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Lipid Absorption and the Aging Process

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KEYWORDS

lipid transport,
intestinal lipid absorption,
lipid absorption in elderly,
CD36 fatty acid,
FATP4.

Abstract

The aging process is significantly influenced by lipid metabolism, affecting various aspects of physiological functions. Aging leads to a reduction in digestive physiology, alters the rate of lipid absorption, as well as impacts the risk of developing metabolic syndrome and other neurodegenerative diseases. Therefore, this study aimed to investigate the relationship between lipid absorption and aging, providing evidence that the existence and contribution of lipid absorption pathways play a role in the aging process. A literature search was carried out to obtain articles from electronic databases namely Scopus and Pubmed. The inclusion and exclusion criteria were used to select relevant articles. After title and abstract screening, 170 possibly relevant articles were filtered for full text, and only 58 were eventually reviewed. The results showed that the rate of lipid absorption decreased with age but the cholesterol level significantly increased. Several endogenous factors influence the level of TC, LDL-C, HDL, and TG, namely the role of adipocytes or fat cells in cholesterol synthesis, insulin resistance, adipokine secretion, and genetics. It was also found that lipid levels in the elderly were higher than in adults. In enterocyte cells, lipid transporters affected the rate of absorption including FATPs, FABP, FAT/CD36, NPC1L1, and ABCA1. The chylomicrons as lipid transporters in adults and the elderly had the same basic structure. However, the amount and sizes transported differed. High lipid levels in the elderly cause aging-related diseases such as chronic disease, coronary artery disease, coronary atherosclerosis, carotid artery stenosis, and cardiovascular issues.

Abbreviations

Apolipoprotein E (Apoe), ATP-Binding Cassette Transporter (ABCA1), Cluster Of Differentiation 36 (CD36), Free Fatty Acid (FFA), Fatty Acid Transport Protein (FATP), Fatty Acid Binding Protein (FABP), Fatty Acid Translocase (FAT), High-Density Lipoprotein Cholesterol (HDL-C), Low-Density Lipoprotein Cholesterol (LDL-C), Niemann-Pick C1-Like 1 (NCP1L1), Non Esterified Fatty Acid (NEFA), Total Cholesterol (TC), Triglyceride (TG).

INTRODUCTION

Lipid is a common source of energy and a means of transporting vitamins and nutrients needed by the human body.(Soenen et al., 2016) In the aging process, lipid metabolism significantly impacts nutrient absorption.(Soenen et al., 2016) Recent studies have shown that aging decreases digestive physiology and changes the rate of lipid absorption.(Holt & Balint, 1993) Consequently, the elderly population is more at risk of developing metabolic syndrome.(Spitler & Davies, 2020) The capacity for fat absorption and energy use remains relatively stable in healthy adults but reduces in the elderly.(Becker et al., 1950; Soenen et al., 2016; Wheeler et al., 2014) This is attributed to several factors, including a decrease in lipase secretion by the pancreas,(Iqbal & Hussain, 2009) telomere shortening, mitochondrial dysfunction, epigenetic changes, genomic instability, and cellular senescence.(Zhe Li et al., 2021)

Dietary lipid derived from plants and animals is predominant in triacylglycerols, phospholipids, and cholesterol esters.(Hussain, 2014) (Zhao et al., 2021) It is digested in the intestinal lumen and subsequently taken up by enterocytes, which produce giant lipoprotein particles known as chylomicrons for secretion. These chylomicrons are broken down through peripheral tissues to produce free fatty acids (FFA).(Hussain, 2014) Triglycerides are hydrolyzed to produce monoacylglycerols and free fatty acids (FFA), while FFA and lysophospholipids are formed from the hydrolysis of phospholipids. The hydrolysis of cholesterol esters also releases free cholesterol and FFA.(Hussain, 2014) Although chylomicrons as transporters in humans have the same basic structure including proteins, phospholipids, cholesterol, and triglycerides, the number and sizes transported are different.(Callahan et al., 2020) These differences are influenced by lipid transporters in enterocyte cells such as FATPs, FABP, FAT/CD36, NPC1L1, and ABCA1,(Zhiqiang Li et al., 2015; Nassir et al., 2007; Siddiqi et al., 2010) all of which play a role in the aging process of the elderly.

At the biological level, aging occurs due to the accumulated effects of various molecular and cellular damage over time.(WHO, 2022) This eventually leads to a gradual loss of physical and mental abilities, a higher risk of illness, and death. Common degenerative diseases in the elderly include cardiovascular and cerebrovascular disease, diabetes, osteoporosis, and cancer.(Kerch, 2015; Zhe Li et al., 2021) In addition, hearing loss, cataracts, refractive errors, back and neck discomfort, osteoarthritis, chronic obstructive pulmonary disease, diabetes, depression, and dementia are all frequent ailments in this population.(WHO, 2022) One of the several causes of these diseases is the low rate of lipid absorption.

This review aims to investigate the relationship between lipid absorption and aging, providing evidence that the existence and contribution of lipid absorption pathways play a crucial role in the aging process.

MATERIALS AND METHODS

This review aims to investigate the relationship between lipid absorption and aging, providing evidence that the existence and contribution of lipid absorption pathways play a crucial role in the aging process. A literature search was conducted to obtain articles from Scopus and Pubmed as well as other internet sources published up to 2023. The keywords used were "lipid transport", "lipid absorption", "intestinal lipid absorption", "lipid absorption in the elderly", AND "CD36 fatty acids, FATPs, FABP", AND "Lipid transporters in enterocytes, CD36, FATP4", AND "CD36, FATPs, FABP, NPC1L1, and ABCA1". The inclusion criteria included articles on lipid absorption in the elderly, discussed the associated molecules and mechanisms of action and published up to 2023.

RESULTS AND DISCUSSION

The initial search yielded a total of 170 articles, out of which 146 were found to be relevant to this study. The inclusion criteria included articles published up to 2023, which focused on lipid absorption in the elderly as well as the mechanisms and molecules associated with lipid absorption.

After title and abstract screening, the entire text of 141 possibly relevant articles was checked. A total of 58 articles were eventually included in the review.

Journal of Chemical Health Risks
www.jchr.org
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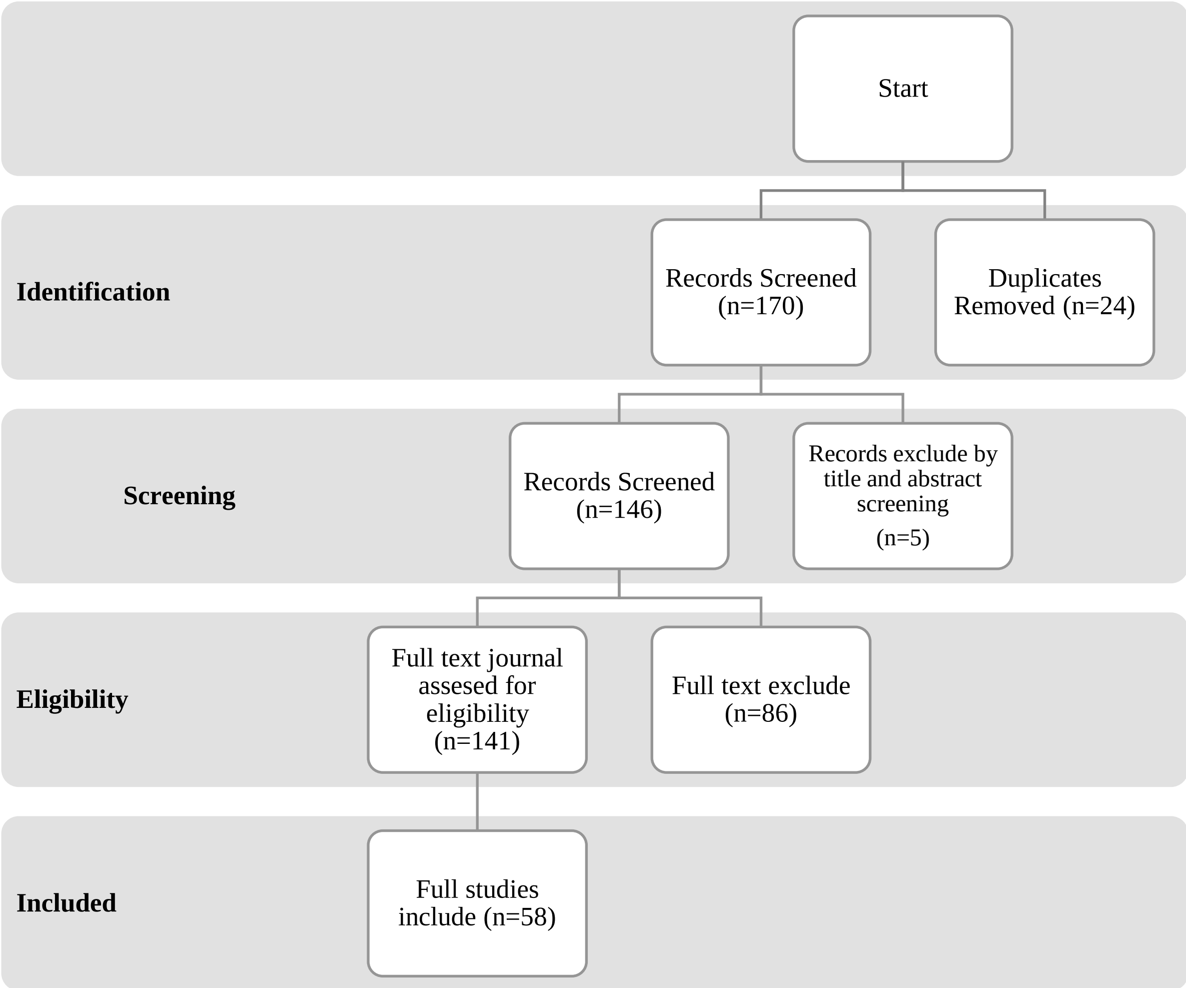

Figure 1. Selection Process and Strategy for Included Studies

Lipid metabolism

Lipid refers to fats ingested or synthesized by the liver, with triglycerides and cholesterol making up the majority of lipid sources from diets.(Davidson & Pulipati, 2022b) Although all lipids are physiologically significant, triglycerides and cholesterol are the main contributors to aging and disease.(Davidson & Pulipati, 2022b) Pancreatic lipase hydrolyzes lipid in the first step of metabolism to produce free fatty acids (FFA), monoacylglycerols (MAGs), and free cholesterol (FC). This process requires the emulsification with bile salts,(Callahan et al., 2020) producing structures called micelles. Upon entering the intestinal epithelial cells, the fatty acids and monoglycerides spread across the membrane after leaving the micelles.(Voet et al., 2013) In the cytoplasm, triglycerides are created by combining fatty acids and monoglycerides. Both triglycerides and cholesterol are bundled into bigger particles called chylomicrons, namely amphipathic structures that transport digested fats.(Jo et al., 2016) Chylomicron particles use apoB48 as a scaffold protein with the help of microsomal triglyceride transfer protein (MTP).(Callahan et al., 2020) These large structures have a core of triglycerides (85-92%), phospholipids (6-12%), cholesterol (1-3%), and protein (1-2%), interspersed with apolipoproteins.(Callahan et al., 2020) (Jones et al., 1950) Chylomicrons enter adipose and other tissues in the body through circulation. After returning to the liver, the cholesterol-rich leftovers are eliminated through an apoprotein E (apo E) mediated procedure.(Davidson & Pulipati, 2022b)

Transporters in Lipid Absorption

The rate of lipid uptake in enterocyte cells is also influenced by transporters such as FATPs, FABP, FAT/CD36, NPC1L1, and ABCA1.(Ghosh et al., 2021) (Cifarelli & Abumrad, 2018) (H. Li et al., 2022)

Journal of Chemical Health Risks

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(Evangelista-silva et al., 2021) Unesterified free fatty acids are absorbed through passive diffusion or active transport by transporters such FATP4 or CD36.(Ghosh et al., 2021), (Umbarawan et al., 2018) FATP4 is the only member of FATP present at the apical brush border of intestinal epithelial cells and plays a role in FA uptake by enterocytes.(Cifarelli & Abumrad, 2018) As stated in a previous study, FATP4 expression between the duodenum, jejunum, ileum, proximal colon, and distal colon in the human intestine was not significantly different.(H. Li et al., 2022) The Human Protein Atlas (https://www.proteinatlas.org/) states that the colon expresses significantly lower amount compared to other intestinal segments, while the stomach has a higher level of expression. FATP4 deficiency prevents intestinal absorption, but overexpression promotes long-chain FA uptake in cells (HEK293 and enterocytes).(H. Li et al., 2022) According to previous studies, a high-fat diet administered to hepatocytes can lead to a shift in FA to TG, which is easily hydrolyzed to glycerol and NEFA, raising blood lipid levels.(H. Li et al., 2022) Free cholesterol (FC) is also excreted back into the lumen through the ABCAG5 and ABCG8 transporters or released into the blood circulation by ABCA1 and apoAI.(Hussain, 2014) In enterocytes, fatty acids (FA) and cholesterol are transported by intracellular FABP1/2 or SCP2 to the endoplasmic reticulum where reesterification and incorporation into chylomicrons occur.(Ghosh et al., 2021) On the apical membrane of enterocytes, newly absorbed FA and MAG are endocytosed by endocytic vesicles (CEVs) that also carry CD36 and contain caveolin-1. This process leads to the creation of pre-chylomicron particles in the ER lumen and in the cytosol, as FA and MAG are re-esterified to TAG.(Cifarelli & Abumrad, 2018) Although lipid droplets in the early stages of disease help minimize the toxicity of protein aggregates and peroxidation, a strong accumulation can become problematic for cells and tissues as the disease progresses.(Bresgen et al., 2023)

Other proteins such as CD36 are also associated with cholesterol absorption at the apical surface of the small intestine.(Zhiqiang Li et al., 2015) The differentiation group 36 (CD36) includes a fatty acid transport protein (FA) which contributes to the absorption process.(Hussain, 2014) (Umbarawan et al., 2018) It also has an additional function in the gastrointestinal tract, although this is not directly related to intestinal fat absorption.(Cifarelli & Abumrad, 2018) After entering the cell, FFA is transported to various organelles for further processing by FA-binding proteins. Recent studies have shown that genetic deletion of CD36 (CD36KO) leads to reduced FA utilization with increased glucose dependence, thereby accelerating the progression from hypertrophy to heart failure.(Umbarawan et al., 2018) Fatty acid transport protein 4 (FATP4), fatty acid transporter/differentiation group 36 (FAT/CD36), and plasma membrane fatty acid binding protein (L-FABP) are additional factors that influence NEFA uptake.(Habold et al., 2009) The role of the small intestine in enhancing the TG profile is also essential.(Kaufman et al., 2019)

Another important modulator of absorption in the colon is the Niemann-Pick C1-like 1 (NPC1L1) transporter,(Kwon et al., 2021) which absorbs free/unesterified cholesterol.(Evangelista-silva et al., 2021) It plays a major role in the uptake by enterocytes and controls the processes of transport and endocytosis, which allow dietary cholesterol to be absorbed in the intestinal lumen.(Makhmudova et al., 2021) Considering that NPC1L1 is a key molecule for intestinal cholesterol absorption, CD36 may also contribute to the regulation of the NPC1L1 pathway.(Y-Y et al., 2018) Moreover, previous studies showed that a decrease in cholesterol efflux occurred in the ABCA1 transporter.(Pullinger, 2015)

Table 1. Transporters in Lipid Absorption with the Aging Process-related Diseases

No.	Subject	Result	Event	Correlation with Disease	References
1	Adult mice	Low lysophosphatidylcholine acyltransferase 3 reduces the absorption of intestinal lipid by the small intestine and decreases plasma cholesterol, phospholipid, and triglyceride levels.	- NPC1L1 ↓ - CD36 ↓ - FATP4 ↓	Hyperlipidemia	(Li et al., 2015) (Zhiqiang Li et al., 2015)

Journal of Chemical Health Risks
www.jchr.org
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No.	Subject	Result	Event	Correlation with Disease	References
2	Adult People	CD36-mediated fat intake can result in intestinal inflammation.	- CD36 ↑ - FABP1 ↑ - FABP2 ↑	Intestinal inflammation	(Cifarelli & Abumrad, 2018) (Cifarelli & Abumrad, 2018)
3	Adult People	Intestinal CD36 regulates intestinal lipid absorption, synthesis, transport, and hormone secretion.	- CD36	Metabolic syndrome	(Zhao et al., 2021)(Zhao et al., 2021)
4	Elderly People > 60 years old	NPC1L1 is essential for the intestinal absorption of cholesterol. High cholesterol increases the risk of CRC.	- NPC1L1 ↑	Colorectal cancer (CRC)	(Kwon et al., 2021) (Kwon et al., 2021)
5	Old Mice	Intestinal lipid absorption is weakened in aged mice accompanied by decreased expression of apical lipid transporters	- CD36 ↓ - FATP4 ↓ - NPC1L1 ↓ - FABP 1/2 ↓	Atherosclerosis	(Ghosh et al., 2021) (Ghosh et al., 2021)
6	Adult Mice	A high-fat diet reduced FAT/CD36 and NPC1L1 and increased levels of L-FABP proteins in the small intestine but not significantly.	- FAT/CD36 ↓ - NPC1L1 ↓ - L-FABP ↑	Obesity	(Evangelista-silva et al., 2021) (Evangelista-silva et al., 2021)
7	Elderly People	FATP4 deficiency causes fatty liver disease	- FATP4 ↓	Fatty liver disease	(H. Li et al., 2022) (H. Li et al., 2022)
8	Aged zebrafish	Exposure to down-regulation of MPs photoaging genes (CD36) is associated with triglyceride resynthesis and transport, resulting in lipid malabsorption and growth inhibition.	- CD36 ↓	Photoaging	(Zhang et al., 2022) (Zhang et al., 2022)

Correlation between Lipid Absorption and the Aging Process-related Diseases

Lipid in the Aging Process-related Diseases

Lipid refers to a group of naturally occurring molecules that include fats, waxes, sterols, fat-soluble vitamins (such as vitamins A, D, E, and K), monoglycerides, diglycerides, triglycerides, cholesterol, phospholipids, HDL, LDL, and others.(Subramaniam et al., 2011) The main biological functions include energy storage, signaling, and acting as a building component of cell membranes.(Soenen et al., 2016) (Subramaniam et al., 2011) Furthermore, hyperlipidemia is a medical condition characterized by an increase in the lipoprotein profiles of the blood.(Prasetyastuti & Gama, 2023) Triglyceride is a glyceride resulting from the esterification of the three hydroxyl groups of glycerol with fatty acids.(CBN, 2009) Meanwhile, triacylglycerol is an effective molecule for storing energy(Blanco & Blanco, 2022) in adipocytes and muscle cells.(Davidson & Pulipati, 2022b) Triglyceride levels can vary greatly reaching ± 25% daily.(Davidson & Pulipati, 2022a) Healthy adults have relatively good absorption rates, but with increasing age, triglyceride levels may become associated with physiological dysfunction.(Johnson & Stolzing, 2019b). Studies have shown that experiments with extra virgin olive oil lowered the average triglyceride level.(Nugraheni, 2012) The ability to absorb and use energy generally decreases with age.(Wheeler et al., 2014),(Soenen et al., 2016) Furthermore, aging can reduce the physiological function of the digestive tract and absorption.(Soenen et al., 2016)

Cholesterol is a key component in steroids, bile acids, cell membranes, and signaling molecules,(Davidson & Pulipati, 2022b) with the two main types being LDL and HDL.(Davidson & Pulipati, 2022a) The cholesterol level varies greatly up to ± 10% daily in the body.(Davidson & Pulipati, 2022a) Studies have shown that the levels of free fatty acids, triglycerides, HDL, and total cholesterol all rise significantly with aging.(Wheeler et al., 2014) The HDL cholesterol is considered good or beneficial because it transports the molecules from the blood vessels back to the liver for disposal, thereby preventing the thickening of the arterial walls or the risk of atherosclerosis. The lower the level of HDL-C, the greater the risk of developing coronary heart disease.(Davidson & Pulipati, 2022a; NCEP, 2018) Furthermore, the most cholesterol-rich lipoprotein is LDL, which is produced through the metabolism of VLDL and IDL. Apo B and hepatic receptors work together to help the liver eliminate between 40 and 60 percent of total LDL.(Davidson & Pulipati, 2022a; NCEP, 2018)

In adults, the digestive system works effectively, but in the elderly, several changes occur such as reduced saliva and mucus production, loss of teeth, difficulty in chewing or swallowing, and decreased energy production. These alterations also lead to reduced production of stomach acid and digestive enzymes.(Dieny et al., 2019) Maintaining optimal lipid levels is essential for both adults and the elderly. Abnormally high levels can cause dyslipidemia, characterized by elevated concentrations of cholesterol, triglycerides, or both, as well as low amounts of HDL cholesterol. Meanwhile, extremely low lipid levels can cause hypolipidemia in the blood.

Lipid metabolism plays a significant role in controlling the aging process.(Johnson & Stolzing, 2019a) Studies have shown that lipid-linked genetic markers have a strong correlation with longevity in humans.(Mutlu et al., 2021) TC, LDL-C, and TG levels in the elderly (> 60 years old) are higher than in adults.(Van Parys et al., 2022) (Kaur et al., 2019) This higher lipid profile is associated with an increased risk of CDV and other diseases.(Liu et al., 2020). High lipid levels are linked to age-related diseases,(Van Parys et al., 2022) (Kaur et al., 2019) such as coronary artery disease,(Abudoukelimu et al., 2015) coronary atherosclerosis,(Kerch, 2015) carotid artery stenosis,(Otsugi et al., 2020) and cardiovascular issues (Kleber et al., 2013) (Nematollahi et al., 2019) (Waßmuth et al., 2019) (Liu et al., 2020) (Zhan et al., 2018)

Table 2. Lipid in the Aging Process-related Diseases

No.	Subject	Result	Event	Correlation with Disease	References
1	Elderly People > 60 years old	High cholesterol absorption in the elderly is associated with cardiovascular disease (CVD)	- Cholesterol ratio (CR) ↑	Cardiovascular Diseases	(Kleber et al., 2013) (Kleber et al., 2013)
2	Elderly People	Oxidation of low-density lipoproteins (LDL) causes coronary atherosclerosis.	- Low-density lipoprotein (LDL) ↑	Coronary Atherosclerosis	(Kerch, 2015) (Kerch, 2015)
3	Elderly People > 50 years old	The high Numb cholesterol-absorbing gene polymorphism in the elderly is associated with coronary artery disease.	- TC ↑ - TG ↑ - LDL-C ↑ - VLDL ↑ - HDL-C ↑	Coronary Artery Disease	(Abudoukelimu et al., 2015) (Abudoukelimu et al., 2015)

Journal of Chemical Health Risks
www.jchr.org
JCHR (2024) 14(1), 3365-3377 | ISSN:2251-6727

No.	Subject	Result	Event	Correlation with Disease	References
4	Adults	Lipid analysis showed that high-density lipoprotein cholesterol (LDL-C), TC, and TG possibly increased high-density lipoprotein cholesterol (HDL-C), elevating the risk of cardiovascular diseases among adults.	- LDL-C ↑ - HDL-C ↑ - TC ↑ - TG ↑	Cardiovascular Diseases	(Zhan et al., 2018) (Zhan et al., 2018)
5	Elderly People	Healthy elderly showed higher levels of total cholesterol (TC), LDL-C, and TG.	- TC ↑ - LDL-C ↑ - Triglyceride (TG) ↑	Cardiovascular Disease	(Nematollahi et al., 2019) (Nematollahi et al., 2019)
6	Elderly People > 65 years old	The higher the cholesterol, LDL-C, and Triglyceride levels, the greater the risk of cardiovascular disease.	- Cholesterol ↑ - LDL-C ↑ - Triglycerides ↑	Cardiovascular disease	(Waßmuth et al., 2019) (Waßmuth et al., 2019)
7	Old adults and elderly aged 50-70 years	In the elderly, the higher the cholesterol and triglyceride levels, the greater the risk of developing chronic disease	- Total cholesterol ↑ - TG ↑ - HDL ↑ - LDL ↑	Chronic Disease	(Kaur et al., 2019) (Kaur et al., 2019)
8	Elderly people ≥ 60 years old Adult < 60 years old	In the elderly population > 60 years, the risk of CDV mortality / and other diseases is greater compared to adults.	- HDL-cholesterol ↑ - LDL-cholesterol ↑ - TC ↑ - TG ↑	Cardiovascular Diseases	(Liu et al., 2020) (Liu et al., 2020)
9	Elderly people 65-84 years old	There was a significant positive linear correlation between maximum lipid core burden index values and lipid areas that cause carotid artery stenosis.	- maxLCBI ↑	Carotid artery stenosis	(Otsugi et al., 2020) (Otsugi et al., 2020)
10	Elderly People and middle-aged People	Elderly people have a higher total, LDL, and HDL cholesterol, as well as triglyceride levels than the middle-aged	- TC ↑ - LDL-C ↑ - HDL-C ↑ - TG ↑	Chronic Disease	(Van Parys et al., 2022)(Van Parys et al., 2022)

Journal of Chemical Health Risks

www.jchr.org

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Studies conducted on animals and humans have shown that the absorption of cholesterol and sterols increases with age.(Makhmudova et al., 2021) High lipid levels in the elderly lead to the emergence of several life-threatening diseases. However, these diseases can be treated with Olive oil gavage.(Syamsu, 2017) An experiment that used olive oil at a dose of 0.36 ml/200 grW/day for 14 days effectively reduced total cholesterol levels by 22.61%.(Syamsu, 2017) (Hastuti, 2022) In addition, total cholesterol levels decreased significantly ($p<0.05$) in the treatment group after 6 hours of acute olive oil administration.(Anggraeni et al., 2017) This suggests that the consumption of extra virgin olive oil can reduce serum lipid. The results from another study proved that the average total cholesterol level after receiving extra virgin olive oil intervention decreased by 31.8457 mg/dl, 61.9972 mg/dl, and 105.1386 mg/dl.(Nugraheni, 2012) Another therapeutic approach to inhibiting cholesterol is the use of ezetimibe.(Sandoval et al., 2010) (Makhmudova et al., 2021) (Wan et al., 2021) (Fujisue et al., 2020) This therapy was found to inhibit cholesterol absorption in patients aged over 75 years.(Makhmudova et al., 2021) Moreover, the use of Reed cylindrical L (Anggraeni et al., 2017), and adherence to disease management program(Gitt et al., 2016) inhibit lipid absorption to avoid diseases related to the aging process.

Table 3. Therapeutic Strategies in Aging Process-related Diseases

No.	Subject	Therapeutic	Event	Correlation with Disease	References
1	Middle-aged mice	Ezetimibe	- ApoB-48 ↓	Hypertriglyceridemia	(Sandoval et al., 2010) (Sandoval et al., 2010)
2	Elderly people > 60 years old	Management programs for diabetes mellitus and coronary heart disease	- LDL-C ↓ - TC ↓ - TG ↓ - Fixed HDL-C ↑	Diabetes mellitus and coronary heart disease	(Gitt et al., 2016) (Gitt et al., 2016)
3	Middle-aged male mice	Reed cylindrical L.	- TC ↓	Hypercholesterolemia	(Anggraeni et al., 2017) (Anggraeni et al., 2017)
4	Middle-aged mice	Olive oil gavage	- TC ↓ - TG ↓ - HDL-C ↑	-	(Syamsu et al., 2017) (Syamsu, 2017)
5	Elderly people > 60 years old	More intensive lipid-lowering therapy with an ezetimibe-statin combination would be beneficial in acute coronary syndrome.	- TC ↓ - Fixed LDL-C ↓ - HDL-C ↑ - Fixed triglycerides - Lipoprotein ↓	Acute Coronary Syndrome	(Fujisue et al., 2020) (Fujisue et al., 2020)
6	75 years and older people	Ezetimibe	- LDL-c ↓	acute coronary syndrome and cardiovascular disease	(Makhmudova et al., 2021)

Journal of Chemical Health Risks
www.jchr.org
JCHR (2024) 14(1), 3365-3377 | ISSN:2251-6727

No.	Subject	Therapeutic	Event	Correlation with Disease	References
					(Makhmudova et al., 2021)
7	Aged mammal	Caloric restriction, time-restrictive eating, and lipid supplementation	- Lipid Droplets ↓	diabetes	(Gille et al., 2021) (Gille et al., 2021)
8	Elderly people > 65 years old	Ezetimibe Plus Statins optimize lipid levels and the patient's chances of avoiding aortic atherosclerosis, coronary artery disease, cerebrovascular disease, and peripheral arteries.	- LDL-C ↓ - Non HDL-C ↓ - TC ↓ - ApoB ↓ - Hs-CRP ↓ - TG ↓ - HDL-C ↑	Atherosclerotic vascular disease (ASVD)	(Wan et al., 2021) (Wan et al., 2021)

CONCLUSION

In conclusion, the current understanding of lipid and aging is constantly growing due to the contributions from recent investigations. Studies have shown that aging is associated with a decline in fat absorption rates. However, despite this decline, various lipid markers such as TG, TC, LDL-C, HDL, and LDL-C tend to increase significantly with age. Cholesterol levels in the body can be impacted by diet, lifestyle, environment, and other external variables. Furthermore, endogenous factors such as adipocytes or fat cells, also have a substantial impact on the levels of TC, LDL-C, HDL-C, and TG, in the body. Adipocytes can influence blood cholesterol levels through mechanisms such as insulin resistance, adipokine secretion, and genetics, particularly affecting LDL (bad cholesterol). Additionally, insulin resistance, reduced LDL Receptor activity, as well as increased activity of other liver enzymes associated with the manufacture of cholesterol are also affected. Due to complex factors, certain people are predisposed to developing high cholesterol despite maintaining a balanced diet. Among the elderly population, higher levels of TC, LDL-C, and TG are often observed compared to adults. Furthermore, lipid transporters that influence the absorption rate in enterocyte cells include FATPs, FABP, FAT/CD36, NPC1L1, and ABCA1. Overexpression of FATP4 in cells such as HEK293 and enterocytes leads to increased long-chain FA uptake, while deficiency results in the inhibition of intestinal absorption.

FABP1/2 facilitates the transport of fatty acids (FA) and cholesterol to the endoplasmic reticulum for reesterification and integration into chylomicrons. Although chylomicrons have the same fundamental structure in both adults and the elderly, the numbers and sizes of lipid transported differ. FAT/CD36 has an indirect impact on lipid metabolism, affecting intestinal fat absorption. NPC1L1 declines with aging, while the ABCA1 transporter also plays a role in reducing cholesterol absorption. Age-related disorders such as chronic illness, coronary artery disease, coronary atherosclerosis, carotid artery stenosis, and cardiovascular issues are caused by high levels of HDL and LDL cholesterol, as well as TC, and TG in the elderly. Based on previous studies, this population can benefit from follow-up disease management programs, a high-fat diet, ezetimibe therapy, or a combination with statins, and cylindrical L reed extract as treatments to improve lipid absorption and lower their risk of developing chronic disease. This study focused solely on the connection between lipid absorption and aging, providing evidence that the presence and contribution of lipid absorption pathways play a role in the aging process. However, further studies are needed to examine more deeply the ABCA1 lipid transporter pathway as well as other factors related to lipid absorption and aging.

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CONFLICT OF INTEREST

The authors confirm they have no conflicts of interest, financially or otherwise.

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