuals. In addition, the results found in this study can target professionals who work together with people with Down syndrome, in order to guide new research possibilities that can be conducted with this population.

INTRODUCTION

Down Syndrome (DS), defined as the trisomy of chromosome 21, is the most frequent chromosomal abnormality that causes intellectual disability[1]. Data indicate that, worldwide, the syndrome affects one in every 750 live births[2]. In the majority of cases, people affected by DS present free or simple trisomy 21, in which all cells in the body have a third chromosome of pair 21[3,4].

The characteristics of this syndrome, such as muscular hypotonia, the presence of congenital heart diseases, and alterations in the hormonal and enzymatic metabolism can favor overweight and obesity in this population[3,5,6]. Eberhard *et al*.[3] suggest that chromosomal alterations that promote a neurochemical imbalance in the production of some enzymes such as phosphofructokinase and superoxide dismutase may interfere with the antioxidative process of the organism, thus favoring early aging.

With regard to the lipid metabolism of people with DS, the literature does not yet provide definite data on the values of total cholesterol, or HDL and LDL cholesterol in this population. Some studies indicate levels considered normal for these variables[3,7], however, recent research has found that the lipid profile of young and adult patients with DS are characterized by dyslipidemia, in which high levels of total cholesterol, LDL and triglycerides (TG) and low HDL levels are observed[8-10]. Lifestyle and the practice of physical activities are strongly related to the control of these factors, which in turn are associated with the incidence of cardiovascular diseases[5,11,12].

In people with disabilities, especially DS, the lack of practice of physical activities is common. Associated with the characteristics of the syndrome, sedentary behavior is one of the reasons for obesity and low levels of physical fitness in this population[13,14]. Thus, a physical exercise program can act positively in physical fitness, lipid, blood pressure and glycemic profile of individuals, which can reduce blood pressure, the need for insulin, total body fat, triglyceride levels and raise HDL cholesterol levels[15,16]. However, there is insufficient evidence to detail which physical exercise programs are effective in improving this profile in people with DS[17-21].

Thus Down syndrome involves a number of morphological and functional characteristics that require specific care. For this care to be managed, it is important to systematize information about the health of this population. The number of professionals working with people with DS is increasing and they still need subsidies to make this performance increasingly specific to the needs of disabilities. In this sense, the review and gathering of literature information on the lipid profile of people with DS becomes relevant to the health of this population.

Based on the above, the objective of this review is to analyze the data available in the literature on the lipid metabolism and the influence of physical exercise on these variables considered as a control for the risk of cardiovascular diseases in people with Down Syndrome

METHODS

The review of the literature was conducted through a search for articles indexed in databases that addressed the topic of the lipid profile in people with Down syndrome and the influence of physical exercise on this variable. The following databases were selected to conduct the search: Pubmed, Medline – Medlars Online (1950 – April 2018); Lilacs – Latin American and Caribbean Health Science Literature (1982 - April 2018); EBSCO Host (1975 – April

2018); Web of Science (1900 – April 2018); PsycInfo (2001 - April 2018).

The following Health Sciences descriptors were used to perform the search: "Down Syndrome", "Intellectual Disability", "Mental Retardation", "Blood", "Lipid Profile", "Cholesterol", "Triglycerides", "Physical Activity", "Exercise", "Fitness", "Training", "Training program", using the Boolean operators OR and AND to expand and refine the searches. No language restriction was placed on the publications. The decision to include articles was taken by two independent researchers and any disagreements were resolved by consensus.

After completing the searches, the articles were selected according to the following inclusion criteria: field studies with the participation of people with Down Syndrome; assessment of the lipid profile of participants with Down syndrome OR effects of an exercise intervention on the lipid profile of participants with Down syndrome. Review studies, as well as dissertations and theses were excluded from this study.

After this stage, the publications that met the inclusion criteria were tabulated and analyzed according to the following factors: research objective (a), characteristics of study participants (b), variables searched (c), and main findings of the research (d). Again, with this more refined analysis, if the studies were not completely in accordance with the proposed inclusion criteria, they were excluded from the review.

RESULTS

Selection of studies

From the searches in the selected databases, 601 studies were found using the terms described. Articles that were indexed in more than one database were excluded, giving a total of 490 articles. A thorough reading of the titles was then carried out to confirm if the publications fit the proposed research theme. After this step, 22 studies were selected.

The remaining 22 articles were then passed for complete and refined reading. After completing the readings, seven studies were excluded as they did not fully comply with the proposed inclusion criteria (did not perform field studies analyzing lipid metabolism or the effect of exercise on this variable in people with DS). Therefore, 15 studies were included in the present review.

The search results are described in Table 1 and the article selection strategy for this review is described in Figure 1.

Table 1: Results of the database searches

Database	Search period	Articles found
MEDLINE	1950-2018	280
WEB OF SCIENCE	1900-2018	166
PSYCINFO	2001-2018	59
LILACS	1982-2018	-
EBSCO HOST	1975-2018	96
TOTAL	601	

Note: Medline - Medlars Online; Web of Science; PsycInfo; Lilacs - Latin American and Caribbean Health Sciences Literature; and EBSCO Host.

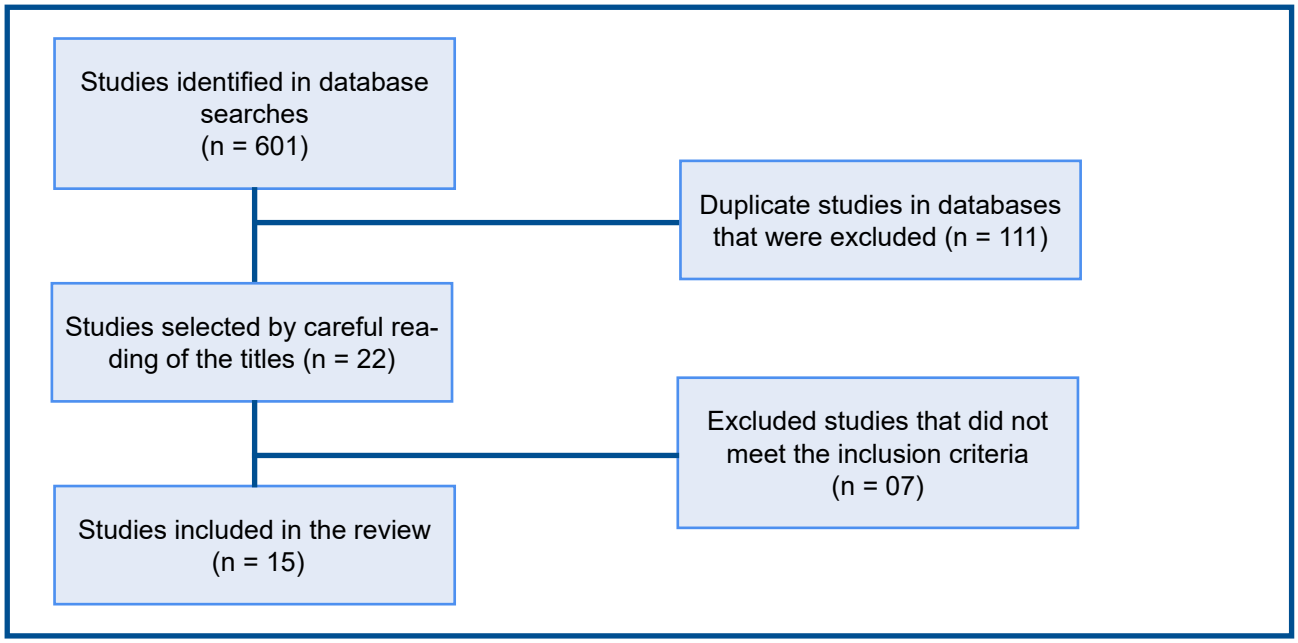

Figure 1: Diagram of the selection process of the studies

Characteristics of the included studies

Most of the studies included in this review had a cross-sectional design. Only three studies were quasi experimental and evaluated the effect of an intervention on the participants[3,22,23]. Of the 15 articles included, ten performed an analysis of the lipid profile and five evaluated the effect of exercise on this variable at a given time. Regarding the study participants, the number of individuals varied from 01 to 52, totaling 1097 people with Down Syndrome. The main findings of the studies are summarized in Tables 2 and 3.

Table 2: Articles that did not investigated the relationship between lipid profile and physical exercise on lipid profile

Reference	Objective	Participants	Analyzed Variables	Principal Findings
Dorner et al.[26]	To evaluate the lipid profile of a large group of patients with Down Syndrome (DS)	186 people with DS: 40 children, 96 adult men and 50 adult women. 51 adults and 575 children without disabilities (controls)	Total cholesterol (TC) and triglycerides (TG)	- No differences were found between men and women. - Cholesterol increases slightly with age. - Children with DS presented lower total cholesterol than control (Percentile 50 of the TC variable for adults with DS = 4.98 mmol / L, 50th percentile of the TC variable for young people with SD = 3.93 mmol / L).
Rimmer et al.[27]	To compare the lipid profile and% fat of adults with DS and Intellectual Disability (DI).	31 adults and young people with DS (21 men and 10 women with DS, 162 men and 132 women with ID, aged between 17 and 72 years.	TC, LDL, HDL and TG	- The lipid profile results were not different between the SD and DI groups. - Women presented worse lipid profile results than men, putting them at higher risk for the development of cardiovascular disease - 32% of women and 54% of men had high cholesterol (> 200mg / dl). (Men with SD: TC = 193,5±34,1 mg/dL, HDL = 40,4±8,2 mg/dL, LDL = 134,0±24,3 mg/dL, TG = 119,3±54,5 mg/dL. Women with DS: TC = 192,3±37,0 mg/dL, HDL = 47,2±11,4 mg/dL, LDL = 144,0±17,9 mg/dL, TG = 105,3±47,4 mg/dL).
Ordoñez-Munoz et al.[7]	To evaluate the correlation between anthropometric parameters and the lipid profile of people with DS.	21 youngsters with DS, with a mean age of 16 years. Not involved in exercise programs in the last 6 months.	TC, HDL, HDL / CT fraction, TG.	- The lipid profile variables were within the recommended values for health, however the HDL was at the lower limit and the Triglycerides were at the upper limit (TC = 192.3 ± 6.1 mg / dL, HDL = 39.8 ± 2, 8 mg / dL, TG = 155.1.3 ± 4.9 mg / dL). - A significant correlation was found between the Hip Waist Ratio and the HDL / CT fraction
Wallen et al.[29]	To investigate the prevalence and severity of cardio-metabolic risk factors and cardiorespiratory fitness among adolescents with intellectual disability (ID) and without disabilities	156 adolescents, 66 with ID, and of these 13 with DS, and 90 without disability.	TC and TG.	- Adolescents with DS presented values within normal levels of total cholesterol and triglycerides (TC = 3.84 ± 0.11 mmol / L, TG = 0.9 ± 1.07 mmol / L).
Draheim et al.[25]	- To determine if people with Down Syndrome have a lower frequency of arteriosclerosis than people without SD.	52 DS adults with mild to moderate intellectual disabilities (27 women and 25 men) between the ages of 35 and 60 years.	TC, LDL and HDL, TG	- No cholesterol differences were found between participants with and without DS (DS: CT = 185.4 ± 34.2 mg / dL, HDL = 45.0 ± 10.2 mg / dL, LDL = 115.0 ± 29,6 mg / dL). - Participants with DS presented higher intake of fats and also fruits and vegetables, higher percentage of fat and also higher triglycerides (TG = 126.5 ± 55.2 mg / dL)

Continuation - Table 2: Articles that did not investigated the relationship between lipid profile and physical exercise on lipid profile.

Reference	Objective	Participants	Analyzed Variables	Principal Findings
Marín and Graupera[28]	To evaluate the nutritional status (biochemical, anthropometric and dietary measures) of young adults with DS.	48 youngsters and adults with DS (15 women and 23 men with DS, aged between 16 and 38 years).	TC, LDL, HDL, TG	- Most of the sample was overweight grade II (28.9%) and obesity class I (28.9%). - The mean values of total cholesterol (men = 171.7 ± 16.6 mg / dL, women = 158.8 ± 11.9 mg / dL), LDL (men = 104.4 ± 10.8 mg / dL, women = 92.7 ± 7.4 mg / dL), HDL cholesterol (men = 48.0 ± 5.8 mg / dL, women = 53.9 ± 4.5 mg / dL), and triglycerides (men = 96 , 3 ± 8.1 mg / dL, female = 61.3 ± 6.0 mg / dL), were in agreement with values considered normal for health.
Adelekan et al.[8]	To compare the lipid profile of children with DS and their non - disabled siblings.	27 children with DS and 31 siblings without disabilities, aged 4 to 10 years.	TC, LDL, HDL and TG	- None of the groups had altered cholesterol levels that required any clinical intervention. However, participants with DS presented higher values of total cholesterol (173.2 ± 24.3 mg / dL), LDL (103.8 ± 20.3 mg / dL) and triglycerides (105.7 ± 53.6 mg / dL) and lower HDL levels (48.3 ± 13.8 mg / dL).
Asua et al.[24]	To describe anthropometric differences in weight-related disorders among adults with DS and non-deficient controls, as well as their impact on glycemia and lipid metabolism.	49 adults older than 18 years with SD and 49 controls	TC, LDL, HDL and TG	- 28 participants were diagnosed with dyslipidemia (17 with DS and 11 controls) and 13 with metabolic syndrome (5 with DS and 8 controls). - Total cholesterol, HDL, LDL and triglycerides were not different between the groups. (TC (DS) = 201 ± 34mg/dL, LDL(DS) = 126 ± 31 mg/dL, HDL (DS) = 56 ± 13 mg/dL, TG (DS) = 103 ± 45 mg/dL)
Buonouomo et al.[9]	To evaluate the lipid profile of a large group of Italian children with DS.	357 children aged 2 to 19 years with SD	TC, LDL, HDL and TG	- 18% of the participants were overweight and 8% were obese. - Participants had high levels of total cholesterol, LDL and triglycerides, and low HDL levels, except for girls over 15 years of age who had adequate HDL (40 mg/dL) and total (144 mg/dL) cholesterol
de laPiedra et al.[10]	To describe the frequency of dyslipidemias in a sample of Chilean children and adolescents with SD	218 children and adolescents with SD between the ages of 2 and 18	TC, LDL, HDL, non-HDL cholesterol and TG	- 58% of the participants have some alterations in the lipid profile, the most common being low HDL and elevated triglyceride levels. - Of these 58%, 49% have only one variable changed, 26% have two, 13% have three variables changed, 9% have four variables and 3% have alterations in the five variables analyzed. (TC = 215,5 mg/dL, HDL = 35 mg/ dL, LDL = 138 mg/dL, TG = 126 mg/ dL, mean values of the group with dyslipidemia)

Table 3: Articles that investigated the relationship between lipid profile and physical exercise.

Reference	Objective	Participants	Analyzed Variables	Intervention	Principal Findings
Eberhard et al.[3]	To evaluate resting physiological parameters and their variations related to the metabolic responses induced by exercise in young people with Down syndrome.	11 boys with DS, 7 active boys and 4 sedentary boys, aged between 15 and 20 participated in the first part of the study. Four boys and two girls (training group) from this first group participated in the intervention.	Blood tests (30 min before the maximum test, at the beginning of the test and 2 minutes after the end of the test): lipid profile (HDL, LDL, VLDL).	12 weeks of aerobic exercise bike training, conducted for one hour, twice weekly at 60% $VO_{2maximum}$ intensity and one hour per day of school games involving races and walks.	The individuals' cholesterol values were close to those recommended. Participants in the training group, after the 12 weeks of intervention, showed an increase in HDL cholesterol (0,41±0.1 g/L).
Flore et al.[31]	To compare results of polysomnography, lipid profile and insulin sensitivity at rest and during exercise of a group with Down syndrome to a rest group of people without disability.	13 adults with SD (mean age 22 years) and 15 control adults without disabilities (physical education students), all considered as active.	Lipid profile at rest	An exercise session with intensity variations of 30 to 75% of the $VO_{2maximum}$.	- The lipid profile was not different between the groups and was at a normal level (TC (g/l) Control = 1.57 ±0.07 / SD =1.62 ± 0.06. TG (g/l) Control = 0.70 ±0.11 / SD = 0.88± 0.14. (HDL) (g/l) Control = 0.53 ±0.03 / SD = 0.55 ± 0.03. (LDL) (g/l) Control = 0.94 ±0.05 / SD = 0.84± 0.07) - No participant with DS presented characteristics of the metabolic syndrome - Lipid profile variables were not evaluated after physical exercise sessions. Only variables related to lipid oxidation were evaluated at these moments.
Eberhard[30]	- Provide information on physiological variables at rest and metabolic responses to the exercise of people with SD. - Specify the type of physical activity preferable to maintain the physical condition of these individuals.	11 adolescents with DS (7 boys and 4 girls) aged 15 to 20 years.	HDL, LDL and VLDL cholesterol at rest and immediately after the end of exercise (40 minutes at 57% of $VO_{2maximum}$ on cycle ergometer)	Acute exertion of 40 minutes on cycle ergometer at an intensity of 57% of VO2maximum	- Participants presented low values of HDL cholesterol (0.39 ± 0.08 g / L) and high rates of VLDL (25.9 ± 5.5 g / L) cholesterol. After exercise there were few changes in cholesterol values.
Eberhard et al.[23]	Redo a study on people with DS, under diet and physical exercise weekly monitoring of a year and compare them to four groups: 1 - individuals without disabilities of the same age, 2- physical education students, 3 - veterans active and 4 - the sample from a 1988 study with children with DS.	34 DS patients, with 7 adolescents (DS control) aged 18-20 years, 27 adolescents (experimental) aged 13-15 years. 20 active men, 17 physical education students and 16 non-disabled adolescents (non-disabled control)	CT, TG, HDL, LDL, fraction of total cholesterol / HDL.	Advice related to health habits, such as the consumption of foods without sugars and fats, fruits and vegetables and the recommendation of practicing physical activities at school and at weekends. The young people were followed up for a year	No differences were found in HDL cholesterol fractions among children with DS who participated in the intervention (boys = 0.44 ± 0.02 g/L, girls = 0.47 ± 0.03 g/L) and without DS (boys = 0.52 ± 0.04 g/L, girls = 0.59 ± 0.04 g/L), whereas children in the control group with DS (boys = 0.38 ± 0.02 g/L, girls = 0.43 ± 0.03 g/L) presented worse results in this variable.
Carmeli et al.[22]	To evaluate the effects of a walking training program on institutionalized elderly with intellectual disability (diagnosed with DS) and peripheral vascular disease.	26 subjects with DS aged 55-70 years.14 adults (9 women and 5 men) with DS performed the intervention.	- LDL, HDL and TG were evaluated before the intervention.	15 weeks of walking done three times a week for 40 minutes at an intensity that would not cause pain	- The participants had normal levels of LHL (86 ± 15 mg/dL) and HDL (40 ± 10 mg/dL) at the beginning of the exercise program.

The results of the lipid profile presented by the surveys included in this literature review were variable and different from each other. Of the ten articles in which lipid profile analysis was performed without the influence of physical exercise[7-10,24-29], in five the participants had some alteration in the lipid profile[9,10,24,25,27].

In the study by Rimmer *et al.*[27], 32% of the women and 54% of the participating men (17 to 72 years old) had high cholesterol values (> 200mg/dl). Similarly, de el Piedra *et al.*[10] reported that 58% of the participants (2 to 18 years old) had some alteration in the lipid profile. Low HDL and high triglyceride levels were the most frequent changes. Asua *et al.*[24] found that 17 of the 49 participants (adults older than 18 years) with DS were diagnosed with dyslipidemia and Buonouomo *et al.*[9] found that participants (2 to 19 years old) presented high values of total cholesterol (TC), LDL cholesterol and triglycerides and low HDL levels, except for girls over 15 years of age, for which normal values of these variables were observed. In the study by Draheim *et al.*[25], cholesterol levels were within normal values and only triglycerides were elevated (participants between 35 and 60 years).

In the study by Adelekan *et al.*[8] lipid profile values were within the recommended range for health, but were still higher than the results of their peers non-DS, which constituted the control group in the study. Furthermore, Ordoñez-Munoz *et al.*[7], Marín and Graupera[28] and Wallen *et al.*[29] found that the values of the lipid profile variables of adolescents and adults were within the recommended range. The search results of Dorner *et al.*[26] indicated that adults with DS had lower cholesterol levels than participants in the "non-deficient" control group.

Of the five articles in which the effect of the exercise on the lipid profile was evaluated[3,22,23,30,31], three had a quasi-experimental protocol[3,22,23] and applied an intervention in the research. Carmeli *et al.*[22] evaluated the effect of a training program with walking in a non-pain intensity range in elderly institutionalized with DS. The lipid profile was evaluated before the exercise period and the elderly had adequate cholesterol levels. However, these variables were not evaluated after the walking program and, therefore, it was not possible to verify the effect of the activities on the lipid profile of the elderly. Eberhard *et al.*[23] applied a diet and physical exercise counseling program for people with DS and without disabilities. No differences were found in the fractions of HDL cholesterol among the children with DS who participated in the intervention and without DS, while the children of the control group with DS had worse results in this variable after the intervention with counseling.

In the study by Eberhard *et al.*[3], a 12-week training program was conducted with young people with SD aged 15 to 21 years. The program consisted of one hour of aerobic activity on a stationary bicycle at an intensity of 60% of VO_2max twice a week and games at school involving races and walks for one hour a day. The lipid profile was evaluated before and after an incremental test of 40 minutes in a cycle ergometer, taking the participants close to exhaustion. The test was performed before and after the training program. At the end of the 12 weeks, authors noticed an increase in HDL cholesterol in the participants after the test.

The other two studies included in this revision performed evaluations after a single session of physical exercises. In the researches of Eberhard[30] and Flore *et al.*[31], who evaluated the acute effect of the exercise, the cholesterol results were in normal patterns among the participants. Eberhard[30] found that participants presented low values of HDL cholesterol and high values of VLDL cholesterol. After an effort of 40 minutes at an intensity of 57% of VO_2max, few changes in cholesterol values were found. Flore *et al.*[31] evaluated cholesterol levels before exercise, but after the tests the variables of the lipid profile were not measured again. Instead, variables related to lipid oxidation after an exercise session with intensity variations of 30 to 75% of maximal VO_2 were evaluated.

DISCUSSION

The objective of this review study was to bring together studies in the literature that investigated the lipid profile of people with Down Syndrome, as well as the effects of exercise on these variables.

As in the population without disabilities, mortality due to cardiovascular diseases has increased among people with intellectual disabilities (ID). Adults with mild to moderate ID and belonging to lower social classes are at greater risk of developing cardiovascular diseases. In addition, age, sex, lipid and glycemic profile, and blood pressure are also risk factors for the development of this type of pathology[32].

When submitted to a physical exercise program, Elmahgoub *et al.*[33] found that, after 10 weeks of combined aerobic resistance training, 15 adolescents aged 14-22 years with moderate to severe intellectual disability, diagnosed with Autism or fragile X syndrome, had an increase in HDL and a reduction in CT, LDL and TG when compared to a control group. The authors explain these results by decreasing body fat, also observed at the end of the training program.

Certain characteristics of Down syndrome, such as the high incidence of congenital cardiopathies and thyroid dysfunctions, as well as the frequent sedentary lifestyle in this population, may increase the risk situation of this group[3,5,6,34]. In this sense, the evaluation and control of the lipid profile of people with Down syndrome may be important in the prevention of cardiovascular diseases.

Regarding the lipid profile, the studies present different results. Of the 10 articles in which these variables were analyzed without the influence of physical exercise[7-10,24-29], in five the participants had some alteration in the lipid profile[9,10,24,25,27], demonstrating a high incidence of these alterations in people with DS.

Increasing age may be a factor that influences higher cholesterol levels[35]. However, when analyzing the age of participants in the studies included in this review that had inadequate levels of HDL, LDL, CT, and triglycerides, in two studies[9,10] participants had from 2 to 19 years. In the study by Rimmer *et al.*[27] in which the participants presented higher values of total cholesterol, the age of these subjects was from 17 to 72 years. Moreover, in the only study in which only elderly people were evaluated[22], the results of lipid profile variables were within the normal pattern at the

initial moment.

These data may indicate that other factors, such as lifestyle and dietary habits, which may lead to overweight and obesity, may have a greater influence on the lipid profile of people with Down's Syndrome than age[36]. In an attempt to understand what leads to possible changes in the lipid variables of people with DS, some hypotheses are raised. Excess weight and body fat, especially in the abdominal region, common among people with DS, may possibly interfere with lipid levels. Two studies included in this review performed analyzes in this sense. Ordoñez-Munoz *et al.*[7] found significant correlations between anthropometric variables (BMI, CA and Waist-to-Hip ratio) and the lipid profile of young people with a mean age of 16 years, highlighting the strong positive correlation between HDL and WHR. However, Asua *et al.*[24] found that adult participants with abdominal obesity, assessed by WHR, did not present CT, LDL, HDL and triglyceride values different from those who were not identified with excess abdominal fat.

Some studies have shown that, when compared to people without disabilities, participants with DS have higher nutritional intakes of carbohydrates and fats, and less consumption of proteins, fibers and some vitamins and minerals[37,38], and these eating habits may be related to excess weight and fat. Therefore, the analysis of food and nutritional intake may be an important strategy to understand the variations in the lipid profile of these people.

Reduced production of thyroid hormones, typical of hypothyroidism, may also be related to changes in cholesterol, especially increased LDL and reduced HDL. Lower concentrations of thyroid hormones decrease the synthesis and expression of LDL receptors, leading to a serum increase in LDL and, consequently, cholesterol. Moreover, the activity of the enzyme lectin-cholesterol-acyltransferase (LCAT), responsible for the esterification of endogenous cholesterol on the surface of HDL, is reduced in hypothyroidism, leading to the reduction of HDL cholesterol in this thyroid dysfunction[39,40].

Hypothyroidism is a common condition in people with DS. Approximately 30% to 50% of children with school-age SD present with hypothyroidism[41]. Thus, the importance of periodic evaluation of this variable is emphasized, also in the aid of the control of overweight and obesity and of the metabolic conditions that are associated with these dysfunctions. A study of this review carried out analyzes of thyroid hormones10 and found that 71% of adolescents with DS had been diagnosed with hypothyroidism. This group did not present significant differences in relation to the individuals without thyroid dysfunction, but a trend of higher levels of TG and lower HDL rates. This fact indicates that the care with the control of hypothyroidism is important for the maintenance of adequate levels of the lipid profile.

The practice of physical exercise can be a beneficial strategy for the control and reduction of cholesterol levels[42]. Research indicates that with physical exercise, muscle tissue increases its ability to consume fatty acids and increases lipoprotein lipase activity in muscle, reducing plasma lipid levels. In addition, the practice of physical exercises seems to increase the activity of the enzyme lectin-cholesterol-acyltransferase (LCAT), increasing HDL-cholesterol. This process removes cholesterol from circulation for its elimination[42,43].

Of the five articles in which the effect of the exercise on the lipid profile was evaluated[3,22,23,30,31], only two studies, of the three who applied an intervention, found improvement in the lipid profile after the exercise program[3] or counseling[23] on positive health habits.

In the study by Eberhard *et al.*[3], after a 12-week intervention with aerobic exercise in cycloergometer and school games, the authors verified the lipid profile before and after a 40-minute incremental test, and verified an increase in HDL cholesterol in the test performed after the intervention. However, even if benefits were found with the application of this training protocol, the type of play performed at school, as well as its intensity and student participation in these moments were not measured, making it difficult to generalize and extrapolate these data. But still, this is the only research found in the literature that applied an intervention with regular physical exercise practices and that evaluated its effect on the lipid profile.

In the research by Eberhard *et al.*[23] participants with SD and without disability received counseling related to health habits, such as the consumption of foods without sugars and fats, fruits and vegetables and the recommendation of practicing physical activities at school and at weekends. The youngsters were followed up for a year and after this period no differences were found in HDL cholesterol in children with and without disabilities who participated in the intervention, while the children in the control group with SD who did not receive counseling presented worse results in this variable. Therefore, also in this research positive effects were found in lipid profile variables investigated. However, no control was performed during the intervention period on the amount and intensity of physical exercise, as well as on the food consumed by the participants during the year. Thus, this research demonstrates that positive habits related to health can be positive even for the lipid profile, but it does not allow to draw conclusions about which exercise program brings these benefits or even if they necessarily need to be allied to food control.

Some studies included in the review present missing information that may compromise the analysis of results. In the study by Carmeli *et al.*[22] for example an intervention was applied, and the authors investigated the effect of 15 weeks of walking performed three times a week for 40 minutes at an intensity that would not cause pain in institutionalized elderly with DS. The variables of the lipid profile were evaluated before the exercise program, but there was no evaluation of these variables after the intervention, which makes it impossible to obtain any conclusions regarding the effectiveness of the exercise program in this situation.

Eberhard[30] evaluated the acute effect of exercise on the lipid profile of 11 adolescents with DS and found that the participants had low values of HDL cholesterol and high rates of VLDL cholesterol. After a 40-minute cycle ergometer effort at 57% VO_2max, few changes in cholesterol values were found. However, the author verified an increase in free fatty acids (FFA), demonstrating that in this type of

exercise the intensity in which it was performed stimulates lipid metabolism. This study presented a proposal different from the others included in this research, since it sought to investigate the effect of only one exercise session on cholesterol. The author did not find any results in this sense and pointed out that adaptations in the lipid profile would probably occur with regular physical exercise, confirming the need for research with these intervention protocols.

It is known that the practice of at least 60 minutes of physical activities at a moderate intensity by adolescents is associated with health benefits[44]. However, it is common for people with disabilities, and specifically among people with DS, to be less involved in more intense physical activity practice[45]. The articles presented in this review found that both the practice of physical activities performed at school or leisure time, as well as systematized exercise practices seem to bring benefits to the lipid profile of people with DS. However, the articles had different intervention protocols, making it difficult to compare results and construct more conclusive answers. Therefore, the effects of regular physical activity on this population still constitute a gap and need to be further investigated.

From this review it was possible to notice that there are not many studies that investigated the lipid profile in people with DS. And, especially, the effect of different physical exercise protocols on this variable has not yet been established. The benefits of physical exercise are widely known in people without disabilities. Considering the characteristics of DS, it is very important to study the effects of physical exercise in this population, specifically in the lipid profile, since the evidence presented in this review shows that both recreational and regular practices can bring improvements in cholesterol levels. This issue is still little discussed, perhaps due to the difficulty of adhering to physical exercise for people with disabilities. Thus, motivational proposals for this population can be placed so that the gaps found in the literature can be solved.

Research limitations

Despite the results found in the present study, some limitations need to be pointed out. Due to the still scarce amount of research produced investigating the lipid profile of people with Down syndrome, it was necessary to gather studies that investigated the cholesterol variables in different conditions: different age groups, recruitment of different participants, with or without physical exercise, or even by different methodologies. However, even with the disparities of research found, it is possible to draw an overview of the literature in the sense that further research is needed to investigate the lipid profile of this population

Still regarding the differences of the studies, the distinct methodological design of each one does not allow the accomplishment of statistical analyzes to search the evidences and to build the profile of the lipid variables of the Down syndrome population.

FINAL CONSIDERATIONS

From the analysis of the studies included in this review, it is possible to perceive that a high portion of the population with DS presents negative results of the lipid profile. Some hypotheses were investigated for the understanding of these results. Advanced age, which may be a factor for inadequate lipid profiles, did not seem to influence the results found in the research presented. Young individuals presented negative cholesterol and triglyceride results for health, while the elderly had adequate levels of these variables. Therefore, regardless of age, the lipid profile of people with DS should be followed up.

Also, we sought to analyze whether body composition or excess fat, mainly abdominal fat, could influence the lipid profile. Important relationships between abdominal fat accumulation and lipid profile were found. Excess abdominal fat is associated with higher total cholesterol, LDL and triglycerides and lower HDL cholesterol. Thus, control of body composition, especially abdominal fat accumulation, may be important to maintain the lipid profile at adequate levels for health.

A third aspect analyzed, which can influence the lipid profile of people with DS, is the production of thyroid hormones. Changes in the production of these hormones are frequent among people with DS, especially hypothyroidism. Individuals with this disorder tend to higher triglyceride and LDL values and lower HDL levels. Therefore, monitoring thyroid hormone levels is also important for cholesterol and triglycerides to stay at the right levels.

Finally, the practice of physical exercises was also considered, and it was verified that both the practice of recreational physical activities and regular and systematized physical exercises seem to benefit the lipid profile, specifically the HDL cholesterol of people with DS, although the shortage of studies and protocols hampers comparisons and extrapolations of data.

Therefore, it is realized that research is still needed with the purpose of investigating the chronic effect of physical exercise on the variables analyzed in this review study. There are few data in the literature on this topic. Considering the importance and benefits of regular physical activity for people without disabilities in these important variables of cardiovascular risk, we can highlight the importance of also knowing the effects of physical exercise for people with DS.

Thus, the data collected here may offer subsidies for professionals who prescribe physical exercise for people with DS, in order to guide practices that may also benefit the lipid profile and also suggest that this variable be monitored in the follow-up of physical exercise practice.

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Resumo

Introdução: Pessoas com síndrome de Down (SD) podem apresentar alterações no perfil lipídico. O objetivo desta pesquisa foi reunir dados da literatura sobre o perfil lipídico e o efeito do exercício sobre essa variável de pessoas com SD. Cinco bases de dados foram pesquisadas (MedLine, Lilacs, EBSCO Host, Web of Science e PsycInfo), utilizando termos relacionados aos objetivos da pesquisa. Ao final das buscas, 15 artigos foram incluídos na revisão. Cinco estudos verificaram alterações no perfil lipídico e incidência elevada de dislipidemias, sendo as alterações mais frequentes o baixo HDL e triglicérides elevados. Dois estudos investigaram o efeito de intervenção com exercícios físicos e com aconselhamento para práticas benéficas para saúde e verificaram melhora principalmente no HDL depois do período de intervenção. Assim, o perfil lipídico deve ser investigado em pessoas com SD e a prática de exercícios físicos pode ser utilizada para o controle destas variáveis.

Palavras-chave: Perfil Lipídico, síndrome de Down, Exercício Físico, Revisão de Literatura